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Sustainable Teaching Practices for Teaching Sustainability

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Abstract

Educational good practice often prioritizes student experience over staff workload and wellbeing. This paper takes an alternative perspective, reviewing methods for balancing the psychological safety of both staff and students in the development of a new sustainable engineering design module. Examining the landscape of higher education, and engineering in particular, via literature review allows for an understanding of challenges facing staff, whilst autoethnographic inquiry enables the paper to ascertain that the majority of these challenges have been mitigated by the methods used. The module uses a discursive teaching approach, plotting a trajectory of learning within a safe learning zone using a teaching team of five different lecturers, reducing staff workload as well as creating an environment in which staff no longer have to be the expert on every topic and in which students can negotiate “wicked problems”.

1 Introduction

1.1 Higher Education Landscape

Universities have existed for over a thousand years. Originally having a solely educational remit (Fayaz 2021), the history of focussing on the student has implications still rippling through the fabric of university life to this day. Though now seen as centres for research, societal progression and enablers of change (Steele and Rickards 2021), marketisation has led to teaching having an increasingly transactional rather than transformative nature (Brooks, et al. 2021). Stemming therefore from both the historical roots of universities and modern neoliberal approaches, good practice in education generally focuses on the benefit to students. Whilst improving student experience and developing teaching practice is highly important, it leads to a seemingly increase in staff workload. With rising workloads being shown to be a major stressor for academic staff (Morrish 2019) and reports that the majority of university staff show signs of depression (Wray and Kinman 2021) it is essential that good practice also considers teaching staff.

1.2 Engineering Education Challenges

Within engineering education, rising workload comes partially from the Engineering Council’s accreditation standards, AHEP 4, requiring greater depth on topics such as sustainability and ethics (Engineering Council 2020). The historic landscape of engineering is one of data and ‘hard science’, with staff being valued for technical expertise, and therefore focusing on teaching fundamentals and absolutes. This shapes engineering education as a territory of hard, applied skills (Becher 1989), in which it is challenging to embark on teaching skills perceived as soft or uncertain. Wicked problems, those which are

complex, of human or societal nature, and which have multiple solutions none of which may be optimal (Rittel 1973), certainly fit within this “difficult to teach” category within engineering education. With the academy valuing recognised expertise, how does one step into the classroom to teach subjects in which you are not the expert, to teach soft skills in a hard territory, and to take on the additional workload of a new module in an already strained environment? Sustainability was first formally required in UK engineering education in 2016 through AHEP 3 which includes the needs for students to be able to “identify sustainability limitations” (Engineering Council 2014, 13, 16, 19). For staff to have been taught sustainability as a compulsory part of their UK degree, they would have to be under 33 years old, whereas 71.8% of academic staff are 35+ (Higher Education Statistics Agency 2022), and few therefore consider themselves experts in sustainability. This can be seen through the heavy reliance in engineering departments on external partnerships, for example with Engineers Without Borders, or on teaching sustainability in brief intensive design challenges distinct from the “standard” teaching model (UCL Centre for Engineering Education 2024).

1.3 Module Beginnings

Within our department, sustainability is addressed in most of the 3rd and 4th year modules, however sustainability is not the main topic in any of these modules. A working group of seven academic staff was formed to discuss ways of including sustainability more prominently in the programme, either by emphasising sustainability-related content in one or more existing modules, or by developing a new, sustainability-focused module. Working group members were identified based on previously expressed interests in the topic and recruited through informal discussions. They comprised a broad range of research groups and academic seniority, whilst also covering the three main academic job families (‘academic’, ‘teaching-focused’ and ‘research-focused’). Membership of the working group did not automatically lead to an expectation to deliver any future sustainability-related taught content. The working group recommended that, whilst sustainability-related content could and should be increased in the various existing modules, there was also a need for a dedicated final-year 5 ECTS module on sustainability in the engineering design process. The main module learning outcomes were defined as:

- Outline the roles of engineers in sustainability on a global and on a local scale
- Critically discuss the importance of sustainable design, development and manufacturing, and the impact they have on humans, society and the natural and built environment
- Evaluate design and manufacturing methods and material suitability for a given product
- Create a life cycle assessment for a product or process

1.4 Research Methodology

To identify transferable good practice, this paper provides an objective review of the module structure and teaching methodologies, as well as an autoethnographic collaborative inquiry into the staff perspective. The module is compared to practice within the department and the authors’ lived experience and is analysed relative to the pedagogic literature.

2 Implementation

2.1 Module Delivery

Five members of staff from the original working group of seven decided to progress with the development and delivery of the new module, titled '*Sustainable Engineering Design*'. Session topics were established as indicated in Figure 1, with detailed learning outcomes created for each. Each of the module teachers took responsibility for three or four sessions, with session 6 delivered by a colleague from the School of Design Engineering, and the final four sessions (sessions 17, 18, 19 and 20) delivered by external collaborators, three from industry and one from a partner academic institution. Ahead of delivery, topics were discussed within the teaching team to ensure a consistently recurring message and to prevent an excess of overlapping content. Each taught session was also attended by at least one member of the team (in addition to the person delivering the session), primarily as part of a discursive approach, to show the student body that concepts such as the 'absolute truth' or a 'correct answer' are typically not applicable to the topic of sustainability. This openly discursive element initiated debate and facilitated active participation during the sessions and leading to the development of a community around the module, both for the students who regularly and actively attended lectures and for staff. The resulting sense of safety and belonging is essential in a module where contentious concepts are discussed, and opinions may be questioned. Secondly, attendance of other teaching staff was an important aspect of the planned development and improvement for the module, allowing adjustments to be implemented in subsequent sessions and suggestions for alternative delivery of specific topics in the next academic year. Staff attendance at lectures also promoted psychological safety and support for the topic lecturer.

2.2 Pedagogic Relations

Traditional approaches within engineering education are generally positivistic (Erden 2003), focusing on quantitative data and consensus. Whilst appropriate for the analytical work needed for engineering processes, it means that students and indeed staff, are not always well equipped to manage the messy, wicked problems posed by sustainability (Lönngren and van Poeck 2021), nor the technical uncertainty as required by the Engineering Council (Engineering Council 2020). Resultingly, students can experience fear, anxiety and cognitive dissonance when expected to engage in discussion, especially where there is no right answer. To mitigate this and support student learning journeys, as well as staff discomfort, away from our shared positivistic comfort zones it was important to create psychological safety within the classroom (AdvanceHE 2022). Doing so enabled students and staff to take risks, knowing that they would be supported if they made mistakes, creating a culture of shared learning and advancement rather than competition and judgement. Learning development and psychological safety were considered throughout the structure of the module, by starting the learning within the comfort zone of engineering science, then extending beyond this into the more uncertain, ambiguous and human elements of sustainability, supporting staff and student zones of proximal development (Vygotsky 1978). Similarly, the nature of the interactions and activities were planned to support the creation of a safe and supportive environment. Where departmental knowledge was considered to lack sufficient breadth, these zones were further extended by guest lecturers bringing different expertise and perspectives, as well as different demographics, to the module. These also helped to decolonise the curriculum and prevent students developing a white saviour (Straubhaar 2015) lens to sustainability. This approach to gradually stretching the engineering "comfort zone" can be seen in **Error! Reference source not found.** which we have created to show the nexus of personal and technical

development in the classroom as supported by the module and is based on Vygotsky’s Zones of Proximal Development and several models for psychological safety to create a mappable 'safe learning zone':

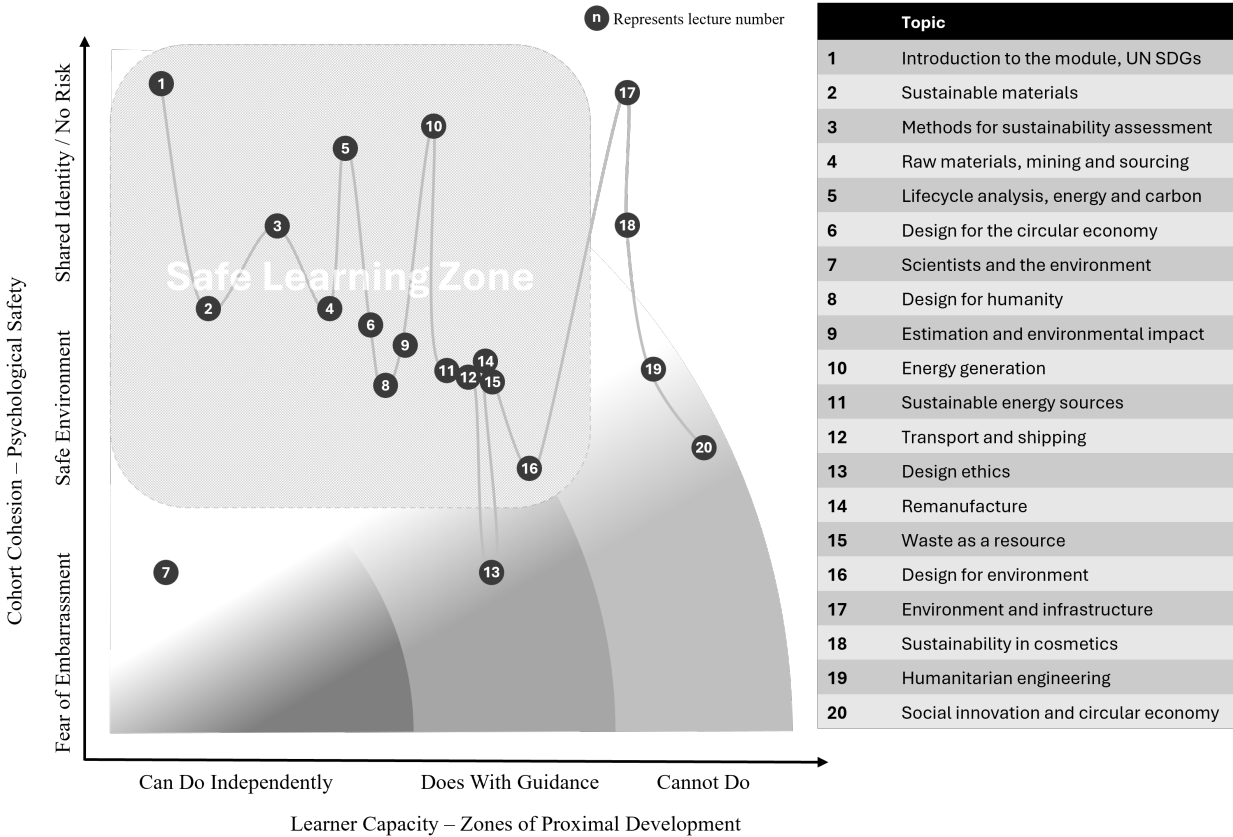


Figure 11 - Overlay of the module lectures against ZPD and Psychological Safety levels

In the introduction lecture (1) learning starts from a very safe and comfortable position, then heads towards the edge of the 'safe learning zone' to stretch the group (e.g. lectures 4 and 8, Sourcing Materials and Design for Humanity), then returns to a place of greater safety so as not to create prolonged stress (e.g. lectures 5 and 10, Life Cycle Assessment and Energy Generation), whilst constantly extending student’s technical capacity. The module ends with industry guest lectures to show students what is possible beyond graduation, hence them not yet being capable of applying the content (lectures 17-20). Recognising that not all topics can be taught with no risk of fear or anxiety, two topics were scaffolded during class to enable their inclusion but still posed a risk to students and staff of discomfort (lectures 7 and 13, Scientists and the Environment and Design Ethics). Due to staffing constraints, lecture 7 was perhaps delivered too early to sit within the planned gradual development of safety and skill, as can be seen from its anomalous “off route” location.

2.3 Autoethnographic Perspectives

The module was taught by a team of five members of academic staff, plus five external experts. This review is written from the viewpoint of two of the team members: a principal teaching fellow, who has a main focus on teaching, and an academic staff member, who combines research and teaching.

Perspective of the principal teaching fellow: My engineering background is as a mechanically focussed building services design engineer. Since stepping into academia 8 years ago though, my journey has moved me away from my technical expertise; being teaching focused often means being asked to teach the more broadly applicable aspects of the curriculum such as design, decision making, teamwork, and equality, etc. My role as a teaching fellow also results in both the need and the opportunity to focus on pedagogic development. These facets of my role combined with my own values and interests have resulted in me developing a specialism in inclusion, ethics and human-centred engineering approaches. The sustainability module has been a great opportunity to teach some of these in a new context, which has been refreshing, to teach only small quantities of a new module which has felt achievable, and to teach new areas within my specialism which has been exciting. My primary teaching in my current role consists of one second year compulsory module on professional skills for ~200 students, and one elective module on equality, diversity and inclusion (EDI) in engineering for third- and fourth-year students, for ~25 students per year. The latter is based on a social constructivism teaching method, with taught content preceding or being interwoven with interactive student activities and discussion in each taught session, a range of lecturers being involved, as well as taking student psychological safety into account as the module is designed (Ojha, et al. 2023). This format, which was new to the department when I instated it 3 years ago, was used as a template for the Sustainable Engineering Design (SED) module. Being familiar with both departmental applications of this methodology then gives me a unique perspective of how it varies across cohorts and subjects. On the EDI module students share, initially cautiously, self-reflective perspectives on the taught content, generally grounded in their own experiences or their observations of their peer groups; a necessity for developing a nuanced understanding of the topics for the cohort as a whole. Comparing this to SED, students were more confident in sharing contentious perspectives, with these often being grounded in activist movements rather than closely held personal experience. On the SED module, there was a greater willingness to debate, and to disagree with staff, using technical data as a foundation for critical discussion. Both EDI and SED have plentiful data available about differences in outcomes, interventions and designs, yet the greater proximity of SED to the familiar “pure” modules within the degree lent students confidence in the interactive elements. This greater confidence, whilst in many ways beneficial, did at times lead to students perhaps not engaging in all the nuance of the wicked problems posed by sustainability, where the EDI students more cautiously examined all aspects. To compare the module to traditional large cohort didactic teaching, the discursive nature of SED was notably more rewarding for myself to teach, giving greater opportunity to witness students’ “lightbulb moments”, and was also less time consuming to develop materials for, as less of the content was coming directly from me. The discursive nature of the module does though leave us vulnerable; it requires us to place ourselves in a position to be disagreed with. This is something which will be a challenge for some, especially any staff who are struggling with mental health, but which in my view is worth overcoming as the reward is worth opening up for.

Perspective of the member of academic staff: I started being involved in academic teaching as a third-year undergraduate student in Mechanical Engineering in the late 1990’s and have been involved in teaching throughout my PhD studies and subsequent academic career. Over the past 15 years my teaching focus has evolved towards Mechanical Engineering Design, being involved in first, second and third-year modules that challenge the students to bring into practice their theoretical knowledge, see e.g. (Masen, Brand, et al. 2014). The past three years I have been the module leader for the Design, Make and Test module, that serves as a 3rd year capstone project and concludes the students’ Mechanical Design education (Masen, Silversides, et al. 2025). This is a 20 ECTS module delivered to 180-200 students annually, where the

students work in groups of four on an open-ended design challenge. With this background, developing the Sustainable Engineering Design module is a logical next step. The module aims to provide students with the knowledge and skills required to incorporate sustainability aspects in an engineering context. In terms of setting up a product design specification at the start of a project, traditional engineering requirements are typically relatively easy to quantify and can be captured with limited ambiguity, whilst any measure related to sustainability is much more opaque. The fourth-year module builds on the students' engineering design experiences in their first three years, but as a lecturer the subject of sustainability is much harder to teach as it touches upon every aspect of engineering and beyond, meaning that a single person cannot be a subject-matter expert on every topic. In addition, there is a growing amount of questionable information available, and the lack of quality is often not easily detected during an initial scoping review. The discursive approach taken allows the students (and members of teaching staff) to encounter many different viewpoints in a safe environment, encouraging a culture in which the critical assessment of data, its sources and the underlying assumptions becomes second nature. This also means that viewpoints can be challenged, which may include students questioning the validity of statements made by staff. Whilst such occurrences may initially be uncomfortable, particularly for staff members, it allowed me to broaden my views to a much greater extent than what I would have expected from delivering a traditionally taught module, making my own sessions as well as attending other's sessions useful and enjoyable for me. For such moments of insight to occur, active participation of the student body is essential. In this module the attendance rate hovered around 50%, with the attending students being the same group every session. It was a very nice to experience their eagerness to participate, but also disheartening to realise that the other half of the student body were missing out and did not fully benefit from the module.

3 Discussion and Conclusions

The process of analysing the module, including informal discussions with the rest of the teaching team, and writing the article highlighted commonalities of experience between staff. The teaching team all set out to develop and deliver the module with a combination of excitement and trepidation, but found the shared support from each other, as well as the student interest in the module, rewarding and empowering. As compared to other teaching experiences, staff on the module found it primarily enjoyable and a manageable workload. This collaborative approach taken by the teaching team had a range of specific benefits; for example, in the development of the module, individual members of the team were responsible for the delivery of only a small number of sessions, reducing the personal time allocation required for the delivery of a new module. Content of the various sessions was coordinated during short meetings, ensuring consistency and preventing overlap. During delivery of the module, attendance of one or more other teaching staff during sessions served as an icebreaker, when contentious topics were being discussed. This helped establishing the teaching room as a safe space where concepts, views and ideas could be challenged by anyone in the room. This approach was perceived as being time-efficient, noting that attending a session requires a much-reduced workload compared to preparing and delivering content in that session.

As explored in the discussion of educational landscape, staff wellbeing is a critical component of good teaching practice. For us to teach sustainability sustainably therefore we need methods which fit staff workload, and that enable staff to remain with a supported zone of development whilst teaching outside their expertise. Our autoethnographic inquiry finds that staff experience of the module is positive, and is of benefit to their growth and wellbeing, rather than being another detrimental burden. Through module

mapping against the zones of proximal development and models of psychological safety we reach the viewpoint that the module has supported student wellbeing in navigating contentious topics. Therefore, key takeaways are:

- By mapping “contentious” module trajectories using a chart such as figure 1, zones of proximal development and psychological safety are considered for both staff and students, thus supporting wellbeing and a safe learning environment.
- Using teaching teams with varied expertise, in particular teaching focused with research and teaching. This spreads the workload, provides support to staff in teaching areas beyond expertise, and prevents singular perspectives being perceived as ‘absolute truths’ in nuanced issues.
- Using teaching methodologies centred around social constructivism and discussion validates students existing knowledge and capacity to research, whilst further reducing burden on staff.

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