ENHANCING SUSTAINABLE DESIGN - THE USE OF NATIONAL AND INTERNATIONAL STANDARDS IN DESIGN EDUCATION.

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ABSTRACT

The British Standards Committee TDW/7 is responsible for publishing the 'Design for Manufacture and Un-manufacture' standard BS8887. This committee includes academic members. As a contribution to design education, this paper explains their use of standards in teaching, particularly with respect to sustainable design. The paper starts with an overview of their use, suggesting advantages and disadvantages. Case study examples are given of their use in four UK Universities and it is concluded that they can give a significant advantage in design teaching.

Keywords: BS8887, case studies, design, standards.

1 INTRODUCTION

The Committee at the British Standards Institution, London, responsible for the suite of *'Design for Manufacture and Un-manufacture'* Standards (BS8887), consists of people from a variety of backgrounds. One grouping is academics. They regularly use National and International Standards as part of their teaching. It was thought it would be helpful to the Design Education fraternity if these academics published information explaining their use of standards as well as the advantages/disadvantages of their use.

2 USE OF STANDARDS IN EDUCATION

The paper identifies the benefits and downsides of using National and International standards within degree courses, seeking to indicate what might be perceived as downsides might be effectively changed and developed into positive attributes for developing student competence.

Benefits identified include:

- Being aware of the need of a systems approach to designing
- Being aware of the need to make effective choices that enable compatibility with other products
- Having an overview of professionally-understood requirements
- Being able to correctly and adequately specify materials and appropriate components
- Being better prepared for professional work outside of the educational setting upon graduation
- Being able to utilise procedures and processes that are commonly used in industry

Perceived downsides include:

- Choices being narrowed down by common industrial practice (that may need some stimulation)
- Lack of freedom that is brought about by the need to meet legislative requirements
- Inability to step outside of the defined standard to perceive the shortcomings of the standard

- Inability to develop alternative and improved standards

The paper will identify practice from several universities and suggest ways that course developers and educators might use to utilise the standards in positive and creative manners. The standards referred to within the paper will be those from the BS8887 group and their international counterparts [1, 2, 3]. These standards present wide-ranging descriptors of sustainable design processes and practices – and are clearly developing industry (and students) in the direction of enhancing and embracing sustainable design principles.

This particular set of standards incorporates concepts around the convenient acronym of MADE – **M**anufacture, **A**ssembly, **D**isassembly and **E**nd-of-Life processing. The BS8887 standards are aimed at providing standards for designers and are couched in terms of 'should' – ie they provide recommendations for Best Practice rather than identifying requirements that are required to be in position so that the standard might be met. It might be described as a standard to aspire to rather than one to adhere to. In taking this approach these standards immediately avoid many of the perceived downsides alluded to above whilst still maintaining the benefits.

Most educational practitioners agree that students learn more by undertaking assignment work than they ever learn by sitting and absorbing information from lectures and case studies, although these always play a part in their education and act as seeds and prompts for the real learning to take place [4]. Thus in order to assess comprehension of appropriate standards it is necessary to request that students DO something to incorporate the recommendations from those standards. Design Higher education has a strong history of getting students to DO design tasks – which is why most of the students have come into higher education in the first place.

There now follows a series of explanations of the use of standards in degree courses, represented by the academic members of the BS8887 committee. They are in no particular order.

3 SUSTAINABLE DESIGN PRACTICES IN SOME UK UNIVERSITIEES

3.1 London South Bank University

Opportunity has been taken at London South Bank University to develop an assignment within a module on Manufacturing Systems to encompass several of the MADE criteria. The students taking the module were final year students from Engineering Product Design and Computer-Aided Design BSc courses and a Mechanical Engineering BEng degree – indicating that the larger part of the group would be anticipating a career as a designer of some sort, with the others looking at careers that might include some design work, but which might also be involved in other parts of the MADE descriptor.

The assignment asked students to identify a product with at least ten separate components, strip the product down and illustrate those ten components. They then had to identify the materials for each of the parts and the production processes for those parts, including finishes. The next requirement was to describe the assembly process including those ten parts and suitable production processes for the assembly. They also had to identify ways that the parts could be reused, recycled or otherwise disposed of, including their final end-of-life scenarios. In perhaps a more positive approach, they have also been asked to discuss options and possibilities including possible design changes to prolong the useful life of each component, and discuss how product quality can be maintained throughout all the product life stages.

Students are not only presented with the standards (which are available in most academic libraries in the UK in any case) but are also given several scenarios covering a range of manufacturing topics, with more of an emphasis on environmental issues and the circular economy than might otherwise be taken. The assessment criteria are set to include a significant weighting upon the analysis and discussion stages rather than simply on identification of parts and assemblies.

3.2 BSc Product Design – University of Sussex

In recent years, the terminology of 'sustainable design' has continued to evolve to encompass many different areas, from new business models to material flows, therefore the teaching of 'sustainable design' has a responsibility to reflect these advancements in our understanding. The 'circular economy' methodology of understanding our relationship with the production, consumption and end-of-life of our products is an area that pulls together many aspects that fit within the new way of teaching 'sustainable design' at all levels.

Within the module 'The Role of Design in the Circular Economy' final year BSc Product Design undergraduates at the University of Sussex are exposed to different areas of discussion and understanding that can lead to the creation of true 'circular economy' ready products – including ensuring products are designed with a suitable material that is from a responsible source which can also be easily recovered and reintroduced at end-of-life back into a manufacture, or re-manufacture process at the highest level of material quality, i.e. with no cross contamination from inseparable materials.

This understanding of the recovery of materials requires an understanding of the complete process of both manufacture and use through to disassembly and recovery, which is taught on the module using a variety of methods. BS8887 Design for MADE takes this full life understanding through each stage – Manufacture, Assembly, Disassembly and End-Of-Life and is therefore a key tool in teaching how circular economy design can be implemented in a clear step by step nature.

One workshop session involves the practical use of BS8887 – Design for MADE - whilst undertaking a product teardown of a low value piece of consumer electronics (such as a £5 kettle). Each set of undergraduate students is given a basic tool kit and timed as they try to disassemble the kettle completely. Each recovered piece is laid onto a large sheet of card and students are encouraged to identify the material, whether this was a suitable material choice for the product and comment on how easy it was to recover from the complete product. BS8887 is used as a reference document to determine how the piece of consumer electronics could have been redesigned, or how the manufacturing processes could be re-thought to allow for a greater, or simpler method of safe material recovery. Each set of students reports back on their findings to the rest of the group, quoting elements of BS8887 that have informed their comments. Each kettle is then conceptually 'reassembled', amended and annotated to create a theoretical kettle design that is more in line with BS8887. Surplus materials are removed, fused / hybrid materials are changed for single type materials and standardised components are introduced.

This practical use of a British Standard has many advantages – not only are the undergraduates assessing an existing design against the guidance set out in the standard and using it as a tool for critical comment, they are becoming familiar with the way standards are written. This is key, as legislation and guidance such as standards can appear too complicated and impenetrable to many undergraduates, regardless of the advantages in design development and understanding they offer. Before this module, most have never read a standard as they considered them to not be applicable to their own work, yet this practical session shows how the development of even conceptual products can follow the guidance set out in a standard and be, in theory, designed for a circular life and material recovery or simple repair at the end of the products usable life.

3.3 Oxford Brookes University, Oxford

Oxford Brookes University (OBU) runs both Undergraduate and Postgraduate programmes in Mechanical Engineering and Automotive Engineering. The university's geographical position in Oxfordshire is at the centre of automotive and related industries which enhances our research and knowledge transfer into and from the sector. This, coupled with the University's strategic objective of ensuring that the learning and teaching it provides is leading edge and that its graduates are well placed to succeed in a competitive labour market, means that it is committed to providing programmes which are research-led, develop practitioner skills and place students in a competitive position to secure their desired career path.

The Automotive industry has continued to see a growth in the number of vehicles produced year on year and the figures for 2015 show a record 1.5 Million cars manufactured in the UK [5]. With this number of vehicles, the demand on materials has increased and consequently the issue of sustainability of materials supply and the need to ensure effective and efficient treatment of vehicles at the end of life, (EoL), is becoming more critical. In fact the EU End of Life Vehicle Directive has stated that by this year 95% of a vehicle must be recycled which requires not only the easy recycling of metals but polymers as well [6]. Research on methods of recycling/reuse of vehicle materials at end of life has shown that increases in sustainability of materials and a reduction in environmental impacts can be achieved [7,8]. However, in practice this will only be possible if the initial design of vehicles consider the whole life of the vehicle at the design stage not just the design and manufacture of the vehicle. BS8887 Part 1:2006 [1] provides the guidelines for designers/engineers to consider the issue of designing for disassembly and end of life.

To ensure that the engineering students at Oxford Brookes University on the Engineering programmes consider the whole life of products at the initial design stage, modules in Materials and Sustainable Engineering introduce the content of BS8887 to both undergraduate and postgraduate lectures and coursework to emphasise the need for whole life methodology in their designs and the requirement for an understanding of environmental impact across the whole life of a product at the design stage. This has been achieved through the use of teardown exercises on various vehicle components such as car seats, bumpers, dashboards etc and suitable non automotive products such as lawn mowers and home stairlifts. The students, in groups of 3 or 4, dismantle the components with minimum tooling, weigh each item, and identify the materials used, methods of manufacture and probable methods of recycling. They are then requested to write a report on their findings and to improve on the designs and perform a life cycle assessment to achieve a reduction in environmental impact.

The students have engaged with this new consideration of sustainability in their designs and the concept of sustainability and the consideration by the students for EOL is evident now in a considerable number of final year projects every year. In fact the development of design for sustainability culminated in the use of the BS8887-1standard as the basis for a Knowledge Transfer Partnership (KTP) project on Whole Life Methodology with an Industrial sponsor. The research conducted by the Research Associate led to a change in company ethos to embed sustainability at its core, new business opportunities for the company, the award of a doctorate to the Associate and a permanent job at the company for the Associate as its Sustainability Officer.

In the KTP project a company expressed an interest in developing a project with Oxford Brookes to develop a more sustainable product and manufacturing process. The Research Associate started the 3 year project by introducing BS8887-1 to the Engineering department and translating the guidelines into the design specification of the product. When this was achieved the need for whole life methodology became evident to the Engineering department and life cycle assessment and environmental impacts were determined. This in turn indicated where cost saving could be made in the manufacturing process, CO_2 emissions could be reduced and new business opportunities became evident.

This latter use of the BS8887 standard highlights the value of using these standards in the education sector from where, through knowledge transfer, their use can embed new methods for sustainable design into all industrial sectors.

3.4 Brunel University, London

Both MEng and MSc Mechanical Engineering Postgraduate students take a module entitled ‘Advanced Modelling and Design’. This consists of two elements – firstly, a study and use of computer-aided-design software including finite element analysis and the second a reverseengineering /tear-down study of a consumer product. Log-books are required to be kept by each individual and at the end of the module, each student has to write an individual report. Students have free-choice of consumer product, old or new and from any sector - office, home, kitchen, toy, leisure or whatever. There are some obvious restrictions such as it must have a reasonably number of parts and that it should consist of a range of materials. Typical products this session have been a remote-controlled toy car, a blender, an e-cigarette. Students mostly choose a new product which they as a group go out and purchase after a guidance lecture on advantages/disadvantages of sectors and products. The product need not be expensive and students often choose one of the cheap 'value' products. Experience of running this kind of exercise over many years is that such products contain poor materials and are of poor quality and there is much beneficial learning from such things! Students work in groups of four and each student is required to concentrate on one of the *'Design for X'* (DfX) aspects as described in the design management standard BS7000-2:2015 [9]. This standard acts as a guide of the critical issues to study since it goes through the design steps that need to be considered in the development of a design. It includes an extensive explanation of the EoL issues which need to be considered at the initial design stage. It is thus a design guide for their work programme. Supporting lectures are given at this stage. All groups choose some end-of-life (EoL) issue like carbon footprint or sustainability or whatever. Indeed all group members will study some aspect of EoL since, for example, one can't decouple the design aspects - if they study say 'design for materials' then they will inherently have to include an element of EoL. Thus, each member will focus on some aspect of EoL even though they may concentrate on DfX. Thus, BS8887 [1] is intertwined in their analysis. The design course consists of alternate series of lectures on DfX issues and surgeries. The group is required to attend the surgery and each make a presentation of their findings. A register is taken. The surgeries are critical. Any non-attendees are followed up. This makes the course intensive and students are monitored carefully. Progress is logged by the design 'doctors' and problems hopefully addressed at an early stage.

This is an intensive course and one which provides an in-depth look at an existing design. It allows the students to explore issues which are not covered by traditional talk and chalk academic subjects. The fact that the students are 'forced' to look at and apply standards to their design analyses means they have to assess other relevant standards and this is another learning exercise. As one student said re the blender product, "I didn't realise how much food safety is covered by standards!"

4 CONCLUDING COMMNENTS

Design experience in an industrial setting brings detail expertise and recognition of the user's needs for information and guidance. When designing a new product, the standards which apply can provide an insight into the factors which need to be considered and the limits or constraints on the design freedom. They can also specify the geometric and other interfaces with standard components so that they may be incorporated into a design. A student absorbs this when they are 'forced' to study standards in a hands-on sense, thus preparing them for the real world.

Standards are regularly revised to ensure they reflect the best current practice. They frequently hold information, provided by industrial practitioners and researchers, which has not yet percolated through to textbooks and reference materials. Thus they are an invaluable aid to designers and a useful addition to student reference materials. One of the earliest activities in a design project should be an investigation of the relevant standards.

In addition, some standards are directly relevant to the design process and its organization and management. These should be embedded in all design related courses. In particular, those standards related to the communication of design details to the manufacturers, and others in the supply and maintenance chain, should be basic references for both students and practitioners.

University courses often neglect any significant teaching on standards. The authors of this paper believe such courses are short-changing their students and have suggested some methods of capitalising on their use.

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