
Student Reflections on a Summer School to achieve SDG 12: A Case Study

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ABSTRACT

In today's landscape of global challenges, the role of the engineer is experiencing a significant transformation. The expectations of engineers are no longer confined to traditional technical expertise; they are increasingly acknowledged as key players in driving sustainable development agendas on a global scale. As nations endeavour to achieve the targets outlined in the United Nations Sustainable Development Goals (SDGs), it becomes critical to equip engineers with a diverse skillset capable of addressing increasingly intricate and multifaceted projects, often characterised as “wicked” problems. The PROFESS 12 research project was conceived to address the gap between traditional and required skills by piloting a summer school which sought to expose students to opportunities where they can develop some of the required skills. This paper describes the design of the summer school and provides evidence from student feedback of its value. A thematic analysis of student reflections also reveals the hidden benefits of an initiative such as a residential school. A toolkit of resources from the design of this summer school are provided for educators who wish to deliver a similar initiative to enhance skills in engineering students to help achieve the SDGs.

KEYWORDS

Summer School, Engineering Education for Sustainable Development, SDGs, Active Learning, Intercultural Skills

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Introduction

The context in which the engineering profession operates has undergone significant transformation since its inception, now necessitating collaboration within diverse, multidisciplinary international teams. The requisite skills for success now extend well beyond technical prowess (Byrne & Mullally, 2014; Craps et al., 2017; Kolmos & Holgaard, 2019). Seminal studies on skill requirements for sustainable development in particular (Wiek et al., 2011; de Haan, 2010; Rieckmann, 2012) have presented a spectrum of competencies that engineers must possess. Recent investigations, such as those conducted under the Erasmus+ project, ASTEP-2030, particularly in the context of achieving the Sustainable Development Goals (SDGs), have further identified a multitude of skills (53 in total) including Sustainability Awareness and Intercultural Skills (Beagon et al., 2022). The UNESCO (2017) report "Education for Sustainable Development Goals – Learning Objectives" provides educators with a framework to enrich their curricula, thereby equipping students with the skills essential for the future. Whilst the lists of skills requirements are a useful starting point, many educators encounter challenges in implementing what is termed Engineering Education for Sustainable Development (EESD) initiatives in the classroom. Successful implementation of EESD necessitates a holistic and transformative approach, entailing the integration of novel strategies and appropriate pedagogical methods into engineering curricula (de Haan, 2010). Kolmos et al. (2016) summarise three response strategies to EESD: (1) the add-on strategy, involving the inclusion of sustainability subjects into the curriculum at the micro-level, (2) the integration strategy, encompassing content and values at the meso-level, necessitating program modification, and (3) the re-building strategy, involving a paradigm shift in education by accentuating values, identity, and commitment at the macro-level. The add-on strategy predominates in EESD however, typically entailing the introduction of new courses or topics (Thürer et al., 2018). The use of situated learning and the importance of self-directed learning is espoused as critical to provide motivation for students to learn about sustainable development (de Haan, 2010). One extracurricular, add-on strategy which has been implemented is the use of summer schools, to enhance innovation and entrepreneurship (Qosaj et al., 2023) and multidisciplinary skills (Larsen et al., 2009).

Background

The project was a joint initiative between Ulster University in Northern Ireland, which is part of the UK and TU Dublin in Ireland. Funded by the Higher Education Authority (HEA), its principal aim was to improve cultural relationships between North and South and build connections between researchers, academics and students in each jurisdiction. Hence the summer school was designed with ten student participants from each university and was hosted in each location with travel and accommodation fully funded by the project.

A key project objective was to develop students' awareness and knowledge of the SDGs in general and SDG 12 (Responsible Consumption and Production) in particular. Engineers can have an immediate impact on ensuring sustainable consumption and production in their day-to-day work and so several of our workshops were closely related to the principles of SDG 12. These included enabling students to have a better understanding of the concepts of sustainable consumption through the circular economy and carbon footprint workshops and the importance of Research and Development (R&D) and lean production practices through site visits to companies involved in the transport sector.

Methodology

Initially, two co-creation exercises were undertaken with engineering students to test ideas and gather information as to what they would expect or hope to achieve from the summer school. The outcome of the co-creation exercises determined the learning outcomes for the summer school and the types of teaching pedagogies to be utilised, which are described in Table 1.

Students were invited to apply to attend the free Summer School through email advertisements in TU Dublin and Ulster University by the two academic partners involved in the project. Students completed an application form and were scored on responses to questions on views on sustainability, motivation and personal competencies in relation to making the Summer School a success. Students were then assessed either through their engagement in the co-creation exercises, or in one-to-one interviews. Selections of students considered gender balance, motivation, discipline and year of study. Ten students from each Institution were selected to attend the Summer School. The project sought to achieve a gender balance (minimum of 40% female and 40% male); however, only six women were able to participate.

There were concerns that students may not commit to a five-day summer school and so the team organised a Launch Day to engage students in the project at an early stage and to allow them to meet each other before committing to the main five-day event. The Launch Day was organised to coincide with the World Engineering Day for Sustainable Development. Staff and students met at an Area of Outstanding Natural Beauty (AONB) halfway between the two Universities where we had arranged a mountain walk in the morning to remind us of the importance of maintaining our natural environment. The afternoon session included a guest speaker on sustainable manufacturing and a rousing call for action from a climate action activist from the National Youth Council of Ireland.

The design of the summer school was carefully planned to ensure that students had the opportunity to meet the learning outcomes as well as enjoy the experience itself. Nine learning outcomes were identified for the summer school:

1. Explain the SDGs and the principles of sustainable development
2. Describe SDG 12 and the concepts of sustainable consumption and production
3. Appreciate the importance of R&D in developing solutions for carbon-neutral transport technologies
4. Apply the concept of the circular economy to an engineering problem
5. Calculate my carbon footprint.
6. Better communicate and present
7. Collaborate with students from diverse backgrounds
8. Appreciate the similarities and respect differences in how people from diverse cultures perceive things
9. Make sense of my reactions in conflict and communication style

A Summer School Toolkit is available on the project website with full details of the itinerary, detailed descriptions of each activity and workshop and a student handbook which was circulated one week before the summer school began. A simplified schedule is included in Figure 1 outlining the main activities and workshops.

In line with the literature on the most appropriate methods for EESD, many of the activities used active learning, self-directed learning, situated learning, future thinking and role playing (de Haan, 2010; Thürer et al., 2018; Chernyshova & Tokmylenko, 2020). The activities were student centred, with lecturers acting as facilitators. A summary of the types of pedagogies used along with simple descriptions of each workshop are included in Table 1, but please refer to the Summer School Toolkit available here for detailed descriptions: [PROFESS 12 website](#).

	Monday	Tuesday	Wednesday	Thursday	Friday
AM	TRAVEL	Circular Economy	TRAVEL	Site Visit	Personal Impact Celebrate
Lunch					
PM	Intro to SDGs	Intercultural – Majoria Minoria	Site Visit	TITANIC MUSEUM	TRAVEL
Dinner					TRAVEL
Evening	ESCAPE ROOM	GUINNESS STOREHOUSE MUSEUM			

Fig. 1. Schedule for five-day summer school

Table 1: Pedagogies employed and descriptions of workshops held at summer school.

Activity	Pedagogies employed	Description
Intro to SDGs	Self-Directed Learning Collaborative Learning	Students are placed in groups and given 45 minutes to research and prepare a 5 minute presentation. Each group is given a different topics so students learn from each other. Topics include: <ul style="list-style-type: none"> • What is Sustainable Development? • What are the SDGs? • What is SDG 12? • How does SDG 12 impact engineering? • What is the linear/circular economy and how do they compare?
Circular Economy	Problem Based Learning Situating Learning Future thinking Active Learning Collaborative Learning	Students work in groups to apply circular economy principles to redesign a product chosen from; office chair, cosmetics packaging, training shoe, food packaging, kitchen accessories. <ul style="list-style-type: none"> • Step 1: Explore function and emotional needs by interviewing a product user (the facilitator) • Step 2: Ideate a new product using Circular Economy worksheets and strategy cards to aid brainstorming • Step 3: Design a new solution that better serves user needs whilst applying circular principles • Step 4: Develop rationale for new product and share design proposals / sketches back to whole group.
Majoria/Minoria	Role Play Active Learning	Students are split into two groups; one group are from Majoria and one from Minoria; two countries with different resources and at different stages of development. Each group is given different instructions. Minorians are asked to plan an independence celebration for their country and need to decide how to greet the Majorians when they arrive. Majorians are asked to plan how to help the Minorians,

		Both groups come together for 30 minutes to negotiate and discuss the situation as their country representatives. After the engagement, the facilitator holds an open discussion and asks each group to describe their culture, how they felt about the other group, how the negotiations went, what preconceptions they had and how they effected their communications, what positive or negative interactions they had and why that was so. The group discussion allows groups to consider how intercultural differences and preconceived notions impacts their intercultural interactions.
Site Visits	Situated Learning Active Learning	Site visits were organised to expose students to two different aspects of manufacturing in the transport sector. The first was to a company which is undertaking cutting edge technology and materials advancement, and students were able to tour the facility to see prototyping and testing facilities. The second site visit was to a long established manufacturer who showcased how they have modified their designs to reduce consumption of materials, and also how they have altered transport logistics of component parts to reduce impacts on the environment.
Personal Impact	Reflection Situated Learning Future Thinking	The aim of the session is to allow students to reflect on their own personal impact. Students begin by calculating their own carbon footprint and then compare with others and identify changes they can make. A padlet is used to record their commitments and engage the group in discussion.
Celebrate	Reflection	The celebrate workshop included an Award ceremony where students were given prizes for different skill sets evidenced during the summer school. These included group prizes for presentations and the circular economy and Majoria Minoria workshops, but also individual prizes for Intercultural Award, Sustainability Champion Award, Outstanding Communicator Award, Outstanding Team Player Award, Natural Born Leader Award and Most Engaged Student Award. We also ran week long competitions which encouraged students to post on social media and take photos to assist in our dissemination and impact and these awards were also presented at our Celebrate workshop. The celebrate event allowed students to reflect on all they had learned and achieved throughout the week, improving their self-esteem and encouraging bonding through shared success.

The research team wanted to investigate if the summer school was effective in reaching the aims of the PROFESS 12 project and also to gather information about the experiences of the students and in particular the hidden curriculum (Villanueva et al., 2018).

The quantitative data provided evidence that the summer school had met the aims of the project, but we were also interested in any other impacts of the summer school, in particular the hidden curriculum. Therefore, the research question addressed in this paper is:

- What were the experiences of the students who engaged in the summer school?

The data was collected from students in three ways; an online survey which was circulated a week after the summer school ended and two reflective exercises (circulated during the summer school) which included a voice/text submission from each student. The survey was used to provide data to assess the effectiveness of the summer school as reported in Beagon et al. (2024). The reflective exercises were used as the data to answer the research question addressed in this paper and the prompt questions for the reflective exercises are included in Appendix A. The students were asked to either provide responses as voice notes or text-based responses— either of these formats were acceptable in line with Universal Design Principles (Novak & Bracken, 2019). For the reflective questions on site visits, fourteen responses (seven from each University) were received. Twelve students (six from each University) provided responses to the interview questions.

Students uploaded their voice or text responses to a Microsoft FORMs questionnaire which was then accessed by one researcher. Voice submissions were transcribed, and all the transcriptions and text responses were compiled into one word document. Each person was pseudonymised using only gender as a marker. Therefore, W1 denotes Woman One and M4 denotes Man Four etc. Once the anonymised document was complete, it was used by the two researchers to undertake the thematic analysis. The team analysed the reflections thematically using a General Inductive Approach (GIA) (Thomas, 2006) to provide the reader with an understanding of the students' experiences which were not measured by quantitative aspects. This involved an independent analysis by two researchers concurrently and then comparison and agreement of themes. Thomas (2006) notes this procedure as independent parallel coding and is recognised as a useful way to check consistency in the coding process and thus trustworthiness in the findings. Final refinement of categories was obtained through discussion, debate and eventual agreement between the two researchers.

The use of questionnaires and reflections, and the handling of gathered data was approved by the ethics committee of TU Dublin (ref REIC-21-74).

Findings

The results from the quantitative survey responses are published elsewhere (Beagon et al., 2024) and indicated that the summer school was successful in reaching the aims of the project with 95% of student responses indicating that they “strongly agree“ or “agree” that they had met the learning outcomes. Further, students mainly selected “strongly agree” or “agree” to having developed specific skills as a result of their experience. These included intercultural skills (19/19), working in a team (19/19), problem solving (16/19), communicating (18/19) and presenting (17/19), where the values in brackets indicate the number of “strongly agree” or “agree” out of 19 responses (Beagon et al., 2024). The students felt that the summer school was well organised however, there were some indications that the pace and the mix of activities were not ideal for all students. Overall students enjoyed the summer school and were clear on what the goals of the summer school were and eighteen (strongly agree) and one (agree) student would recommend the summer school to others (Beagon et al., 2024). A detailed analysis of the quantitative results are described in Beagon et al. (2024).

The research team considered that there was value in analysing the qualitative reflections to further understand the students' experiences and to draw out aspects of the hidden curriculum (Villanueva et al., 2018). The thematic analysis is presented in Figure 2 and is described in detail below with accompanying quotes to support the analysis. All student reflections were anonymised prior to analysis

and allocated a label based on their declared gender, hence in quotations provided below, M1, M2 refers to Man Student 1, Man Student 2 and W5, W6; Woman Student 5, Woman Student 6.

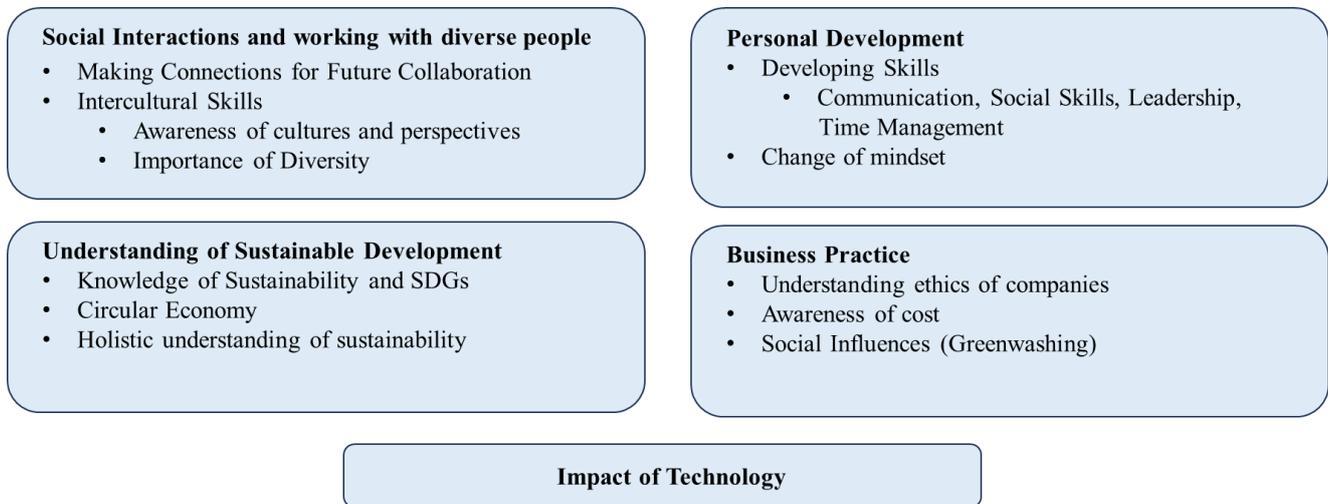


Figure 2: Themes and subthemes emerging from GIA analysis of reflections.

Social Interactions and Working with Diverse People

The first key theme which emerged through the analysis of reflections was the students' experience of social interactions with others. They discussed how they understood that the aim of the project was to foster socialisation skills by engaging and collaborating with other engineering students. Their reflections suggest that they did achieve this outcome mentioning developing skills such as communication and interpersonal skills.

So this summer school, it was called PROFESS 12 and was mainly focused between the collaboration between Southern and Northern Ireland, which means that it was a collaboration between Northern Ireland and the Republic University and engineers between both. The main goal was to get them together so they could work together and develop more their communication, presentation, and interpersonal skills. (M2)

I think it was a very good summer school and I got to meet new people, people from different backgrounds and everything. So very good. Yeah. (M10)

Students showed evidence of realising the importance of collaboration with other students, not just in the short term for the purpose of the summer school but also being aware of developing connections that may be useful in future.

It was mostly about connectivity, getting to know other students from equivalent college down in Dublin. It was pretty good. It was five-day trip, had some site visits, team building, activities, that sort of stuff. It was very good for getting to know other people. Knowing other engineers, especially if we're going to be doing work down in the South and having connections is always a plus. It's always useful. (M1)

I really benefitted frommaking friends through it also and to have great links for the future for other engineers. (W3).

The benefits of the summer school in developing social and team working skills was evident through some of the commentary from students. The quote from the student who talks about working as a team, not a group shows an awareness of the closeness they felt and the friendships they made. There was also reference to students practising their social skills and how that will help them when they join a company.

It was amazing because.... all the team we worked actually as a team and not as a group, a group of people. We worked as a team where we were getting support from each other. We were helping each other. We would.....If someone was missing, [during all the workshops/events/trips] we'll like look for that person and we will constantly look at and count how many was there, who was missing. (M2)

Like at the start, we were all a little bit quiet, but by the second day we were all talking to each other and we're all kind of good friends. So I think that will be a big advantage to working in a company, you know bringing a nice and friendly environment to the place. (M11)

One of the main objectives of this summer school was to help students develop intercultural skills and one workshop specifically addressed this issue through a role play scenario. In this exercise, Majoria/Minoria (Michigan State University, 2000), the students are allocated to be a resident of Majoria or Minoria and each country is given a set of contextual background issues (one is developing but resource rich, the other, financially wealthy and politically stable but resource poor). Members of each country come together to negotiate a treaty being unaware of the contextual aspects that the other team have been provided with and which can be controversial. The concept of developing intercultural skills, being aware of different perspectives and an acknowledgement of what they had learned in relation to intercultural skills, came out clearly in student reflections:

I gained a thorough awareness of intercultural abilities and their significance in today's globalised world because of my participation in the PROFESS 12 Summer School. I learned to accept and respect cultural similarities and differences while working closely with students from various backgrounds. This experience gave me a better understanding of varied methods to dispute resolution and communication techniques across countries. I learned essential skills in negotiating cultural variety and establishing effective communication by actively participating in intercultural exchanges. These intercultural competences are critical creating welcoming and productive cultures in both academic and professional settings. (W2)

So I learned that different people have different perspective and perception... So for example, we did a workshop where we like I mentioned before, we had a majority and a minority group that were simulating one country and another country, two different countries with different cultures and different approaches, and then they were put together and they had to make a discussion. Something came along and basically, respect, communication actually being able to listen and speak clearly and present your ideas in an efficient way, that was key. It was an amazing experience where you could actually see and feel the moment and how different cultures can affect a person and how a conversation can lead a completely different way if there is a misunderstanding. (M2)

Within the theme of intercultural skills, there were two aspects which the students felt were important. The first was an increased awareness of different cultures and the realization that people view

situations differently as a result of their own backgrounds. The students were positive about and open to the idea of getting to know other students as an initial means of breaking down barriers.

So people from different cultures, view situations very differently. And it's very important to try to understand where people are coming from..... or try to make an effort at least because everyone has different upbringings, different ways of thinking. You have to understand where they're coming from in terms of their ideas, so it's easier for us to collaborate with them because my way of thinking could be different to your way of thinking. So if I get to know you as a person, we break that barrier, then it would be easier to collaborate. So it will be very good to collaborate with people from different cultures and in turn you can come to a conclusion or idea for a project or anything, that suits both parties. (M10)

The Majoria/Minoria activity aimed to help students better understand how essential it is to respect the similarities and appreciate the differences of other cultures whilst working with different individuals on various challenges.

One of our workshops was Developing Intercultural Skills. This was a very eye-opening workshop where we discussed the importance of how different cultures might interact with one another. We also had an open discussion after the group task where we talked about people's different backgrounds and the differences and similarities between cultures. (W1)

Evidence from student feedback demonstrated the importance of developing intercultural skills, in particular the ability to work with people from diverse backgrounds and the importance of understanding what they can contribute.

I mentioned previously about working with the Ulster students and they all came from various cultural and engineering backgrounds, which really benefited me as I could hear all sorts of opinions and gave me a new outlook on engineering also. We did several workshops together in team building and building our intercultural skills, which taught us how to maybe not judge others initially and a huge benefit on communication and working through arguments or working through disagreements. (W3)

Personal Development

The second key theme which emerged from the analysis was the personal development that students felt they had gained over the course of the summer school.

The students reflected extensively on the types of skills that they had learned through the summer school; these included presentation and communication skills, social skills, leadership and time management.

I think communication, intercultural skills, interpersonal skills, presentation skills, and I think those they were key.So yeah, yes, like it was amazing, really good. I learned a lot and I believe these skills, they were really good for the industry. (M2)

In particular, one that struck me was designing a project with the circular economy in mind. We decided to improve a cosmetics product due to many problems our users had with it. So I took leadership of that company and it taught

me how to present and to come up with drawings and develop an idea into an actual product. I think this was entirely beneficial to my career.... (W3)

I think it goes without saying that this summer school has really given me insights and a greater understanding of what it is to be an engineer and I think can really benefit me as a working engineer. (W3)

I also think that the strong intercultural element that we learned would be very important in companies. (M11)

The project work and activities also gave students an opportunity to develop their leadership skills, showcased in several reflections.

We also engaged in many other activities like I mentioned the design project, which I think really showed how I could take leadership in a project and really benefited me in terms of being able to maybe lead a team or put out my ideas and it also gave me a huge boost in confidence in terms of presenting myself to a crowd. (W3)

Students also provided reflections wherein they mentioned an opportunity to get to know other engineers and to open up to them and talk about various aspects of the summer school. This bond that was developed during the 5-day summer school was demonstrated in how they worked together on group activities and helped them improve their interpersonal communication skills.

The main skills I developed were my social skills definitely, because during the PROFESS 12 summer school we're always in groups, where we were having to talk to each other and you know, the social element was really, really impressive. (M11)

The five-day event did include many tasks and required the group of students to complete activities within strict time frames, be it tasks or cultural activities, thus helping them understand the importance of time management.

Also we had to develop a product based on customer complaints, opinions, what they wanted, what they would like to develop, what they would like to improve, things that they want to make better. So and we had to come up with all that in one hour. So time management it was key with the team that basically you just met but you could actually work with and we all work together and we were able to achieve really good skills also. (M2)

Some of the students reflected on their growth in learning about sustainability and how engineers can impact the future of our planet. Specifically they mention a change of mindset, a cornerstone in making the transition to a different way of thinking about how engineers operate and think about the future.

This programme basically made me achieve all those skills and that mindset that can actually change and are seeking to change the future for a greater good. (M2)

Some key things I learnt during the week were about how I can be sustainable within both my day to day and my work. (W1)

We also learned about our own kind of impact on the Earth and what we can do to help to help reduce that. (M11)

The key take away for me is to continue to work hard to reach our goals. Certainly we are moving in the right direction, but I believe we have a long way to go to reach that goal. But we're on the right track and as engineers, we have a key role to play in changing and making differences from the way we design to the way we consume material and products, so really it's been an awakening and an eye opening experience for me and I think it's going to be helpful for both of us as engineers to making sure that in whatever area that we end up in our career, we should be more aware on how we design, consume and maintain our products so that we become a part of this change. A part of this initiative that is going to be helpful in making the world a better and secure and safer place for everybody.
(M12)

Understanding of Sustainable Development

The third key theme which emerged from the analysis related to an increased knowledge of sustainability issues. On the first day of the Summer School, students were asked to create a presentation on aspects of sustainable development and the SDGs, and SDG 12 in particular. The students were able to build on the knowledge they gained about SDGs and SDG 12 when they took part in workshops such as the circular economy and the site visits later in the week. There are three sub themes within this section; Knowledge of Sustainability and SDGs, Circular Economy and Holistic Understanding of Sustainability.

Initially students did have a basic understanding of sustainability but through their participation in this school, they developed an in-depth understanding of the SDGs and SDG 12 in particular. They also gained significant insight on how the principles of SDG 12 can be incorporated in an engineering project.

I also mainly gained a huge knowledge of sustainability through this programme, it really taught me how to see it and notice it and apply it to any aspect of life, not only engineering. (W3)

First and foremost, I gained a better knowledge of the Sustainable Development Goals (SDGs). I learned about the principles and concepts of sustainable development and how they may be implemented to address global concerns through workshops and conversations. (W2)

We visited a number of facilities to see how sustainability is thought of as an issue in the real world. And we just learned a lot of different things about how we can implement sustainable practices. So I believe it was a great, fantastic beneficial experience because it gave us a chance to see what it's really like and it gave us so much knowledge, really of sustainability, that we might not have otherwise gotten.
(M4)

Although the students were introduced to the circular economy through a one-off activity to design a product in line with circular economy principles, it was encouraging to see that this concept remained with them as they reflected on the summer school. Real life examples which were used highlighted the waste and potential recycling capabilities of standard products, however students came away with a good understanding that recycling should be the last resort; reducing our consumption should be the priority.

One specific key thing I learned was how we can reduce the materials we use.....We're using the materials we have, so in turn to decrease the materials

that we have to recycle. So it's very important because I think right now in today's world, there's a lot of focus on recycling. But what can we do before we have to recycle, because recycling in itself has emissions, it's expensive. It uses energy. So before we get to this stage where we have to recycle, we could reduce the materials we have already, we can reuse them. So we don't have to go to the process of recycling. So you can think of it as a Plan A, Plan B, plan C. Plan A should be reducing, Plan B should be reusing, and recycling should be the last resort. (M10)

I also learnt how important the life cycle of products are and how they can become part of the circular economy compared to the linear economy. (W1)

. Within the circular economy, we learned about how products should really be made where, these products should be made to be strong, lasting, should be able to come apart and be fixed easily. They should have a long life and shouldn't just break after a few years. And if they do break, you should be able to replace parts. (M11)

Often, sustainability or sustainable development focusses on the impact of production processes on the environment, but students reflected on a more holistic understanding of sustainability and the importance of taking a holistic view. In particular, one student commented on the impact on society showing a broad range of understanding about what the concept of sustainability incorporates.

So really this school equipped me with skills that the average engineer may not have. Just because of how niche the subject was and really isn't taught in engineering courses. Especially like taking a holistic view to many things. (M11)

It's a big word at the minute and not everyone would fully know the full extent of which sustainability is, whereas as part of this school we've learned about a number of different aspects and see how there's multifaceted problems relating to sustainability. (M4)

Making products more sustainable and efficiently benefits all parties and even our society as a whole by decreasing waste and pollution. (M9)

Business Practice

The fourth key theme which emerged from the analysis related to business practice and specifically the attitudes of companies in relation to sustainability. The students reflected here mainly on what they learned during the site visits to the two companies.

There was a realisation from students that there are some companies that are really trying to make a difference and to do things sustainably.

We made two visits to different companies and on their facilities we saw how they are actually worried about the environment and with technologies and researchers they're actually making to improve those areas and try their best to not affect [the environment] as much as possible... ..and it was an amazing experience... ..Both companies were excellent. Excellent. I was speechless how they are actually developing, how they are focusing on those SDG areas and they will have a big impact on those on reducing the amount of pollution. (M2)

We also covered how not only us as individuals can have influence but how companies can take a key interest in their own carbon footprint and impact on the environment. (W1)

It was great seeing how companies take an interest in becoming more sustainable. (W1)

This summer school helped me to understand small ways that companies can make changes to reduce their carbon footprint and increase their sustainability. (W1)

With the {REDACTED COMPANY} I found, you know, I think the whole idea for their {PRODUCT} was really SDG-12 oriented – they cared about delivering a cleaner form of travel. (M11)

Despite cost not being brought in as a focus in any of the exercises, several students mentioned the impact that sustainable practices in companies can have costs, or that if there is a cost associated with a sustainable practice, this should be made clear to the customer and highlighted. Yet there was also an awareness that companies need to consider the financial impact of introducing sustainable practices which may reduce their profit margin.

We had to make presentations.....we had to develop presentations in a short period of time, come up with innovative ideas and ways that to use renewable materials and materials that we can actually come along and easily be sustainable, but also focus on the profit, how much that would cost, how much that the company would be able to actually provide and also think in those areas, not just think about sustainability and the good for the environment, but also think about the cost and how that would affect the customer. (M2)

Doing research and investing, actually investing a lot on research and development to do their best to be sustainable and actually show that to the customer, that this has a cost, but the cost is also worth it so we can have a planet in the future. (M2)

Companies are keen and are focussed on developing products and services that are sustainable not only for the environment but also because it is financially beneficial for them in the long run. (M3)

Students also realised through the site visits that companies are not only making an effort to reduce their negative impact on the environment but also doing so without using the ‘buzz words’ of sustainability.

We did a workshop where we looked at four products and we chose makeup. The makeup industry, a lot of makeup brands, they greenwash people, where people think they are buying a sustainable product, but they really aren't. (M11)

It was also nice to see from {REDACTED COMPANY} that there is a genuine demand for eco-friendly and green transportation and that it is actually less superficial than I had originally believed.....that a lot of companies were using the buzzwords of eco-friendly and green and sustainability to improve their image without actually dedicating to creating something that is manageable for the planet and for the humans that reside on it, as well as the wildlife and fauna. (M6)

Key messages have taken away from the site visits. Really, that sustainability has finally grown beyond a fad and has really become a crucial and everyday facet of engineering and manufacturing. (M6)

Impact of Technology

The final theme which emerged was the importance of Research and Development (R&D) and new technologies on finding future solutions to sustainable development problems. Students foresaw this as being a critical part of achieving SDG 12.

There are new methods and techniques that can be developed that will help the economy reduce its carbon footprint and produce products and services that are for the circular economy that's helping the future of the company. (M3)

I believe research and development have a huge role to play in terms of sustainable development because as I said earlier, the sustainability point of anything involves the entire supply chain, the entire life cycle assessment of the product or project or you know services. So research and development can help by doing these life cycle assessments from the cradle to cradle again, and in each stage they can calculate the carbon emission and then compare. (M12)

Without research and development, there is no sustainable development. People won't ask the right questions. The right testing won't be done. The right data won't be gathered to really create, a greener and more sustainable future, and to explore different materials and new processes and setting up new networks for the trade of raw materials and finished goods. (M6)

Discussion and Conclusion

A thematic analysis of the student reflections revealed five key themes. Students enjoyed the social interactions and working with diverse people, recognising the importance of making connections and building relationships for the future. The group of students bonded very well, and this can be recognised in some of the quotes about how they looked after each other and how they made friends not only with other students from their own university but also with students from the partner university. For some students, working with a diverse group of people was new to them and they did not seem to have had much opportunity to interact with such a diverse group of students before. Being put in such a diverse group for the duration of the Summer School was a new experience for them. However, many students recognised the value of diverse teams and the importance of developing intercultural skills, whilst being aware of different perspectives from different cultures.

Students achieved personal development in developing communication skills, social skills, leadership and time management. Several students specifically reflected on developing their communication and presentation skills and that their confidence in their communication ability improved over the course of the week. It was also clear that the social aspects of the summer school gave them an opportunity to practice socialising in a non-formal way and helped strengthen their bonds. Although not mentioned in the reflections, one student did relate to the tutor that this was the first time they had begun to socialise properly since the COVID lockdown and that they found it mentally exhausting as they had been out of practice. Although time management was not a specific aim of the summer school, it is interesting to note that this was a skill they became aware of because of the way the researchers allocated activities within the sessions.

Not surprisingly, the students indicated that they had learned a lot about sustainable development, which was a core focus of the school. To meet sustainability targets a change of mindset is needed and this was evident in some students' thoughts as they reflected upon the summer school. In particular, there are action orientated statements which show that students are considering how they can take the learning from this summer school into their future projects and future life (working life/career and outside work) as an engineer and as a person. This change of mindset can be viewed as a significant professional development achievement, and a distinct learning gain from their involvement in the summer school.

Another finding which was not necessarily part of the design considerations was the impact that the site visits had on the students understanding of business practices with regard to sustainable development. The initial assumption of some students was that companies claiming to have a commitment to sustainability can appear to be in favour of it without doing anything to support it, in other words have a "greenwashing" agenda. However, through this experience students realised that some companies actually engage in social aspects of sustainability, considering how their designs impact the environment, the economy and the community. Further, some students made the link that as an engineer in practice they would want to work for an ethically sustainable company, perhaps making them more aware of considering a company's sustainable practices as an ethos that would attract them to join a particular company. Students also recognised the efforts that companies are making in research and development to achieve the SDGs.

Our findings indicate that the summer school was a success, the learning outcomes were achieved and for the twenty students involved, it had an impact on their thoughts and behaviours. However, this pilot project is an example of the add-on strategy at a micro level (Kolmos et al., 2016) yet we are challenged to achieve the integration or the rebuilding strategy which would require a paradigm shift in our delivery of engineering programmes at the macro level. Nevertheless, our intention in the design and delivery of this summer school was to pilot this initiative on a small scale to build confidence in our design and delivery and to ignite a wider integration of EESD into the overall curriculum.

We hope that the resources provided on our website can be used by other educators as a catalyst for similar reform strategies in order to move from small to large scale implementation, or rather from an add-on strategy to an integration, or full-scale rebuilding strategy (Kolmos et al., 2016) to enhance engineering curricula to prepare our students to solve the sustainable development challenges we currently face. Each strategy requires different levels of engagement with university management, external companies and society (Kolmos et al 2016). This pilot project is an example of the "add on strategy" as it was an elective for interested students without academic credit. Further, it was initiated by interested academics, early adopters hoping to lead change within the department. However, it is recognised that systemic change requires support from a top down and bottom up approach. Accreditation requirements and recent strategic plans in both Universities recognise the importance of Education for Sustainable Development (top down influences) and it is intended that piloting of the summer school will give confidence to the lecturers involved to become change agents and to incorporating these activities more widely in the curriculum (bottom up influences). The challenge lies in finding room in an already overcrowded curriculum and therefore this will take time. We would be interested in hearing about similar summer schools, particularly in different disciplines to see if the learnings are similar or discipline specific. Our next steps are to investigate a similar initiative which would include European partners, in an effort to make the intercultural skills development more explicit.

Facilitators' suggested improvements

At the end of the summer school, the facilitators reflected on what had gone well and what might be improved in another iteration. Preparation was key to the success of the week. In the months before the summer school, each workshop was planned in detail and more content was provided than was needed. This allowed for things to go wrong, such as when a guest speaker could not attend, there were additional activities which could be used. Buses for transport between sites and to company visits saved time, rather than trying to book taxis or walking. Contingency plans were also built in to allow for traffic and other delays.

We also acknowledge that there were some challenges faced in the project, most notably in encouraging students to attend. This was a fully funded summer school which included hotel accommodation and all meals and transport for the students. Even with these attractions it was difficult to garner interest from students, because it was during the summer holidays when many are working and could not commit to five full days. This may be a reflection of the socio-economic status of many of our students in each University and may differ to other jurisdictions. We also identified some barriers to engagement for women who were restricted from attending due to childcare responsibilities. We recommend to other summer schools that considerations should be given to providing some funding towards childcare arrangements or to explore the possibility to attend on a part time basis or participate in some elements remotely (i.e. daytime only or non-residential options) to assist women or single parent students to attend.

Finally, in terms of feed forward advice to others, we found that energy levels were low at the end of the week and students were not as receptive to learning due to tiredness or overstimulation. The recommendation for the next iteration is to allow some down time for students to rest or explore the local areas in their own time to enhance their cultural understanding.

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References

- Beagon, U., Kövesi, K., Tabas, B., Nørgaard, B., Lehtinen, R., Bowe, B., Gillet, C. & Monrad, C. (2022) Preparing engineering students for the challenges of the SDGs: what competences are required? *European Journal of Engineering Education*, Vol 48. Issue 1, pp. 1-23. <https://doi.org/10.1080/03043797.2022.2033955>
- Beagon, U., McKennedy, J. Jani, R., Bowe, B., Morgan, M., Henry, R. (2024) Examining The Effectiveness Of A Summer School To Equip Engineering Students With Competences Required To Achieve The SDGS. Presented at European Society for Engineering Education (SEFI), Lausanne.
- Byrne, E. P. & Mullally, G. (2014). Educating engineers to embrace complexity and context. In *Proceedings of the Institution of Civil Engineers-Engineering Sustainability* Vol. 167, No. 6, pp. 241-248. Thomas Telford Ltd. <https://doi.org/10.1680/esu.14.00005>
- Chernyshova O., & Tokmylenko, T. (2020). Summer School: a non-formal way to tackle education challenges. *Education Dimension*, Vol 3, pp.267-287. <https://doi.org/10.31812/educdim.v55i0.3942>
- Craps, S., Pinxten, M., Saunders, G., Leandro Cruz, M., Gaughan, K., & Langie, G. (2017) Professional roles and employability of future engineers. In *Proceedings of the 45th SEFI Annual Conference 2017-Education Excellence for Sustainability, SEFI 2017* (pp. 499-507). European Society for Engineering Education SEFI.
- De Haan, G. (2010) The development of ESD-related competencies in supportive institutional frameworks. *International Review of Education*, Vol 56, Issue 2, pp. 315–328. <https://doi.org/10.1007/s11159-010-9157-9>
- Kolmos, A., Hadgraft, R. G., & Holgaard, J. E. (2016). Response strategies for curriculum change in engineering”. *International Journal of Technology and Design Education*, Vol 26, Issue 3, pp. 391-411. <https://doi.org/10.1007/s10798-015-9319-y>
- Kolmos, A., & J. E. Holgaard. (2019) Employability in Engineering Education: Are Engineering Students Ready for Work? In S. H. Christensen, B. Delahousse, C. Didier, M. Meganck, & M. Murphy (Eds.), *The Engineering-Business Nexus: Symbiosis, Tension and Co-Evolution*. Philosophy of Engineering and Technology, Vol. 32, pp. 499–520. Cham: Springer International Publishing. https://doi.org/10.1007/978-3-319-99636-3_22

- Larsen, P.G., Fernandes, J.M., Habel, J., Lehrskov, H., Richard, V., Wallington, O., & Zidek, J. (2009) A multidisciplinary engineering summer school in an industrial setting. *European Journal of Engineering Education*, Vol 34, Issue 6, pp. 511-526. <https://doi.org/10.1080/03043790903150687>
- Michigan State University. (2000) Understanding Special Issues. Michigan State University Board of Trustees. https://www.canr.msu.edu/uploads/236/67555/YEA_Issues_book.pdf
- Novak, K., & Bracken, S. (2019) Introduction: Universal Design for Learning: a global framework for realizing inclusive practice in higher education. In *Transforming higher education through Universal Design for Learning*. pp. 1-8. Routledge.
- Qosaj, J., Corti, D., Terzi, S. (2023) Innovation & Entrepreneurship in engineering curricula: evidences from an international summer school” In *IFIP International Conference on Advances in Production Management Systems*. pp. 461-475. Cham: Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-43666-6_32
- Rieckmann, M. (2012) Future-oriented higher education: Which key competencies should be fostered through university teaching and learning?, *Futures*, Vol 44, Issue 2, pp. 127-135. <https://doi.org/10.1016/j.futures.2011.09.005>
- Thomas, D. R. (2006). A General Inductive Approach for Analyzing Qualitative Evaluation Data. *American Journal of Evaluation*, 27(2), 237-246. <https://doi.org/10.1177/1098214005283748>
- Thürer, M., Tomašević, I., Stevenson, M., Qu, T., & Huisingh, D. (2018) A systematic review of the literature on integrating sustainability into engineering curricula. *Journal of Cleaner Production*, Vol 181. pp. 608-617. <https://doi.org/10.1016/j.jclepro.2017.12.130>
- UNESCO. (2017) Education for Sustainable Development Goals – Learning Objectives. ISBN 978-92-3-100209-0. Available: <https://www.unesco.org/en/articles/education-sustainable-development-goals-learning-objectives>
- Villanueva, I., Di Stefano, M., Gelles, L., and Youmans, K. (2018) Hidden Curriculum Awareness: A Comparison of Engineering Faculty, Graduate Students, and Undergraduates. *World Education Engineering Forum*, Albuquerque, NM.
- Wiek, A., Withycombe, L., & Redman, C. L. (2011) Key competencies in sustainability: a reference framework for academic program development. *Sustainability Science*, Vol 6, Issue 2. pp.203-218. <https://doi.org/10.1007/s11625-011-0132-6>

Appendix A

Students were asked to reflect on their experiences of the summer school using the prompt questions indicated below:

Student Reflective Exercise 1: Site Visit Reflections

Students were asked to reflect on their visits to the companies and were encouraged to consider the prompts below.

- What did you learn about sustainability from the site visits to {REDACTED} company and {REDACTED} company?
- How do you think research and development can contribute to sustainable development?
- What are the key messages you took away from site visits; in general and specifically in relation to SDG 12?

The responses aimed to obtain student feedback on the effectiveness of the site visits and their general thoughts on manufacturers' approaches to sustainable development.

Student Reflective Exercise 2: Job interview questions

The second reflection session focused more on how students would describe the summer school experience if they were asked about it in an interview. They were asked to use the following questions as prompts:

- I see from your CV, you attended a Summer School, what was that about?
- What were the key things you learned at this summer school?
- I see you did something on intercultural skills, can you tell me what you learned from that?
- What skills did you develop, I mean, how does your participation in that summer school help me if I employed you?

The design of this reflective exercise sought to support both personal development (in terms of preparing students for interviews - employability /interview skills) as well as providing a mechanism to gather evidence for the evaluation.