INCLUSIVE BY DESIGN: EMBEDDING EDI IN ENGINEERING THROUGH DESIGN THINKING HACKATHONS

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ABSTRACT

Design decisions – a fundamental skill in engineering education – shape how individuals interact with the world, but can unintentionally exclude users when there is a mismatch between design and user diversity. While equity, diversity and inclusion (EDI) are increasingly recognised as vital in engineering education, there is a pressing need for more practical, hands-on approaches to embedding these principles in design practice. This paper explores the use of an inclusive design thinking hackathon as an educational intervention to embed EDI into engineering education. In this context, inclusive design and design thinking are integrated to create a learning experience that combines the iterative, empathy-driven process of design thinking with the social responsibility focus of inclusive design. This synthesis provides students with a framework for critically addressing design ethics and considering diverse user needs. EDI is framed as a threshold concept – one that transforms students' understanding of design, society and their role as engineers. Drawing on surveys, observations and student-generated artefacts, the study demonstrates that experiential team-based learning fostered greater empathy, awareness of bias, and inclusive thinking. The findings support the integration of inclusive design thinking hackathons as an effective method for developing ethically responsible engineering graduates, aligned with accreditation frameworks across Europe.

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1 INTRODUCTION

Design inherently shapes a person's ability to "access, participate in, and contribute to the world", yet often results in 'mismatches' of design that unintentionally exclude users (Holmes, 2018). Inclusive Design, as articulated by Treviranus, offers a methodological approach to explicitly anticipate and address these mismatches through intentional engagement with user diversity (Treviranus, 2018). Despite its relevance to the ethical and social responsibilities of engineers, inclusive design is still largely absent from mainstream engineering education. Integrating principles of equity, diversity and inclusion (EDI) into engineering curricula provides a direct route to embed this awareness systematically, aligning engineering education with broader sustainability agendas. In particular, inclusive design supports several United Nations Sustainable Development Goals (SDGs), including Quality Education (SDG 4), Gender Equality (SDG 5), Industry, Innovation and Infrastructure (SDG 9), Reduced Inequalities (SDG 10) and Sustainable Cities and Communities (SDG 11), thereby reinforcing engineering's role in addressing global social and environmental challenges (UN, 2022; UNESCO, 2017).

Despite the acknowledgement of its importance, there remains a significant gap between theoretical recognition of EDI's value and its practical integration into engineering curricula (Royal Academy of Engineering, 2022). Traditional educational approaches often fail to meaningfully address EDI in practice.

This paper responds directly to the educational gap by presenting an inclusive design thinking hackathon as an innovative experiential approach to embedding EDI in engineering education. The intervention was designed not only to expose students to inclusive design principles in practice but also to explore how short, immersive formats can serve as catalysts for long-term shifts in students' perceptions of engineering, ethics and human-centred design.

2 LITERATURE

2.1 Engineering Education, EDI and Accreditation

Engineering education is increasingly expected to address complex global challenges, not only as a moral imperative but as a curricular requirement embedded within accreditation frameworks. In the Irish and broader European context, Engineers Ireland (EI) and the European Network for Accreditation of Engineering Education (ENAEE) both emphasise the need for graduates to demonstrate awareness of ethical responsibilities, sustainability, and the broader societal impact of engineering decisions (ENAEE, 2021; Engineers Ireland, 2021). Engineers Ireland's Accreditation Criteria explicitly require that graduates should have "an understanding and appreciation of the environmental, social and economic impacts of their decisions" and recognise "the importance of equality, diversity and inclusion, and their impact on professional practice" (Engineers Ireland, 2021). Similarly, the EUR-ACE Framework (ENAEE, 2021) specifies that accredited programmes must ensure students "inform judgements that include reflection on relevant social and ethical issues".

Therefore engineering educators are now obligated to teach EDI, social responsibility, and ethical awareness as integral elements of the engineering graduate profile. However, accreditation bodies do not prescribe how these values should be meaningfully embedded into the curriculum. This paper presents an inclusive design thinking hackathon developed as a targeted response to the gap between accreditation expectations and practical curriculum implementation.

2.2 Inclusive Design

Inclusive design, as defined by Treviranus, is a human-centred design methodology that considers the full range of human diversity—including ability, language, culture, gender, and age (Treviranus, 2024). It goes beyond accessibility, though accessibility is considered within inclusive design. Inclusive design celebrates difference and focuses on designs that allow for diversity to thrive (CABE, 2023; Treviranus, 2018, 2024). Unlike universal design or accessibility-focused approaches, inclusive design shifts the focus from creating a one-size-fits-all product to an iterative design process that continuously asks, "who are we missing?" (Treviranus, 2018). Holmes highlights that mismatches in design—where user needs are not met—are the very building blocks of exclusion (Holmes, 2018). In this sense, inclusive design is not only an ethical imperative but a creative one, encouraging solutions that respond to complexity and difference.

2.3 Inclusive Design Thinking Framework

Design thinking provides the structural foundation for this study's pedagogical intervention. Originating from the Hasso Plattner Institute of Design at Stanford University (the Stanford d.school) and popularised by IDEO, the design thinking framework is widely adopted across engineering, design, and business education. It consists of five iterative stages: empathise, define, ideate, prototype, and test (Plattner, 2023). Each stage supports the development of user-centred solutions by guiding students through processes that begin with understanding users' lived experiences and culminate in iterative testing of potential solutions. The framework's nonlinear and recursive nature encourages exploration, creativity, and responsiveness to feedback—qualities essential to inclusive design.

However, while design thinking places the user at the centre, it does not inherently guarantee inclusion. Without intentional reflection on who is—and who is not—at the design table, key perspectives can be overlooked (Bennett & Rosner, 2019; Holmes, 2018; Treviranus, 2018). In this hackathon, inclusive design principles were embedded across each stage of the process, explicitly prompting students to ask: Who is missing? Who might be excluded from current designs? In doing so, students were encouraged to centre marginalised voices and to expand their design decisions beyond the average user, creating space for equity-driven innovation. Using the curb-cut example, students learned that designing for those previously marginalised often led to a bigger market share through product-use by unintended users (Treviranus, 2014).

2.4 Threshold Concepts and Design Education

Threshold concepts are transformative ideas that offer a new and previously inaccessible way of understanding a subject. Once grasped, they fundamentally shift the learner's perception of the discipline. These concepts are typically characterised as transformative, irreversible, integrative, bounded, and troublesome (Meyer & Land, 2003). To embed inclusion meaningfully, students must confront their unconscious biases - often shaped by what Kahneman describes as "System One" thinking, the fast, intuitive metal processes that can lead to error and bias - by developing new cognitive and behavioural habits that promote equity (Kahneman, 2012). Because engineering education rarely invites students to examine these automatic assumptions, inclusive design calls for an intentional, empathetic rewiring of perspective. This paper argues that EDI functions as such a threshold concept,

challenging students to reframe design as a socio-ethical practice rather than a purely technical exercise (Emberton, 2021; Moule, 2009). Learning experiences that foreground empathy, critical reflection, and diverse user needs are essential for developing these perspectives. Design-based pedagogies such as hackathons and sprint-style workshops—common in software and industrial contexts—offer powerful opportunities to surface these concepts in action (Flus & Hurst, 2022; Plattner, 2023; Vilariño & Serra-Ruiz, 2021)

3 METHODOLOGY

3.1 Hackathon Design

The 2-day Inclusive Design hackathon was designed to embed EDI principles into engineering. 21 participants (12 female, 9 male) took part, forming self-selected groups of three newly-qualified engineers. Participants were based across Ireland, Europe and Asia and represented various engineering and science backgrounds.

3.2 Day 1 – Self-reflection and learning

Day 1 focused on was raising participants' awareness of unconscious bias, inclusive design and design thinking. The event opened with two serious mini-games: a Vevox quiz and 'My trusted 10', which highlighted group bias. This was followed by a lecture on unconscious bias and unintended design consequences when teams lack diversity (Murphy & Goodman, 2022).

Inclusive design training included two breakout sessions: one on designing a persona for an excluded 'edge case', and another on improving a basic wheelchair design. A final session introduced the five-stage design thinking framework.

The day concluded with wheelchair basketball, led by a trained instructor. Participants experienced physical and communication limitations (instructor-led demonstration of varying levels of disability), promoting empathy and a level of understanding of disability in sport and everyday design.

3.3 Day 2 – Design Sprint Hackathon

Day 2 began with a testimonial from an engineer and wheelchair user, who shared his personal story in a very impactful way. The engineer then allowed for a very open questions-and-answers session with the participants where they could 'ask him anything'.

The remainder of the day was dedicated to the hackathon. Participants selected a theme (within the category of medical devices), and developed a solution related to the product, its use, packaging, instructions or disposal. Guided by the design thinking process, they created empathy maps, defined a problem space, brainstormed and developed a paper-based prototype. Each team presented their hackathon assets consisting of the persona, problem statement and prototype at the end of the day.

3.4 Data collection and Analysis

Data sources included anonymous pre- and post-event surveys, observer field notes and photos of the groups' assets. Observers recorded notes on team dynamics and engagement. Survey data combined Likert-scale questions (analysed in Excel) with open-ended responses, which were coded using Delve.

Structural and simultaneous coding techniques were applied to identify themes relating to EDI awareness, curriculum relevance and participant development.

4 RESULTS AND INSIGHTS

The results below highlight how participants engaged with the hackathon experience, both intellectually and emotionally. The findings reflect shifts in thinking around inclusion, design ethics and social responsibility – aligning with the educational goals of the intervention.

It should be noted that a disproportionate amount of hackathon time was spent at the empathy stage. This emphasis was intentional: in engineering education, "empathy as a concept in design is still all too often brushed aside in favour of a post-industrial mindset of mass-production of products that are designed for an 'average' user" (Howcroft et al., 2021). The value of this shift was validated by one participant:

"The engineering course really would have benefitted from more user-centered design as I feel like I learnt more during this event than I did in 4 years of uni surrounding inclusive design and having empathy for the end user"

4.1 Awareness of EDI and Bias

Survey responses and observations indicated that the hackathon significantly raised participants' awareness of exclusion in design. Participants described how their thinking shifted through reflection, group discussion, and first-hand experience.

One participant shared, "*It has made me reflect on how products are designed and who is being excluded in that design*." Another noted, "*It really opened my eyes to all the unconscious bias that exists and how exclusion can occur in so many ways*."

Several commented on how the games and activities on Day 1 created a foundation for understanding exclusion: One participant shared, "*Trusted 10 game instantly made what we are learning applicable. Once I filled out my trusted 10 and understood that there is little diversity in my group I knew I had to be aware I don't show unconscious bias in my work and personal life when interacting with people. It is something I aim to remember throughout my life."* Others pointed to the impact of the wheelchair basketball session: "*The wheelchair basketball gave me the most insight—it made me realise the daily difficulties that would never occur to me before*."

A notable observation from Day 1 was that no engineer physically approached the wheelchair provided during the redesign task, despite being invited to make improvements. This hesitation revealed a discomfort or uncertainty around engaging with disability-related design, possibly rooted in fear of doing or saying the wrong thing. It served as a live example of how exclusion can persist—even in environments designed to challenge it—when certain user perspectives remain unfamiliar or intimidating.

4.2 Curriculum Relevance and Pedagogical Preferences

Participants were largely supportive of embedding inclusive design early into the engineering education. Several highlighted the societal value of such content, describing it as vital for shaping ethical and forward-thinking engineers. As one participant put it, "*From just a human-level, this extra element to our education would, in my opinion, drive the future in society that we should all be aiming for*."

The design thinking structure was frequently highlighted as useful: "I liked that we were guided through the design stages. I'll definitely think about empathy mapping in future design projects." Others appreciated the engaging and practical nature of the hackathon, commenting that it allowed them to learn in a way that was both enjoyable and impactful. One wrote, "*It expanded my knowledge in a fun and interactive setting*

and I have taken away a lot of knowledge to this," while another noted, "*I enjoyed the event and had fun while learning which is not very common*!" Observers noted high levels of engagement and collaboration throughout, particularly during the hackathon's ideation and prototyping stages.

However, there were a couple of participants that questioned whether inclusive design warranted a full module. Some felt that the topic, while important, might not align with the content or demands of certain engineering programmes, particularly in highly technical fields such as chemical engineering.

One of the stark revelations from the hackathon was the perceived absence of the user/people from engineering design teaching. The participants were asked about the education they had received on human centred or inclusive design and on their understanding of it. Using a 10 point Likert scale, with 0 representing no training or understanding, the answers given by the participants are given in Figures 1 and 2.

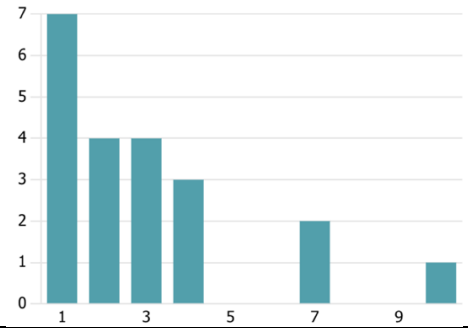
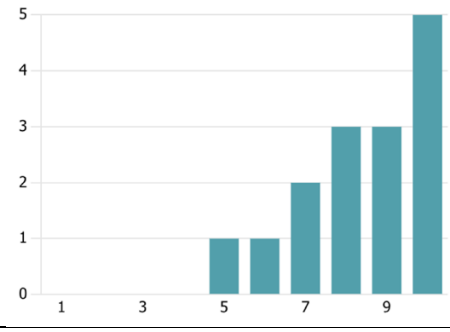
Have you received any education or training around human-centred / ID?	Post-Hackathon, how do you rate the training you received on human-centred/ ID?
	
Average 3.0	Average: 8.4

Fig. 1. Pre- and post-survey data – human centred/inclusive design knowledge

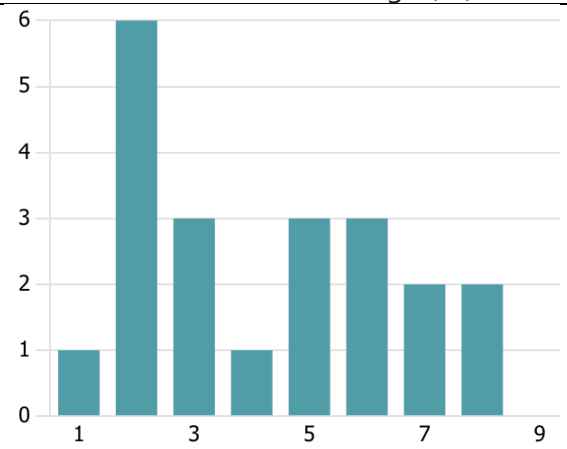
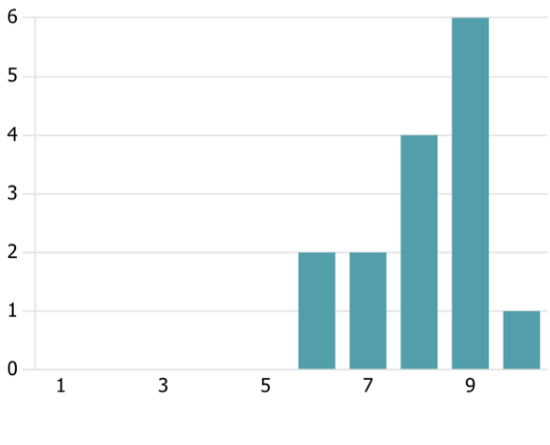
Rate your level of understanding of human-centred / inclusive design (ID)	Post-Hackathon, how do you now rate your knowledge of human-centred/ID?
	
Average 4.24	Average: 8.13

Fig. 2. Pre- and post-survey data – training on human centred/inclusive design knowledge

4.3 Personal Development and Transformative Learning

Participant reflections suggested a strong personal impact and mindset shift – consistent with the framing of EDI as a threshold concept. Several described the experience as transformative, noting a lasting change in how they viewed inclusion, design and their role as engineers.

One participant stated, "*The learnings i got from the hackathon is something I will take with me throughout the rest of my career*." Another shared, "*That led me to really take home the following: just because we aren't in the situation doesn't mean we won't be, and especially doesn't mean we shouldn't take into account others who are when* designing for the world around us."

The talk given by the wheelchair-using engineer emerged as a particularly impactful moment. His honest sharing of his story created a space where participants could ask questions openly and reflect deeply on disability and exclusion. One participant wrote, "*I had never spoken to, or heard a wheelchair user talk about what it's like to go from life as a fully functional able-bodied human to being wheelchair bound. It is soooo much different in person compared to seeing someone describe it on video, as even the way he came in - on his own, in the wheelchair had a big impact on me*." Others echoed the effect of that moment: "*Instead of empathizing with other non-wheelchair users on the use of a wheelchair we heard directly how different life is on a wheelchair and how you are still able to complete your goals. I thought this was a brilliant activity particularly paired with the wheelchair basketball to experience the difference in activities*." 10 out of the 15 participants who completed the post-survey reported that this talk was their favourite part of the event. One participant reflected, "*When he mentioned his farming, it made me aware of my unconscious bias as I probably didn't believe that was possible for someone in a wheelchair before he spoke. It really brought the benefits of designing for those 'end users' to life and gave me a real life example on how designing for all can open more doors for those in society who we sometimes dismiss as 'not able' for certain activities/jobs*."

For others, the concept of inclusive design itself was newly reframed: "*As highlighted during the course, inclusive design not only benefits those in the minority, but it benefits all of us. As young engineers we are not encouraged to think of it from that perspective*." Finally, the personal growth extended beyond technical understanding: "*Not only does it improve them as engineers in terms of hands-on learning, collaboration and exposure to user-centered design, it also improves them as people*."

These reflections point to an internalised, irreversible shift—supporting the claim that EDI can act as a transformative threshold in engineering education.

5 CONCLUSIONS AND IMPLICATIONS

This study explored the use of an inclusive design thinking hackathon as a pedagogical intervention for embedding Equity, Diversity, and Inclusion (EDI) into engineering education. Drawing on survey responses, participant reflections, and observed behaviours, the results show that even a short, intensive experience can prompt deep learning, emotional engagement, and a fundamental shift in how students perceive design, society, and their responsibilities as engineers.

Through a blend of active learning tools—serious games, applied design tasks, direct interaction with disabled users, and structured reflection—the hackathon stimulated empathy, challenged unconscious biases, and foregrounded the human dimensions of engineering practice. The emphasis on the empathy stage was both intentional and

necessary, offering a counterbalance to traditional engineering education's focus on abstract systems and 'average' users.

Threshold concepts - ones that are integrative, irreversible, and often troubling – are inherently more difficult to teach. They require a learning experience to go beyond theory to engage students emotionally, socially, and ethically. This intervention created a space for that kind of learning of EDI.

Importantly, while accreditation bodies increasingly obligate engineering programmes to address inclusion and ethics, they rarely specify how to do so in meaningful ways. This hackathon model offers one such response: structured, replicable, and deeply aligned with both curricular requirements and the broader goal of developing socially responsible graduates.

As one participant put it, *"The learnings I got from the hackathon is something I will take with me throughout the rest of my career."* Another participant shared *"I think the world we live in still caters for mainstream i.e. people at the centre of the bell curve. Hopefully current and future generations can build inclusive design and empathy into all aspects of the life and work to help create a world that ensures everyone feels seen and catered for".* The findings from this study suggest that inclusive, experiential approaches to teaching EDI are not just impactful—they are essential.

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