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PERSPECTIVES ON DESIGNING FOR A SUSTAINABLE FUTURE; PRODUCTS FOR THE DEVELOPED AND DEVELOPING WORLDS

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ABSTRACT
The aim of a sustainable product solution is to fulfil a user need while creating a net positive sustainable impact - environmentally, socially and economically [1]. The concept of sustainability can be complex for a product design student to come to terms with, since the creation of new physical products consumes the Earth's scarce natural resources [2]. So, should we ideally have no new products in the future? More likely, we should hope to have more sustainably aware product designers, working for companies that need to - due to regulations or consumer preferences - produce and provide more sustainable product solutions. Dublin Institute of Technology's BSc Product Design uses two project-based-learning classes as part of one module to guide students through the concepts of sustainability. One project focuses on design for behaviour change [3] in the developed world. Students identify a current behaviour that has a negative environmental impact and work to develop a design intervention that facilitates and encourages a "better" behaviour. A second project focuses on design for an underprivileged or marginalised population. Students engage with Engineers Without Borders and design products aiming to solve a problem for a poorly served community in a certain context. Students complete the module by reflecting on their understanding of sustainability and how it relates to their own identity as a designer. This paper shares the outcomes of the process and provides a pedagogical approach for helping students to delve deeper into the complex and contentious area where product design and sustainability intersect.

Keywords: Sustainability, behaviour change, ethics, reflective learning

1   INTRODUCTION

1.1 Background
Sustainable innovation and design is about creating ecologically sound, socially just and economically viable [4] solutions that consider both current and future generations. These three elements of sustainability, (often labelled planet, people and profit) make up the Triple Bottom Line [5]. Education on sustainability has evolved from education about the environment, to an education which will enable better stewardship of it [6]. To enable this stewardship, a more holistic education that encompasses the three elements must be adopted.

1.2 Sustainability in Dublin Institute of Technology's Product Design Programme
In Dublin Institute of Technology's interdisciplinary BSc Product Design programme, students attend the Institute's Schools of Mechanical and Design Engineering, Creative Arts and Marketing. The programme's early years equip students with the fundamentals of each core discipline and as they progress, they undertake more integrated interdisciplinary projects [7]. This approach primes the students to deal with the interdisciplinary nature of sustainability. In the final year of the degree, students take a module focused on sustainable product design solutions. In the next section, the module pedagogy is briefly outlined along with the research method used to gather the students' perspectives on designing for a sustainable future.

2   METHOD

2.1 Module Structure

Over the first semester of final year, two classes per week guide students through the concepts of sustainability. The pedagogy mixes lectures and project-based learning. One class per week focuses on design for behaviour change [3] in the developed world. Students undertake, on an individual basis, a project, whereby they initially identify a current behaviour that has a negative environmental impact, and then develop a design intervention that facilitates and encourages a more environmentally sustainable behaviour. Students question their assumptions and critically discuss green washing, planned obsolescence, consumerist culture and inequality, while exploring approaches to address associated issues. They are introduced to dematerialisation concepts including product-service business models [8], design for life-cycle analysis including design for disassembly and recycling [9], and tools from the behavioural economics literature [10] including gasification [11], feedback and progress provision, and incentive and forfeit design. They discuss case studies and equip themselves with new language and concepts.

The second weekly class focuses on design for an underprivileged or marginalised population. Students are given a brief which focuses on a geographical area or user population, typically in the developing world. The inherent difficulties involved in asking students to design for a context with which they are not familiar are addressed through a series of workshops with experts in the area. Where possible, guests with first-hand experience in the intended environment or community are brought in. A key aspect of this approach is a link-up with the Irish chapter of Engineers Without Borders, which gives access to contacts of this nature. They watch documentaries and employ empathy tools to understand the needs of inaccessible populations. A true user-centred and immersive design approach presents challenges due to the geographical and lifestyle differences between the target group and the student cohort. To help address this difficulty, guest speakers with first-hand experience of the target regions visit the class to share their insights. Throughout the concept development and final design phases, experimental design methods are promoted, and students are expected to engage in prototyping and testing. Students investigate local resource availability and manufacturing strategies and work to specify low cost, materials and components in their designs. At the end of the semester, the project outcomes are entered in the local "Where there is no Engineer" competition run by EWB. DIT Product Design students have won two of the three annual national EWB competitions that have run.

2.2 Student Reflective Essays

Students complete the module by reflecting on their understanding of sustainability and how it relates to their own identity as a designer. They are prompted to reflect on their learning by first creating a mind-map and then writing a response to questions;

- Has your understanding of/perspective on sustainability changed over the last semester? If so, how? Reflect on what you've learned and how you will apply this in the future.
- Has your understanding of/perspective on sustainable design changed over the last semester? If so, how? Please make reference to: sustainable design for the developed world and sustainable design for marginalised communities.

Thematic analysis was used by the authors to analyse the reflective responses produced by the cohort who took the module September-December 2017.

3   RESULTS

This section will first briefly describe some of the students' design results. This is followed by the results from the student reflections.

3.1 Students' product design concepts

3.1.1 Products for the Developed World; Design for Behaviour Change

Students identified human behaviours that had an impact on the environment, including energy and water usage, noise pollution, and waste and recycling. Three products are described here and shown in Figure 1, though all students developed a unique idea. A smart hose concept that consists of a retrofit nozzle with a flow meter and feedback screen aims to assist a homeowner in using less water. Modes

for washing a car or watering a garden show the user an increasing percentage of a recommended volume that they should use for those tasks. A universal mode provides a basic "volume expelled" metric, which aims to simply make the user more conscious of the water they are using. A second student designed a laundry scale to optimise washing machine usage. The scale is calibrated to the washing machine model and the user then aims to fill the machine with the optimal load-weight for a cycle. This aims to reduce wasted water caused by underweight loads and increase the lifespan of the machine by avoiding overweight loads. A third student identified a growing issue with septic tanks, where overuse of antibacterial cleaning agents reduces a tank's efficiency. Alternative cleaning agents and bacteria "bombs" can mitigate this. This student developed a monitor to help users maintain the right amount of bacterial activity in their septic tank.

Figure 1. Students' Sustainable Products for the Developed World: (From left) Smart Hose, Laundry Scale and Septic Tank Monitor

3.1.2 Products for the Developing World; Design for Displaced Populations

In the 2017 cycle, the brief for the social sustainability aspect of the module was focused on "Design for the Displaced Population". Students were tasked with addressing some issue related to the global refugee crisis, one of the key humanitarian crises of our time. In the research phase, several guests who had first-hand experience of the issues involved visited the studio. Students engaged with these guests and developed products in response to the problems raised. One team addressed the issue of female menstrual hygiene in refugee camps. This design solution aimed to address health, hygiene and dignity issues for women, while considering the requirement for materials to be low cost, readily available and easily cleaned. Another team focused on the security issues involved in using toilet facilities in refugee camps after dark. They developed a simple system for turning plastic water containers, currently being discarded in the target regions, into portable toilet units which can be used in individual dwellings during the night.
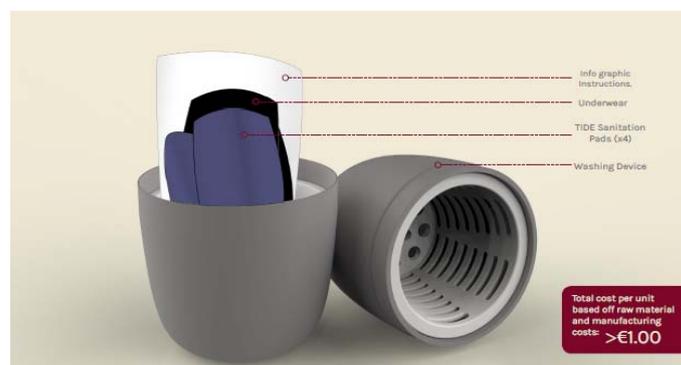

Figure 2. TIDE: Menstrual tool kit with reusable sanitation pads, developed in conjunction with multiple stakeholders

A third example aimed to address the issue of fatalities in tents and temporary shelters due to the inappropriate use of electric heaters and cookers to keep the space warm while inhabitants are sleeping. The proposed solution involved the use of storage heater blocks, again a commonly discarded waste material, in modular stove units to keep dwellings warm during the night.

3.2 Student development; reflections on designing for a sustainable future

By way of a reflective essay, students conveyed how their perceptions of sustainability had changed over the semester. In 2017, a class of 32 final year BSc Product Design students took the module and completed the reflective essay. Thematic analysis was used to analyse and find patterns in the essays. Six themes were identified. After the analysis, two groups emerged, which reflect the axes of the T-shaped person [12] model. Tim Brown of IDEO posits T-shaped people make good design thinkers and can operate well in interdisciplinary environments. The vertical axis represents a depth of discipline specific skill that allows a person to contribute to the creative process. The horizontal axis represents a person's disposition for collaboration across disciplines and is "about empathy for people and for disciplines beyond one's own… (it) tends to be expressed as openness, curiosity, optimism, a tendency toward learning through doing, and experimentation" [12].

AFTER DESIGNING PRODUCTS FOR A SUSTAINABLE FUTURE, STUDENTS FELT THEY HAD DEVELOPED IN THE FOLLOWING WAYS;

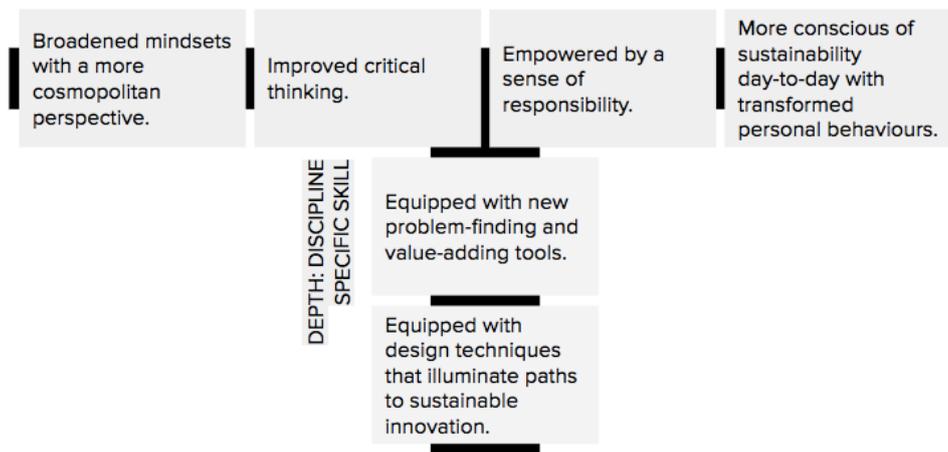BREADTH: DISPOSITION TO COLLABORATE, TO BE OPEN AND EMPATHIC

Broadened mindsets with a more cosmopolitan perspective.

Improved critical thinking.

Empowered by a sense of responsibility.

More conscious of sustainability day-to-day with transformed personal behaviours.

DEPTH: DISCIPLINE SPECIFIC SKILL

Equipped with new problem-finding and value-adding tools.

Equipped with design techniques that illuminate paths to sustainable innovation.

Figure 3. Student Development Mapped on the T-shaped Thinking Model

3.2.1 Broadened mindsets and with a more cosmopolitan perspective

Sustainability is an ethical issue. Students' reflections suggested that the lectures and project classes connected them to a sense of world citizenship, being able to better empathise with future generations and marginalised populations. Students said "designing (for a marginalised population with EWB) has made me think more deeply about the refugee crisis". Other students said that project made them explore "much more about the economic and social aspects of sustainability" and noted that "sustainable product solutions should not interfere with cultural beliefs". Cosmopolitanism is the ideal that all humans matter, and therefore, "every human being has obligations to every other" [13]. A person is not just related to their state or community, but rather we all have a universal shared identity [14]. Cosmopolitanism has been highlighted as a core idea in liberal sustainability education, along with interdisciplinary and civics [15]. It emerged that most students had equated sustainability with environmental concerns rather than social and economic concerns. "My thinking was very one-dimensional, i.e. about recycling, whereas in reality every decision has a knock-on effect." Another said, "sustainable design requires a big picture view of how our choices affect more that the present." Another said, "sustainability is more than a trend; it is a mindset". Students also recognised the importance of regulation and government, saying "responsibility needs to be put on industries" and that we must "regulate the usage of renewable materials now".

3.2.2 Critical thinking

Complex design problems which involve many unknowns and unanticipated consequences are often referred to as "wicked problems" [16]. Wicked problems have no right or wrong solutions, only better or worse ones. Better solutions usually uncover more design challenges and a solution to a wicked problem that works today might not work in the future. With this in mind, designers need to have a high tolerance for ambiguity and complex situations and be able to think about and navigate through the contextual and critical issues that emerge though the design process. Students said that the process of designing sustainable solutions "made (them) think more deeply" and "ask questions (they) wouldn't have previously". The responses suggested that students were more critical of marketing and media messaging too, mentioning a "new healthy scepticism". Students said, "the media has pushed the environmental agenda, but the social and economic aspects of sustainability are less well understood by the public". The *wickedness* of sustainability problems were understood too, with one student stating that "there are few truly sustainable solutions, as every resource has a limit; it's about trying to get the balance right".

3.2.3 Empowered by a sense of responsibility

Students' responses suggested that they felt a new sense of responsibility - as both designers and consumers. They said that "it is reckless not to consider the three pillars (of sustainability) as a designer" and "designers are the crux of the issue". Another student said, "as product designers we design for the future - users in the future and the climate of the future". They were not apathetic, but rather empowered saying, "our actions seriously impact the world we live in" and "sustainable design solutions are created when we think for tomorrow".

3.2.4 Transformed personal behaviours

Throughout the module, students reflected on their own behaviour to understand the problems they were attempting to solve. One student wrote that "studying sustainability has changed me as a consumer and user". Others said, "I apply small behaviour changes in my own life now" and "I am more aware of how I use energy and interact with products, services and people".

3.2.5 New problem-finding and value-adding tools for product design

Students indicated that they felt they had improved their ability to see the *invisible* negative impacts of unsustainable activities and products and, therefore, had also improved their ability to identify problems to solve. On student wrote, "users never really see the waste they create; they are sheltered from it while their waste is sent away somewhere invisible". Another reflected, "we don't see the waste – our good infrastructure glosses over the cracks". Another student said that "I have learned that while it's great to have a product that's (manufactured) sustainably - what's the point if people use it in an unsustainable way? Sustainable design solutions should inspire people to live more sustainably". Anther agreed, stating that by "applying the triple bottom line approach, what I design in the future be a more well-rounded product or service".

3.2.6 Design techniques that illuminate paths to sustainable innovation

Students' responses suggested that they don't see sustainability as just a problem to solve - but as an opportunity. One wrote, "sustainability is a constraint that must be incorporated into every brief. It is not a negative constraint - it opens the door for innovation". They highlighted the importance of focusing on more than environmental feasibility and viability, saying that the "desirability of a product is core - an environmentally friendly product that goes unused is not environmentally friendly! Products need to be meaningful." They pointed out the needs to "create simpler products that are easier to recycle than complex ones", "plan for the rebirth of a product" and "design things to last rather than to just be recyclable". The idea of designing more sustainable behaviours through interaction design was new to most students, with quotes emerging like, "it was a huge learning curve", and "behaviour was not something I associated with the concept of sustainability". Beyond products, students acknowledged the interdisciplinary requirements of sustainable solutions, pointing to effective education and information provision and stating that "social media platforms can be a powerful way to promote alternative sustainable approaches; ideas spread faster that way".

4   CONCLUSIONS

4.1 Pedagogical recommendations for teaching sustainability to product design students

In terms of teaching and learning, this work suggests that critical discussion and reflection are paramount in sustainability education. Students were fully engaged in discussions that questioned stereotypes and assumptions about the environmental, social and economic aspects of product design. Case studies related to existing products, services and behaviours were good jump off points for these discussions. Tutors should also work to have students acknowledge and embrace the ambiguous and interdisciplinary nature of designing for a sustainable future. In doing so, students should work to explore all the contextual issues related to a design problem, rather than focus on solving what they initially understand to be the problem. Though students didn't include a lot about metrics and measurement in their reflective essays, this is an important subject for tutors to address. The sustainability impact of a design intervention is complex to measure. This difficulty has been identified as an issue for organisations and work is ongoing to develop mechanisms to measure product and system sustainability [17]. The suite of tools we can access as designers will continue to grow, but the aim in higher education should be to instil in students a lifelong interest and understanding in the area of sustainability so that they, as both designers and consumers, can play a part in creating a more sustainable future.

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