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Abstract

Engineering Education for Sustainable Development requires serious engagement with a range of negative interconnected phenomena such as poverty, inequality and the climate and nature crisis, in order to ground understanding of the polycrisis (Morin and Kern, 1999, p.74). In this context, we have identified 'Hope' as a promising response. Although definitions of hope are diverse, we draw attention to the need to support students as 'change agents' in taking creative and positive action, whilst respecting the complexity of the systems which they are trying to influence. Hope has been studied in a variety of educational contexts, but there are few case study accounts introducing hope into the context of engineering for sustainable development. We outline interventions which introduce three distinct groups of engineering students to hope in different ways. Our reflections suggest that these sessions stimulated aspects of systems literacy and fostered distinctly positive outcomes for at least some of the students involved.

1 Supporting Change Agents

Engineering Education for Sustainable Development necessitates deep engagement with difficult realities. Walker (2006) notes that change agents are 'highly aware' individuals with personal motivations and emotional responses to the sustainability crisis and their role within it. She argues that they often struggle with doubts, making it crucial to integrate emotional resilience and support mechanisms into our practice. It is increasingly recognised that students must also contend with a range of negative emotions, often framed as eco-anxiety (Eriksson et al., 2022), but also extending into socio-economic concerns such as poverty, inequality and injustice. Homer-Dixon (2024) warns that failure to address the emotional impact of the polycrisis may have consequences for the outcomes *'Anxiety about the future, detachment, self-deception, and feelings of resentment and helplessness… makes the future we fear far more likely to happen…'*.

Programmes that seek to develop change agents, must therefore find ways to support students through their education, despite the challenging circumstances (Gutiérrez Ortiz et al., 2020). In this paper, we present the concept of hope as a framework with which to address the challenge. From the outset, we recognize the challenge of engaging with a concept that varies so much in meaning and application across many disciplinary frameworks. And yet, in a world of constant change and uncertainty, we maintain that a purely cognitive response is wholly insufficient.

2 Exploring Hope

As a starting point, we explore the concept of hope through an unconventional lens for engineering—the Irish poet Seamus Heaney. Inspired by the statesman, artist and dissident Václav Havel, Heaney viewed hope as '*not the expectation that things will turn out successfully but the conviction that something is worth working for, however it turns out. Its deepest roots are in the transcendental, beyond the horizon.'* (Heaney, 2002, p.47). This perspective is particularly relevant in the face of complex, uncertain challenges in engineering and sustainability because it emphasises the resilience that exists in trusting or hoping for future possibilities that are impossible to predict, which leaves only the process of the moment. To contextualise hope further, we turn to storytelling—or rather, three framing stories as a segue into fostering hope in engineering for sustainable development.

Macy and Johnstone (2021) present three overarching stories that serve as both metaphors for reflection and practical frameworks for navigating change. 'The Great Unraveling' describes the collapse of human and ecological systems under mounting pressures, including climate change, and failures in democratic governance. This story highlights the urgency of a collective, systemic response to address the interconnected challenges shaping our world. But up till now, the dominant response has been the story of 'Business as Usual'—attempting to address the polycrisis using the same strategies and approaches that contributed to it in the first place. The only viable path forward is 'The Great Turning', which calls for a fundamental shift in how we approach social, technological, economic, and political transformation. This shift requires building capacity and resilience for deep systems change—recognizing that both the ecological and social worlds have always operated within interdependent and complex systems. More importantly, this final story activates the inertia of hope.

Engineers play a key role in developing responses to the polycrisis, and are integral to the story of 'The Great Turning', through the design and implementation of products, services and systems which are necessary to support the emergence of new, more sustainable patterns of living. They have a tremendous opportunity to act as 'change agents', challenging orthodoxy to shift human systems for sustainable pathways. But engaging with such turmoil has a cost at the personal level. This paper situates Engineering Education for Sustainable Development within these challenges and uncertainties of our time, acknowledging the obstacles engineers face are also opportunities that can be cultivated through a mindset of hope– *'in the transcendental, beyond the horizon,'* echoing Heaney.

A cursory literature search suggests relatively few studies have discussed how we can foster hope in engineering for sustainable development. Reflecting on a climate writing course, Warford (2022) explored the ethics of hope in relation to climate despair, drawing out the concept of 'critical hope and praxis' as a guiding pedagogy, but stopped short of discussing how this might translate into specific session designs. Jones et al., (2024) sought to evaluate the change in hope **(**and other student attributes such as agency**)** across the semester of an engineering programme, though there is a notable absence of an evaluation of the taught content and how it might support or inhibit the cultivation of hope.

Wise (2022) provides a guide to educators and community members which responds to growing climate '*impacts on individual and community mental health and wellbeing.'* [p3]. She introduces the idea of 'Messy Hope' as a practice which recognises conflicting, complex emotions, and provides practical guidance on how to nurture hope. Wise (2022) offers a suite of options including solution-based thinking,

connection with like-minded folks, and learning to sit with emotions, rather than dismissing or trying to replace them. Eriksson et al. (2022) examine a course on 'ICT and Sustainability' and draw on suggestions by Pihkala (2020) to map activities which have capacity to mitigate eco-anxiety, arguing that a whole programme approach is needed. They also argue that one should 'make room for student emotions' without necessarily seeking to induce them, concurring with Ojala (2016) in noting that strong emotions may need professional therapeutic support. Whilst there is increasing recognition of the need develop novel responses to the challenges of education in the polycrisis, we are yet to find studies which introduce the notion of Hope into engineering for sustainable development related programmes and explore the outcomes.

3 Session Design – Introducing Hope to Different Cohorts

3.1 University College Cork [UCC] – Process and Chemical Engineering (ME)

The UCC session addressed an undergraduate cohort which predominantly originates from the global north, at the third year of a four- or five-year chemical engineering BE(Hons)/ME programme. The award-winning course has been recognised for the integration of sustainability into the curriculum (Byrne and Fitzpatrick, 2018). The session was led by a senior engineering professor experienced in transdisciplinary practice and theory, and a doctoral researcher with a professional background in both art and anthropology. Together, they sought to explore the value of art in utilising the concept of hope as a basis for transformational potential in authentically addressing the polycrisis. The session leaders presented three film resources; two which explored artistic expressions of hope, and a first-hand account of an individual's relationship with hope. Prompts encouraged students to explore the nature of hope, contrasting hope with optimism, wishful thinking and wanting, also exploring whether hope can be dangerous. Finally, the students were encouraged to express their own conceptions of hope, consider whether losing hope was a privilege, and evaluate the potential contribution art and hope in transformative change.

3.2 University of Cambridge [UCAM] – Engineering for Sustainable Development (MPhil)

The UCAM programme seeks to support engineering graduates in becoming change agents for sustainable development. The cohort is populated by students from global south and north, and from a range of engineering disciplines, with many students holding postgraduate engineering experience. The activity responded to feedback from previous cohorts, which noted that specific readings can be distressing and demotivating and that the programme could present more positive narratives. At the start of the year, students were introduced to Heaney's conception of hope and encouraged to capture 'something' they are working for, acknowledging that this may evolve over time. A seminar was convened just before the halfway point of the programme with the aim to explore the students' relationship with this source of hope. Drawing inspiration from the UCC session, students were encouraged to bring a piece of art that inspired hope in them, alongside the 'something' they are working for. During the session, students were asked to reflect on the sources of hope they had brought and how (or to what extent) the sources supported them, to identify personal takeaways, and to consider what else might be needed to support hope and translate it into action.

3.3 University of British Columbia (UBC) – Environmental Engineering and Sustainability Leadership

The UBC case is based on a technical elective course taken by mostly engineering students in 4th year and graduate programmes. Both global north and south were represented in the cohort. The course covers sustainability related topics focusing on complexity and systems approaches. When they start the course, students are asked to upload an image of a place that brings meaning. Over the course of a 13-week term, students are asked how optimistic they feel about the future (Fig. 1, overleaf) giving a context for the shifts overtime. For the session related to futuring and hope in week 12, the framework of Active Hope (Macy and Johnstone, 2022) was used along with an art-based drawing activity drawn from Messy Hope (Wise, 2022) [p27]. Students recalled their place that brought meaning, reconnecting to the image uploaded earlier in the term. They participated in an activity where concerns related to climate were raised, shared and witnessed. They were then asked to draw out their concerns. Forming a dialogue around their artwork, they have discussed where we see 'the great unravelling' and how we can engage with 'the great turning.' Discussion prompts included - How can we build stamina to witness without judgment, right/wrong, like/unlike, story/wrong-story? How might we make space in society for deep listening and for collective witnessing?

3.4 Session Evaluation

The impact of each intervention was assessed by observations and reflections of the session leaders, augmented by surveys which sought insight on student reactions - see below.

Programme	Survey Probes (Truncated for the paper)
UCC	To what extent, or in what way, might you consider that 'Hope through Art' can be of value in the context of Engineering Education of Practice?
UCAM	What art did you bring to the session? How does this support hope for you? Describe the source of hope you recorded in response to the Heaney quote. If this source of hope has evolved since then, please briefly note how. To what extent has this supported you through the year to date? What have you taken from discussions of hope with other people? What will you be taking forward from the session? What else would you like to convey in response to the session?
UBC	Level of optimism (0-100) [Week 4 and Week 13]; Level of Hope (Week 13].

4 Feedback, Impact and Reflections

A majority of responses (n=15/28) at UCC were considered positively disposed towards the premise of the session (e.g. *'We should think beyond the utilitarian aspects of engineering'*), with a significant minority (n=10/28) offering a negative view 'e.g. '*Hope through art doesn't really have a place in engineering'*. Three responses were characterised as vacillating (e.g. *'Hope to make a change but maybe not through art'*).

7 out of the 23 attendees of the UCAM session provided feedback through the optional post session survey. Each of the respondents identified key ideas or actions they would be taking away from the session (e.g. *'I will be more of actions-oriented person comfortable with not seeing outcomes the soonest, or [that] someone else can see them…'*[SR7]) and several used the free entry response to highlight the positive

experience of the session, or to request future similar sessions (*'I loved this session and can't express how grateful I am that the program sees the value in sessions like this. Thank you!'* [SR4]). There were also responses that suggested that the conception of hope offered in the session did not resonate with their perspective (*'I feel that people living with privilege (in affluent nations and first-world countries) define hope in overly complicated ways…Personally, this session does not relate much to me (compared to diversity exercises or other workshops), probably because I do not overcomplicate things.'*[SR3]*)*.

At UBC, 23 respondents out of a class of 29 have given a number between 0 to 100 based on how optimistic they feel about the future (Fig. 1 first two data from the left), noting an upward shift in their numbers over a 9-week period. Towards the end of the term, students were asked how they define hope, and a number between 0 to 100 on how hopeful they feel about the future, depicted in Fig 1 as the right most data. There was evidence that students adopted different conceptions of hope.

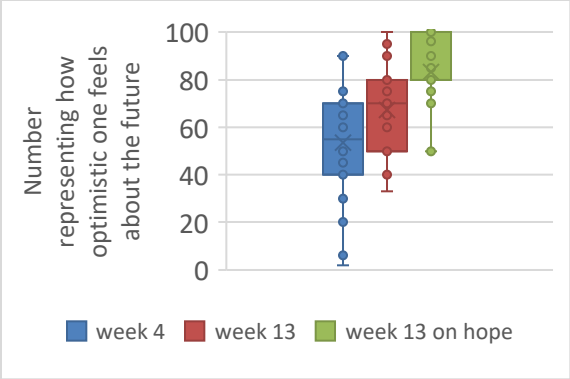

Figure 1. UBC Survey results on optimism and hope.

Overall, the survey responses suggest that the sessions had resonated with at least some of each cohort, although we also acknowledge that reservations were expressed about the relevance of the themes and content of the session, and that individuals' conceptions of hope varied. The positive response observed by instructors in the rooms and from some survey respondents suggest that the sessions were at least partially successful in acting as an antidote to the polycrisis. In the UBC case, levels of optimism improved, and levels of hope exceeded the equivalent rating for optimism, despite engaging deeply with climate concerns. The following subsections explore themes which emerged across the three cases.

4.1 Hope and the development of Systems Literacy

Drawing on Gladwin & Ellis (2024), we use the Affective-Relational-Cognitive (ARC) framework to illustrate how aspects of systems literacy *('the capacity to identify, interpret, co-create, relate to, and communicate about how systems work'* [p684]) were observed. There was clear evidence of students critically analysing their beliefs and assumptions and engaging in metacognition. For example, one student articulated the conception of hope they would be taking forward; *'Hope does not have to be future-focused as I felt it was, I can be wholly present in the moment and yet filled with hope (still not sure how that works though).'*[SR6]. Whilst another UCAM student reflected on the relevance of the conception of hope discussed in the session (see quote from SR3 in section 4 above), questioning whether the forms of hope discussed had relevance for them. In the UCC session, students articulated their view on the link (or lack of) between engineering, hope and art (e.g. '*Art does have value as it encourages approaching engineering from a different perspective.'& 'logical thinking has much higher value than wishful thinking')*.

The sessions also stimulated relational thinking where students made connections between disciplines (e.g. *'in art and engineering alike we create things – hope can be found through creation and building things together and for each other'*). There was also evidence that discussions had fostered a sense of community

(e.g. *'I really enjoyed…the discussions with my group about their sources of hope. It made me feel more connected to them and I love feeling like I have a supportive community within the university'*[SR5]). Furthermore, one respondent articulated a common understanding that the group had arrived at *'We reached that hope cant be tracked or identified but we are more sensitive to absence of hope. Thus, may be our daily life and moves are driven by hope that we even don't know about!'*[SR7].

The Affective dimension of systems literacy encourages critical reflection on acting and being acted upon in the world. This aspect is more difficult to interrogate from the text responses alone, but we observed evidence of students curating their experience in the UCAM session. A group of students who found the process of gardening to be a common source of hope (e.g. *'Nurturing plants without expecting much from them is the embodiment of hope.'*[SR1]), reported conducting the second half of the seminar on the Fen behind the engineering department, changing the stimulus their bodies were receiving by relocating to a more natural environment. This led the same student [SR1] to *'Prioritise outside activities'* going forward. The student response illustrates the interplay between ideas and experiences, and highlights opportunities to enhance hope related sessions, for example by changing the setting to connect with nature, art, a problem context, or by incorporating alternative physical modalities within the classroom setting (e.g. movement, or breathing exercises) to enhance experiences.

4.2 Differing approaches to introducing sources of hope

The UCC session provided resources where others were expressing hope, to support the class discussion. The UCAM session asked students to bring their own resources, supported by prompts. The UBC session provided opportunities to share their concerns and then reflecting on any possible shifts to hope. None of the sessions were explicitly generative, where students created new expressions of hope in the form of art or other consolidated outputs, although some discussions generated new individual or collective understandings of hope. We see potential value in each approach (i.e. introducing, inviting or generating sources and expressions of hope). The introduction of curated resources can be used to bring attention to perspectives, or issues which might not otherwise have been tackled. In the UCC session, the first-hand account introduced the question *'Is losing hope a privilege?'* challenging the predominantly global north audience[1]. This might be beneficial where specific topics are relevant to the curriculum.

The sharing of personally meaningful resources in a session has potential to deepen understanding between participants. One UCAM student reported '*It made me feel more connected to them and I love feeling like I have a supportive community'*[SR6] and another noted how they had taken *'inspiration for new sources or perspectives on hope'*[SR2] and *'So many human aspects of my classmates'*[SR1] from their discussions. At the time of the session, the UCAM group were experienced in holding open ended discussions and sharing personal perspectives with each other and could choose the groups they worked with. The sharing of personal matters may require greater levels of trust and may require established norms (e.g. listening, reserving judgement, choice over depth of participation) to make the most out of the session.

A generative session, engaging with hands-on creation of art or other expressions of hope, may allow students to reach even deeper levels of connection and engagement. This may help engineers step beyond rigid outcome driven structures and instead foster a process-oriented approach that highlights exploration,

[1] A related theme emerged organically in the more globally diverse UCAM cohort see section 4, par. 2, code [SR3].

iteration, and innovation. This approach provides a less prescriptive alternative to being introduced to the work of others but may need more support to achieve a meaningful response.

4.3 Differences in engagement

Whilst a significant majority of UCC respondents were positive about the session, some responses did not ascribe value to the perspectives of hope or art (*'Logical thinking has much higher value than wishful thinking'; 'Don't think abstract art has much of a place in engineering'; '[the exercise was perhaps] Helpful for children, not so much for adults'*). These responses may derive from the students enacting an engineering identity, which typically focusses on objective and rational analysis. The students are relatively early in their disciplinary journey, and some may not yet be comfortable with transgressing conventional boundaries. By contrast, the UCAM group seemed more comfortable when engaging with matters which were not directly related to disciplinary norms. This group are more experienced, and, having established their engineering credentials and actively sought new perspectives by opting into a sustainability programme, perhaps felt more comfortable straying from conventional engineering thinking. Experience with discussing emotions may also be a factor which influences engagement, with some groups reporting difficulty in responding to the prompts. These observations suggest that the timing of interventions and the cohort's level of development, sustainability buy-in, and confidence in discussing personal matters may be relevant dimensions to consider when designing sessions. Some scaffolding and developmental support within and between sessions may therefore be beneficial, depending on the group.

5 Conclusions & Recommendations

'Hope', as Han (2024) notes, 'presents us with a future' (p.2). This is a profound statement that presents both responsibility and possibility. As such, hope has emerged as a promising response to the challenges of engineering education in the polycrisis, with potential to support creative responses and bolster resilience in the face of challenging circumstances. We examined the impact of three interventions which encouraged student reflection on their personal relationship with hope, and the role of hope in response to the polycrisis – catalyzing momentum for a future.

Student reactions varied from those that struggled to see the relevance of hope in the context of engineering education, to those who found the framing and discussions impactful, expressing new understandings and pathways for action, as well as enhanced sense of community, providing evidence that the sessions had supported aspects of systems literacy. There was also evidence that optimism had been enhanced for some, even where climate concerns had been directly confronted. Our analysis is based on a relatively limited data set (i.e. short form responses, responses from a limited sample of the group, limited quantitative data, reflections of session leaders) and there is little reflection on the features of sessions which were most effective, nor the influence of wider programme design on experiences with and perceptions of hope.

Systematic study of interventions would help deepen understanding in this area. Despite these limitations, we experienced that even relatively modest interventions (on the scale of a two-hour session) which seek to foster hope through discussion and reflection, can provide meaningful outcomes for students. There may be potential to enhance outcomes through the adoption of affective strategies, and the inclusion of generative activities. However, our experiences suggest that interventions need to be carefully curated to

match the needs and capabilities of the cohort, and must also recognise the many forms that hope can take, embracing a plurality of perspectives on the subject.

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