INTERNATIONAL CONFERENCE ON ENGINEERING DESIGN, ICED'07
28 - 31 AUGUST 2007, CITE DES SCIENCES ET DE L'INDUSTRIE, PARIS, FRANCE

RE-VISONING DESIGN PRIORITIES THROUGH SUSTAINABILITY EDUCATION

Tracy Bhamra and Emma Dewberry
Loughborough University

ABSTRACT
Many commentators stress the need for a change in the values and practice of learning to enable society to respond to new, emerging questions that face the world today. Empowering people to ask the right questions should be a prime motive of education for sustainability as the learning outcomes of this will be key to delivering effective agendas – in this case for design - towards sustainability. This paper outlines a design for sustainability pedagogical approach that aims to explore the impact of design on sustainable development priorities. It explores ways in which design can be used as a lever for change towards sustainability by giving students the opportunity to consider very different design briefs. The paper will explore these issues using examples from an undergraduate course developed and taught by the authors.

Keywords: Design for Sustainability, Design Education

1 INTRODUCTION
The process of sustainable development requires us all to think differently about what we do, how we do it and why we do what we do. While this may sound a straight forward enough task there's plenty of evidence out there - climate change, loss of biodiversity and increasing social dislocation - to suggest otherwise. Today, policy and action towards sustainable development give emphasis to scientific evidence over values; technical competence over behavioural change; and clear definitions and answers in preference to asking questions [1]. The inadequateness of current initiatives in understanding both the mechanics and values of sustainable development has resulted in not only a mainstream acceptance of (the current perception of) the issues but also in a belief that current levels of integration and change towards sustainable development will suffice [1]. Our inertia to change tack is perhaps inevitable given that problems of unsustainable development necessitate complex responses that look to radical changes within and across the existing system. The challenges therefore, in implementing a more sustainable development agenda, are directly linked to the way in which people perceive the risk of such change and how the outcomes of such change are explained.

A survey by Environics International [2] recognised industry as the sector that will be charged with making sustainability happen. As such it is critical that corporations are made aware of their environmental and social impacts and their role in seeking new solutions to alleviate such impacts in the future. UN Secretary-General Kofi Annan concurs that, in essence, what is required is a move to a very different way of thinking within business about global development, *'globalisation of the economy implies globalisation of responsibility'* [3]. While it can be shown that the business community is influential, what is less clear is the motivation for business to demonstrate leadership towards sustainable development. To date much of the business response can be categorised as compliance led activity [4]. This suggests a barrier to more holistic business thinking – thinking beyond unsustainable development - as current legislation tends to focus on single-issues as opposed to areas that promote optimum environmental and social gains. Sir Geoffrey Chandler [5], Chair of Amnesty International UK Business Group said in his presentation to the 10th Environment Foundation Consultation that '*Business is an integral part of the country's social and economic failures. In public perceptions of social utility, business ranks at the bottom …'* How do we therefore turn this around to enable business to recognise the context and challenges of sustainable development and to do something about it? We need new language, new concepts and radical change, and it is these

components that need to be effectively integrated into different educational approaches. Education is one of the most vital mechanisms we have to activate a sustainable way of thinking, and behaving, in our world today. In 1990 twenty-two university leaders convened in Talloires, France to voice their concerns about unsustainable development and to establish the need for action from the higher education community: '*Universities educate most of the people who develop and manage society's institutions. For this reason, universities bear profound responsibilities to increase the awareness, knowledge, technologies and tools to create an environmentally sustainable future.*' [6].

This paper specifically addresses the development of an educational approach to sustainability grounded in a design for sustainability discourse that promotes creative and systems thinking towards sustainable change.

Design for sustainability aims to generate as much utility and enjoyment as possible out of the smallest possible quantity of natural resource over the longest possible period of time. The activity of design today is responsible for conceiving of, and delivering, many of the elements of our man-made world – from houses, cars and consumer durables to packaging, engineering components and consumables. These activities involve manipulating natural resources into some form of physical output; unfortunately the agenda of sustainable development (and resource efficiency) does not tend to manifest as a consideration in the production of such 'stuff'. We believe that the scope of design for sustainability presents connections across whole lifecycle impacts of both products and of organisations. From a product (business output) perspective these lifecycle issues include the origin of resource, the nature of energy used and pollutants produced in extraction and production, the environmental and social impacts of resource, product and service travel, consumption culture and methods and adaptation of design outputs in use, the cultural impetus to dispose, to seek the new, and the collation of resource and the energies expended in dealing with reuse, regeneration and disposal. This scope not only embodies supply issues (familiar to current production activities) but also issues of demand (consumer behaviour, cultural expectations and trends). From an organisational lifecycle perspective, these issues include employee wellbeing, fair-trade, equitable working practices, local alliances, and life-long learning. They affect the strategic journey the company chooses, the scale at which decisions are made and impacts felt and the (un)sustainable nature of the outputs generated.

When we begin to challenge the current paradigm of development (as sustainability requires us to do) we will need people who have the ability to think creatively and laterally and draw on disparate areas of knowledge and to vision new, more sustainable futures. These people are the designers of the future. Here lies an opportunity for educationalists to begin to embrace the scope of design for sustainability in visioning more sustainable scenarios for this century and beyond.

2 SUSTAINABLE DEVELOPMENT EDUCATION

The scale of response required for sustainable development points toward solutions embracing individual, as well as group, motivation and accountability. This level of adaptation necessitates people to think and act differently in order to ask questions that challenge the status quo. People therefore need to be made more aware of the issues and given the skills with which to deal with such change. It seems likely therefore that education could be transformative in encouraging different perspectives across the whole lifecycle of products and systems (supply and demand), and that this goal requires a shift away from current educational practice.

Current educational practices predominantly focus on the ability and *need for* students to gain skills and knowledge. The content is discipline focused and about a 'top-down' *transmission* of facts and messages. It also often focuses on rigid, pre-defined learning outcomes that allow little room for manoeuvre for both teaching staff and students alike. This type of education however, is of little use when the subject being explored spans many types of discipline, has many possible processes and outcomes and more importantly, continually reflects on the learning process and in so doing elicits new questions for investigation. Sustainable development - as a 'subject' of study - does just this and cannot be bounded by traditional values and approaches to learning. Thus, trying to force-fit aspects of sustainability into current curricula presents a number of problems:

1. Current curricula tend to be discipline based. Sustainable development on the other hand is a trans-disciplinary subject and requires a reflective and iterative approach to see emerging

discipline links. This enables learners to contextualise the subject and to understand the perspective and scope of specific themes [7];

2. The concept of responsive, dynamic and process learning to enable a 'real' understanding of sustainable development poses a conflict with the established, pre-defined learning outcomes currently used to measure student performance [8]; and
3. Sustainable development has been described as being too abstract [9]. To avoid such claims it is important to promote an educational philosophy that connects everyday living to the more generic policy objectives. This is encouraged through local ownership of learning - both content and process - and is something that can't be governed 'centrally' through rigidly defined curricula content and outcomes [8].

According to Ali Khan [10], the pedagogic approach for sustainability necessitates a shift away from a teaching to a learning paradigm that, '*emphasises independence of mind and the ability to make sense of, rather than reproduce, information*'. [8] expands this view in addressing the different approaches and values of transmissive (transfer of information to learner) and transformative (learner constructing and owning meaning) methodologies '*that go beyond teaching method to also reflect philosophy and purpose of education*'.

Sterling [8] argues that 'education for change' is complex and involves ambiguity and uncertainty and as such alternative learning strategies are required to make sense of this new learning landscape. This new context for learning embraces trans-disciplinary, participative, creative, constructive and responsive methods that allow for (and respect) new perspectives and understanding and the continual reflection necessary for problem reframing and capacity building. It is about the engagement of the individual and the whole learning institution in meeting the challenges and opportunities for change. It is apparent from viewing these different approaches and philosophies to education that sustainable development requires not only different content but, perhaps more importantly, different frameworks of understanding and learning. In thinking about the kinds of knowledge and the kind of research that we will need to build a sustainable society, a distinction needs to be made between intelligence and cleverness. True intelligence is long range and aims towards wholeness. Cleverness is mostly short range and tends to break reality into bits and pieces. The goal of education should be to connect intelligence with an emphasis on whole systems and the long range cleverness, which involves being smart about detail [11]. Introducing educational practice that embodies these new values presents an opportunity to encourage a more linked and holistic way of viewing the problems of, and solutions to, unsustainable development.

3 DESIGN FOR SUSTAINABILITY EDUCATION

Interestingly, best practice design education shares some key characteristics with a transformative education approach. It involves creative, solutions-focused learning; self-directed team work; learning by doing (commonly 'live' projects); iterative refinement and reflection; and drawing from a range of disciplines: e.g. mechanics; electronics; manufacturing; marketing; sociology; ergonomics; and history, to inform the outputs that emerge as a result of design-based activity. To date (within proactive design education) sustainability has been viewed as an 'additional subject' to be addressed in the design process to inform a range of outcomes. For example, the innovative use of recycled material, more energy efficient processes and products, alternative construction materials and reduced wastes. Such examples illustrate that while design has taken 'on board' some requirements of sustainability (e.g. resource efficiency and waste minimisation) the outcomes of this process conform to traditional expectations of what the scope of 'designing' is. To reach conceptually different solutions towards sustainability one has to begin to see design thinking in a context of sustainability. This then immediately places design and its outcomes in a broad trans-disciplinary setting [12]. The onus here is to make new links and to see a range of issues from new perspectives. 'Ecological design intelligence [Design for Sustainability] is not just about things like technologies; it also has to do with the shape and dimension of our ideas and philosophies relative to the earth. At its heart ecological design intelligence is motivated by an ethical view of the world and our obligations to it … I believe that educators must become students of the ecologically proficient mind and of the things that must be done to foster such minds. In time this will mean nothing less than the redesign of education itself.' [11].

In essence the role of design for sustainability education is about shifting minds – away from the 'bolting on' of environmental issues - to allow designer's to develop a deeper understanding of a broad and diverse sense of sustainability that becomes intrinsically embedded in their designing.

The following section describes the integration of sustainable issues within a second year industrial design module at Loughborough University.

3.1 Creating new perspectives

At Loughborough University the second year sustainable design module sits within a traditional BA & BSc in Industrial Design programme. This is an optional module and currently almost half of the second year students are registered on it (around 60). The module was established in order that graduates from the course would be able to respond to future challenges around sustainability, whether they chose to go into the design profession or any other area. The module aims to give an awareness of the issues of sustainability to industrial design students in order that they are better prepared when faced with these challenges in the workplace. The key learning objectives for the module are that students should be able to demonstrate knowledge and understanding of:

- The core concepts of sustainable development
- Issues of sustainability which are particularly pertinent to the activities of industrial design;
- The potential impacts of such issues on designing;
- Sustainable design within an industrial context; and
- Sustainable design methods and tools

Based on the work of Ali Khan [10], a DETR and Forum for the Future report [13] outlined a core curriculum for sustainable development, identifying the key concepts outlined in Figure 1 below.

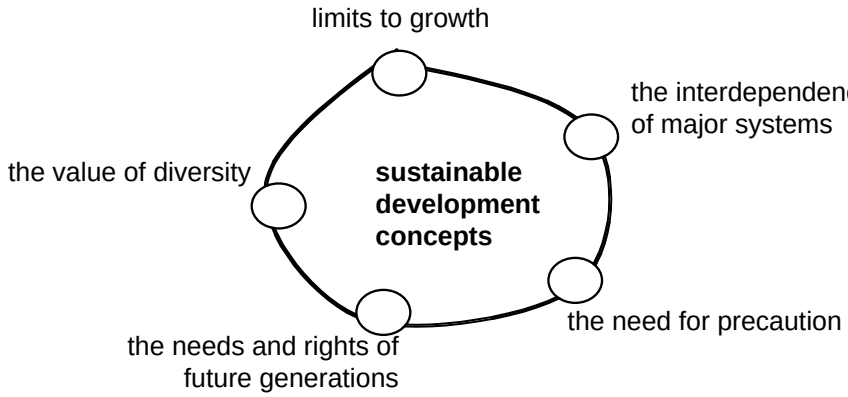

Figure 1 Key Concepts of Sustainable Development

In the first semester the module bases its programme of study around these concepts. It explores these components of sustainable development through traditional lecture programme; it also links these concepts in a practical way to a design context where the students work in small groups to explore, interpret and critically analyse these concepts in an activity. To perhaps make the sustainable development concepts more 'digestible' the module team decided to convey them under three main headings: Resources; People; and Systems. Concepts and headings are linked as follows:

1. RESOURCES: limits to growth; the need for precaution;
2. PEOPLE: the needs and rights of future generations; the value of diversity
3. SYSTEMS: the interdependence of major systems; the need for precaution; and

These key themes provide a framework for activity across both semesters but more from an explicit to implicit state as the students become more familiar with the landscape of the broader picture of sustainability and its links to designing. Table 1 illustrates the structure, content and outputs of the sustainable design module.

Table 1 Sustainable Design Module Outline

Semester One	**Content**	**Focus**
Introductory lectures	Scoping sustainable development	Breadth and diversity of sustainable development
Core concept lectures:	Resources People Systems	Understanding and analysis of core sustainable development themes
Self Directed Seminars	Eco-Efficiency Service Systems	Understanding, Integrating and Articulating links between sustainable development and design Developing presentation skills
Semester Two		
Supporting Lectures for sustainable Design Activity	Creativity User interface Tools and Methods Information Resources	Applying different approaches within designing
Sustainability Design Briefs	Examples include: Packaging Redesign, Educating consumers about energy use, developing refill systems, public lighting.	Analysing, re-framing and delivering on the brief set; presenting to a range of stakeholders; demonstrating sustainable design thinking and practice in real-life problem solving context.

As can be seen, the module incorporates a range of learning styles. The first semester period of 12 weeks focuses on delivering core content by combining traditional lectures with design activity. Students engage with the formal lecture approach and then split into sub-groups to discuss and respond to a short design activity that reflects that week's core sustainable design concept. Towards the end of this semester the students are split into seminar groups of 4 to 5 and are asked to research one of two main topics, eco-efficiency and service systems. Each group has a week to research and prepare a 30 minute seminar on one of these topics. They then present to a number of their peer group. Feedback from the students on the seminar activity at the end of semester one has concurred that they have valued a more active learning mode:

"working with different members of the group and researching for the seminar- notified just how little information was out there compared to some other modules, obviously awareness of problems and solutions needs to be greater."

"It was good to organise the seminar - to divide up the topic and who would research which area in particular. Better than a short presentation as a much more in depth look at the topic could be covered."

“It makes you work things and ideas out yourself, you get a better idea of what is actually achievable.”

“I liked the subject and everyone put a fair amount of effort in this assignment. I found the last part of our presentation more interesting (when you asked questions) because then you hear other peoples’ opinions and you can put in your opinion as well instead of just stating facts.”

The second semester is dominated by project–led learning where external organisations deliver a series of design briefs to the students who then work on developing sustainable design outcomes over the 12 week period.

However, remainder of this paper focuses on the link between transmissive and transformative educational approaches in the early part of Semester One. The aim here is to deliver a foundation of knowledge on sustainable development and on the links between sustainable development issues and the activities of design. As described previously, the module team decided to cluster the sustainable development concepts under three key themes: resources, people and systems. The following section details this process and the outcomes generated by the student group.

3.2 Linking design and sustainability

In opening peoples’ minds to the scope of the connection between sustainable development and design it is important that they have the opportunity to translate these abstract concepts (e.g. precautionary principle; limits to growth; scale) into language and action that has resonance for them. The main idea behind linking a traditional lecture to a practical design brief was to provide design students with a familiar ‘zone’ (the act of thinking in a designerly way) to explore an unfamiliar area - in this instance the core concepts of sustainability. What was of interest was whether the outcomes that emerged from a response to a design brief reflected a level of comprehension that suggested the students had been able to ‘unpick’ the core concepts in a practical and applied way. In other words, had they been able to create a frame a reference for each lecture and design brief theme that previously had not been a part of their design horizon?

Each theme was addressed one at a time, over three sequential weeks. The general format of the three hour session was an hour long lecture followed by a design briefing, a 90 minute design activity within small groups, culminating with a 30 minute large group session of presentations, review and discussion. The initial lecture each week supported concepts introduced in the introductory two weeks of the semester. The design activity then aimed to allow the students to explore and develop their own understanding of these issues by responding to them through a practical design task. The role of the tutors in this stage of the session was as advisors to the small groups of 5 to 6 students; to be a point of clarification and guidance.

The output of these exercises was not to produce final solutions to ‘a problem’ but rather, to provide a flexible framework for in-depth discussion, practice and reflection of the complex issues embedded in the sustainable development agenda. The design briefs for each of these sessions are presented below, alongside the initial design outputs and discussions that emerged.

3.2.1 Brief 1: Resources

Resource Efficient Transport of the Future

Volkswagen have been concerned about issues of sustainability for a number of years but with the recent arrival of a new CEO and increasing government pressures around the world they feel it is time for more decisive action. This action covers many aspects relating to the operation of the company but also includes changing the design of their vehicles.

A study commissioned by the company has shown that their vehicles use a range of non-renewable materials including steel, copper, aluminium etc and non-renewable fossil-fuels (diesel and petrol) to power the vehicles.

You have been commissioned by the company to propose a radical new concept for resource efficient transport for the future targeting existing VW customers in Western Europe. You should use information from the lecture to guide you. Work in groups of 5 or 6.

- As a group brainstorm initial ideas for 20-30 minutes
- Select the most promising idea and spend 60 minutes adding detail
- You need to be able to demonstrate how your concept is more resource efficient
- Identify whether it is Factor 4, 10 or 20 level of improvement
- Represent your idea visually if possible (diagrams, images etc)
- You will have five minutes to "sell" your idea to the Volkswagen Board of Directors so make sure you highlight the company and customer benefits of your concept

The outcomes generated by the students from this first brief demonstrated a clear understanding of the key issues raised in the resources lecture. There were a range of issues addressed by the groups including size/weight reduction, alternative fuel/power and shared/public transport. Most groups addressed more than one area in the design concept and most managed to generate an innovative concept which was very different from their usual design outputs.

Three groups came up with the idea of designing adaptable vehicles for families to ensure that they always used the correct size vehicle for the number of passengers and amount of luggage they were carrying. They recognised that whilst small vehicles had the lowest impact they were not always a practical option for a family and therefore modular vehicles were proposed. These designs all shared some common characteristics, vehicle modules that a user could easily fit together to create anything from a one to seven person vehicle, Figure 2 illustrates one concept.

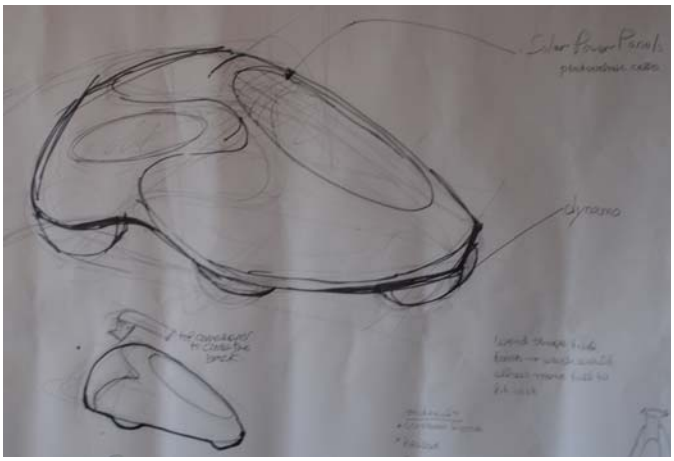

Figure 2 Modular Vehicle

Every group considered alternative fuel or power to some degree either proposing to replace fossil fuels with bio fuel or using electric vehicles powered by solar or kinetic energy. Two groups proposed a public transport system that was powered at least in part from kinetic energy from users. One of these groups proposed a "Tram Sport" solution whereby kinetic energy was harnessed from a network of gyms connected to the tram system. The other group proposed an optional but incentive based scheme to encourage tram or bus users to pedal whilst in their seats; the more energy they created by

pedalling the more they saved on the cost of their journey. These two ideas are illustrated in Figure 3 below.

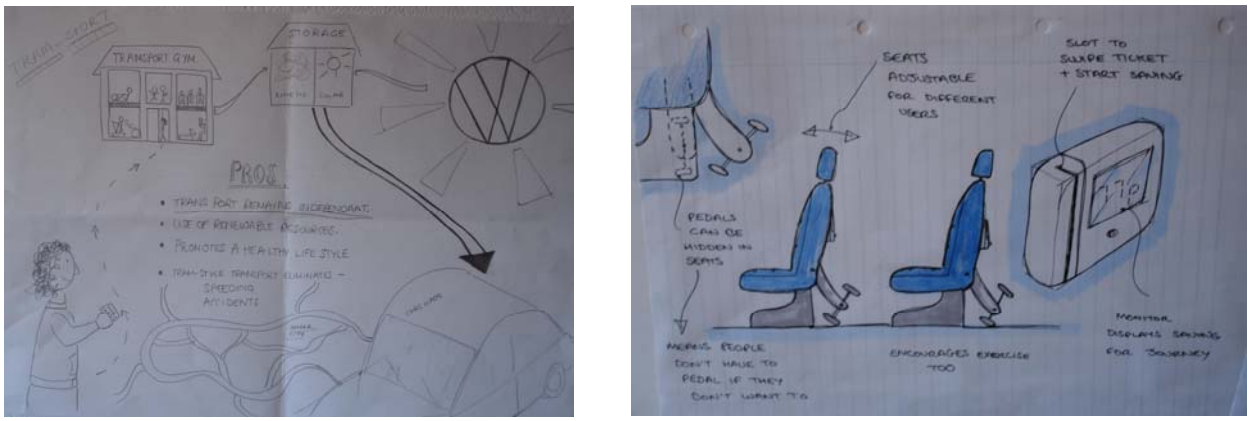

Figure 3 Alternative Power Public Transport

Finally one group focussed on encouraging users to move away from ownership of vehicles to shared use and services. They proposed a swipe card car share system using two different sizes of vehicles (2 or 4 seats) which could be collected and dropped off at many different places throughout cities and rural areas. The vehicles would be electric powered and the collection/drop off point would charge the battery whilst parked. Figure 4 below illustrates this concept.

Figure 4 Vehicle Share

From the design concepts generated and the student feedback it appears that this brief gave students the opportunity to explore how it was possible to radically reduce resource use. As these quotes from students illustrate it proved to be a challenging activity.

"This exercise got us thinking about how much we take modern transportation for granted and it surprised me how difficult it was to come up with a sustainable solution".

"This design brief was interesting as it involved designing sustainably for the entire product (the vehicle). In other modules to think sustainably is useful when designing a product, but in a vehicle there are so many areas to look into, it made you think in a lot more detail."

3.2.2 Brief 2: People

Design Manifesto for Twenty-First Century

"The very exercise of developing a code is in itself worthwhile; it forces a number of people to think through, in a fresh way, their mission and the important obligations they as a group and as individuals have with respect to society as a whole." (DeGeorge, 1987)

As was outlined in the lecture, industrial designers do not have a code of ethics to guide them. As a group of product designers you have been asked, by the UK Chartered Society of Designers, to develop and propose a Design Manifesto for the Twenty-First Century. This will inevitably need to address issues of design ethics in the context of the environmental and social agendas inherent within sustainable development.

Activity:
Work in group of 5
Read the 1964 & 2000 First Things First Manifestos.
How do these relate to product design?
- What alternate issues should you be considering?
- Define the purpose of your manifesto - to regulate behaviour, to aspire to, or to inspire, a combination of these?
- Brainstorm and prioritise the values that you think are important to product designers.
  - Values = the philosophy of practice.You might think about:
  - What specific problems to product designers contribute to?
  - What is unsustainable about their work?
  - What needs to change?
- Identify 10 principles for designers to follow.
- Principles = how to practice

- Consider how the code will be implemented.

- Does the ethics code include some form of enforcement? If so state what kind?

The design brief here took a different focus and moved students away from thinking directly about products and systems towards their own responsibilities and how to encourage designers to change. Most students were not aware of the First Things First Manifesto and reading this for the first time opened their eyes to the fact that many designers are already considering sustainability to some degree.

“Interesting to see what was considered in the manifestos from the past, especially by updating them.”

Many groups were able to brainstorm some useful points but where then unsure how to present them as a manifesto. It appeared that the term “manifesto” was rather unclear to many students but those that did understand the concept were able to produce an output which proved to be a useful starting point for later discussion about how to inform designers about issues of sustainability. Figure 5 below illustrates one group’s manifesto.

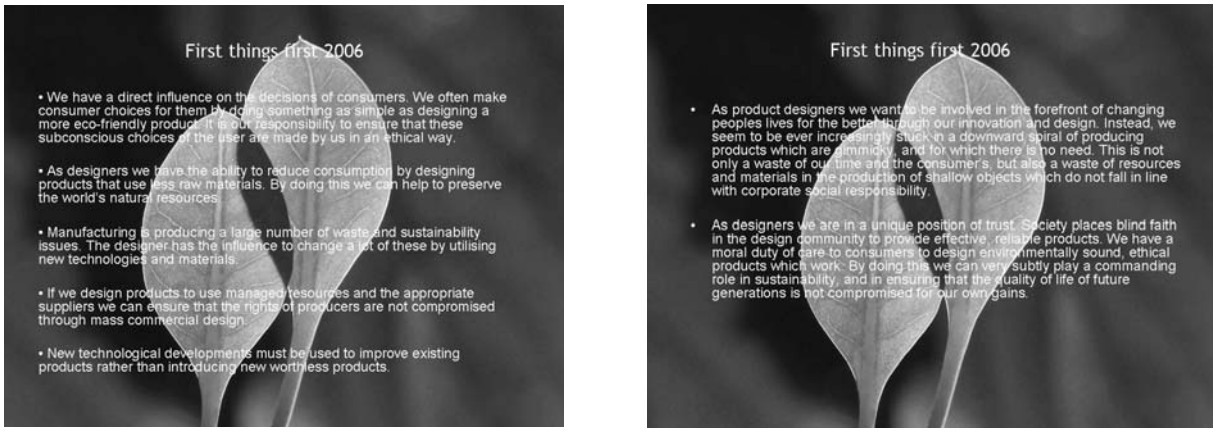

Figure 5 Manifesto for Designers

3.2.3 Brief 3: Systems

Systems Design

Context

Designers are greatly implicated in the environmental crisis – in fact Van der Ryn and Cowan in their book *Ecological Design* (1996) suggest that *the environmental crisis is a design crisis as it is a consequence of how things are made, constructed and used*. Design is about the intentional shaping of ideas into everyday objects, systems and settings. As such it occupies the space between us and our surroundings which both influences, and is influenced by, our wants and needs, our material choices and actions. It is this unique position of design as interface between consumers and that which is consumed, which firmly establishes its potential to influence the environmental impact of products, services and environments and hence, to contribute towards the goals of sustainable development. It is this interconnectivity between design, society and the natural environment that holds the potential for positive change towards sustainable development. Recognising this interconnectivity is an important first step: as the Scot and Naturalist John Muir once said,

When we try to pick out anything by itself,
We find it hitched to everything else in the universe.

Brief

The UK Government are moving towards making it an imperative of Planners and Developers of new Housing Developments to integrate comprehensive systems promoting energy efficiency, water and waste recycling and the appropriate use of resources. Alongside this there is also a need to promote sustainable lifestyles through the inclusion of solutions that meet the needs of households in new ways. **Your brief is to choose *one* element of the household to investigate in more detail and to draw up a concept design based on systems thinking that promotes the notion of sustainable living.** For example you may wish to focus on the kitchen as an area of interest for new solutions, or on 'wet areas' in general (e.g. the water system across both kitchen & bathroom). Equally your interest may lie in the infrastructures supporting these households such as ideas of sustainable transport and the promotion of the benefits of this to users.

In groups of 5-6

1.Choose one area within existing households and map as a system [how do the elements of this link together?]
2.Develop and describe a new design concept that makes the existing 'system' more sustainable
3.Summarise the key features of your design concept that would *sell* sustainable living to existing households

The idea of examining a whole system from a design perspective appeared quite challenging as a starting point for this activity but within a short amount of time the groups were able to find a focus for their designing. The most popular part of a household system selected to redesign was water use with six groups having this as their focus. Four groups focussed on heating the home, one group looked at waste and recycling, and one group look at turning a product into a system. Three of the aforementioned groups looked at water use and heating as a combined system.

One of the groups who focussed on water use developed a system whereby grey water arising from different areas of the home was collected separately and reused in the most appropriate place for example warm bath water could be used in the central heating system. Water supplies for different areas of the home were topped up using mains and rain water.

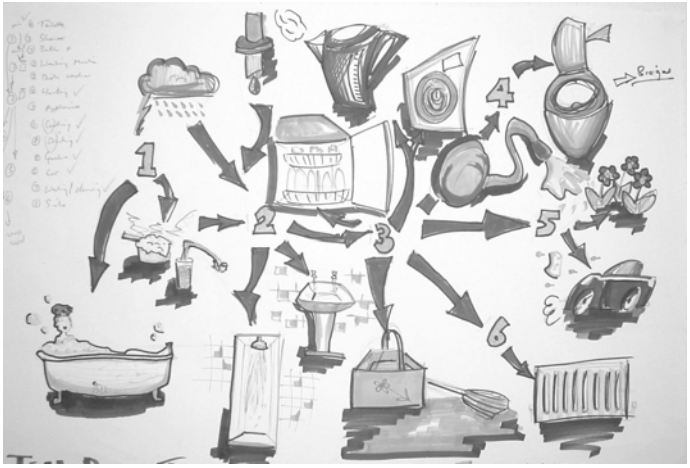

Figure 6 Grey Water Recycling

Another group looked at solar rain water heating for the home with grey water being used for flushing toilets.

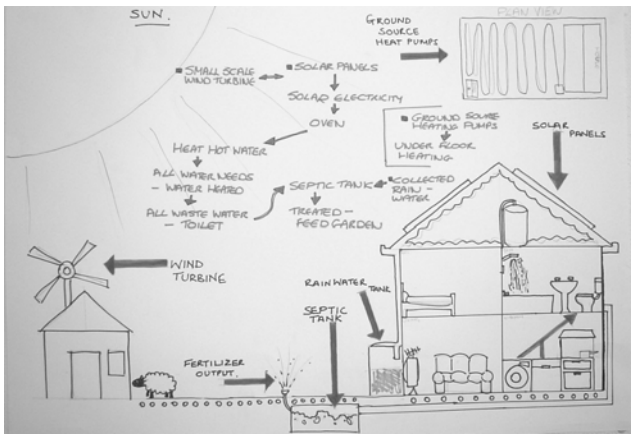

Figure 7 Solar Rain Water Heating

Finally, one group developed an innovative heating system that collected heat lost from the home via water pipes in the roof. The heat was then re-circulated through the house via hot water.

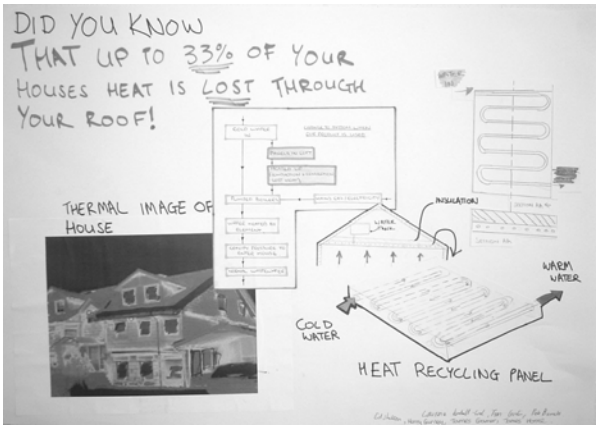

Figure 8 Heat Capture System

These solutions whilst having some flaws provided a useful starting point to discuss opportunities for making radical changes to the systems with the household and moved the designers well away from their usual product focus for design. As their comments below illustrate they found it a interesting exercise.

“This was interesting to look at everyday systems which are used and how they can be improved - a less obvious way of being sustainable”

“This was good. It was one of those exercises where the longer you looked and worked at it, the more you could break the problem down and improve it, could have really gone mad with another couple of hours!”

“I think we completed this project really well and worked successfully as a team. I'm not sure that the idea we produced was very feasible in real life but I am sure elements could be adapted to be economically viable in the future.”

4 KEY LESSONS

It has become more and more apparent that creativity is vitally important in addressing problems of unsustainable development; this is achieved to some extent by the trans-disciplinary team approach to problem re-framing and problem-solving, this also happens to be core elements of designing.

Ultimately, courses of this nature aim to evolve an education process grounded in the knowledge that we are aware of what we currently do (through ‘real’ projects) and where we need to move to (a trans-disciplinary understanding of sustainability). What we suggest in this paper is that one route to this is to foster a sense of exploration, of creative investigation into asking different questions of complex problems. We are at the beginning of this journey and through continual reflection of teaching, project

questions and outcomes and learning experiences we hope to advance our understanding of how we can cultivate design for sustainability, in education and in practice.

This trans-disciplinary team approach to sustainability projects has proved to be very successful enabling the students to complete complex and demanding work in a relatively short time frame. As has been highlighted earlier problems around sustainability usually have a number of different solutions and which very much depend on an individual's perspective. The team approach has meant each student has gained a greater awareness of the possible solutions and therefore increased the learning that can be taken forward to the next project.

By setting design briefs that require students to use their skills and knowledge quite differently we have shown students that sustainability isn't just an addition to their designing but rather it is an opportunity to re-vision design solutions. This is a new and innovative approach to teaching design for sustainability.

ACKNOWLEDGEMENTS

The authors would like to thank the students who have taken this module over the past 6 years for their enthusiasm and hard work that has enabled the writing of this paper. They would also like to thank all the academic and administrative staff who have helped develop and deliver the courses and support the students. Finally they would like to thank collaborating organisations who have worked with the students on projects.

REFERENCES

[1] Huesemann, M. H. The limits of technological solutions to sustainable development. Clean Technologies & Environmental Policy 2003; 5 (1): 21-34.
[2] Environics International Global survey of experts. Environics International Ltd: 2001.
[3] Townsend S. Variety and Values: a sustainable response to globalization. British Telecom, London: 2000 source accessed 06-08-03: http://www.btplc.com/Betterworld/StandardsandPublications/varietyandvalues.pdf.
[4] Sarkis, J. Manufacturing's role in corporate environmental sustainability: Concerns for the new millennium. International Journal of Operations & Production Management 2001; 21(5/6):666.
[5] Chandler, G. Reflections on the way forward. In: Executive 21: Business Education for a Sustainable Future,10th Environment Foundation Consultation. Windsor Castle (UK): 19-21 January 2000.
[6] Warburton, K. Deep learning and education for sustainability. International Journal of Sustainability in Higher Education 2003; 4(1): 44-56.
[7] Sterling, S. Sustainable Education: re-visioning learning and change. Schumacher Briefing No.6: Schmacher Society, Green Books, Dartington: 2001.
[8] Filho, W.L. Dealing with misconceptions on the concept of sustainability. International Journal of Sustainability in Higher Education 2000;1(1): 9-19.
[9] Ali Khan, S. Taking Responsibility: promoting sustainable practice through higher education curricula. Pluto Press, London, 1995.
[10] Orr, D. Earth in mind – on education, environment and the human prospect. Washington DC, Island Press,1994.
[11] Fletcher K., Dewberry, E. demi: a case study in design for sustainability. International Journal of Sustainability in Higher Education 2002; 3(1): 38-47.
[12] DETR & Forum for the Future (1999), Sustainable Development Education: Design Specification, Sustainable Development Education Panel Position Paper, part of the HE21 (Higher Education for the 21st Century) project.

Contact: Dr Tracy Bhamra
Loughborough University
Department of Design & Technology
Loughborough, LE12 8HH, UK.
Tel: +44 (0)1509 228316
Fax: +44 (0)1509 223999
E-mail: t.bhamra@lboro.ac.uk