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CREATING SUSTAINABLE STUDENTS THROUGH PROJECT-BASED TEACHING

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1. Introduction

Sustainability has become an important target for leading organisations with high environmental profiles. Many companies now produce a sustainability report alongside their annual report, describing their efforts to protect environment and society whilst still making a living. Applying pressure from the opposite side of the table, sustainable financial indexes are beginning to emerge, in order to both help the sustainability-aware investor, but also to pave a path of steady improvement in the direction of sustainability. But how can companies be sure that they are on the road to sustainability, especially when there exist different schools of thought about the order of changes necessary for sustainable improvement? Depending on which theory one studies, it is argued that ecologically related improvements in the order of magnitude factor 4, 10 or 20 are necessary [Reijnders, 1998] to achieve an ecologically sustainable society.

Whether one follows factor 4 or 10 as a guiding influence, a certain level of innovation is required, in order re-think traditions and existing systems. In industry a multi-disciplinary approach to problem solving is proving to be a vital way of enabling new solutions to traditionally narrowly fielded problems. A key success factor of a multi-disciplinary approach to problem-solving is that the arising solutions are most frequently the result of an orchestration of solutions arising from two or more core disciplines; solutions that in isolation most probably would have been missed.

2. Case study: International summer course

Working on a hypothesis that a multi-disciplinary approach to sustainability would be able to create innovative solutions, a summer course was designed for international students under the BEST-regime[1]. The students applying for the course were supplied with a short summary of the course title (*"Creating Sustainable Products Through Radical Innovation"*) and a description of the course's goals.

Twenty-seven students from 19 different European countries were chosen to study on the intensive two-week course on sustainable and innovative product development. The course attendants, who represented a broad range of subject backgrounds, had a collectively low level of environmental experience from their own universities, but had all chosen the course based on their own motivation for sustainable improvement.

[1] The Board of European Students of Technology (BEST) is a non-profit, non-political organisation managed entirely by students with the aim of helping European students of technology become more internationally minded, reach a better understanding of European cultures and to develop capacities to work on an international basis. Among other academic activities the BEST organisation is responsible for some 50 summer courses offered in the 21 member countries.

The summer course took the challenge of developing an understanding, knowledge- and skills-base in the subject area of innovative sustainable product development. From the first day the students were split into three teams of nine people, within which they worked on and delivered their project, *"The Sustainable Kitchen of 2031"*. This choice of project topic gave all course participants – regardless of background and culture – an equal starting point for the course and an opportunity to bring their unique set of experiences and values, with which they could contribute to the course. The topic chosen for the course also enabled easy access to real-life examples, such as a hospital kitchen and an in-flight food kitchen, which were visited as a part of the course.

The course's modular structure guided the students through an interlinked set of course topics:

- the context of innovation
- factor 20
- the future of food
- new product development
- life cycle thinking
- problem solving
- creative techniques
- product innovation
- sketching and worksheets
- introduction to LCA
- implementing environmental strategies
- eco-design best practice
- working in teams.

These topics were delivered to the students via workshops, lectures, debates, company visits, etc. and were directly integrated into their project work.

In order to ensure a high level of activity and feedback from the students, a project gallery was established for each team and used for their interim and final project presentations.

2.1 Research method

At the beginning of the two-week course, a research framework was established, to aid the process of evaluation of this teaching experiment. This framework, which was shared with the course participants, contained the following four points:

- To what extent does the changing of our attitudes/values affect the way in which we design for sustainability?
- How important is it to understand the context in which we are making changes to the norm?
- What happens to radical ideas when we go out and try them in reality?
  - *How do we achieve consensus when we try to redefine the context?*
- What is the necessary balance between analysis/synthesis, a qualitative/quantitative approach to sustainability?

The course followed a structure of lectures/discussions in the morning and project work in the afternoon and early evening. This structure gave an opportunity to have the participants reflect on their previous day's work as a large class, and to follow their project work in smaller groups, in the afternoon.

At the end of the course the participants were asked to write a reflection report; a two-page document describing their own personal development during the course, and reflection about the way in which the course achieved its goals, as perceived by the student.

3. Experiences

The four research questions posed above were tested via observations and direct questioning of the course participants, and later reflected in the students' reflection reports. The students were highly aware of their own learning development throughout the course and showed a great maturity of reasoning about the problem of sustainability and their own effect on this process.

3.1 Attitudes and values

An important part of this research experiment was to gauge the level of engagement and detail that can be reached in creating solutions, when a group of otherwise non-specialists try and make a change to a system, depending almost solely on their approach to the problem.

The course syllabus was built up with a careful selection of concrete environmental tools and techniques, and team-related exercises, to ensure that a "sustainability mindset" was established and developed over the two-week course. Through discussions in class working definitions of important criteria were crystallised so that the students could continue to build their sustainability mindset, on the basis of which they were to develop concepts for the sustainable kitchen of the future.

This exercise seemed to prove fruitful to the coursework and the students could appreciate the need to create new, but also respect existing mindsets, when suggesting sustainable improvements: [all following quotes are taken from course delegates' reflection reports]

> *"Making radical changes means radical mentalities. So, how can we change minds, or how are minds to be changed by themselves when discovering that the only way to improve is to change? And not changing a few habits, but changing a whole 'waste' culture."*

An understanding was also gained, of the necessity to spend a substantial amount of time in the concept-seeking phase, where one is free to create many concept suggestions without being limited by the boundaries of reality:

> *"Radical innovation is not so far away when we think about it - strange ideas are not so bad after all."*

3.2 Understanding the context

Although the collective level of competence in environmental issues was low at the start of the two-week course, the students showed an ability to quickly adopt a whole-life view of the problem in hand. Certain techniques were trained, where the students were to live themselves into the product's lifecycle and to discover the many systems that the product meets in its lifetime and the many stakeholders who have a relationship to the product. This technique of whole-life thinking gave impressive results in the projects and the students demonstrated an ability to evaluate many trade-offs that are experienced when considering sustainability in product development:

> *"We tried to consider new products that can be placed inside a life cycle, that is a system in which each component can be reused as much as possible; we evaluated the positive and negative aspects of these choices, through the different phases of the product's life."*

The project topic chosen for the course was especially good due to the fact that solutions to the problem depended very heavily on the social context in which they were set. The multi-cultural nature of the participant group gave rise to many good discussions about solutions, where a certain chosen solution might have been be greatly accepted in Germany, but not at all in Greece!

> *"Each product has to find a place in a specific social context, and to respond to a particular social demand. It was really interesting trying to consider how the concept of sustainability could go together with the concept of freedom. To consider if, and how, the sustainability of a product can limit the freedom of the single person, and if it's possible to find a kind of 'agreement'. As an answer to this problem, we considered the possibility to rebuild a social system where each part of it has a place in the life cycle, in order for each part to have its freedom (an acceptable one!), without compromising that of the others."*

By placing the students in an environment with other peers of equal motivation but diverse backgrounds, it was possible to create a context and let this develop through the presentations that the students carried out to each other and the rest of the course participants.

3.3 Turning ideas into reality

It is clear that in the space of a two-week course it is difficult to expect that all corners of the sustainability profile of a new concept for a product can be explored and defined. However, the students were equipped with a toolset that encouraged a dialogue with reality and a connection to the real world.

A major learning element of the course was that the students should meet reality and have the opportunity to confront their ideas and concepts with specialists from the field that they were working in. Study tours were carried out, to a hospital kitchen and an in-flight food kitchen. Before carrying out the study tour the whole class was gathered to discuss what the goals of the tour were, and therefore what the participants wanted to learn from the subject specialists who they were to meet. On the basis of this each of the three teams was assigned a line of enquiry, which was their job to find the answers to in the course of the tour. After the tour a report was compiled from the notes taken by each of the teams.

> *"It was exciting to be in a real-life kitchen and to talk with them about our ideas. But it was a shock to hear that our ideas cannot only be sustainability arguments – money and time is more important."*

Good presentation is vital for product developers to be able to communicate their ideas and concepts, especially in the early stages of product development where no real concrete examples or models exist to aid the process of communication. Great emphasis was therefore placed on presentation techniques. The students were denied computer presentation facilities, in favour of a large gallery and a toolbox of pens, paper and scissors. Oral presentation techniques were also trained throughout the course and the students were given three opportunities to present their work to a large group and gain critique, before their final presentation at the end of the course.

> *"It was important for me to realise the power of visual communication in a presentation; it is not just important to present a product, but it's fundamental how to present it."*

3.4 Balancing analysis/synthesis and quality/quantity

Good environmental design activity requires skills in both analysis and synthesis, if the problem is to both be understood and acted upon. Based on earlier research in balancing the levels of environmental analysis and synthesis [McAloone, 2001], the experiment was continued in this course, to attempt to find a level of expertise in both environmental analysis (i.e. reading the environmental effects *out of* the product) and environmental synthesis (i.e. making design actions in order to consciously *add environmental characteristics* to the product).

The course participants could not be expected to be able to reflect on this question, as their task was to master both levels of professionalism to a level where they could embody their expertise in a product concept. It was not their task to reflect on this process.

However, the results of their work showed a good balance of both facts and figures. The students appeared to be satisfied with the opportunity to be able to spend a great deal of time in a creative environment and to play with many ideas and concepts. Once they had chosen a concept, however, the participants showed the ability to structure and quantify these ideas with the help of the simple life cycle analysis and eco-design techniques that they were trained in throughout the course.

4. Conclusions

This paper has described an empirical study where it was possible to gather a mutli-cultural and multidisciplinary group of participants, and train them to create concepts for sustainably oriented products and systems, through the development of a mindset for sustainability and innovation and by training in specific techniques.
It can be concluded that the hypothesis that a multi-disciplinary approach to sustainability is able to create innovative solutions, can be said to be correct. The course participants could see the need for each other's expertise in their project work and there was a high and productive level of discussion during both the lecture sessions and the project time. The final results presented by all three teams clearly contained elements from chemistry, electrical engineering, sociology, mechanical engineering, industrial design and biology, to name a few of the disciplines represented.

It can be concluded, therefore, that the changing of our attitudes and values affects the way in which we design for sustainability to a great extent. The project work demonstrated that the very early and principal discussions and decisions form the shape of the rest of the project. By laying great emphasis on informing the course participants in the early days of the summer course, a sustainability mindset was established in the three project teams.

The context for which solutions are developed is extremely important. The project work illustrated the difficulty, for example, of developing one sustainable kitchen that would both satisfy and fit into the contexts of each and every culture represented on the summer course. A great deal of fruitful discussion was carried out, regarding appropriateness, acceptability and tradition. Alone these three issues have great potential effects on the final results expected from a product such as a sustainably-designed kitchen.

It was highly important for the course participants to go out and meet the people who were working with and in the systems that they were trying to re-develop. Much of the time, the people who were using the systems in real life gave answers that the students were not expecting or did not like to hear! This was a lesson that many of the students found very sobering, but also very important to consider in their work. The exercise of going out into the real world also gave an opportunity for the students to attempt to accommodate the experiences, opinions and preferences of their customers into their product concepts.

The course described in this paper was focused particularly on innovation and concept development. In these phases of product development greater emphasis is placed upon the problem solving activity as a qualitative process. The course therefore had a relatively low level of quantitative analysis content. It was seen, however, as important to include a significant level of analysis in the project work, in order for the course participants to be able to relate their concepts to existing models and examples, but also in order to be able to master some basic eco-design tools and techniques. [McAloone, 2001] states that a carefully planned blend of analysis and synthesis (and the respective supporting methods) leads to deeper understanding of the product in a whole-life context. This statement can be said to be true in this investigation, with a relatively unskilled group of participants effectively being trained in a comprehensive set of techniques within a very short period of time.

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