APPROACHING EQUITY, DIVERSITY, INCLUSION, AND SOCIAL JUSTICE EDUCATION AS IMPERATIVE TO ENGINEERING CURRICULA

Renée Pellissier, Faye Siluk, Claudia Flynn, and Marwan Kanaan
Faculty of Engineering; McGill University
renee.pellissier@mcgill.ca, faye.siluk@mcgill.ca, claudia.flynn@mail.mcgill.ca, marwan.kanaan@mcgill.ca

Abstract – *It is increasingly recognized that integrating concepts of equity, diversity, and inclusion (EDI) into engineering education is critical to the students' personal and professional development. When engineering students learn about EDI, it can improve their working relationships with teammates and illuminate the social impact of their work on the communities they serve. It is integral to incorporate EDI into the undergraduate engineering curriculum; however, there are several challenges and questions regarding the ideal method of implementation. Since 2019, the E-IDEA (Engineering Inclusivity, Diversity, and Equity Advancement) Teamwork Initiative has been developing a series of workshops focused on EDI and teamwork that are conducted directly in engineering classrooms. Using both problem-based and experiential learning approaches, these workshops teach interpersonal skills through an EDI lens, preparing students for success in diverse teams, in the workplace, and in their communities.*

Keywords*:* Teamwork, equity, diversity, inclusion, social justice, problem-based learning, experiential learning, engineering, education, pedagogy.

1. INTRODUCTION

Engineers occupy a unique role in society, and it is inevitable that their control and influence over resources will have widespread impact on the communities in which they work [10,15]. This position affords engineers the opportunity to challenge systemic barriers; however, this requires a robust understanding of the social dimensions of their work [6, 15]. It is therefore critical for engineering education to include topics such as equity, diversity, and inclusion (EDI). This knowledge will illuminate the ways in which students' future work can perpetuate the harmful status-quo—or create a more just world by addressing societal inequities. Engineering educators can assist students in developing awareness and concern for well-being and social justice [15] while also building students' interpersonal skills and cultural competence [4].

While the value of incorporating EDI concepts into engineering education is widely acknowledged, there is no consensus on the best method of implementation, which leads to several challenges. To begin, the responsibility of bringing EDI into the classroom currently falls to individual professors, many of whom do not feel qualified or comfortable broaching these topics [1, 13]. Even in cases where students are engaging with EDI in their education, the connection to engineering coursework may not be explicit. Additionally, the adaptive, open-ended solutions of EDI education are often out of sync with traditional engineering classrooms, which tend to be geared toward technical solutions and finite answers [12].

In response to these challenges, McGill University's Faculty of Engineering has created the E-IDEA Teamwork Initiative. Using a methodology that teaches EDI in tandem with teamwork, the Teamwork Initiative designs and facilitates interactive workshops for early, mid, and late stream engineering students. These workshops teach critical interpersonal skills that students can put to immediate use in their project teams, while simultaneously encouraging students to examine their own collective diversity, power dynamics, and biases in a practical context [7]. Teamwork Initiative workshops are embedded directly in engineering classes, emphasising to students how equity, diversity and inclusion exist at the core of engineering. The outcome is students who are better prepared for the workforce, and who understand the long-term societal impacts of their work.

2. CONTEXTUALIZING EDI IN ENGINEERING EDUCATION

2.1. Challenges of Incorporating EDI in Engineering Education

Incorporating EDI into engineering education is a multifaceted challenge. Adding new courses to existing engineering curricula is often not feasible, as the extensive technical learning throughout the degree leaves little to no room for additional 'soft skills' development [12]. It is therefore necessary to weave EDI concepts into pre-existing courses. Unfortunately, this places the responsibility of EDI education solely on individual

instructors. While some instructors have embraced this role and successfully integrated EDI into their teachings, there remain many who feel they lack the skills and knowledge to adequately address EDI in their classrooms [1, 13]. This lack of EDI knowledge reflects a gap in engineering education. Some students may have access to EDI learnings throughout their degree, while others may graduate without ever having been exposed to these concepts.

A further challenge is the perceived relevance of these topics to the students themselves. EDI has become more common in university settings, but is often taught as stand-alone training, rather than integrated with coursework. As such, the relationship between EDI and engineering may not be immediately apparent. It has been observed that engineering students benefit from the ability to visualize the implication of their course material in real life [8]; therefore, if students are taught EDI concepts in a way that is siloed from their technical education, they are unlikely to engage very deeply with these learnings or make the connection between EDI and their future work.

Finally, there is the matter of pedagogy. EDI concepts are abstract and open to interpretation. These topics are often explored through open discussion and guided reflection. Mainstream engineering education, on the other hand, prioritizes technical learning [12], and engineering students tend to be visual learners who prefer concrete, observable data over abstract theory [8,9]. The misalignment of these learning styles can be a barrier for students when EDI is taught in an engineering classroom.

2.2. Bringing EDI Learning into Engineering Classrooms

Since 2016, McGill University's Faculty of Engineering E-IDEA (Engineering Inclusivity, Diversity, and Equity Advancement) initiative has been committed to shaping a culture of engineering that values diverse backgrounds, perspectives, and opinions [3]. To address a gap in equity and ethics pedagogy, E-IDEA launched the Teamwork Initiative in 2019 with the goal of enhancing students' interpersonal skills to better prepare them for future leadership roles [12]. The Teamwork Initiative partners with courses that have a teamwork component, such as projects or labs, offering between two and four in-class workshops throughout the semester. Instructors are encouraged to select workshops that directly relate to the coursework, including assignments linked to project deliverables. These 50 - 80-minute sessions demonstrate that teamwork and EDI are not complementary subjects, but are, in fact, a core component of student's education.

To address the learning needs of students at all levels, our material is divided into early, mid, and late stream workshops. As students progress throughout their degree, they will see workshops that build upon previous material, reiterating the importance of EDI and teamwork in an engineering setting. A featured Teamwork Initiative workshop entitled *Power, Privilege, and Implicit Bias* is organized into multiple levels, allowing students to find new and innovative uses for the tools in their EDI toolbox. The early stream section of this workshop provides students with foundational knowledge of equity, diversity, and inclusion by recognizing it in action, while introducing them to ubiquitous and covert impacts of power and privilege in society. Students are asked to reflect on their own privilege, as well as the realities of EDI issues in the field of engineering. Part two of this series, recommended for late stream courses, dives deeper into discrimination and microaggressions. Students have the opportunity to reflect on bias in their project teams and extrapolate how similar dynamics may occur in their lives as engineers. This allows students to apply the critical thinking skills they have acquired from our previous workshops to real-world scenarios.

The E-IDEA Teamwork Initiative takes strides to integrate social concepts into analytical settings, addressing the misalignment between typical EDI pedagogy and the common learning styles of engineers. We teach practical teamwork skills such as collaboration, communication, and conflict management, all of which are necessary for future leadership positions [12]. We do so, however, with an EDI lens, helping students develop the cultural competence necessary for success in today's global workforce [4]. The aim is for students to critically analyze their team members' behaviours, as well as their own, to identify the power dynamics at play. Using their own teams as a context for learning allows students to solidify the concepts with their own experience, proving just how applicable the material can be.

The Teamwork Initiative team calls upon a variety of perspectives from engineers, non-engineers, and student staff in their workshop design. Our design team uses themselves as a test-ground for learning, and our process serves as a relevant experience that draws direct connections to scenarios students may face in their project teams [3]. The different backgrounds of our team members allow us to model diversity while practicing teamwork in complex interdisciplinary professional contexts. We also use this modeling approach in our teaching, often referring to our lived experiences and openly reflecting on our own biases and challenges. Not only does this display how the theories unfold in practice, but this transparency and vulnerability open a door for students to begin engaging in difficult conversations.

The Teamwork Initiative gains momentum each semester as we continue to learn and grow. With each iteration, we engage more deeply with EDI concepts that actively connect to our students' lives and their professional development, as well as advancing awareness of EDI throughout our entire faculty.

3. EDUCATIONAL STRATEGY

The Teamwork Initiative's strategic approach is based on a unique pedagogy. Rather than conducting traditional EDI seminars with engineering students, our workshops combine a variety of teaching methods adapted to the particular needs of our participants. This ensures our material is accessible, relevant, and directly applicable to all participants.

3.1. Building Knowledge and Interpersonal Skills Through Problem-Solving

The Teamwork Initiative workshop series diverges from mainstream EDI training to include a wide range of topics focused on interpersonal skills, self-awareness, and social impact. One of the most effective teaching methods used in these workshops is problem-based learning (PBL). During our sessions, engineering students are provided with the opportunity to 'problem-solve' as a team [5]. These 'problems' are interpersonal in nature, usually in the form of case studies directly from engineers in the workforce. For example, they might illustrate an engineer facing discrimination in their workplace, or an engineer struggling to communicate with co-workers. As student teams work through the problems, they often become intrigued as they see how the skills taught in our workshops will be relevant in their futures [17]. Not only does this problem-based approach increase students' knowledge of the subject matter [17] but it supports the development of teamwork and communication skills [1]. Given that our partner courses always have a pre-existing team component, students carry the skills acquired in our workshops over to their project teams, showing the value of committing time and effort into their relationships. This supports one of our core messages to students, which is that positive working relationships are paramount to successful teamwork.

An essential feature of PBL is scaffolding students' learning by offering lectures and resources on the topic before providing the problem to be solved [1]. We address this by assigning a small amount of preparatory work prior to the workshop. The intent is to use thought provoking material in the form of a video, podcast, or non-academic article that will provide students with context without piling onto their heavy workload. In the workshop itself, we often begin with a theory lesson, such as identifying conflict styles or understanding the principles of psychological safety. We ground this theory in real-life examples, often directly from the field of engineering. This is followed by the case study 'problem' for the students to solve, allowing them to apply the theory in practice. The student teams are then required to diagnose the problem and recommend actions; however, there is no one correct answer. Students can make recommendations, which are then shared with the larger class, allowing them to challenge each other's ideas and gain perspective from others' experiences.

3.2. Learning Through Reflection

While the case study 'problems' are used to expose students to the realities and complexities of specific workshop topics (ex. conflict management or collaboration), another key feature of our workshops is reflection. Students already have access to a wealth of knowledge from their lived experiences; however, they rarely have the time and space necessary to reflect and learn. As such, the Teamwork Initiative workshops use an experiential learning approach to tap into that knowledge and connect it to our subject matter. As opposed to traditional lecture, this teaching style opts to instead create an experience that students can reflect upon [2]. Through active experimentation and reflection, students link their learnings to past experiences, and consider how it may apply in future [2]. In the case of our workshops, students engage in an activity with their existing project teams, followed by a reflection on the experience that is guided by the facilitators. Generally, students will have worked on teams in the past, in some form or another; therefore, they can compare their experiences in the workshop to those that came before and use that as a basis to understand the theory.

The reflection portion of the workshop is often conducted under the guidance of facilitators, which can lead students to consider aspects they may have otherwise overlooked, such as the personal biases at play in their groups and their own emotions in reaction to others. Ideally, students will then use this same lens to reflect on their past teamwork and begin to recognize patterns of behaviour. We also create the circumstances for students to engage in the active experimentation stage of experiential learning; as these workshops are conducted early and mid-semester, students will continue working with their teams and will have the opportunity to experiment with new behaviours. This not only provides students with an arena to practice skills but ensures that students are active participants in their own learning [14].

3.3. Teaching EDI Through Teamwork

A key element in our approach to EDI education is linking it directly to teamwork. Quite simply, we teach students how to work in diverse teams, by giving them experience working in diverse teams. We achieve this by working directly with instructors throughout the semester. In early discussions, we offer guidance to instructors on forming teams using the intentional design elements suggested by Oakley, Felder, Brent, and Elhajj [16]. For example, we advise instructors to assign students to teams rather than having them self-select. This approach reduces the chances of teams being formed based on students' implicit or explicit biases. We also encourage instructors to collect data about students prior to creating the teams to

ensure there is a mix of stronger and weaker performing students, and that no minority student, including women, is left isolated on a team [16].

Once in their teams, our workshops teach students the interpersonal skills necessary for effective teamwork, while simultaneously examining individual, societal, and systemic structures of power and privilege. In a sense, their team is a microcosm of society; the behaviours students experiment with in these situations will be applicable later in their careers. Students are asked to critically assess their own team experiences, reflecting on questions such as: Who holds influence in the group, and does it mirror power and influence in society? Is the team perpetuating harmful patterns that silence certain peoples or identities? How does gender influence which roles team members fill? Is this creating a space for more equitable and inclusive ways of working together? Not only does this help students become better team members, but ideally, will initiate reflection on how these same dynamics are at play in their everyday lives.

A key advantage of using teamwork to teach EDI is that instead of teaching *about* EDI, we teach *with* EDI. The diversity of the classroom is a great resource from which students can learn [7]. Our workshops are highly discussion-focused, asking students to share their thoughts and experiences on a variety of topics. Therefore, students will hear diverse perspectives on the material organically, creating a richer and more dynamic learning experience rather than passively absorbing the subject matter [7].

One of our aims with this approach is to create a culture of learning that will encourage curiosity and openness amongst students. Acknowledging power dynamics, identifying personal biases, and engaging in difficult conversations is never easy. However, it's extremely daunting to do so for the first time in a high-stakes situation such as a workplace. Our workshops are led by trained facilitators who are ready and willing to make space for difficult questions and nuanced opinions. The topics addressed in our workshops are complex and can be intimidating to students, which is why we create a space to engage in guided reflection. Incorporating these topics directly into engineering courses also offers validation for students to whom EDI is not new—for those whose lived experiences has been intimately marked by inequity, discrimination, and isolation. For the E-IDEA Teamwork Initiative, it's imperative that we hold space for students to learn new ways of seeing or being, while also recognizing the discomfort or suffering of students who have not had the privilege of ignorance. Our program provides opportunities for students to try new behaviours, ask questions, and take risks in safer, lower-stakes contexts [11]. By linking the EDI concepts directly to teamwork, Teamwork Initiative workshops ensure students have a space to recognize EDI in-action, as well as a contained environment in which to explore their own behaviour and influence.

4. CONCLUSION

The impact of engineering work on society is such that EDI education is imperative in engineering curricula. The E-IDEA Teamwork Initiative's unique approach of incorporating workshops directly in engineering classrooms aims to address many of the key challenges of this endeavor. Using teaching methods such as team problem- solving, reflection, and teaching EDI through teamwork, students actively engage with the material and better comprehend the role of EDI in engineering.

While the E-IDEA Teamwork Initiative is still quite new, the program has shown early signs of success. In 2019, the pilot version was launched by one designer-facilitator working with four collaborating instructors. Only three years later, the program has expanded to include two designer-facilitators and one data analyst partnering with 20 instructors across five departments. This increased demand displays great enthusiasm for the Teamwork Initiative's approach. As we move forward, our goal is to establish workshops in every engineering department, ensuring all students have at least three touchpoints with E-IDEA throughout their undergraduate education.

Further research into the efficacy of the Teamwork Initiative's approach will include the collection and analysis of student feedback. Currently, each workshop includes a student-feedback assessment component, which has been used to tweak and ameliorate not just what we teach, but how we teach it. In future, we intend to collect feedback from students on their EDI and teamwork learning throughout their degree and after graduation. This longitudinal data will provide insight into the overall impact of our program both during students' education and afterwards in the workforce.

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