Does the boat float? - The impact of teaching sustainable development in design and engineering

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Abstract

Education for sustainable development fundamentally calls for a change in the way we educate (teaching methodologies), what we teach (the curriculum and subject matter), and why we do it (learning outcomes & professional impact) (Bhamra & Dewberry, 2007). But what should this change look like in Engineering and Design?

This paper outlines and compares a series of educational initiatives to inculcate literacy for sustainability within design & engineering that have been developed in the Netherlands and Ireland at TU Delft, University of Limerick and the Institute of Technology Carlow over the past 7-12 years. The approaches described are open to a range of design and engineering disciplines at an undergraduate, Master degree level, post graduate level and professional development levels in the three institutions. The data, gathered from an online survey as well as in-depth interviews with recent (2-5 years) graduates, addresses how they see the link between sustainability in their curriculum and in their practice.Through cross case analysis this paper identifies the impact of current best practices in education for sustainable literacy.

The paper is intended as a pre-study for a more elaborate future study of the impact of SD education in Engineering and Design, and as such concludes with several propositions that will form the basis for that future study.

While this paper does not offer a single ideal solution for educating for sustainable development, from the lessons learned, it does present an insight in to the impact of a range of educational approaches that have been proven to increase sustainable literacy and engagement.

2 Introduction

There is growing evidence that the Design business has a keen appetite for graduates who have a sustainable literacy as an integral part of their undergraduate skill set (de Eyto, 2009). Unfortunately many educators are at odds with each other as to how to effectively implement Education for Sustainable Development. Opinions diverge from arguments on stand-alone courses (Kliucininkas, 2001), to others for embedding Sustainable Development inherently into all third level programs (Jucker, 2001); while the most radical re-builds the entire curriculum with SD underpinning it (Mulder et al., 2012). There is however evidence (O'Rafferty and O'Connor, 2006) to suggest that businesses are starting to address the lack of capacity in sustainable design practice.

The research outlined here shows how a sample of the current and next generation of designers, from TU Delft [TUD], IT Carlow and University of Limerick [UL], and business decision makers are implementing a range of skills to help them deal with the broad and varied issues around sustainable development. The paper explores not only how the recent graduates have experienced (or not) the integration of SD into their professional work, it also looks at how they are taking on the mantle of deciding what key decisions to make regarding the sustainable manufacture and design of consumer products and services that the world continues to use.

So far, empirical underpinning of the need and success of SD education for engineers and designers has been largely based on expert opinions and evaluations of current students. This study aims to extend the research by taking recent graduates as the basis. As such, this is a position paper based on preliminary research using a sample group of 48 participants from six courses at the three Institutions. The follow on interviews with 10 of the graduates generated some rich data with respect to the nuances of their responses and their individual circumstances. While the research is in its early stages the findings presented here can build a clearer picture, from a comparison of the three institutional approaches, as to the impact of SD education on a graduates' career. It is envisaged that the research will be developed into a more longitudinal study of graduates with respect to SD education. The benefits of that the educational methodologies outlined in the paper, while still in development, could also contribute to a wider strategy for introducing and building sustainable design practice for both students and SME professionals in the European context. The development of longitudinal research may also help inform the development of SD education curricula and teaching methods as it gives a picture of the impact of that education on the graduates society and industry.

2.1 The Irish Context

Within Ireland there has been very little movement on introducing change to the product design curricula with respect to sustainable development. As can be seen in research done by de Eyto and McMahon (de Eyto, 2009, Mc Mahon and Bhamra) the current institutions that teach industrial design and product design have changed little in their approach to sustainability. Aside from the initiatives at IT Carlow and UL the other courses have dealt with it at a token level rather than at syllabus level. In the wider context Engineering, Marketing & Business courses have shown little inclination to radically alter their syllabi and teaching practice to reflect the changing world environmental and social needs. There is evidence of a small number of specialist courses which focus on 'sustainable engineering' and 'sustainable energy' however these have tended to be rebranded courses with small add on modules. Architecture and social sciences on the other hand have shown that they are dealing with the changes: a small number of undergraduate courses and master's programmes have been developed which show, at least in course name, that sustainability is central to their focus.

Comhar the Sustainable Development Council (one of the policy development bodies of the Irish state) began addressing the shortfall in education in the in 2008/09 and the evidence of the effectiveness of this work is still under review (Gregg et al., 2010). Their initial response has been broad and non-specific and would seem to focus on incremental change in a few sectors and broad vision statements for others. There are few direct recommendations or policy directions that give the commitment of the QQI (Quality, Qualifications Ireland) or the HEA (Higher Education Authority) to their vision.

Work undertaken by the authors with IT Carlow, Bournemouth University, UK, Loughborough University, UK and a number of other Irish Universities and IoT's (Institutes of Technology) has attempted to address some of the shortfalls in the Irish context and to provide an example of how multidisciplinary sustainable design education can be implemented at undergraduate, master and professional levels.

2.2 The Dutch Context

In the Netherlands on the other hand, TU Delft has been working on 'sustainabilizing' its education from 1996 onwards, clearly stating in its mission that it wants to educate 'broad' engineers that are aware of the consequences of their designs in society. Delft is the largest and oldest University of Technology of the country. Until the 1990s, its education was rather typical for a traditional engineering school: science and mathematics based technology. The role of technology in society and in companies was to be left to extracurricular activities. "We don't bother our students with that, let them participate in business visits, or attend the student parish if they want to know about that". However, this attitude was increasingly criticized, by employers as well as by the Department of Education.

Sustainable Development was an important issue in the Netherlands. Being Europe's most densely populated country, the issue had attracted due attention ever since "Limits to growth". It was no coincidence that this book was best-selling in Japan and the Netherlands. In 1991, a group of staff members of the Delft University of Technology had already advised to pay more attention to SD in its curricula. However, a national university curriculum reform came in the way. In 1996, the TU Delft University board installed a new Sustainable Development committee. Leo Jansen, an engineer, industrial researcher and former Green MP, was the driving force of the committee. SD became the issue by which Delft would modernize its curriculum. Initially, this resulted in three interconnected operations to create 'sustainable engineers':

1 - Designing an elementary course 'Technology in Sustainable Development' (TiSD) for all bachelor students of TU Delft.

2 - Intertwining sustainable development in regular disciplinary courses, where this would fit, in a way corresponding to the nature of each specific course.

3 - Developing a graduation track 'Technology in Sustainable Development' that would fit into each Master programme.

From 1998, these plans were implemented. Nowadays sustainable development is well-integrated in most of the TU Delft curricula. In 2002, TU Delft organized the first EESD conference to internationalize its achievements. Afterwards, special MSc. Programs "Industrial Ecology" (with

Leiden University) and “Sustainable Energy Technologies” were created. These programs attract a large number of foreign students. The Technology in Sustainable Development graduation specialisation is also increasingly popular and a selling point of the university.

3 Educational Models - The Programs under study

The specific graduate case studies in this research all graduated from a variety of courses at TU Delft, University of Limerick or IT Carlow. In each case the HEI (Higher Education Institutions) has developed course level and strategic level responses to introducing and developing competencies within students for dealing with sustainable development issues. The approach has been different in each case.

3.1 The TU Delft graduation track “Technology in Sustainable Development”

The intention of this graduation track was to train Sustainable Development specialists within specific engineering disciplines. These graduates could later work as SD experts within specific engineering branches. For example a chemical process engineering firm could use a specialist informing colleagues about newest environmental impact frameworks and environmental toxicity, in an architecture firm, a specialist could inform colleagues about environmental aspects of specific materials, etc. But the core would be that these graduates could develop a long term strategic perspective on technological change for Sustainable Development. Hence, the requirements of the SD graduation track would involve program specific courses (to be chosen by the students from a list), and an SD targeted graduation project.

The core element of the graduation track would be the course “Engineering in Sustainable Development”, which came to be known as “the boat week” although it covers more than a week on the boat. (de Werk and Mulder, 2004, Mulder, 2006) The main aim of the course is to train the students in developing a strategic perspective on long term technological change: quite often students suffer from restrictions of their own discipline. “If all you have is a hammer, everything looks like a nail” is a right expression for many students. “Energy” is not the only SD challenge, nor is “closing material loops”, “recycling” or “wildlife protection”. SD is multifaceted, but before everything else, it is a long term and strategic effort. Therefore, the boat week was introduced: it aimed at confronting students with the diversity of SD challenges and the interrelation between them. The boat was efficient (combining transport, lecturing and accommodation) to be able to visit various sites, but also important to create a group process between SD committed students (one you are on the boat, you cannot leave and you have to socialize). The students did not know each other before and so they are confined to the other SD interested students on the boat. This idea works out well: indeed boat week graduates often were the core of multidisciplinary SD groups within the universities.

> *Leo Jansen once put it: “you need a discipline in order to be able to work interdisciplinary. Just being interdisciplinary does not sell: graduates are then seen as extreme green missionaries. You may be a missionary as long as you contribute something recognizable…..”*

After the boat week, the students have to carry out a Backcasting exercise (Quist et al., 2006). In groups of 4-5 they develop a sustainable future vision regarding a societal need and they develop pathways that could make this vision a reality. These pathways contain social as well as technological elements, and are partly speculative. Scenarios might play an important role in the exercise. The final

product is a plan that is convincing as a strategy to sustainability in a specific area. “Student housing”, “Public Lighting”, “Providing drinking water”, or a “Climate positive airport terminal” are examples of student Backcasting projects. The most important lesson is that the more students think in fulfilling needs, the more creative solutions can be developed. After the ‘boat week’ course, the students generally start with their graduation work. In each MSc program, there is an advisor to help the student in making his thesis project SD relevant. Basically, that can be done in two ways:

SD is the target of the graduation project. The student compares, for example, various options to fulfil a certain need, or starts with an SD problem which is a more fundamental research project. In such a project, the student should assess the SD impact of the research/technology under development. Often, it is important to distinguish long term and short term impact.

For more details on the implementation of SD in the design curriculum at Delft see: (Boks, 2006 A, Dewulf K, 2009, Boks, 2006 B).

3.2 The Institute of Technology Carlow model at undergraduate and professional levels

At the Institute of Technology, Carlow there was a dual approach taken towards developing a focus on sustainable design since 2004. An integrated approach and focus was taken within the undergraduate design program while at a later stage in 2008 a CPD (Continuing Professional Development) program (The SDI Certificate) for design professionals was developed to address the needs of practicing designers and graduates. The focus here was to try to develop students who could critically appraise the social and environmental challenges but also apply some of that thinking in a business/industry context see: Figure 1 . The undergraduate students are facilitated in learning about SD issues through multidisciplinary projects at 2nd and 3rd year levels while the final year students iterated their responses through final year project works (sometimes with SMEs). The SDI (Sustainable Design Innovation) certificate which ran between 2008 and 2010 gave a range of professional practicing designers and engineers the opportunity to up-skill and address their skills deficit with respect to sustainable design and development. This 20 week course took a more workshop/project focus, supported by visiting experts from different SD fields.

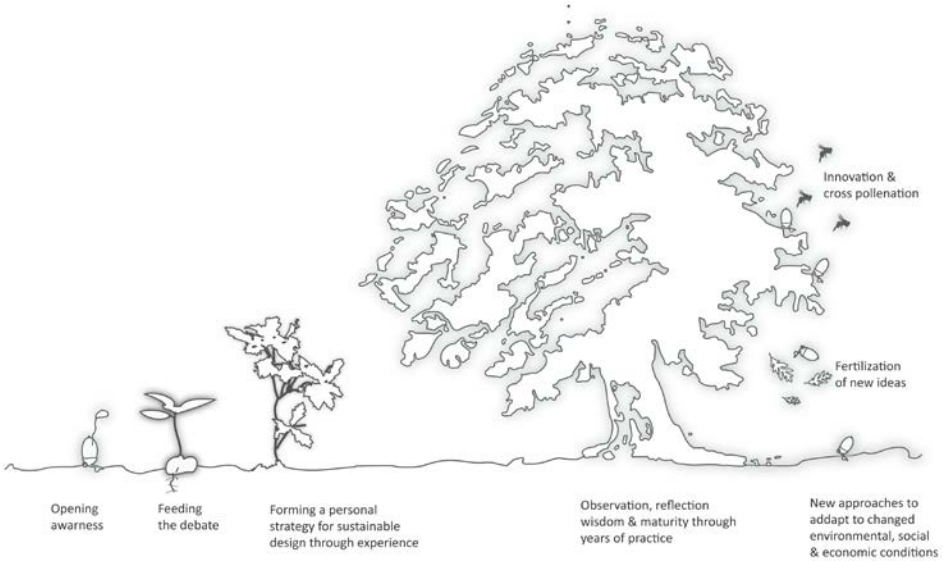

Figure 1: An Education for sustainable design learning model as proposed by (de Eyto, 2009)

For More Details on the implementation of SD in the Curricula at IT Carlow see:

(de Eyto, 2009, de Eyto et al., 2008, de Eyto and De Werk, 2008)

3.3 The University of Limerick Approach

At the University of Limerick a new module in Design for Environmental Sustainability was developed in 2006 for the third year of the Product Design and Technology degree programme. The initial focus of the module was on the environmental aspects of Sustainability. Over the years however with changes in teaching staff and developments in the field, the content has expanded to include social aspects in parity with the environmental aspects. Economic issues are dealt with but not to the same extent as the other two SD pillars. Since the inception of the module anecdotal evidence indicates that the students have begun to integrate their learning into their design work in studio and also in a lot of cases, has influenced their choice of final design project in their graduating year.

For More Details on the implementation of SD in the Curricula at UL see: (Mc Mahon and Bhamra, Mc Mahon et al., 2010)

4 Methodology

The research methods used here were qualitative in nature. The flexibility of qualitative methods reflects the design process in that no fixed answer is available at the inception stages of a project and it is only through research, idea generation and development that a solution (or solutions) emerge (Robson, 2002). Qualitative methods also allow for a smaller sample size of people to be studied but the information gleaned needs to be richer and deeper (Cohen et al., 2000).

4.1 Gathering the Data

Given the dispersed nature of the graduate groups from both Ireland and The Netherlands it was decided that a survey would be the best method for gathering initial information about their experiences. The anonymous web based questionnaire format was decided upon in order to gather information quickly from the graduates irrespective of their location and also to allow them to answer in an unbiased manner. The structure of the questionnaire comprised a mix of three types of questions; simple yes/no, agree/disagree; summated rating questions based on a Likert-type scales - where participants were asked to rate statements and Open ended questions- where participants could give more in-depth feedback if they wished (Robson 2002). It was decided to keep the language casual to reflect the relaxed mood of the project. The closed questions served to gauge the students' initial reactions and attitudes towards broad aspects of the projects. The open-ended questions afforded students the opportunity to provide more reflective and deeper feedback on specific areas of sustainability education and practice. The questionnaire was subjected to pre-testing with a number of independent individuals to ensure clarity and relevance.

Following the completion of the questionnaire participants indicated whether they would be willing to take a further part in the study. Those who confirmed their interest participated in semi-structured interviews with one of the researchers from outside their graduating institute. This avoided bias and influence over the responses. The semi-structured format allowed for flexibility, depending on the interviewee and the direction the interview took (Robson 2002). The information gathered during these interviews provided richer qualitative evidence of the subsequent impact their Sustainable Education experience had on their professional work (King, 1994). These interviews were recorded on audio and through field notes.

In the end, we collected 48 questionnaires (with 10 from Delft, 21 from Carlow and 17 from Limerick) and we held 10 interviews (4 from Delft, 6 from Carlow).

4.2 Analysing the Data

As there is no single way to analyse data resulting from qualitative studies, it was decided for the purposes of this research to assign a 'best fit for purpose approach' (Cohen & Manion et al., 2000). The responses from the interviews were reviewed initially to allow a small number of Open 'a priori' Codes to emerge (Robson, 2002). These codes were reviewed and comparisons and similarities were drawn between the various interview responses (Ryan and Bernard, 2012). Common themes emerged and collective narratives were built around these themes. These formed the themes for the discussion section. Anomalous experiences were identified also as these contribute to formulating a holistic picture of the graduate experience.

The scope of this research was limited to graduates from three Dutch and Irish institutions; as such the findings have limitations on a wider scale. The focused nature of the study allows for an in-depth analysis of these two contexts so as to better understand how the educational experience is impacting on the professional designers' career.

5 Findings

The research established a number of categories under which the respondents were measured. These categories form the basis of the conclusions later on but also provide scope for the study to develop in to further research.

5.1 Benefit to graduates on a personal level- The graduates who participated in this study broadly acknowledged that the SD modules that they undertook gave them a holistic basis on which to build their professional careers. Many of them were reluctant to point to specific skills and competencies that were of benefit but they did acknowledge that along with the other knowledge and skills from their program of study they were better prepared for the complexities of their jobs. 50% of the graduates said that SD influenced their current professional activities however in the interviews many of them could not clearly define what areas of SD their company valued. The graduates who were interviewed pointed to the knowledge expansion and holistic thinking that the SD modules they took gave them.

"It is more a way of thinking and a way that I use product design and keeping all those things in the back of my mind."

"The main strength of the SDI course was that it was a widespread introduction to a lot of topics. Enough depth to give an understanding, and then I felt equipped to go into more depth"

There is also evidence that the courses that they took developed their critical thinking capacities. That it helped to equip them with keeping them up with state of the art practices, it is also clear that the SD courses provide them with a broad understanding of a very complex topic.

"The SDI course at ITC informed my sensibilities. The subject is fraught with people claiming things are sustainable when they are not; the term has been bandied about a lot without substantiation. It explained the fundamental thinking in an easy way."

"I have a more complete understanding of it as I have read more about it since I graduated"

It was interesting to note how the respondents viewed their SD competencies and how those supplement their more general design and engineering skills; Figure 2

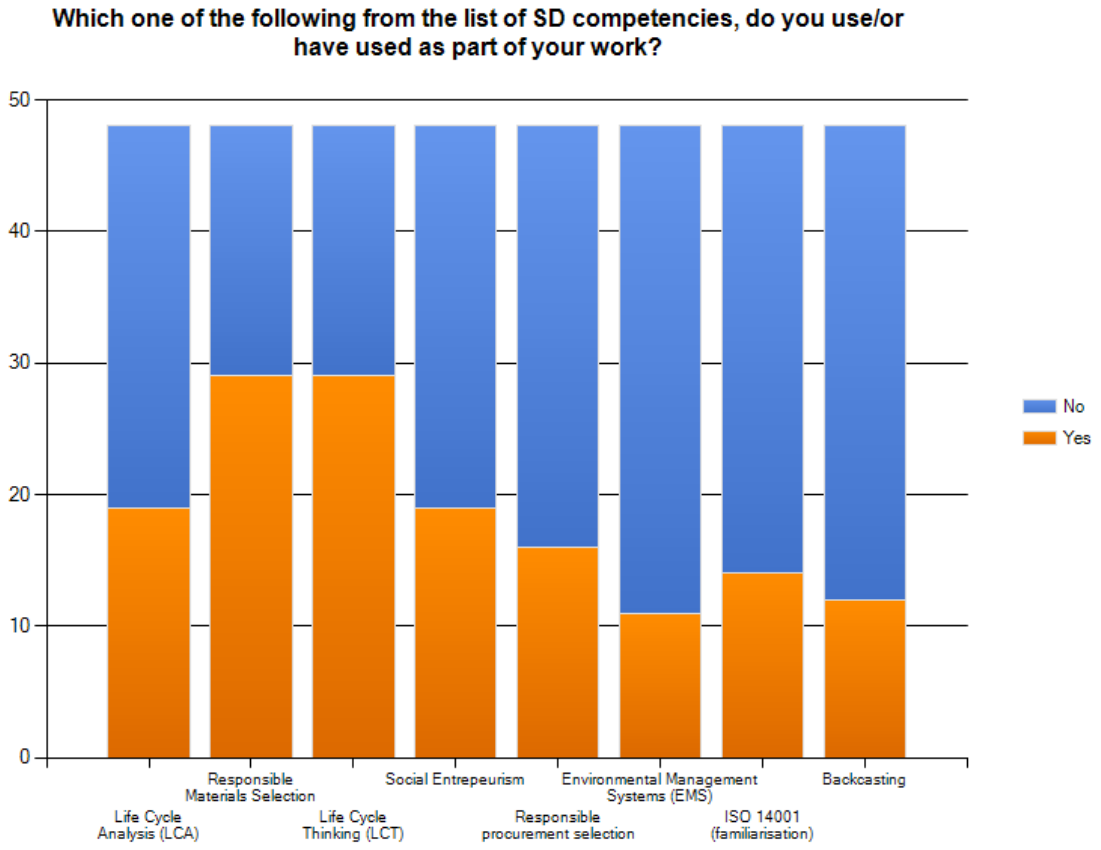

Figure 2: Evaluating the usage of the graduates SD competencies in their current work

There is a suggestion here backed up by the interview discussions that many of the graduates do not *explicitly* use their SD competencies regularly but rather that they use them *implicitly* alongside of a range of holistic skills.

The research is inconclusive so far regarding the impact of the SD courses on their career progression. Some did feel that it offered opportunity and provided a stepping stone to a career path or change, in the main these graduates directed their own career choices based on their interest in SD. Some respondents could not identify the exact reasons that were recruited for their specific jobs however they acknowledged that studying SD did enhance their current work, help shift the focus of their employers and introduce new ideas to the company.

5.2 SD's influence on company practice- The responses of both the interviewees and the questionnaire respondents (Figure 3 & Figure 4) in this research confirmed much of what we already know from prior studies i.e. that the graduates confirm that:

- Some companies are explicit about their sustainability activity (however deep that goes) via a specific company ethos (e.g. Patagonia, Ecover, El Natura Lista), through CSR (Corporate Social Responsibility) as in the case of most large multinationals, or through 'Greenwashing' as illustrated by Laufer (2003).

- Some companies practice more implicitly- as an offshoot of conserving-money, materials, time; i.e. LEAN, Six Sigma, ISO14001.

- Some companies consider it to comply with legislation; i.e. RoHS (Reduction of Hazardous Substances), WEEE (Waste Electronic and Electrical Equipment) directives

- Some companies don't deal with it at all.

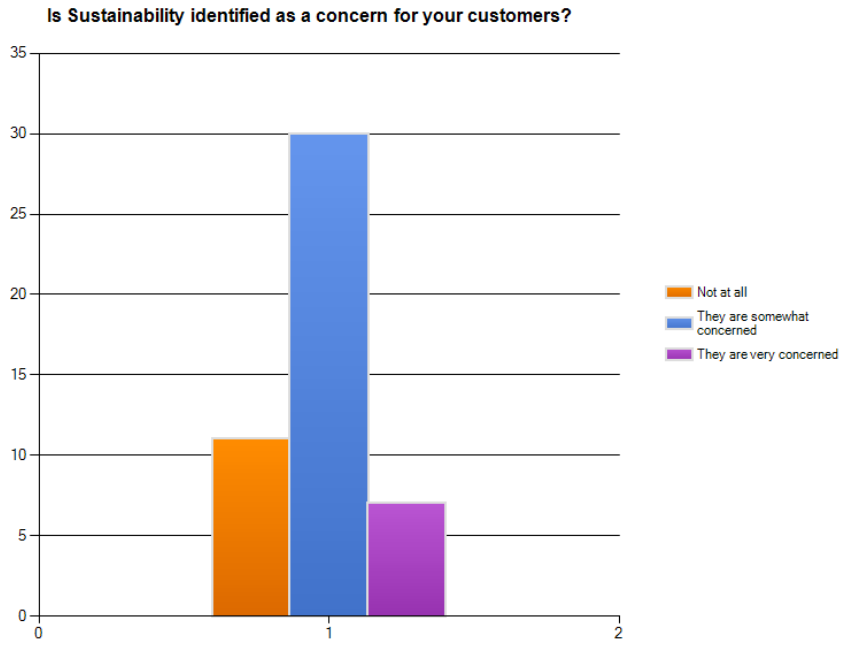

Figure 3: Is sustainability identified as a concern for your customers?

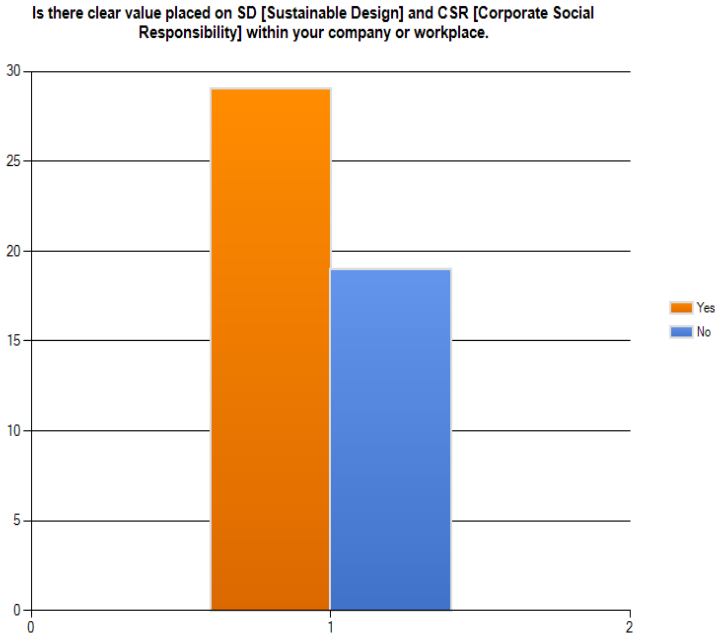

Figure 4: Is there a value placed on SD/&CSR within your company?

6 Discussion

The findings of preliminary research seem to be in line with the Sustainable Design Learning Model as proposed by De Eyto (2009, see Figure 1). The Personal Interest corresponds to the 'forming of a personal strategy for sustainable design through experience'. The Enrichment aspects observed corresponds to the cross-pollination. 'Offer opportunity' and 'Influence on company practice' is in line with the fertilization of new ideas.

Based on the extent literature and the results of this questionnaire and these interviews, we have formulated several propositions, which will form the basis of a more elaborate follow-up study.

It would seem from the survey that a majority of graduates value the fact that they studied SD as part of their education and that it does influence their professional activities however to varying degrees.

Many students remarked that they were not using the skills from their SD modules in their daily work. Nevertheless they still see value in the modules, which results in proposition 1:

P1: SD fulfills a role of teaching higher-level thinking and reflection on the students' role, capacities and ambitions, even if the students do not actively engage with SD in their professional career.

Hearing their actual activities, we, as SD academics, would sometimes qualify their work as highly related to SD. This different perspective on what constitutes SD leads to proposition 2:

P2: Graduates retain a somewhat narrow view of SD.

There seems to be a disconnect between the education for SD and the reality of what is happening in professional practice. Are the expectations are too high? The issues are complex and confusing; however designers need to develop a holistic picture in order for them to understand this complexity. SD courses that introduce a wide range of topics are successful- e.g. Boatweek, SDI Course. These courses give a broad understanding of SD but allow the designers to focus their interests.

This leads to proposition number 3:

P3: SD modules within Design courses tend to be more holistic, ambitious and idealistic than the average industry practice

There is a clear problem with crowding of the designers professional path and the range of skills and knowledge is largely informed by the workplace environment that they find themselves in.

The route to gainful employment is complex with career choices being often serendipitous. Connections, Skillsets, differentiation, opportunities at the given time of graduation, the state of NPD and SMEs at the particular moment in time etc. all have a bearing on where they end up. Graduates do largely design their career progression through the choices they make. Choosing a job over self-employment, choosing a sector, choosing to emigrate etc. is all part of the story.

From the responses so far there seems to be a common thread regarding the experiences gained through a specific project or the development of a specific product. ISO 14001, EMS (Environmental Management Systems), CSR (Corporate Social Responsibility), RoHS (Reduction of Hazardous Substances), and other obligations seem to trigger an excuse in the graduate to implement sustainable design strategies with a broader holistic knowledge just being part of their repertoire of skills.

The many satisfied graduates and the varied responses as to what aspects were missing from their SD training, which seem strongly influenced by their chosen career path, suggest that the basic training is sufficient, but more space for elaboration, for instance through electives, would be sensible.

Furthermore, Undertaking this research and asking designers to address the role SD occupies in their professional life has reawakened a consciousness in them about the issues of SD. This realisation has made us wonder whether courses should have follow-ups to remind and re-engage the graduates in the topic?
This leads us to the final proposition number 4

P4 - The boat does float but could do with a little more buoyancy.

7 Conclusion/ Summary

In summary there is quite a complex picture developing from the research as to how graduates from these three institutions have developed in their professional and personal careers. This was to be expected considering the intention of their education was to give them the skills and competencies to adapt and change as the employment environment developed. Studying the curriculums of the three institutions also shows that a basic grounding in and understanding of Sustainability issues is essential to help designers to make sense of the complexity involved.

At one level the career paths are somewhat defined by their disciplinary education however there is also clear evidence that many of the graduates are not using the specific skills that they would have learnt through their sustainable development modules. They are however using the generic skills and they continue to see the relevance for SD as a shaping ethos in their careers and in their daily work. While some designers didn't recognise that they are explicitly using Sustainability strategies when questioned further it became apparent that Sustainability is implicitly embedded into their professional practice. This insight is one of the interesting areas to be explored in the larger study which will be built from this paper. There is evidence that graduates forget much of the specific information that they have learnt with respect to SD but that the ability to process new information and to communicate to their employers and the wider marketplace the importance of sustainable development has aided them in progressing their careers.

It would seem that for the graduates who chose to engage with SD as part of their work or research practice it has offered them the opportunity to progress their career paths in much more specialised directions. However these opportunities are rare and not available to the majority of recent graduates. This presents a challenge as to how to make businesses recognise the benefit designers literate in Sustainability can bring to their companies.

The initial research described in this paper has presented a number of insights that require further exploration in order to build a clearer picture of *what* Sustainability Education should look like for Design and *how* this is then translated into professional practice. While this paper appears to present more questions than it addresses, it has provided clearer path to understanding how recent graduates can realistically begin to imbed Sustainability as a fundamental aspect of their professional practice.

The preliminary findings in this study do confirm that the research approach chosen, namely to explore experiences of recent graduates from multiple European design courses, is indeed a fruitful approach, which will add new insights to the field of SD education to engineering and design students.

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