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MATERIAL FUTURES: AN INTRODUCTION OF REGENERATIVE DESIGN PRINCIPLES TO PRODUCT DESIGN STUDENTS

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ABSTRACT
Our material world and consumer habits have a significant negative impact in the environment. Across its life cycle the average product results in carbon emissions of 6.3 times its own weight (1). Designers are developing biomaterials from waste or generating renewable growable materials rather than extracting and mining.
Materials developed from mycelium, bacteria, algae, and cactus help to reduce the environmental impact of single use and to rethink our relationship with convenience and consumption. These materials offer some of the insulating, lightweight, waterproof, and transparent properties of plastic, but are non-toxic and compostable. Moreover, these materials often use bio fabrication techniques, instead of traditional manufacture processes, by harnessing biological organisms to design and grow products and clothing.
Truly Regenerative Design considers interconnected dynamics that are people and planet centred with a focus on circular economy and regeneration. Material Futures used biomaterials and bio fabrication to introduce Regenerative Design principles to second year Product Design students, towards a co evolutionary process between humans and natural systems, understanding of local context and a living system thinking approach. Students were asked to design a product made entirely of mycelium that considered user needs whilst helping to decarbonise the material world. Design methods such as cone of futures, future back casting and the thing of the future were used so students had to consider future micro and macro impact of their proposals. The project was supported by a Regenerative Design Studio Lab through a workshop, in which students had the opportunity to learn mycelium's bio fabrication processes and properties. The paper includes examples of experiments with mycelium in class, the methods used for concept development and student feedback, that illustrates the importance of introducing Regenerative Design principles to increase ecoliteracy and consequently reduce the environmental impact of product design.

Keywords: Regenerative design, bio fabrication, living systems approach, ecoliteracy, future back casting

1 GREEN VS SUSTAINABLE VS REGENERATIVE DESIGN

1.1 Regenerative design definition
According to the Regenesis Group definition, Regenerative Design uses a living system thinking approach. It generates resilient and equitable processes that regenerate rather than deplete underlying life support systems and social ecological resources. In summary, it encourages to 'design capability instead of designing things' (2) shifting the focus from objects to nurture relationships with the wider context. Although, the notion of Regenerative Design has been lingering since at least 1970, there has been a recent re-evaluation of what sustainable development means and how Regenerative Design can be used to go beyond mitigation.

1.2 Difference between Green, Sustainable and Regenerative Design
There are important distinctions between the concepts of Green, Sustainable, and Regenerative Design. These distinctions are important to how product design lecturers convey environmental education, increase ecoliteracy and the impact it has on future design graduates.

Green Design is centralized around specifically decreasing environmental impact from human development, as Van Der Ryn wrote 'Green Design only slows the rate of destruction' (3).

The definition of sustainable or **sustainability** has been widely accepted as the ability to meet the needs of the current generation without depleting the resources needed to meet the needs of future generations. However, this definition emphasises an anthropocentric view as explained by Raymond J. Cole. The current sustainability modus operandi 'is allowing technological and engineering processes that perpetuate a mechanistic worldview and its limitations in dealing with complex and living systems, that are bringing both Green and Sustainable Design to an evolutionary dead end' (4). Sustainable Design focusses on using fewer resources and producing less waste and pollution by incremental change but still leads to negative environmental impact and fails to include local context, leading to a neutral and zero waste framework instead of a positive impact one.

A **Regenerative Design** system 'takes advantage of flows and feedback loops that allow for greater adaptability' (5). The key distinction of Regenerative Design is that both humans and natural systems are 'viewed as partners and need to co evolve' within a certain context, meaning that humans depend on the integrity and health of natural systems that they live in (4). In sum, Regenerative Design goes beyond the green and sustainable principles of measuring environmental, social and economic impact and generating mitigating solutions. Instead, it aims to understand a specific place and its unique patterns, design reciprocal relationships with living systems and create a culture of co-evolution (6).

1.3 Ecoliteracy

In 1990 Professor David Orr coined the term 'ecoliteracy', describing the ability to understand the complex natural systems that enable and support life on Earth. Orr's findings concluded that the more ecoliterate the more likely people would change their behaviour towards a co evolutionary process with natural systems. Sustainability, along with environmental education, is a key requirement of most design programmes worldwide. However, as Hempel described, 'knowledge is not enough' (7). Studies about the effectiveness of environmental education conclude that leads to polarisation. Ecoliteracy, can conveniently skirt moral and political issues, but when it is treated in the broader context of environmental education, 'the issues of personal responsibility and social equity become inescapable' (7). Hempel shows that the factors that contribute to eco-complacency and disbelief, amongst others, are psychological distance – e.g.: human separation from natural world– and technological insulation – e.g.: technology will provide the solution to all negative environmental impact. Much attention in environmental education as concentrated in 'knowledge deficit' and not so much in 'behaviour deficit'. Therefore, How can design lecturers introduce more robust Regenerative Design principles within Product Design undergraduate programmes in U.K.?; How do we overcome eco-complacency in environmental education within product design?; and How do we go beyond sustainable literary?.

2 MATERIAL FUTURES

2.1 Knowledge is not enough

The premises of the Material Futures brief were to introduce Regenerative Design principles to undergraduate product design students and to increase ecoliteracy focusing on improving psychological distance and avoid technological insulation.

As part of the Design Futures module second year product design students were asked to design a household good made of mycelium. Over the past decade, the use of mycelium in product design has gained popularity due to its unique and sustainable properties, it has been used in packaging, insulation panels, clothing, vases, and lighting shades. Mycelium is a root like structure of fungus that combined with a substrate can grow and form complex structures without the need for external inputs such as water and sunlight, making it highly resource-efficient and durable material that can withstand wear and tear (8).

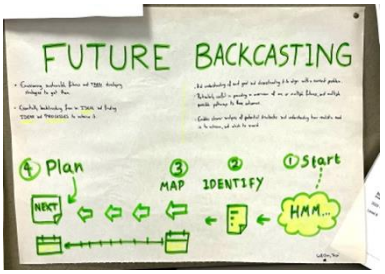
Students had approximately 4 intense weeks to explore future mycelium applications and consider user needs and local context, in addition to harnessing the potential of biological organisms. The project was supported by a Regenerative Design Lab: Osmose Studio. The studio delivered a lecture, a hands-on workshop and provided mycelium along with technical support, so students could explore the material first hand (Figure 1 to 3).
Students were strongly encouraged to question 'throw away and convenience culture', a behaviour so ingrained in the western society that has been difficult to shake off. It is predicted that by 2050 as much as 12 billion tonnes of plastic will have accumulated in landfills or the natural environment.

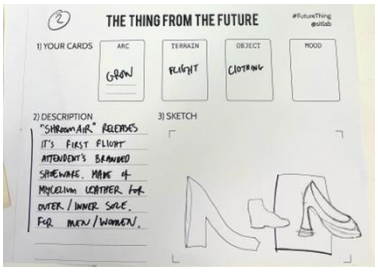


Figures 1. to 3. Mycelium workshop by Osmose Studio

2.2 Methodology

The project was divided in 3 stages. During **stage 1** students were exposed to biomaterials, bio fabrication concepts and principles of Regenerative Design. The mycelium workshop aimed to address phycological distance as students had the opportunity to experiment and manipulate with a living organism. There were 6 Regenerative Design principles covered within the project: 1. positive impact in ecology, society and health, 2. use of biomaterials and bio fabrication processes that harness the potential of biological organisms, 3. local context and data, 4. design 'capability' instead of 'things', 5. involves a community and or a specific user group on a continuous basis and 6. considers the wider context and unintended consequences. These principles were based on Regenesis Group framework for regenerative development (2).
Within **stage 2:** concept development, methods such as: cones of future, future back casting, and the thing from the future, were used to spark debate and question how some sustainability principles such as recycle can lead to negative environmental impact. The first method used was futures cone, through outlining preferable and probable future scenarios, once that was defined, students started working backwards to identify strategies that connect future to present, in this specific case how to create a culture of co-evolution between humans and mycelium (future back casting method). Within this method students were encouraged to explore concepts of convenience, single use within bio fabrication (e.g.: if we use biomaterials do we need to worry about single use?) and negative environmental impact offset strategies. In addition, students drafted a system map that considered the local social and health context of their proposal and unintended consequences to natural systems. Besides future back casting, The Thing from the Future game, created by Situation Lab, was introduced to students. Players were challenged to work collaboratively, in small clusters, to describe objects from a range of alternative mycelium-based futures and generate design proposals to randomly allocated scenarios. This stage was highly enjoyed by 85% of the students as per project feedback (Figure 4 to 6).



Figures 4. to 6. Stage 2 concept development included Future Cones, Future Back Casting and The Thing of The Future methods

S**tage 3** involved aligning design proposals to the 6 Regenerative Design principles (described in stage 1) and apply a system thinking approach. To support students on this we asked them to highlight the most important principles in relation to their ideas and provided a table in which they could rate the inclusion of the regenerative principles and check whether they could improve it.

3 VALIDATION, RESULTS & FEEDBACK

The study was validated through triangulation of data and methods. Data collection methods included a survey, students' comments throughout project stages, discussion groups/ roundtables and lecturers' observations.

Material Futures aimed to increase ecoliteracy, with a focus on improving psychological distance and avoid technological insulation. To improve psychological distance the project allowed hands on experimentation with mycelium through a workshop and subsequent growing process. Before the project 86% of the students never heard about the potential of mycelium as a biomaterial as compared to 100% knowledgeable after the project (Figure 7). Moreover, 60% of the students considered the workshop extremely useful to their learning experience and their feedback was encouraging: 'The Osmose presentation for the project was really helpful in understanding the makeup of the Mycelium. Overall, the project was fantastic' (9) and 'The workshop was good and provided all essential info, the only thing I would add is a deeper look into other ways of manufacturing mycelium' (9). Regarding the use of biomaterials in other future projects, 60% of students stated they were likely and 40% very likely, due to the positive environmental impact.

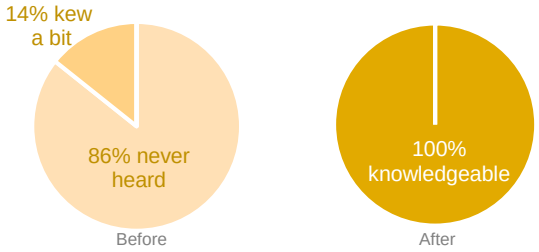


Figure 7. Student feedback on how knowledgeable they were before and after the project about the potential of mycelium as a biomaterial

In terms of understanding technological insulation and how to avoid it to decrease eco-complacency 42% of students mentioned that single use products should be avoided even when using biomaterials and bio fabrication processes with another 42% having a neutral stance. Similarly, 60% of the students demonstrated the importance of shifting from designing 'things' to design 'capability', with 72% of them showing evidence of unintended consequences of methods and processes as per the following student comment 'even when using biomaterials there is waste and manufacturing processes that require energy, and designers need to be aware the impact' (9).

The acquisition of Regenerative Design principles was assessed through Material Futures student survey and how students' projects outcomes aligned with regenerative principles. The knowledge of Regenerative Design was assessed before and after the project, with 57% of the students stated they 'knew a bit' of Regenerative Design before the project compared to 86% agreeing to be 'knowledgeable' about Regenerative Design after the project.

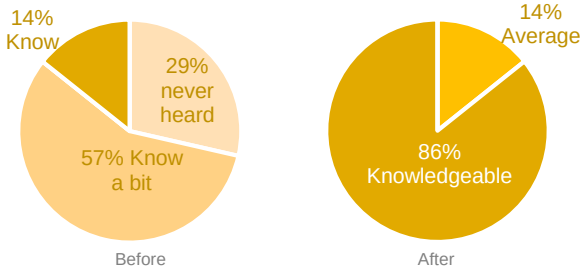


Figure 8. Student feedback on how knowledgeable they were before and after of Regenerative Design principles

However, as ‘knowledge is not enough’, to evaluate in depth the effectiveness of the introduction of Regenerative Design, students were asked to rate how their proposals aligned with the 6 Regenerative Design principles covered within the project.

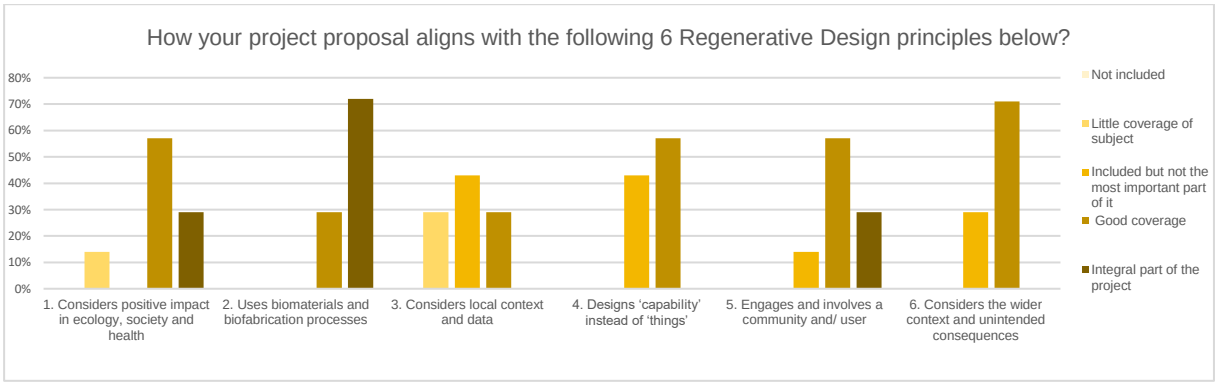


Figure 9. Student self-evaluation on how their project proposal aligned with the 6 Regenerative Design principles covered within Material Futures project

The use of biomaterials and bio fabrication processes was an integral part of the project for 74% of the students. Considerations about the wider context had a good coverage for 71% of the students. A total of 57% said their project had a good coverage of the positive impact in ecology, society and health, design ‘capability’ instead of ‘things’ and engages and involves a community and/ user. The principle that students thought had less coverage was considerations about local context and data, with 43% acknowledging that was not the most important part and 29% saying that had little coverage. In order to cross analyse students’ opinions to project outcomes, a comparison table was generated below (Table 1).

Table 1. Analysis of how Regenerative Design principles were included in students’ project outcomes

	Students' projects											Total of score per principle
Regenerative design principles	A	B	C	D	E	F	G	H	I	J	K	
1. Considers positive impact in ecology, society and health	1	1	0	1	1	1	1	0	1	0	1	8
2. Uses biomaterials and biofabrication processes	1	1	1	1	1	1	1	1	1	1	1	**11**
3. Considers local context and data	0	1	0	1	0	1	1	0	0	1	1	6
4. Designs ‘capability’ instead of ‘things’	0	1	0	1	0	1	0	0	0	0	1	4
5. Engages and involves a community and/ user	1	1	1	1	1	1	0	0	1	1	1	**9**
6. Considers the wider context and unintended consequences	1	1	0	1	0	1	0	0	0	1	1	6
Total score per project	4	**6**	2	**6**	3	**6**	3	1	3	4	**6**	

The results, concerning the principles that had an integral part in the project, the use of biomaterials and bio fabrication processes and involving a user, were similar to student self-evaluation (Figure 9), but differed from students’ perceptions on designing capability instead of things and considerations of the wider context and unintended consequences.

4 CONCLUSIONS

How can design lecturers introduce more robust Regenerative Design principles within product design undergraduate programmes in U.K.?

The project was successful in imparting principles of Regenerative Design to design students, especially in harnessing the potential of biological organisms with bio fabrication processes as well as considering a user and /or community. The brief focussed on designing reciprocal relationships with living systems (in this specific case mycelium) and the use of biomaterials, that is evident in both students’ feedback and lecturer’s analyses.

Other principles such as the consideration of the positive impact in ecology, society and health and the wider context and unintended consequences were covered mainly in stage 2 during future back casting and the thing of the future methods, and although student feedback shows a good coverage of these principles, project outcomes indicated that it could be improved. However, students' perceptions demonstrate that the discussions in class around it were relevant and can be emphasised at a practical level. The principle that was more difficult to evaluate was design 'capability' instead of 'things', as students were more inclined to take a product solution approach and found difficult to integrate a system thinking model. Also, the brief directed the students to design a household good made of mycelium, a prescriptive approach might facilitate considerations of the wider context of their products. Overall, the results reveal that using biomaterials and bio fabrication processes enables the acquisition of regenerative principles.

How do we overcome eco-complacency in environmental education within product design?

The opportunity to experiment with materials and bio manufacturing processes was efficient to overcome psychological distance, this was one of the most enjoyable parts of the project as per 86% of the students. In terms of legacy, in order to evaluate how these principles will be applied in other modules and future projects, it requires a longitudinal study. However, results are promising with 57% of students saying that they are likely to apply Regenerative Design principles in the future.

How do we go beyond sustainable literacy?

Material Futures project was a good starting point. By setting up a practice-based brief that focussed on Regenerative Design principles, students were exposed to concepts that otherwise they would not have the opportunity to learn. In discussions during stage 2 sessions, methods such as future back casting and the thing of future enabled 86% of students to question current sustainability literacy. However, it will require a profound re design of the product design curriculum to include Regenerative Design principles from level 4 to level 6. As per Hempel 'ecoliteracy will need to accommodate the traditional knowledge derived from nature-based attachment to place. Moreover, it will need to incorporate explicit social and economic concerns within an action framework that joins ecoliteracy with political literacy about governance' (7).

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