Embedding Education for Sustainable Development in the Engineering Curriculum through Challenge-Based Learning

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Motivation

The needs of tomorrow's engineers are changing, and so must their education today.

A drive for net zero is influencing all sectors and industries. Our graduates need to be literate in sustainable development (SD), understand the role of engineering to meet this agenda and hold core SD competencies [1]. Sustainability now included in UK Spec vr4, AHEP and subject benchmark statements are changing. Evidence also shows that students in Higher Education expect sustainable education as part of their studies [2].

Fig 1 In this, the decade of action all engineering graduates need to be ready to help make change [3]

Introduction

Strathclyde EEE have embedded SD into the curriculum with the Engineers Without Borders (EWB) Engineering for People Design Challenge. There are ~230 1st year UGs from across the department's degree programmes who meet in weekly small group seminars with a staff mentor.

Learning Outcomes

1. Understand the role of Engineers for Sustainable Development
2. Participate in collaborative engineering projects
3. Appreciate and prioritise designing for the people and context, to ensure appropriateness and sustainability of ideas

Guiding Principle

Demonstrate engineering is more than maths and physics, amps and volts.

Project Outcomes

Engagement levels were consistently high across the seminars with student teams generating a wide array of problem statements and even wider array of proposed solutions.

> **EEE 1A** @EEEStrathclyde
>
> Our project group sought to improve thermal efficiency of aging houses in Govan so that residents' heating bills could be decreased. We had to consider the community's needs, a method which would allow maintaining the historical aspect of buildings and a method which wouldn't be disruptive to residents. We decided to implement a window film to keep heat in the houses.

> **BME 8A** @EEEStrathclyde
>
> We were tasked with solving food insecurity in Govan and our solution was to create a 'Community Group' in the library where people can come and share food ideas, ingredients, and recipes from their culture whilst we help reduce cost of food in the area by bulk buying, sharing coupons and finding the best deals. @EEEStrathclyde and @ewbuktag 🍇.

> **EME 2A** @EEEStrathclyde
>
> For the EWB project. The main focus for us was connectivity and transportation. So the solution is, a little card that connects Nextbike, busses and subways. Where the people of Govan can have a discount on transport, which will save them a lot of money.@EEEStrathclyde @EWB

Educational Framework

Challenge Based Learning & The EWB People Design Challenge

Every year EWB work with a partner organisation to develop an engineering brief based on real-life problems that people within their country face. Students:

- Identify a detailed **problem statement** by embedding themselves in the needs of the community across the broad range of topics.
- Work to **propose a solution** to the identified problem that is well thought through and reasoned. Critically it must be appropriate to economic, environmental & social context.

Students engage in large real-life challenges in an active environment, acquiring and applying a wide range of knowledge, skills and critical thinking competencies.

Scaffolded Learner Journey

The scale of the EWB Challenge is no small ask. Our 1st year students have little to no previous experience of SD, the SDGs, or long-term group projects. A scaffolded approach [4] supported student attainment using the *Engineering Process* as the baseline problem-solving technique for problem ID and solution interrogation. This was a touchstone map for students & staff to refer to, and importantly highlights the iterative nature of sustainable engineering problems.

Our Learner Journey

Theme	Content	Deliverable
Stage 0:Team Building		
Stage 1: Context	• Introduction activities for SD and the UN SDGs • Responsibility & purpose of individuals and engineers to SD • How to create equitable, inclusive and appropriate solutions	
Stage 2: Defining the Problem	• Project briefs & project context investigation toolkit • How to ideate • Introduction of the EWB Challenge and Case Study Brief • Building teams (of 3-6 students) • Identification of problem statement and criteria for success	

Stage 3: Exploring Options	• Ideation
	• Interrogating ideas
	  ○ against problem statement and criteria for success
	  ○ for inclusivity and appropriateness
		Problem Statement Presentations
		
		Presentation: Problem & Solutionvr1
		Initial Design Description

Stage 4: Justifying your choices	• Design Development including technical detail • Implementation & maintenance considerations/strategies • Final presentations and reporting	 Implementation & Maintenance strategy Final Reporting
Feedback and Next Steps		

Authentic and Patchwork Assessment

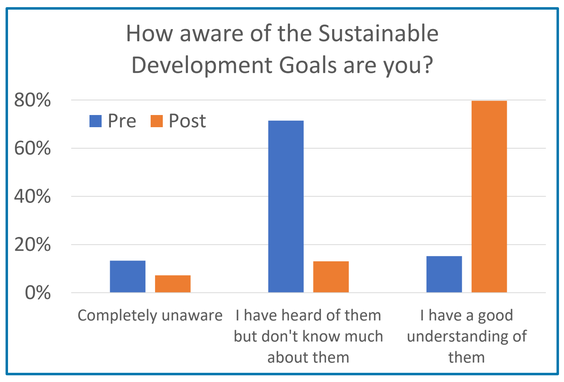
- Use of the *Engineering Process* ensures students' practice is closely aligned to professional (authentic), as does using the language of industry (project milestones & deliverables).
- Interim deliverables (continuous assessment) act as *patches* for students to bring together to form the final deliverables.

The centralisation of Feedback

- Peer Feedback & Assessment: Students assess how they work as a team and also each other's presentation deliverables (for additional feedback & increased awareness of rubrics)
- Self-Assessment: Students reflect on what feedback meant for their practice going forward.
- Staff Feedback & Assessment: Continuous assessment is measured against attainment of competencies & final deliverables is regards criteria aligned to the LOs via a rubric.

Student Opinions

Student surveys pre- and post-project showed that students awareness of the SDGs grew, as well as their understanding of the relevance of SD to their course of study (Figures 2a&b). A growth in self-perceived skill levels across SD competencies across was of thinking, practicing and being (Figure 3) was mirrored in high attainment in the module with impressive grading outcomes.



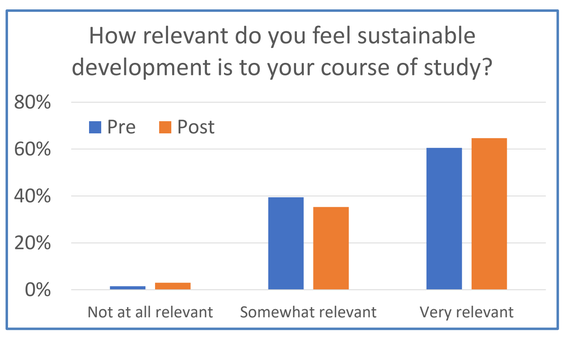


Fig 2a&b Student surveys pre- and post- project show a shift in understanding and attitudes

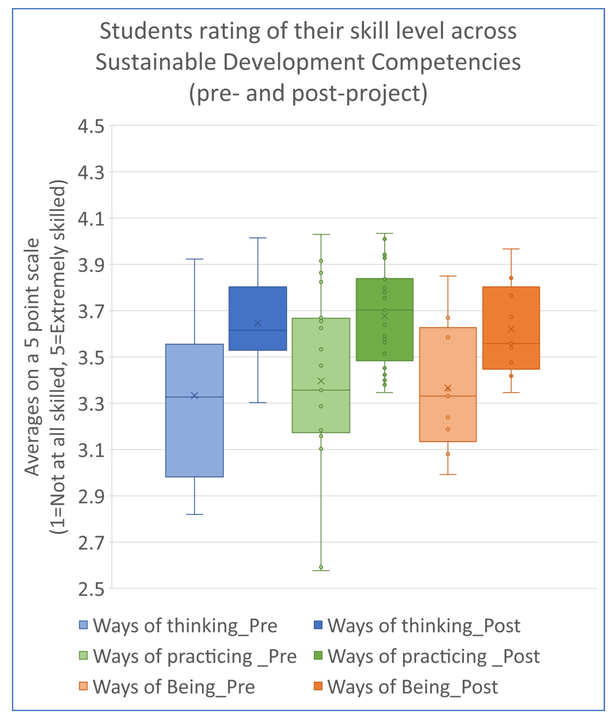


Fig 3 Student surveys pre- and post-project show a growth in self-perceived skill levels

Benefits

1. Active role of authentic assessment *for* learning
2. Collaborative learning & reflective self-assessment centralises students agency
3. Framework is structured and aligned to scaffold students through learning
4. Gaining ILOs is inevitable consequence of taking part

Challenges

1. Curriculum needs to make room for ESD
2. Staff must be proficient in ESD delivery
3. Students and staff need to be literate in assessment and feedback methods
4. Must prepare students for self- & peer-assessment, with benefits clearly explained and demonstrated

Conclusion

We offer a framework to integrate ESD through CBL. All in HE must consider how to integrate ESD into our students' curricula so all students have opportunities to engage in the experiential learning opportunities of challenge-based ESD.

Offering a high-quality SD learning experience for our engineering students today, the engineers of tomorrow.

References [1] UNESCO, *Education for sustainable development goals: Learning objectives*, 2017. [2] Advance HE & QAA, "Education for Sustainable Development Guidance" 2021. [3] https://unhabitat.org/about-us/sustainable-development-goals [4] R. Wass, T. Harland, & A. Mercer, "Scaffolding critical thinking in the zone of proximal development" *Higher Education Research & Development,* vol. 30, no. 3, pp. 317-328, 2011/06/01 2011.