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IS "IMPROVING THE QUALITY OF LIFE" THE ONLY SUSTAINABILITY ISSUE THAT IS RELATED TO ENGINEERING? – EXPLORING ENGINEERING STUDENTS' CONCEPTIONS OF SUSTAINABILITY

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ABSTRACT

UNESCO's (2021) report on engineering for sustainable development has emphasized the critical role of engineers in achieving the 17 Sustainable Development Goals (SDGs). Yet, there is a lack of clarity about the conceptualization or definition of sustainability (Moore et al., 2017), which makes it difficult to integrate sustainability into the curriculum. While Walshe (2008) conducted a study on high school students' conceptions of sustainability in the UK, there appears to be a lack of research conducted in the context of higher education. The study presented in this paper explores engineering students' understanding of sustainability in engineering and how it is influenced by their learning experience in the Integrated Engineering Programme (IEP) in University College London (UCL) . Taking a mixed-methods approach, a survey was administered to 139 first-year engineering students followed by individual interviews with 10 students. The survey contained a section which asked students to indicate the extent to which ten different sustainability issues (e.g. creating economic growth, saving lives) are associated with the field of engineering (Klotz et al., 2014). It was found that 65% of the students indicated that "improving the quality of life" is "very much" related to engineering, but less than 50% of them indicated that the remaining nine sustainability issues are "very much" related. Follow-up interviews suggest diverse understandings of sustainability among engineering students, with individual differences in their perception of the learning experience at the university. Findings from the study have important implications for the integration of sustainability in engineering education and will be discussed.

1 INTRODUCTION

As the world continue to face global challenges such as climate change and biodiversity emergency, there is a need for engineers to accelerate their efforts towards achieving UNESCO's Sustainable Development Goals (SDGs). Recognizing the critical role of engineers in sustainable development, accreditation bodies around the world have included outcomes that focus on ethical standards, responsibility towards people and the environment to the accreditation criteria of professional engineering programmes. For example, as indicated in the UK Engineering Council's (2020) accreditation criteria, engineering programmes are expected to develop students' ability "to evaluate the environmental and societal impact of solutions to broadly-defined problems".

Embedding sustainability in engineering education is not without its challenges. Although there has been a continuous effort to define and operationalize the concept of sustainability, it remains ambiguous due to its multidimensionality, making it difficult to integrate into the higher education curriculum (Moore et al. 2017). Previous studies have described a variety of approaches to implementing engineering education for sustainable development, ranging from courses about sustainability (e.g. Quist et al. 2006) to total curriculum redesign (e.g. Mesa et al. 2017). While many universities have sustainability as one of their core values, and have also stated what university graduates should know about sustainability, very little research has been published about what engineering students actually know about sustainability. To properly integrate the sustainable development goals into current education, it is necessary to understand students' conceptions of sustainability and current issues of sustainable development.

Thus, this study aims to explores engineering students' understanding of sustainability in engineering and how it is influenced by their learning experience in the Integrated Engineering Programme (IEP) at University College London (UCL).

2 CONTEXT

One of the key features of the IEP in UCL is the common curriculum structure shared by all engineering departments during the first two years of students' undergraduate studies, with shared objectives, format and assessment protocols across the different departments. The curriculum consists of the following key elements :

(1) Engineering Challenges: two five-week projects at the beginning of Year 1 introducing students to the role and scope of engineering;

(2) Scenarios: one-week intensive design projects for students to integrate critical engineering skills and knowledge developed through lectures;

(3) Design and Professional Skills: a structured discipline-focused programme to facilitate students' development of skills which they can apply and build upon in their Scenarios and Challenges (Hailes et al 2021).

While the aim was to develop a common syllabus that would cover a range of topics required by accreditation bodies (including but not limited to ethics, professional standards and sustainability), both the Scenarios and the Design and Professional Skills module are heavily tailored to each engineering department (Mitchell et al 2021), so students' experiences in these two modules can differ.

3 STUDENTS' CONCEPTION OF SUSTAINABILITY

Previous research investigating engineering undergraduates' conception of sustainability seems to be scarce. In early 2000s, Walshe (2008) investigated high school students' conceptions of sustainability in the UK and found wide variety of understanding of sustainability among the students which included the nature, purpose and timescale of sustainability. Similarly, Carew and Mitchell (2002) found substantial variations in the way chemical engineering undergraduates understood sustainability: from vague and incomplete understanding to comprehensive and elaborate understanding of sustainability. Also, while there is growing consensus among researchers that conceptions of sustainability must include consideration of environmental, economic, and social factors (Purvis et al 2019 ; Hansmann et al 2012), Zeegers and Clark (2013) found that many of the students majoring in environmental management and sustainability in a university in Australia leaned towards an environmentally focused perspective of sustainability.

4 METHODOLOGY

4.1 Participants

Table 1 below presents the demographic information of the survey participants. A total of 139 first-year engineering undergraduate students from a UK university participated in the study. Majority of them are between 17 to 21 years old, except for 3 mature students who are 21 years or older. As presented in Table 2, a total of 10 students who completed the questionnaire volunteered to participate in an individual follow-up interview.

Table 1. Demographic information of the survey participants

	Frequency	Percentage
Gender		
Female	41	29.5
Male	74	53.2
Unreported	24	17.3
Engineering Department		
Biochemical Engineering	3	2.2
Chemical Engineering	13	9.4

Civil, Environmental and Geomatic Engineering	11	7.9
Computer Science	35	25.2
Electronic and Electrical Engineering	22	15.8
Mechanical Engineering	26	18.7
Medical Physics and Biomedical Engineering	9	6.5
Unreported	20	14.4

Table 2. Demographic information of the interview participants

Student	Gender	Engineering Discipline
1	Female	Biomedical
2	Male	Electronic and Electrical
3	Male	Chemical
4	Female	Chemical
5	Female	Biochemical
6	Male	Biochemical
7	Male	Chemical
8	Male	Chemical
9	Female	Chemical
10	Male	Electronic and Electrical

4.2 Instrument

The survey instrument consisted of three key sections with a total of 49 questionnaire items. The first section (34 items) asked students to self-assess 34 generic skills items in terms of the extent to which they agree that each skill is important to becoming a successful engineering on a 5-point Likert scale ranging from 1 (very unimportant) to 5 (very important). The second section (10 items) contained an item adapted from the Sustainability and Gender in Engineering (SaGE) questionnaire which asked students to rate the extent to which ten different sustainability issues (e.g. creating economic growth, saving lives) are associated with the field of engineering (Klotz et al. 2014). This section employed a 5-point Likert scale ranging from 0 (not at all) to 5 (very much so). The last section required students to provide their personal information, including their gender, age, domicile (UK, EU or Non-EU), ethnicity and the engineering department which they are from (five items).

4.3 Procedures

An explanatory sequential mixed-methods design (Creswell 2014) was adopted in this study, such that the follow-up interviews will allow further investigation of students' conception of sustainability in the context of engineering.

Ethical approval for the research was obtained prior to data collection.

A purposive sampling approach (Johnson and Christensen 2014) was undertaken, such that an email invitation to participate in the survey was sent to all first year engineering students in the university where the study was conducted, at the beginning of the first term, in October 2022. The questionnaire required approximately 30 minutes to complete.

Individual interviews were conducted with 10 students, after the first term between January to March in 2023. The interviews were guided with questions designed to elicit ideas related to students' experiences of learning about sustainability in the university. Findings from the questionnaire were also used to stimulate discussion with the interviewees to maximize the alignment between the questionnaire and interview data (Harris and Brown 2010). All the interviews were conducted online via Microsoft Teams and lasted for about an hour.

5 RESULTS

5.1 Findings from the survey

In general, more than 50% of the survey participants indicated that all 10 sustainability issues are much (i.e. rather much or very much so) related to engineering (Table 3). It was found that majority of the students indicated that "improving the quality of life" (65%) is "very much" related to engineering. However, less than 45% of them indicated that the remaining nine sustainability issues are "very much" related.

Nonetheless, the survey findings suggest that students have quite a balanced view of sustainability which includes economic, social and environmental sustainability. At the same time, it is interesting to note that around 30% of the students believe that creating economic growth (33.1%), preserving national security (33.1%), including women as professional colleagues (31.7%) and feeling a moral obligation to other people (36.7%) are only related to engineering to some extent. In other words, there are a group of students who are less able to relate the economic dimension and some of the social dimensions of sustainability to engineering.

Table 3. Students' perception of issues related to sustainability

In your opinion, to what extent are the following associated with the field of engineering?	Frequency (Percentage)				
	Not at all	Only a little	To some extent	Rather much	Very much so
Creating economic growth	1(0.7%)	9 (6.5%)	46 (33.1%)	50 (36%)	33 (23.7%)

Preserving national security	2 (1.4%)	8 (5.8%)	46 (33.1%)	42 (30.2%)	41 (29.5%)
Improving quality of life	1 (0.7%)	1 (0.7%)	12 (8.6%)	34 (24.5%)	91 (65.5%)
Saving lives	1 (0.7%)	3 (2.2%)	33 (23.7%)	42 (30.2%)	60 (43.2%)
Caring for communities	2 (1.4%)	8 (5.8%)	33 (23.7%)	47 (33.8%)	49 (35.3%)
Protecting the environment and biodiversity	1 (0.7%)	7 (5%)	30 (21.6%)	48 (34.5%)	53 (38.1%)
Including women as professional colleagues or stakeholder / participants in the field	6 (4.3%)	15 (10.8%)	44 (31.7%)	39 (28.1%)	35 (25.2%)
Including racial and ethnic minorities as professional colleagues or stakeholder / participants in the field	3 (2.2%)	15 (10.8%)	38 (27.3%)	50 (36%)	33 (23.7%)
Addressing societal concerns	2 (1.4%)	8 (5.8%)	25 (18%)	55 (39.6%)	49 (35.3%)
Feeling a moral obligation to other people	2 (1.4%)	11 (7.9%)	51 (36.7%)	44 (31.7%)	31 (22.3%)

5.2 Findings from the interview

While findings from the survey suggest that engineering students do have quite a balanced view of sustainability, engineering students who participated in the interview tended to lean towards an environmental perspective. When asked what is their understanding of sustainability, all of the student interviewees, regardless of engineering discipline, talked about the environmental aspect of sustainability. For example:

> *My understanding is if something is sustainable then it will not degrade the environment and the well-being of future generations. I do tree planting at home, so I guess that's something that is focused on sustainability.* (S2, Electronic and Electrical)

Majority of them also referred to the concept of time as they spoke about things lasting into the future, suggesting that students do a have 'future perspective' of sustainability.

> *I think for me, sustainability means long lasting. So it's like materials or things that can constantly be refreshed and it's not damaging to the environment because we're not exactly taking away from it at the end of the day, it's still being put back in the same way so that everything stays.* (S6, Biochemical)

However, few considered the possibility of changing or improving the future as part of sustainability, except for one student who identified and envisioned alternative futures which are more just and sustainable:

> *Using only the resources that you need. But that's one part of it, another way of engaging in it is trying to be fair between people, like offer everyone proper working conditions etc. So, to make sure that everything is sustainable, try to go for the better alternative that benefits everyone.* (S1, Biomedical)

S1 was also the only student who was able to identify the issue of intra-generational equity, which is related to social or economic sustainability.

An interesting finding from the interview was that students from the different engineering departments have different experiences of learning about sustainability. As illustrated by the excerpts below, a biomedical engineering student and a chemical engineering student described their experience of learning about sustainabiltiy as "optional", such that it depends on whether they choose to focus on sustainability for their assignment.

> *But we haven't done like any sustainability related issues, except for Engineering Challenges in which we only did a bit of it. For the assignment, we didn't have to consider any environmental factors, unless you chose to do risk analysis.* (S1, Biomedical)

> *In Design and Professional Skills, there's a technical communication component, and I did a research project about biofuels. It was just by chance that my topic was about something related to sustainability. A lot of people chose topics which are completely different from mine.* (S3, Chemical)

On the other hand, a biochemical engineering student and an electrical and electronic engineering student described their experience of learning about sustainability as being an integral part of their course.

> *During Design and Professional Skills, I think they've kind of specifically gone over reasons why engineering practices should be sustainable and how it affects the quality of life. And I think it's really reiterated throughout all our courses and I think in one of my biology focused lessons. We were looking at different reports and they were really emphasizing on how those research or experiments were done in a sustainable way to minimize bad effects that may come from the research and how it would be more beneficial for everyone if they were carried out in a more sustainable way.* (S6. Biochemical)

> *I think it's in Design and Professional Skills that we have to go through the life cycle of a electrical component, think about how does it affect the environment, and to see like how sustainable it is and how to improve it over time?* (S10, Electronic and Electrical)

6 SUMMARY

This paper explored engineering students' understanding of sustainability in engineering and how it is influenced by their learning experience in the Integrated Engineering Programme (IEP) in UCL.

In contrast to the findings from the study by Zeegers and Clark (2013), first-year engineering students in thisstudy have quite a balanced view of sustainability. The finding that the student interviewees tended to have an environmental perspective of sustainability in engineering suggests a possibly strong influence of the curriculum

given that the interviews were conducted towards the end of the term, while the survey was conducted at the beginning. This is supported by the comparison of student experience in the different engineering departments, which suggests that students' conception of sustainability is influenced by the course content and assessment. In other words, our findings suggest that one module (i.e Design and Professional Skills) alone is insufficient to broaden students' understanding of sustainability. In fact, it seems to have focused students' attention to specific aspect of sustainability which students find easier to relate to their discipline. To address these issues, steps can be taken to integrate sustainability more comprehensively into the engineering curriculum, including incorporating sustainability into all engineering courses, not just a single module. This can be achieved through proposing the development of learning outcomes that explicitly address sustainability and the use of teaching methods that encourage critical thinking about sustainability. Additionally, faculty development programs can be implemented to support instructors in integrating sustainability into their courses. Finally, follow-up studies with students in different stages of their degree programme is needed to determine whether there is any evidence of critical thinking about sustainability, whether their conception of sustainability changes and what aspects of the IEP influence any of these changes.

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