INTEGRATING SOCIAL FACTORS THROUGH DESIGN ANALYSIS

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ABSTRACT
In recent years there has been a drive to embed sustainable development (SD) into UK higher education design curricula, encouraged and supported by the professional institutions. Progress is evident with approaches involving problem based learning (PBL) and peer assisted learning (PAL) yielding measurable benefits. Activity has focused toward quantitative environmental and economic impacts while less tangible qualitative social factors are ignored or isolated from the design process. Recently the "social usefulness" concept has emerged, engaging these aspects within the design process. To engage students with the broader elements of SD, particularly the social sphere, a short course was developed from ongoing research. Building upon previous work the compulsory course ran for the first week of the academic year with first and second year students involved in no other academic activities. Groups conducted design analysis of consumer products broadening to a sustainability perspective. This included social usefulness, the product-service mix and material utilisation. Didactic elements were restricted, emphasising underlying concepts with learning delivered through PBL, PAL and student presentations, discussion and reflective learning accounts. Students developed understanding of sustainability and relevance to engineering and design. They discriminated between aspirational and inspirational products, understood how social usefulness links to function and how the product-service mix influences material utilisation. PBL and PAL encouraged students to develop strategies for problem solving and learning, skills required for study within HE and beyond into lifelong learning and continuous professional development. Emotional attachment to the products was unexpected and inhibited the students' ability to consider them objectively.

Keywords: Sustainable, social, design, education, materials

1 INTRODUCTION

Sustainable Development has often been viewed as too complex or diverse to be successfully integrated within Higher Education [1]. Although the definitions and models are broad and often contradictory in nature [2] the fundamental principles remain simple and Sustainable Development can be classically defined from the Brundtland report as *"development that meets the needs of the present without compromising the ability of future generations to meet their own needs"* [3]. For education within design and engineering, the goals should reflect the three spheres (pillars) of sustainability yet much of the effort has been directed toward the economic and environmental ignoring the third, social sphere of sustainability [4-5]. Reasons for this are complex but essentially relate to familiarity of quantitative methodologies within the environmental and economic spheres [6-7] and how they reflect the designer's and engineer's traditional roles; tools such as life cycle analysis (LCA) and cost benefit analysis (CBA) sit comfortably within this frame [8-9]. Where the social sphere is addressed in the literature it is typically restricted to Enterprise level impacts such as corporate social responsibility (CSR) rather than product specific impacts [10]. However, institutional guidance from the both the Engineering Council UK [11] and the Royal Academy of Engineering [12] clearly relates to the social aspects of sustainability and reflects the interlocking nature of sustainability; the reality that none of the spheres can be viewed in isolation and each are inexorably linked. More recently, the concept of social usefulness has been developed as a tool to raise awareness and understanding of the social sphere of sustainability within both education and enterprise [6] and is directly linked to the product rather than the enterprise. A methodology for implementing the concept was developed from the ongoing research and international best practice; using a combination of problem based learning

(PBL) and peer assisted learning (PAL) to explore social barriers to product development in unfamiliar markets [7].

2 SUSTAINABILITY WITHIN THE DESIGN PROCESS

The design process can vary considerably between methodologies with both iterative and linear models, however, the general process is fundamentally the same, following that described in BSI 8887 [9] and adapted (Figure 1).

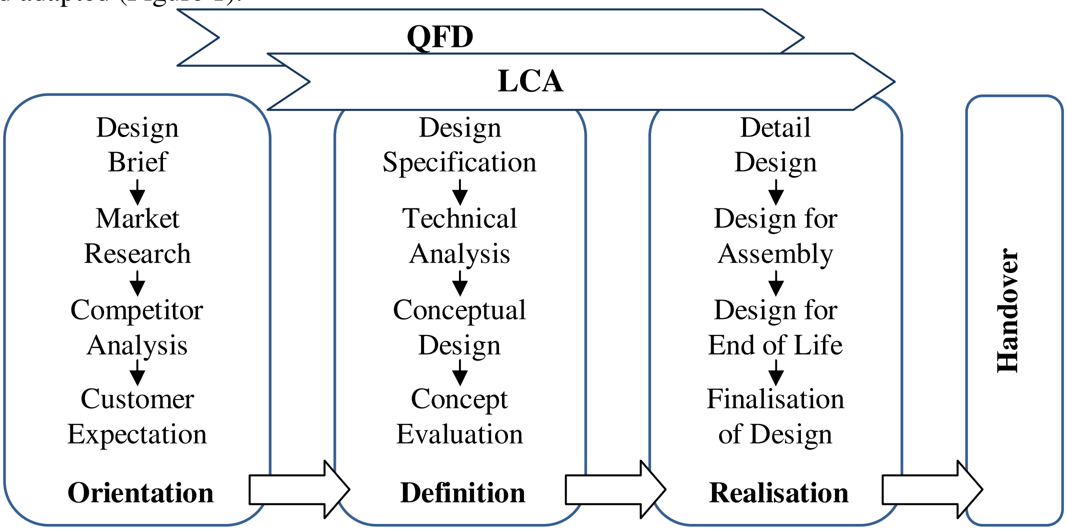

Figure 1.The Design Process, adapted from [9]

Typically, sustainability is restricted to the economic and environmental domains through lifecycle analysis (LCA), design for assembly (DfA) and design for end of life (DfEOL). It is estimated that that 90% of a products impacts are cast at the outset of the design process, however, LCA only becomes accurate as the product develops and knowledge increases and can therefore be considered a downstream process [13]. Essentially, influence over the environmental impact is at its greatest when product knowledge is least (Figure 2).

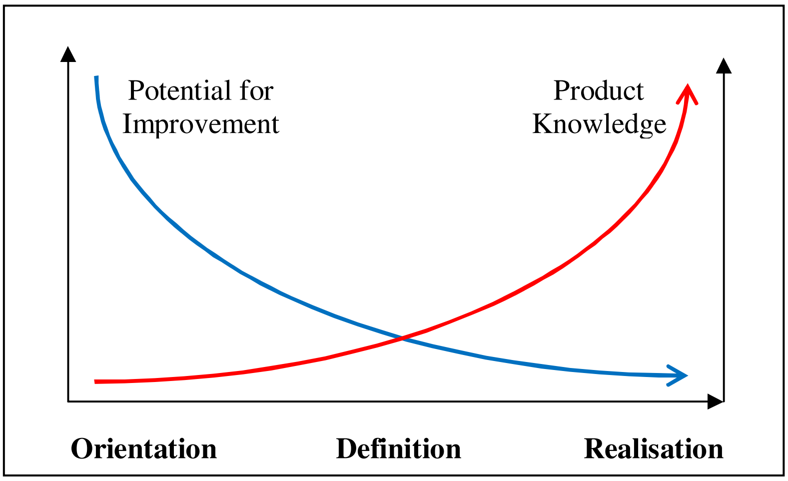

Figure 2. Relationship between potential improvement and product knowledge along the development timeline, adapted from [13]

Alternative routes to market through the product service mix can also improve sustainability performance by concentrating upon the function or service delivered by the product using techniques such as product service system (PSS) [14], here the product is considered a mechanism for delivering the service to the customer. Where material utilization is discussed it invariably relates to the production process, or resource consumption, however it could also describe the efficient deployment of materials and resources or in many cases, tying up non-renewable resources in the non-use phase.

2.1 Social usefulness in the design space

The social usefulness test can be initiated by asking the two simple questions: Is it socially useful, or a waste of the Earth's natural resources?

Social usefulness can act as a catalyst for understanding a products value to society by examining the wider social context of functionality delivered by the product and as such can be directly linked to PSS, the service being delivered by the products function. For social usefulness it is the wider context of the products function that should be examined: How does this function enrich the users life and those around them? Is it inspirational or aspirational?

For some products, the social usefulness is positive and can provide balance and justification for material use, for others there may be little or no social usefulness and no justification for resource use. In some cases, the PSS and target market may need to be adjusted to yield a positive social usefulness and at the same time yield a change in the material utilization. A conceptual model can be derived from the product population, material use, product life and usage patterns and ascertains materials that are tied up in products not in use and could therefore be put to more productive use elsewhere (Eq1).

$$U_M \stackrel{\text{def}}{=} \frac{1}{P_P} \times \frac{1}{M} \times \frac{U_P}{L_P} \qquad (1)$$

Where U_M is the utilization of materials; P_P is the product population; M is the materials used; L_p is the life of the product and U_p is the usage of the product.

Both the Social usefulness and material utilization test are upstream, within the orientation phase, where the majority of impacts are cast and are therefore more flexible and powerful than quantitative downstream methods such as LCA (Figure 3). The upstream nature of these methods also enables the product to be designed to a specific or revised target market and PSS from the outset or even withdrawn with lower cost implications.

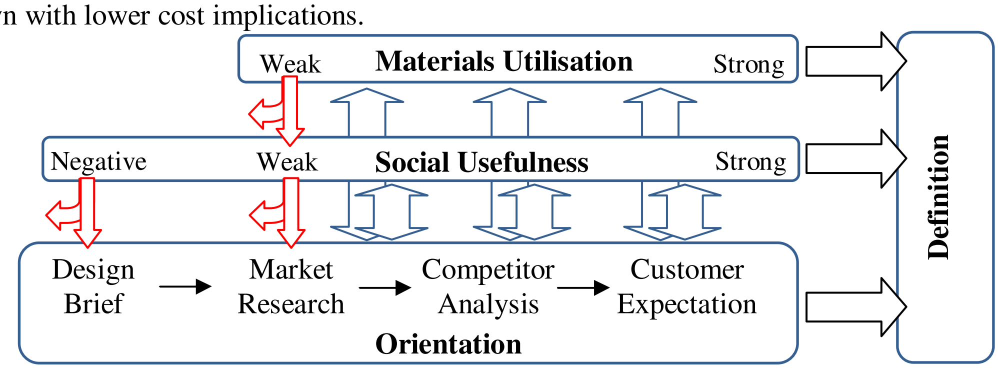

Figure 3. Social usefulness and material utilisation in the orientation phase

3 SUSTAINABILITY FOR DESIGN ENGINEERING STUDENTS

A previous course had introduced the concepts of sustainability in the design process to first and second year design engineering students during the first week of the academic year [7]. This course utilized a product brief of clear social usefulness as a catalyst to examine the deeper constraints on designing for unfamiliar markets and the social issues involved. However, despite excellent results during the programme, most students failed to take the concepts further.

3.1 Programme outline

A revised course was developed to address the shortcomings and incorporate social usefulness and material utilisation directly into the design process. Mixed groups of first and second year students were again brought together for the first week of the academic year with no other teaching elements present. The revised programme included two short didactic elements in the form of micro-lectures to provide priming information and some direction to the students endeavour. Learning was enabled through a combination of PAL and PBL with all members of the groups participating in activities. Students delivered regular daily presentations followed by feedback and student reflection through open discussions with the goals for the subsequent element set at this point. Student learning was further reinforced by requiring regular submission of short reflective learning accounts at key stages.

3.2 Delivery

Each Group was given a packaged generic consumer product and allowed 2 hours to formulate a description to be delivered as a 5 minute presentation (P1). After feedback and open discussion this was followed by a micro-seminar on the design process and new goal for the next presentation (P2) to be delivered the following day. Students were asked to provide a technical analysis examining the materials, processes and technologies utilised in their products as well as quantifying the operational performance. Students were also asked to submit brief individual reflective learning accounts identifying new learning from that day.

The second round of presentations, feedback and discussion of salient points raised by the groups were followed by a micro-seminar on sustainability in design. This included topics such as social usefulness, resource depletion, product as a service delivery mechanism, scale and end of life; students were asked to examine their products from a sustainability perspective and deliver a new presentation (P3) the next day. They were also asked to individually submit a brief definition to two key-words: sustainable design and design analysis.

Following presentation, feedback and discussion, students were asked to examine the functional design and materials palette to transform for an alternative market, from "value" range to a premium product. Within this 48hr period, groups were provided with consultations delivering guidance through questioning rather than direction. The final presentations (P4) brought all the discussed elements together with groups expected to justify their decisions from social, environmental and economic perspectives.

4 RESULTS

Student understanding of both social usefulness and material utilisation were recorded from presentations P3 and P4, summarised and presented (Table 1).

Table 1. Social usefulness and material utilisation attributed to products

	Group 1: Electric citrus juicer. £5.99
Social usefulness	*Improved quality of life, health and well-being. Associated juicing with a healthy lifestyle. Attributed showing off and product was "a gimmick and not a necessity".*
Material utilisation	*Questioned if the juicer was a "good use of our vital resources in the world?" and if the materials used could have been used for "amenities which are essential for lifestyle".*
	Group 2: Electric can opener. £6.49
Social usefulness	*Product increased productivity in the kitchen and could help the elderly or physically disabled, advantages to business (commercial kitchen) where continuous use may occur.*
Material utilisation	*Did not address directly but discussed continuous repetition of task hence high utilisation in commercial kitchens.*
	Group 3: Kitchen scales. £3.99
Social usefulness	*Suggested "only bought when needed and is mostly useful rather than a luxury item" and "It has a greater purpose", discussed reduced reliance upon ready meals.*
Material utilisation	*Discussed minimising use of materials but omitted maximising use or reducing volumes.*
	Group 4: Rechargeable screwdriver. £4.99
Social usefulness	*Suggested the value of the product is in the saving of time.*
Material utilisation	*Suggested using a tool library to increase product use and a loan and post back scheme from flat pack retailers. Suggested "stronger and more versatile products would spend less time in the drawer". Buy back schemes could improve re-use and recycling rates.*
	Group 5: Electric hand mixer. £4.49
Social usefulness	*"Inspires customer to cook for themselves".*
Material utilisation	*Questioned if the materials could be justified for the performance of the product. Poor performance limited the range of uses and product life. Noted that materials are wasted on infrequently used products. Estimated the product use as 1040 minutes a year and asked "is this product really necessary for a non commercial use?"*

5 INTERPRETATION

Examining the results it is clear that the level of understanding of the social usefulness concept and material utilisation appeared to vary between groups. The results for social usefulness are interpreted for each group and balanced against a considered definition identifying how key understanding has developed. Results for material utilisation are examined more generally from the perspective of the whole course cohort.

5.1 Social usefulness

For the citrus press, an attempt to identify the product's social usefulness was made but poorly defined. However the recognition that the product was a “gimmick” and associating “showing off” did reveal the group distinguishing between aspirational and inspirational products. Examining the product's function from a wider perspective reveals there is little or no social usefulness to the product.

For the electric can opener, social usefulness was demonstrated through the physically impaired and commercial catering. However, the product was designed and marketed as a low cost consumer product and as such has little or no social usefulness. Redesigning for an alternative market would change this but group did not choose do so.

In the case of the kitchen scales the group recognised the product was bought because it was needed and that it could displace the reliance upon ready meals. This is well founded since the product allows the user to take responsibility for what they eat, and feeding their family. It can be viewed as an inspirational product rather than aspirational.

The definition for the rechargeable screwdriver was also poorly defined, merely describing a benefit that the function delivers. The product's poor performance yields little real social usefulness. The group recognised the benefits that could be derived from improving performance and alternative routes to market but failed to express them within the context of social usefulness, such changes would yield a product that empowers the user and promotes self reliance.

For the electric hand mixer the social usefulness was derived from the wider context of the products function and well defined. However, while this would be the case for a product that delivered upon its promised performance, the actual performance fell short and would likely discourage the user.

It was clear that products with a genuine social usefulness were relatively easy to identify and the social usefulness easy to define. Where products had little or no social usefulness, students struggled to recognise this and attempted to persist with weak definitions, even where they had acknowledged their products were “gimmicky”, more suited to an alternative market or unable to deliver the level of performance required.

5.2 Material utilisation

The level of understanding and implementation of material utilisation also varied from group to group but in general terms, more confidently. Four of the five groups questioned the frequency of usage for the product while three recognised that redesigning the product for an alternative market, or improved performance, would improve utilisation. One of these, the rechargeable screwdriver, suggested a number of methods to improve material utilisation ranging from buy back schemes, tool libraries and loan/post back schemes from furniture retailers. Two groups questioned if the materials could be justified for the performance and functionality provided, in essence, is it a waste of the Earth's natural resources?

6 DISCUSSION

For the products described here, the social usefulness could be described as positive or weak but not negative and for most products, but not all, this is the case. Where social usefulness is positive, or indeed negative, this should be readily apparent. For products with little or no social usefulness, this can be more difficult to ascertain and proved the case in some of the examples shown. However, examining the wider social context of the products function should reveal the social usefulness if present.

For material utilisation the students were much more comfortable and were able to formulate a good understanding of the issues and how they influence the overall impact. Students successfully identified each of the elements that derive material utilisation: product population, material use, product life and usage patterns. From this they were able to question if the product was worth the materials it was made from or a waste of the Earth's natural resources.

7 CONCLUSIONS

For the course cohort, the level of success largely depended upon whether the product actually possessed social usefulness. This was as much a reflection upon the student emotional attachment as the difficulty in identification. At the beginning of the course, when groups were first issued with their products, they were dismissive of the products and their quality. This was observed across all groups and persisted through the first task and presentation. However, by the time of the second presentation they became more defensive of the products and even though they had not designed them, they had invested time and effort into developing an understanding. The emotional attachment to their products interfered with their objectivity, preventing criticism. Although this aspect is something that can hinder any creative or productive environment it was unexpected for this short project. However, it should not be understated for the social usefulness test since it is entirely reliant upon separating the functional needs from the emotional wants, the inspirational from the aspirational. The techniques being developed yield a number of positive outcomes to the designer, enterprise and wider society. Social usefulness enables the optimisation of product design for the role it plays and the benefit it brings through the delivery of wider functionality. Examining the material utilisation can minimise the materials tied to delivering that wider context of functionality through the most efficient route to market, hence delivery of the product's service. Both techniques are upstream where the opportunity to influence product impact is at a maximum and financial commitment is at a minimum.

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