

## **Fostering Diversity, Equity, and Inclusion in Engineering Education: A Case Study of UIC Chemical Engineering Department**

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## **Abstract**

The persistent lack of diversity in engineering remains a pressing challenge, with limited signs of improvement. Efforts to promote diversity within engineering schools have yielded modest gains. In response to the changing landscape of engineering education, including recent updates in ABET criteria emphasizing diversity, equity, and inclusion (DEI), the UIC Chemical Engineering (CHE) department has embarked on a mission to be a change leader. This paper provides an overview of the department's ongoing DEI activities and initiatives, with a focus on creating a more inclusive educational environment.

The UIC DEI committee, in collaboration with a student DEI committee, has implemented a structured model to address DEI issues. To assess the current state of the department, climate surveys were conducted among students and faculty/staff. Action items were formulated to enhance racial equity within the department. Senior exit surveys and group interviews of graduating seniors were employed to capture their experiences and receive valuable feedback. Furthermore, the establishment of the ChemE Culture Club has provided a platform for celebrating the diverse cultures within the department. The senior design course now includes modules dedicated to global competency development and the incorporation of DEI statements in senior design projects. Additionally, the sophomore thermo course features sustainability projects, helping students understand the societal impacts of their engineering designs.

This paper not only summarizes the current DEI efforts at UIC CHE but also highlights the challenges and gains experienced during this journey. It aims to inspire the broader engineering community to undertake more concerted efforts to promote diversity, equity, and inclusion in engineering education. As the UIC Chemical Engineering Department strives to be a model for change, it sets an example for others to follow, addressing the critical imperative of fostering DEI in engineering curricula and beyond.

## **Introduction**

The importance of diversity, equity, and inclusion (DEI) in higher education and the workforce is increasingly acknowledged as a cornerstone for fostering rich educational experiences and driving societal progress. These principles are not simply beneficial; they are imperative for educational leaders to integrate into their practices, aiming to transform students into globally aware and responsible citizens [1]. Such transformation is essential for creating environments that celebrate and leverage a diversity of thoughts and experiences. Historically, the representation of diverse groups in higher education has been markedly lacking, which highlights the urgent need for policies and practices that promote equity, ensuring that all individuals have equitable access and opportunities to contribute and benefit [2]. This call for equity is more than a moral imperative; it is a mechanism for societal change, providing the diverse perspectives necessary to address complex global challenges.

Moreover, the promotion of an inclusive culture within educational institutions is a dynamic process, requiring ongoing development of policies and implementation of best practices [3]. As the world becomes more interconnected, these policies and practices must be continually reassessed and adapted to ensure that they remain effective and relevant in a global context. The complexities of initiating and managing the institutional transformation necessary to fully embrace DEI cannot be underestimated. It calls for committed leadership that is not only aware of but also actively promotes the value of diversity and inclusion within their organizations [4]. Such leadership is pivotal in guiding institutions through the multifaceted processes of change necessary to create truly inclusive environments.

Engineering, as a discipline, has long been a cornerstone in the advancement of society, serving as a conduit for innovation and societal transformation. Historically, the field of engineering has reflected the broader societal trends with regard to diversity, equity, and inclusion (DEI)—often mirroring the exclusions and disparities prevalent in the social fabric of the times [1]. For much of its history, engineering has been a profession dominated by a homogenous group, with limited representation of women, minorities, and other underrepresented groups [2]-[10]. This uniformity has, at times, inadvertently influenced the direction of research priorities, the design of systems, and the implementation of technologies, potentially overlooking the needs and perspectives of a diverse population.

In recent years, however, there has been a burgeoning recognition of the need for DEI within engineering [11]-[13]. The current state of DEI in the discipline is one of active evolution and commitment. Institutions, professional societies, and industry leaders are increasingly emphasizing the creation of more inclusive environments that attract and support a diverse workforce. Efforts are being made to dismantle the barriers that have historically led to underrepresentation in engineering fields. Initiatives ranging from outreach programs aimed at young students to institutional reforms in hiring and retention practices reflect this shift towards a more inclusive engineering community.

The relevance of DEI in engineering cannot be overstated, as the field significantly impacts every aspect of modern society. From the infrastructure that supports urban living to the technologies that drive communication and healthcare, engineering solutions touch the lives of a diverse global population. When the engineering workforce mirrors the diversity of the community it serves, it leads to a richer array of perspectives, fostering innovation and creativity. Diverse teams are better equipped to anticipate the needs of a varied populace, leading to the design of products and systems that are more inclusive and beneficial to a broader segment of society. Furthermore, the inclusion of diverse perspectives in engineering promotes the development of solutions that are culturally sensitive and environmentally responsible. It encourages the consideration of a wider range of ethical implications and societal impacts. By embracing DEI, the engineering discipline is better positioned to tackle the grand challenges of our time, from climate change to equitable access to technology, with solutions that are as varied and complex as the issues themselves [14], [15]. In essence, the integration of DEI into the engineering discipline enhances the field's ability to generate transformative solutions that are equitable, sustainable, and reflective of the needs of all segments of society. It is not just an ideal to aspire to but a practical necessity for the continued relevance and progress of the engineering profession.

Chemical Engineering, like many engineering fields, grapples with the underrepresentation of women and ethnic minorities [16]-[22]. The challenges stem from a complex mix of issues including a lack of awareness among underrepresented groups, few role models, and perceived barriers due to stringent academic requirements. Retention is equally challenging, with hurdles such as non-inclusive curricula and unconscious biases within academic and workplace cultures. However, these challenges present opportunities for improvement through targeted outreach, mentorship programs, and initiatives aimed at creating a more inclusive environment.

Studies have underscored the benefits of a diverse workforce, particularly in innovation-driven fields like Chemical Engineering. Yet, there remains a gap between the recognized value of diversity and the current demographics of the field. Data from contemporary research shows a persistent gender gap and lower representation of minority groups [23]-[25]. This gap highlights the need for intentional DEI efforts in recruitment, retention, and culture within both academia and the industry.

Globally, the state of DEI in Chemical Engineering varies, with different regions at different stages of addressing these issues. International collaborations and exchange programs are promising avenues for enhancing DEI, allowing for a diverse exchange of ideas. Academic institutions and industry are beginning to implement DEI strategies, recognizing the need to adapt to an evolving global community and the diverse populations they serve, thus ensuring the field remains relevant and vibrant.

Amidst these challenges and opportunities in the field of Chemical Engineering, it becomes evident that a thorough exploration of DEI initiatives is both timely and necessary. This paper aims to contribute to this exploration by examining the specific case of the Chemical Engineering Department at the University of Illinois at Chicago (UIC). The goal is to understand how the department is navigating the complex landscape of DEI, and what measures it has implemented to foster an inclusive environment that reflects the diverse society it serves. Through this case study, the paper will provide insights into the effectiveness of DEI strategies in the context of Chemical Engineering education. It will evaluate the department's initiatives against the backdrop of national and global DEI efforts within the field.

The ultimate goal of this paper is to contribute to the broader conversation about DEI in engineering education and to support the development of an engineering workforce that is diverse, equitable, and inclusive. By drawing on the experiences of UIC's Chemical Engineering Department, the paper aims to highlight the tangible benefits of DEI and provide actionable recommendations for educational leaders, policymakers, and industry stakeholders committed to advancing these crucial values within their organizations.

## **DEI Model**

The Chemical Engineering Department at the University of Illinois at Chicago (UIC) has made strides in integrating DEI into its core operations and educational framework. This collaborative model ensures that DEI considerations are not only reflective of the administrative viewpoint but are also resonant with the student body's experiences and needs.

## **DEI Committee Collaborations:**

The DEI committee within the Chemical Engineering Department at UIC originated from a faculty initiative, recognizing the imperative need to address DEI issues within the department comprehensively. Initially, the focus was on faculty-driven efforts to identify and implement strategies for enhancing DEI. However, it soon became evident that student involvement was crucial for a more holistic approach. This realization led to the establishment of a student DEI committee, designed to ensure the student body's perspectives and experiences were directly influencing DEI initiatives.

The formation of the student DEI committee followed a democratic process. Both undergraduate and graduate students were encouraged to participate through self-nominations and peer nominations, ensuring a wide outreach and participation. This process aimed to identify students who were not only passionate about DEI but also represented the diverse demographics of the department. After a careful selection process, a seven-member student committee was formed, characterized by a diverse mix of gender and ethnicity, including one graduate student. This structure was intentional to mirror the department's diversity and ensure a broad range of viewpoints.

The student DEI committee's primary role was to serve as a liaison between the student body and the faculty/administration, bridging any gaps in communication and understanding regarding DEI issues. Monthly meetings were held between the faculty DEI chair and the student committee to discuss the issues students were facing. These meetings were pivotal, providing a platform for students to voice concerns—gathered both informally and formally from their peers—while maintaining anonymity. The student committee also participated in faculty meetings, offering a direct line of communication to other faculty members about DEI concerns and suggestions.

Collaboration extended beyond the department, with the committees engaging with UIC's Office of Diversity. This partnership allowed them to explore and learn about additional activities, training, and resources available for promoting DEI. Leveraging these resources, the committees conducted climate surveys to better understand the department's DEI climate and identify areas for improvement.

One of the tangible outcomes of these efforts was the enhancement of the department's website to include more DEI-related content, making DEI initiatives and resources more visible and accessible to both current and prospective students. Additionally, the committees organized town hall meetings with the department chair, offering an open forum for discussing DEI issues, gathering feedback, and outlining future DEI actions.

Another significant outcome of the DEI committee's efforts at UIC's Chemical Engineering Department was the development of the "Advancing Racial Equity" strategic plan. This comprehensive document outlines the department's short-term and long-term goals to foster racial equity, demonstrating a committed and structured approach to addressing racial disparities within the department. The plan serves as a blueprint for targeted actions and initiatives aimed at

creating a more equitable environment, ensuring that efforts to advance racial equity are both intentional and measurable.

In parallel with the strategic planning, the DEI committee took a proactive step by participating in the university's Bridge to Faculty program. This innovative initiative is designed to enhance diversity among faculty members by supporting the hiring of postdoctoral scholars who transition into faculty roles after two years. During this period, these scholars receive mentorship to facilitate their integration and success within the academic community. The program represents a significant opportunity for departments to contribute to the university's broader diversity and inclusion goals by actively recruiting underrepresented scholars.

Thanks to the diligent efforts of the DEI committee, the Chemical Engineering Department successfully secured a position within the Bridge to Faculty program, leading to the hiring of a Latinx faculty member. This hiring was particularly noteworthy given UIC's status as a Hispanic Serving Institution and the fact that, despite having a student body with 30% Latinx students, the Chemical Engineering Department previously did not have Latinx representation among its faculty. The arrival of the new Latinx faculty member was met with enthusiasm from students, marking a pivotal step towards reflecting the diversity of the student population within the faculty and enhancing the department's commitment to racial equity.

Through these comprehensive efforts, the faculty and student DEI committees at UIC's Chemical Engineering Department have exemplified a collaborative and inclusive approach to DEI. This model not only facilitates direct student involvement in DEI initiatives but also fosters a department-wide culture of openness, respect, and continuous improvement toward equity and inclusion.

### **Assessment Tools:**

#### ***Climate Surveys:***

To gain a comprehensive understanding of the current state of diversity, equity, and inclusion (DEI) within its community, the Chemical Engineering Department at UIC has implemented climate surveys as a cornerstone of its DEI assessment strategy. These surveys are conducted among students, faculty, and staff, serving as a critical tool for capturing the nuances of the department's DEI climate. The insights garnered from these surveys are instrumental in highlighting the department's strengths in DEI, as well as pinpointing areas that require attention and improvement.

The design and execution of the climate surveys are the result of a collaborative effort between the department's DEI committee and UIC's Office of Diversity. This partnership ensures that the surveys are not only comprehensive but also sensitive to the diverse experiences and perspectives within the department. The surveys encompass a range of questions designed to elicit honest and reflective responses from participants, covering aspects such as the inclusiveness of the departmental culture, experiences of discrimination or bias, and the effectiveness of current DEI initiatives.

The climate surveys act as a diagnostic tool, offering a clear and objective snapshot of the departmental environment from a DEI perspective. By systematically analyzing the survey

results, the department can identify specific areas of success in its DEI efforts, as well as areas where further work is needed. This evidence-based approach allows for targeted interventions, ensuring that resources are allocated effectively to enhance the DEI climate within the department.

Furthermore, the department is committed to transparency and engagement with the broader academic and professional community regarding its DEI efforts. As such, individuals interested in a deeper understanding of the climate survey methodology, findings, or implications for DEI strategy are encouraged to reach out to the corresponding author for access to the full survey and its results. This openness fosters a culture of continuous learning and improvement, not only within the UIC Chemical Engineering Department but also among peer institutions and the broader engineering community, contributing to the collective advancement of DEI in the field.

The climate survey conducted at the end of Fall 2022 semester among the Chemical Engineering Department's students at UIC revealed a nuanced understanding of the DEI climate. The survey, participated in by both undergraduate (n=76, total number of undergraduate students is 216) and graduate students (n=8), assessed various DEI-related experiences and perceptions within the department. Key areas explored included feelings of inclusivity, experiences of bias or discrimination, and the perceived effectiveness of DEI initiatives. Analysis of the survey data will provide valuable insights into the department's current DEI climate, highlighting strengths and identifying areas for improvement to foster a more inclusive and equitable environment.

The climate survey conducted by the Chemical Engineering Department at UIC reveals significant findings regarding the students' sense of belonging, support, and comfort within the department:

- A majority of students, 69%, feel at ease fitting into the department, suggesting a general sense of belonging.
- A slightly higher percentage, 72%, feel that they have a voice in classroom settings, indicating positive inclusion in academic discourse.
- However, only 63% of students feel the department provides sufficient academic support, with a notable 37% perceiving a lack of academic support.
- The provision of social and emotional support seems to be an area of concern, with only 32% of students feeling that the department sufficiently provides this, and 45% of students reporting a need for such support.
- Despite 69% of students recognizing the need for academic support, only 55% sought it out. In contrast, even though a lower percentage (45%) indicated a need for social/emotional support, an even smaller portion (24%) pursued it. This indicates potential barriers to seeking social/emotional support.
- Comfort in reaching out to faculty in instances of bias is low, with 25% of students feeling uncomfortable doing so. They prefer to approach the department head (20%) or other staff (16%) with these issues.
- Incidences of racial microaggressions have been reported by 13% of students, with a lower occurrence of racial stereotyping, suggesting that while overt discrimination may be less common, subtle forms of discrimination persist.

- While students report positive interactions with peers, faculty, and staff, a significant portion does not feel comfortable discussing racial or ethnic issues, even with peers of the same racial or ethnic background (20%) or those from different backgrounds (30%).
- The overall sentiment towards the department's culture is positive, with approximately 75% of students feeling comfortable, but a noteworthy 15% remain neutral, indicating neither comfort nor discomfort.

These results highlight the importance of enhancing social and emotional support systems within the department and addressing barriers to discussing sensitive DEI issues. Furthermore, the data suggests a need for more accessible and comfortable channels for students to report and discuss instances of bias and discrimination.

### **Senior Exit Surveys and Group Interviews:**

The senior exit surveys and group interviews at Chemical Engineering Department provide a comprehensive feedback mechanism for understanding the graduating students' experiences. In hour-long group discussions, seniors reflect on the curriculum, departmental culture, extracurricular activities, and their experiences with the senior design project and mentors.

From these surveys and interviews, several actionable suggestions have emerged:

- Students find transport phenomena classes too theoretical and recommend integrating more practical applications.
- The option to offer summer courses is suggested to aid transfer students in graduating earlier.
- The need for extracurricular activities scheduled at convenient times for commuting students is emphasized.
- Establishing communication channels, such as town halls with the department chair, is suggested to enhance dialogue with administration.
- Training faculty and students on cultural awareness and microaggressions is proposed to improve the departmental climate.

These insights are invaluable for continuous improvement, guiding the department to tailor its strategies and initiatives to better meet the needs and expectations of its students.

### **Cultural and Educational Initiatives:**

#### **ChemE Culture Club**

The ChemE Culture Club at UIC's Chemical Engineering Department is a testament to the department's dedication to fostering a rich, inclusive environment. Recognizing the ethnic diversity within the department, the club aims to bridge cultural gaps by educating students and faculty about different cultures and their unique celebrations. It serves as a vibrant meeting ground where members of the department can engage with and celebrate the rich tapestry of cultural identities present. The club organizes events that showcase various cultural traditions, food, and festivities, thus enriching the department's social fabric and promoting a deeper, mutual respect and understanding across different cultural backgrounds. The club hosted events that celebrated a tapestry of cultures including Hispanic, Black, Middle Eastern, and East European heritages, highlighted by the sharing of traditional foods. At a notable gathering, a faculty member combined culinary arts with engineering principles by preparing lentil soup in a pressure cooker. As the soup simmered, she explained the design of pressure cookers, the thermodynamic properties of water, and the calculations behind the weight needed to seal the cooker. Session concluded with sharing the soup. Many students expressed that they really loved



to learn about cultures, integrating cultures with their course materials and connecting with peers and faculty through the food and culture. Multiple students commented on that was their first-time eating lentils.

## **Curriculum Integration**

### **Global Competency in Senior Design Course**

The senior design course in UIC's Chemical Engineering Department has strategically incorporated modules that focus on developing students' global competency, recognizing the necessity for modern engineers to be both technically skilled and culturally adept. The course now mandates the inclusion of an analysis of the societal impact in senior design projects. This requirement encourages students to contemplate broader considerations in their project development, including sustainability, environmental and safety concerns, as well as cultural and societal influences. This holistic approach to engineering education prepares students to create solutions that are responsible and responsive to the diverse needs of society globally.

### **DEI Statements in Senior Design Projects:**

The requirement for DEI statements in senior design projects at UIC's Chemical Engineering Department is a significant educational innovation. These statements require students to consider and articulate the societal, cultural, and ethical implications of their engineering solutions. By integrating DEI considerations into the capstone projects, students are encouraged to think critically about the broader impact of their work, fostering a mindset that values diversity and inclusivity. This integration ensures that students are not only capable engineers but also conscientious contributors to society who understand the importance of their work in various cultural and societal contexts.

### **Sustainability Projects in Sophomore Thermo Course:**

The sophomore thermo course at UIC's Chemical Engineering Department incorporates a project focused on sustainability, where students engage in team-based design of processes or products. This educational approach instills early awareness and understanding of sustainability concerns. The course culminates in a competition where teams present their designs through websites and 3D models, with industry judges evaluating their work. This initiative not only teaches sustainability and design process but also equips students with teamwork skills, providing them with valuable experience in project development and execution in a collaborative setting. Students create a website and 3D model of their process as their artifact. One example from Fall 2023 can be found on this website: <https://new.express.adobe.com/webpage/psKc26QXftJGE>.

## **Challenges and Lessons Learned**

In the pursuit of advancing diversity, equity, and inclusion (DEI) within the Chemical Engineering Department at UIC, we encountered several challenges that tested our resolve and required us to adapt our strategies.

### *Challenges:*

One significant challenge was the **integration of DEI principles into existing curricula**. It was crucial not to compromise the technical rigor of engineering education while ensuring that DEI

concepts were meaningfully embedded. Achieving this balance required faculty development and the re-evaluation of traditional teaching materials.

Another challenge was in **measuring the impact** of our DEI initiatives. It was not enough to implement new programs; we had to develop robust assessment tools to gauge their effectiveness. The climate surveys served this purpose, but interpreting the data and translating it into action presented its own set of complexities.

We also faced challenges in **engaging all members of the department**. Change can be uncomfortable, and not all individuals were immediately receptive to new DEI-focused activities. Resistance, whether due to inertia or differing beliefs, necessitated thoughtful dialogue and engagement strategies.

#### *Lessons Learned:*

Through these challenges, we learned the importance of **collaborative approaches**. The establishment of both faculty and student DEI committees facilitated a comprehensive view of the department's culture and allowed for the incorporation of diverse perspectives in decision-making.

The need for **ongoing communication** was another lesson. Town hall meetings and open forums proved crucial in building trust and encouraging open discussions on DEI matters. Transparency in our actions and in sharing our progress helped to align our goals with the expectations of the department.

Lastly, the process taught us the value of **flexibility and adaptability**. As the DEI landscape is continually evolving, so too must our strategies and tactics. The “Advancing Racial Equity” strategic plan, while structured, is a living document that allows for growth and change as needed.

## **Conclusions**

In conclusion, the Chemical Engineering Department at UIC has demonstrated a comprehensive commitment to integrating DEI principles into its culture and curriculum. Through structured initiatives like the DEI committees, the department has worked to identify and address the needs for a more inclusive environment. The senior design projects, climate surveys, and the establishment of the ChemE Culture Club are tangible examples of this commitment. Moreover, the curriculum enhancements, including sustainability projects and global competency modules, prepare students to contribute positively to a diverse society. As the department continues to refine its approach to DEI, it sets a precedent for how academic institutions can evolve to meet the challenges of equity and inclusion in a rapidly changing world. The progress at UIC serves not only its immediate community but also provides a model for others, highlighting the significant role engineering education plays in shaping a socially conscious and responsible future workforce.

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