Promoting equity in engineering education for sustainable development through community-based learning and teaching

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Abstract

Global challenges that call for environmental, social and innovative solutions have consistently pushed us to be open to the changes and challenges within engineering education (Crawley et al, 2007; Lawlor, 2013; RAEng, 2007). As engineering educators in higher education, we also share a commitment to innovation to better engage with inclusion and diversity in our teaching practices (RAEng, 2023).

In recent years, there have been growing efforts to implement community-based learning and teaching (CBLT) in the academic curriculum (Salam et al., 2019). CBLT approaches are educational experiences in which students engage in organised activities that benefit the local community as part of their academic curriculum (Bringle and Hatcher, 2000). Education for sustainable development (ESD) plays a crucial role in equipping learners with the knowledge, skills, and attitudes necessary to create a sustainable future. ESD emphasises education as an important part of the process of achieving human development in an inclusive, equitable and secure manner (UNESCO, 2023).

Based on collaborative pedagogical research through our universities over the past three years, this practice paper presents reflections from a workshop delivered at EESD. The workshop explored how the mapping of sustainable development goals (SDGs) and cross-cutting sustainability competences (namely normative competency, strategic thinking competency, collaboration competency and integrated problem-solving competency) to identify and discuss key challenges and opportunities for embedding sustainability within engineering education from the perspective of CBLT. The outcomes highlight the potential of CBLT to promote inclusive, practice-based approaches to sustainability education in engineering and foster stronger connections between universities and their local communities.

1 Introduction

1.1 Workshop aims

In response to global challenges requiring environmental, social, and innovative solutions, engineering education must adapt to equip students with the necessary skills and awareness to tackle sustainability issues (UCL, 2024). CBLT provides a pedagogical framework that integrates real-world learning experiences with academic curricula, enabling students to engage with their local communities while addressing sustainability concerns.

The aim of this workshop was to explore the intersection of CBLT and ESD, addressing how these approaches can be integrated within postgraduate engineering programmes. Participants engaged in discussions and activities that mapped SDGs to existing modules, examined the role of universities in sustainability education, and reflected on barriers and enablers to embedding CBLT in engineering curricula.

The workshop began with a brief introduction and outline of its aims and highlighted the relevance of CBLT and ESD within engineering education. This was followed by an interactive discussion to build a shared understanding of the core concepts of CBLT and ESD. Participants then took part in an interactive group mapping exercise to explore how the 17 SDGs could be meaningfully linked to existing engineering modules. The session continued with a focused discussion on the challenges and opportunities of integrating CBLT and ESD into the curriculum, and concluded with time for reflection and the identification of practical next steps for embedding CBLT approaches within participants' own teaching contexts. The workshop outcomes contribute to a growing body of research that underscores the importance of experiential and community-based learning approaches in fostering sustainable development education.

1.2 Our participants

The participants (n = 10) in this workshop came from a diverse and dynamic range of disciplines, reflecting the interdisciplinary nature of both CBLT and ESD. Their expertise spanned systems thinking and sustainability, computer science and artificial intelligence, as well as civil engineering and international development. Also represented were areas such as agricultural and environmental engineering, and sustainable energy—fields that are at the forefront of addressing global challenges. This diversity brought rich perspectives to the workshop, reinforcing the importance of cross-disciplinary collaboration when embedding sustainability and community engagement into engineering education. The varied backgrounds of the participants allowed for meaningful discussions on how CBLT and ESD can be tailored and integrated across different contexts, while remaining grounded in real-world relevance and impact.

2 SDG module mapping exercise

As part of the workshop, participants engaged in a group activity designed to explore the integration of ESD into existing engineering curricula. Working collaboratively, participants reviewed two sample postgraduate module outlines and completed a mapping activity focused on aligning each module with relevant United Nations UNSDGs (Figure 1) and a selection of key specialised competencies interrelated to the SDGs.

This 30-minute session encouraged critical thinking about how current academic offerings in engineering support or could better support sustainability-related outcomes, while also highlighting the opportunities and challenges in embedding ESD more meaningfully across engineering disciplines.

Figure 1: United Nations Sustainable Development Goals (United Nations, n.d.)

The two modules selected for review represented distinct but complementary approaches to sustainability and innovation within engineering education. Module 1 titled *Innovation for a Fairer World* is a design-based learning module grounded in social justice and multidisciplinary practice, encouraging students to explore how technology and innovation can drive equitable change. In contrast, Module 2 titled *Advanced Group Project* challenges students to apply engineering methods in team-based settings to address society's grand challenges, including sustainability and the future of mobility. Together, these modules provided a rich foundation for mapping exercises, helping participants reflect on the real and potential contributions of engineering education to sustainable development.

2.1 Mapping of SDGs

The first discussion around the mapping activity revealed that certain SDGs were more prominently represented across the two module outlines (Figure 2), while others appeared to be largely absent.

Figure 2: Prominent SDGs from mapping activity for both modules

Goals such as SDG 9 (Industry, Innovation and Infrastructure) and SDG 11 (Sustainable Cities and Communities) emerged as the most visible, reflecting the modules' strong focus on technological innovation, urban development, and systems thinking. SDG 7 (Affordable and Clean Energy) and SDG 13

(Climate Action) were also noted as relevant, particularly in relation to the engineering challenges and social justice themes explored in the modules.

In contrast, SDGs 1 (No Poverty), 2 (Zero Hunger), 5 (Gender Equality), 14 (Life Below Water), and 15 (Life on Land) were seen as the least represented. This suggests that while the modules engaged meaningfully with some core aspects of sustainable development, there remains an opportunity to broaden the scope and better integrate underrepresented goals—especially those related to biodiversity, food systems, and equity—into future curriculum design.

In further discussion, participants identified a mix of strongly and weakly represented SDGs across the two module outlines. In particular, Module 1 (*Innovation for a Fairer World*) was noted to align most clearly with SDGs 3 (Good Health and Well-being), 9 (Industry, Innovation and Infrastructure), 10 (Reduced Inequalities), 16 (Peace, Justice and Strong Institutions), and 17 (Partnerships for the Goals), with SDGs 9 and 16 standing out most prominently. These connections reflected the module's strong emphasis on social justice, inclusive innovation, and collaborative problem-solving. However, several SDGs appeared underrepresented or absent altogether, including SDGs 1 (No Poverty), 2 (Zero Hunger), 6 (Clean Water and Sanitation), 7 (Affordable and Clean Energy), 12 (Responsible Consumption and Production), 13 (Climate Action), 14 (Life Below Water), and 15 (Life on Land).

The relative invisibility of environmental and ecological goals suggests an opportunity to strengthen links to planetary sustainability in future iterations of the modules or through complementary learning experiences.

2.2 Recommendations for engineering teaching practice

The broader discussion centred on conversation around embedding ESD within engineering curricula and notably how sustainability is communicated within module descriptions. Feedback acquired highlighted the need for greater granularity to clearly convey ESD themes and suggested incorporating relevant keywords to make connections more explicit for students. There was also a call to break down content into smaller, more digestible components to enhance accessibility and engagement. Crucially, the discussion raised the question of how sustainability can be presented in a way that genuinely resonates with students to motivate their active participation. These points serve as valuable exemplars to guide ongoing reflection on how best to represent sustainability within academic offerings.

3 Competency mapping exercise

3.1 Culturally responsive pedagogy

Another area we invited our participants to consider was culturally responsive education in engineering and how it can be enriched through CBLT approaches, which emphasises the value of students' cultural identities and lived experiences as assets in the learning process. As reflected in participants' responses, culturally responsive education involves recognising, respecting, and integrating the diverse cultural backgrounds, traditions, and perspectives of students by embedding inclusive teaching resources that reflect this diversity (Ladson-Billings, 1995). CBLT creates space for meaningful dialogue, co-creation, and shared understanding, allowing students to see themselves in the curriculum and relate their learning to real-world community contexts. This approach encourages self-reflection and helps students make sense of how engineering knowledge applies both within and beyond their immediate academic environment. Fundamentally, culturally responsive engineering education grounded in CBLT requires an ongoing commitment to understanding the cultures represented in our classrooms—and using this understanding to design more responsive, relevant, and impactful learning experiences.

3.2 Mapping sustainability competencies

We invited the groups to consider 4 out of the 8 (highlighted in bold) cross-cutting sustainability competencies identified by UNESCO (2017):

- Systems thinking competency
- Anticipatory competency
- **Normative competency**
- **Strategic thinking competency**
- **Collaboration competency**
- Critical thinking competency
- Self-awareness competency
- **Integrated problem-solving competency**

These competencies have been identified as essential for preparing learners to address complex global challenges. In this workshop, we focused on mapping four competencies which have been previously used to in other higher education workshops to look at the value of different forms of CBLT in sustainability learning (AdvanceHE, 2021).

One such competency is integrated problem-solving, which is fostered through interdisciplinary teamwork where students draw on diverse subject perspectives to tackle complex real-world issues. This approach mirrors the collaborative nature of sustainable development challenges, encouraging learners to think holistically.

Collaborative competency is also central to CBLT, as students work in supportive social learning environments alongside peers, educators, and community partners, co-constructing knowledge through shared inquiry and practical engagement. Through direct involvement with local communities, normative competency is cultivated when students are exposed to and learn to value diverse cultural perspectives and lived experiences, promoting inclusivity and social justice.

Finally, strategic thinking competency is embedded as students are encouraged to design and implement innovative, context-sensitive actions aimed at creating meaningful social or environmental change, both locally and globally. Together, these competencies highlight the strong synergy between CBLT and ESD, positioning students not only as learners but as active contributors to a more sustainable and equitable future.

Our participants used the four competencies to map their potential to address CBLT. As shown in Figure 3, for Module 1 (Innovation for a Fairer World), integrated problem-solving was the most popular mapped competence (identified by 7/10 participants), followed by the collaborative (6/10), strategic thinking (5/10), and normative (3/10) competencies. This indicates that participants strongly associated the module with interdisciplinary thinking and group-based learning, with slightly less emphasis on embedding diverse values and long-term planning for change.

In contrast, as shown in Figure 4, the Advanced Group Project (Module 2) was mapped more evenly across competencies, with integrated problem-solving and collaborative each being identified by 5 out of 10 participants, followed by the Normative (4/10), and Strategic thinking (3/10) competencies. While this suggests a more balanced but slightly less intense alignment with some ESD competencies, the lower identification of Strategic Thinking was identified in both module descriptions points to a shared opportunity for deepening future-facing, action-oriented components.

Overall, the activity served to reinforce the value of CBLT in supporting ESD, while also indicating potential areas for stronger competency integration, particularly around normative and strategic dimensions.

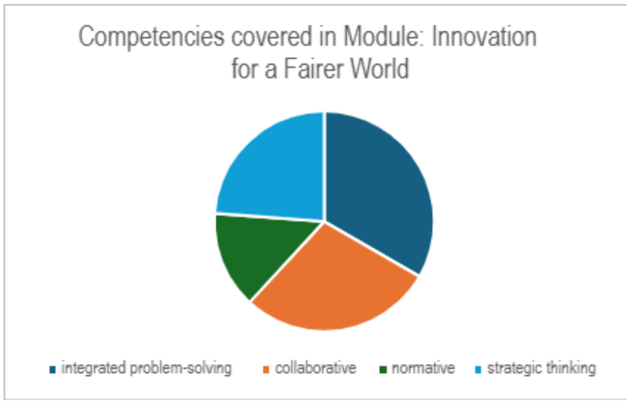

Figure 3: Participants' mapping of competences for Module 1: *Innovation for a Fairer World*

Figure 4: Participants' mapping of competences for Module 2: *Advanced Group Project*

When the results from the mapping of both modules (*Innovation for a Fairer World* and *Advanced Group Project*) are combined, a pattern emerges in terms of the perceived alignment with key ESD competencies (Figure 5). Integrated problem-solving remains the most strongly mapped competency overall, (mapped 12 times out of 20), closely followed by Collaborative Competency (11/20). This suggests that participants see both modules as effectively fostering interdisciplinary thinking and teamwork—two central pillars of CBLT. Strategic thinking scored 8/20, indicating a moderate presence of forward-looking, action-oriented learning opportunities, while normative competency was the least mapped competence identified by each participant (mapped only 7 times out of 20 across both modules). Although still recognised, this suggests that the modules could do more to engage with diverse cultural values and ethical dimensions.

Overall, the combined mapping points to a strong foundation in potential for CBLT-aligned sustainability competencies, with strengths in problem-solving and collaboration, and potential for deeper integration of normative and strategic dimensions to further support transformative sustainability learning.

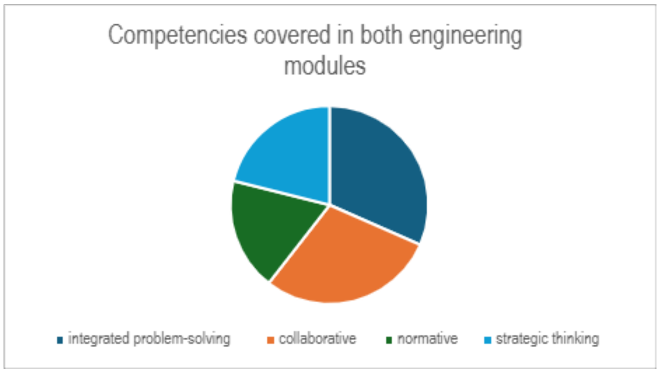

Figure 5: Participants' mapping of competences for Modules 1 and 2

4 Conclusions

This workshop underscored the transformative potential of CBLT as a strategy for promoting greater equity in engineering ESD. Through a series of collaborative activities, including SDG and competency mapping, 10 participants engaged critically with how sustainability is currently represented in example postgraduate engineering curricula and where opportunities for deeper integration lie.

The SDG mapping exercise revealed that modules tend to foreground goals such as SDG 9 (Industry, Innovation and Infrastructure) and SDG 11 (Sustainable Cities and Communities), reflecting strong alignment with technological innovation and systems thinking. However, goals related to poverty reduction, biodiversity, gender equity, and responsible consumption (e.g., SDGs 1, 2, 5, 12, 14, 15) were largely underrepresented, signalling a need to expand the sustainability narrative in engineering education to more fully address social and ecological dimensions.

The sustainability competency mapping further highlighted strengths in integrated problem-solving and collaboration, demonstrating that participants saw real potential in CBLT for fostering interdisciplinary and teamwork-based learning. Yet, lower scores in normative and strategic thinking competencies point to the need for more intentional inclusion of ethical reasoning, long-term visioning, and diverse cultural perspectives. Taken together, the workshop reinforced that CBLT could offer a powerful pedagogical framework for embedding ESD in ways that are not only academically rigorous, but also socially inclusive and practice oriented. By connecting students with real-world community contexts and encouraging reflection on diverse values, CBLT supports the development of more equitable and holistic approaches to engineering education—approaches that are essential for tackling the interconnected challenges of the 21st century.

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