Developing Sustainable Literacy in Industrial Design Education

A three year Action Research project enabling Industrial Design students to Design for Sustainability

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BDes Industrial Design (Hons 2:1)

A thesis submitted in fulfilment of the requirements for the degree of PhD

The School of Engineering
University of Western Sydney

Submitted 23rd February 2009
I certify that the thesis ‘Developing sustainable literacy for Industrial Designers’ submitted for the degree Doctor of Philosophy is the result of my own research work, and that this thesis, or any part therein, has not been submitted for a higher degree to any other university or institution.
I would like to thank my supervisors Dr Abby Lopes and Professor Michael Singh for their guidance and support throughout this project. Special thanks are also given to Dr Erik Bohemia for his early supervision and assistance in establishing direction at the design stage of the thesis. I would like to express my appreciation to all the industrial design students from the University of Western Sydney who participated in the unit Sustainable Design: Sustainable Futures, generating visionary content for analysis. Finally, I would like to thank Dr Gaye Wilson for her careful eyes in editing the thesis.
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<td>CBSM</td>
<td>Community Based Social Marketing</td>
</tr>
<tr>
<td>CO2e</td>
<td>Carbon Dioxide Equivalent</td>
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<td>DES</td>
<td>Developing Ecological Sustainments</td>
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<td>DIS</td>
<td>Design for sustainability</td>
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<td>DOS</td>
<td>Design-oriented scenario</td>
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<td>Ecodesign</td>
<td>Ecological Design</td>
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<td>EFs</td>
<td>Education for sustainability</td>
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<tr>
<td>EPR</td>
<td>Extended Producer Responsibility</td>
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<tr>
<td>ESD</td>
<td>Ecological Sustainable Development</td>
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<tr>
<td>EUE</td>
<td>Eco-Design of End Use Equipment</td>
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<tr>
<td>IPAT</td>
<td>Impact = Population x Affluence x Technology</td>
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<td>IPP</td>
<td>Integrated Product Policy</td>
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<td>KCI</td>
<td>Knowledge Constitutive Interests</td>
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<td>LCA</td>
<td>Life Cycle Analysis</td>
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<td>MIPS</td>
<td>Material Intensity per Unit of Service</td>
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<td>PAR</td>
<td>Participatory Action Research</td>
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<td>SDSF</td>
<td>Sustainable Design: Sustainable Futures</td>
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<td>SF</td>
<td>Strategic Foresight</td>
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<td>WEEE</td>
<td>Waste Electrical and Electronic Equipment</td>
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Abstract

This thesis is an investigation into why Industrial Design students cannot Design for Sustainability (DfS); that is, students are unable to design in a way that can contribute in real terms to a sustainable society, economy or ecology. To proactively address the question, a three year action research project at the University of Western Sydney took place within the sustainable design stream of the undergraduate Bachelor of Design / Industrial Design program. This study examined over 400 conceptual DfS scenarios, which were the outcomes of student assessment tasks at the end of the sustainable design stream. Using content analysis, the ‘conceptual design scenarios’ were examined against progressive DfS theory to locate the effectiveness of both the theoretical and pedagogical interventions. Through the process, insight into Industrial Design Education for Sustainability was gained to inform the three key findings of the thesis:

First, the definition of the unsustainable problem being worked with strongly determines the quality of the design outcome in terms of DfS (how you define is how you design). To enable Industrial Design students to design for sustainability, a sound, targeted definition of unsustainability is first required, a task that has been neglected in Industrial Design Education.

Second, the role of pedagogy is equally as important as the theoretical material to which Industrial Design students are exposed. The pedagogy of deep learning and a student-centred approach to teaching was employed. These assisted both to progress students’ understanding of unsustainability and to transform their understanding into Designs for Sustainability.
Third, if Industrial Design students are to be motivated and engaged in DfS, sustainability needs to be presented as more than a responsibility; students need to see clear, feasible, future vocational opportunities in DfS. Hence DfS needs to be presented as an opportunity with explicit career paths for their future vocations. The proposed future opportunities expand from the product focus of Industrial Design

The three key findings of the thesis informed the pedagogical framework for Industrial Design Education for Sustainability that is presented. To summate, the thesis argues that students can design for sustainability if an appropriate understanding of unsustainability is defined (the problem context), supported by pedagogic processes to transform this understanding into appropriate and forethoughtful design outcomes, which are seen as viable potential proposals justified for real world applications in a transformed Industrial Design practice.
1 Introduction

This thesis investigates why Industrial Design students cannot Design for Sustainability (DfS), in that students are unable to design in a way that can contribute in real terms to a sustainable society, economy or ecology. When Industrial Design students present DfS solutions and the question ‘does this design contribute to a sustainable society, economy or ecology?’ is asked, the designs frequently fail, often catastrophically.

The objective of this thesis is to provide data and suggestions towards the reorientation of Industrial Design education to enable students to answer the above question positively, in that their designing enables change from the unsustainable present to a more sustainable future in the context within which their designing is focused. It is considered that if students cannot design for sustainability in an academic environment, then there is a limited chance of success for DfS when they become practitioners. Vocational training is limited within the industry as there has been a low adoption of progressive DfS to date.

The scale of design’s influence on society is largely underestimated in Industrial Design education. The question is often asked of students to identify one activity that they complete, which in some way is not dependent on a designed object. This question highlights the pervasiveness of design in everyday environments and activities. The impact that design has on everyday life is enormous, yet is also inconspicuous: look around the room you are sitting in, surrounded by objects that have at some stage been designed and produced, most likely with the assistance of an Industrial Designer.

DfS in this thesis is defined as design that enables positive change for sustainability; various types of Design for Sustainability will be introduced. The type that this thesis is interested in from this definition will be referred to throughout as DfS3.
This leads to the premise that there will always be design in some capacity, while ever there are products to assist with our daily life. Existence without designed objects is unimaginable. What these products are, how they are realised, from what materials and processes, in what numbers, and with what influence on our daily behaviour are questions that Industrial Designers engage in within DfS.

As professions go, design is relatively young. The practice of design as a thing that people do predates professions. In fact, the practice of design — making things with a useful goal in mind — actually predates the human race. Making things is one of the attributes that made us human in the first place. (Friedman 2000, p. 5)

Industrial Design’s contemporary focus has taken the human attribute of making things to a mass scale, producing affordable products in large volumes. The consequences of this present challenges for Industrial Design that need be addressed. Industrial Design as a discipline offers skills and agency in ‘making things with a useful goal’ that is well suited to DfS. However this capability needs to be realised in ways that vastly reduce the flow of materials and non-renewable resources upon which our lifestyles currently depend. To gain insight into how sustainability may be developed we must first investigate why we are unsustainable (Fry 1999).

1.1 Research Questions

The following questions have been developed to guide this study. The primary research question is ‘Why are students of Industrial Design unable to design in a way that can contribute in real terms to a sustainable society, economy or ecology?’

In order to answer the primary research question, the following subsidiary research questions were devised.

1. What DfS approaches are represented in the conceptual design scenarios of Industrial Design students?
2. What DfS approaches offer the highest sustaining potential?
3. How are the approaches with the highest sustaining potential integrated into Industrial Design education?


1.2 Lexicon of Terms

The following terms are used throughout the thesis. Definitions of the terms and their interpretation specific to the orientation of this thesis are outlined below.

**Unsustainability**: the inability to continue for prolonged periods of time. The term in this thesis is concerned primarily with the decline of the ecological systems that support us. The term unsustainability is favoured over sustainability in this thesis as it encourages an acknowledgement and critique of current practices that are unsustainable; sustainability is hard to define as there is no universal definition widely accepted. As Fry states ‘striving for solutions without having a fundamental grasp and definition of the problem can never advance sustainment (unless by chance)’ (2000, p.4).

**Inconspicuous Consumption**: the unnoticeable and non-perceived use of resources in everyday circumstances. ‘A distinction is suggested between a world of relatively individualised consumer behaviours involving the selection of discrete and visible commodities and a muddier world of embedded, inter-dependent practices and habits explicable in terms of background notions such as comfort, convenience, security and normality’ (Shove and Warde 1998, p. 13). Inconspicuous consumption is different from conspicuous consumption where personal preferences, freedom of choice and social issues are considered in the decision making process. For example, when renovating a bathroom a conscious decision is made to select appropriate hardware that will look good, in contrast to the inconspicuous habitual use of that bathroom in daily showering. Inconspicuous consumption is used in this thesis as it affords an exploration of the everyday decisions that are driving unsustainability.

**Embodied Consumption**: embodied is to ‘to make part of a system or whole’. Energy, water and natural resources are embodied within products and services used every day, which largely go unknown by the consumer. As Frasca notes: ‘ready-made products appear like magic’ (1996 p 45). We only see the tip of the iceberg (as low as 5%) of what we consume; embodied energy, water and natural resources are hidden.

**Ecological rucksack**: an indicator for the amount of natural resources disturbed to make a product. i.e. to make one kilogram of aluminium disturbs 85 kilograms of
natural earth (Schmidt-Bleek 1999, p.9). Ecological rucksacks are an indicator of embodied consumption.

1.3 Brief Overview of the Literature

The possibility of irreversible change to our planet through the use of resources in a manner that is ecologically damaging and cannot be sustained has been the topic of many publications from the early 60s onward (for example Carson 1962; Meadows 1972; World Commission on Environment and Development 1987). According to a growing body of literature we are living beyond the ecological limits of our planet, with a suggested reduction in resource use by up to 95% for western countries in order to avert irreparable damage (Vergragt 2004). It is argued that there is a causal relationship between resource consumption and CO$_2$e production (Lenzen 1998), with increasingly stringent targets and timeframes for CO$_2$e reduction. Although the focus of this thesis is aimed at industrial design education for sustainability, the issue of the enablement of sustainability is a greater global problem to which all disciplines need to contribute.

Indust ational Design has an uneasy relationship with the ecological crisis; it is seen as a double edged sword. On one hand, DfS is concerned with the consequence of a consumer society; whilst on the other Industrial Design has been responsible for inflating it. Thus it is a ‘challenging subject for designers to come to grips with’ (Moggridge 2007, p.656).

In the first instance Industrial Design is implicated in the creation of the consumer society within the United States of America (USA) in the 1930s (Andrews 2007, pp. 17–20). Increasing consumption was an economic strategy developed to lead the USA out of the Great Depression (Fry 1999, p.113), a strategy in which early Industrial Designers played a key role. However, whilst this demonstration of design’s agency may have led to increased consumption, it is also suggestive of design’s capacity to re-orientate the crisis.

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$^2$ CO$_2$e stands for Carbon Dioxide equivalent, which is a measure of the warming potential of each greenhouse gas. It is used in this thesis as it is inclusive of all gases with warming potential, not only Carbon Dioxide.
Design’s capacity to re-orientate the ecological crisis has received the most attention through designing products with a reduced ecological impact over their lifetime: this is the Ecodesign position. Ecodesign is seen to be the first of three positions DfS has to offer and will be referred to as DfS1 for the remainder of the thesis, encompassing the technical product design focus. This thesis proposes that there are two further positions that DfS may offer in re-orientating the ecological crisis.

As noted above, design has an enormous influence on society, yet industrial design’s role has not been widely acknowledged. This informs the second position in DfS (DfS2), which acknowledges the relational impact of design on unsustainable behaviours, representing a more ‘theoretical’ approach to DfS. In acknowledging design’s influence it may be possible to utilise designers’ skill to make our default everyday actions more sustainable. The distinction between DfS1 and DfS2 is likened by Fletcher, Dewberry et al. (2001, p.223):

The most common approaches to design for sustainability tend to focus on pollution reduction and resource efficiency [DfS1] rather than human choices and actions [DfS2]. In contrast to this, design for sustainability with a focus on people considers ways of satisfying fundamental human needs.

The third position of DfS (DfS3) takes Design for Sustainability in the literal sense, which is design that contributes to positive real change to assist in a move towards a sustainable society. This is a future-orientated-change-focused approach to DfS. Table 1.1 summarises the three positions.

<table>
<thead>
<tr>
<th>Table 1.1 Three positions of Design for Sustainability</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DfS 1</strong> = Technically orientated Ecodesign, a design approach that maintains a strong product focus to reduce the ecological footprint of products.</td>
</tr>
<tr>
<td><strong>DfS 2</strong> = Theoretical approach to DfS, acknowledges the demand side of consumption as problematic (human behaviours), more socially and theoretically orientated to reduce the ecological footprint of people’s actions.</td>
</tr>
<tr>
<td><strong>DfS 3</strong> = Future orientated approach to design for sustainability, design that is focused upon bringing about fundamental change for a sustainable society (DfS in a literal sense).</td>
</tr>
</tbody>
</table>

Four key theorists whose work is aligned in different ways with the above positions of DfS were influential in informing the direction of this thesis. The theorists illuminate both the problem of unsustainability, and design’s preferred strategic response to sustainability. These are: Hanz Brezet, Elizabeth Shove, Ezio Manzini and Tony Fry.

3 A more substantial critique of Ecodesign follows in the literature review.
Hanz Brezet is influential in forecasting design’s suggested response to sustainability and was at the forefront of Ecodesign. While his ideas are debated, Brezet (1997) proposed that, in order to design for sustainability, designers are required to move towards strategies of functional and systems innovation, a shift in part from DfS1 to DSf2. This marks a shift from traditional industrial design practice which focuses on improvements and innovation purely on products.

Elizabeth Shove provides insight into habitual consumption; Shove’s (2003) work is used to present a rationale for our unsustainability by asserting that the great majority of our resources are consumed in maintaining standards of comfort, cleanliness and convenience in our everyday life (2003, p. 395). Our sense of normality is defined by this consumption and sustained by our everyday habits and routines and by the vast array of goods and consumables that service them. Shove’s work is used to frame a sound definition of unsustainability as over-consumption that is largely unnoticed in our everyday habitual activities, providing insight into the human choices and actions that inform the position of DfS2.

Tony Fry’s philosophy confronts the complexity of design’s role in generating unsustainability head on and offers a new philosophy for recognising design’s influence. Defuturing is ‘a learnt act of critical deconstructive reading’ (1999, p. 11) that enables a transformed perception of design’s agency. This transformed perception allows designers to recognise their designing as either contributing to a more sustainable future or not. Fry’s philosophy is used heavily within this thesis to understand design’s ontological and relational contribution to the ecological crisis. Once understood, the challenge that this thesis confronts is how to apply such understanding into realised DfS3 conceptual scenarios.

Finally, Ezio Manzini has set a precedent for designers to operate at the alternate levels proposed by Brezet. Manzini’s Design Oriented Scenarios (2003a) and the EMUDE project (2006) showcase design at a community level. Manzini’s work is influential to this thesis as he champions designs ability to Design for Sustainability in the literal sense (DfS3). The Design Orientated Scenarios present hypotheses focused on contributing to positive sustainable ways of living and working.
A deficiency appears to exist between the sound and progressive definitions of unsustainability presented by Shove (2003) and Fry (1999) informing DfS and the dominant approaches used in Ecodesign (DfS) to date. A framework ‘How you define is how you design’ has been developed here to explore these complexities. Largely informed by Habermas’ knowledge constitutive index (1972) the framework assists in examining Industrial Design DfS practice within an educational context. The framework is introduced in Section 1.7 below.

Industrial Design education is a critical site of reoriented practice, as it is a site for the acquisition of new ideas but also a chance to practise sustainable design as we educate tomorrow’s practitioners. The preliminary literature review raised concern from both theoretical and pedagogic perspectives; Ramirez’s study of industrial design disciplines within Australian universities (2004; 2006) indicated that Industrial Design education excludes a number of DfS approaches. There is limited literature available that reflects upon what industrial designers should be taught in relation to DfS. Industrial Design has no national curriculum or governing body to certify courses; there has not been a critical review for input in the area.

The pedagogical approach of how to teach DfS to Industrial Designers again has limited supporting literature. This is concerning as Tilbury and Adams (2004) have highlighted the weakness of using prescriptive toolkits within industry to implement sustainability, yet rules of thumb and toolkits were frequently taught as a method for sustainability (Ramirez 2004). In summary, the preliminary literature review identified that Industrial Design education may be teaching only half of the available DfS approaches, with pedagogic approaches that are questionable and would benefit from revision.

Neither Industrial Design education nor the DfS theory can be viewed in isolation from Industrial Design practice, particularly as the initial literature review indicated a slow adoption of progressive DfS practices. There are theorists advocating for a reorientation of practice. Kemmis’ ‘knowing practice’ (2005) is drawn upon to locate education’s role within professional practice and society at large. Therefore discourse on DfS education is required to synthesise DfS for Industrial Design with regards to what students should learn and how this may be taught.
1.4 Innovativeness of this Research Project

The project is seen to be innovative in two ways. First; the project explores areas within the discipline that have not been looked at before (Pugh and Phillips 1994) in that there is insufficient scholarly information on Industrial Design Education for Sustainability with regards to both ‘what’ should be taught and ‘how’. Second, the research design of action research and the teacher as researcher takes advantage of the unique position of Industrial Design education not having a national curriculum. The research design allows multi-iterations of the action research cycle to take place using content analysis to internally validate the outcomes of the interventions.

1.5 Contribution to Knowledge

The research questions that the thesis has been guided by are as follows:

1. What DfS approaches are represented in the conceptual design scenarios of Industrial Design students?

2. What DfS approaches offer the highest sustaining potential?

3. How are the approaches with the highest sustaining potential integrated into Industrial Design education

It is envisaged that through exploring the above questions the study will provide insight to advance knowledge in relation to Industrial Design Education for Sustainability.

The specific findings of the thesis explore the correlation between problem defining and designing (how you define is how you design) in relation to Design for Sustainability education. One of the conditions for Industrial Design students to successfully utilise approaches with the highest sustaining potential in their designing is that a sound and nuanced definition of unsustainability is first established.

The study provides new insight into Design for Sustainability approaches that offer the highest sustaining potential, and proposes how such approaches are integrated into Industrial Design Education for Sustainability.
1.6 National Benefit

The thesis provides a national benefit in several ways. First, the education of Industrial Design students from the studied institution leave with an improved skill set to be able to Design for Sustainability in the literal sense.

Second, the results of the study will be disseminated to the Industrial Design Educators Networks of Australia. As Industrial Design does not have a national curriculum the results may be beneficial in informing the curriculum design of other design institutions within Australia.

Finally, the results of the study will be disseminated to the Design Institute of Australia for discussion with respect to the proposed career vocations presented in Chapter Nine.

1.7 Theoretical framing of the research process

The theoretical framing of this thesis has drawn upon Jurgen Habermas’ early work in his theory of ‘knowledge-constitutive interests’ (KCI) (1972, pp. 308–312). KCI is used in conjunction with my framework ‘how you define is how you design’ to explore DfS and its application in practice within DfS Education for Industrial Designers. Habermas argued that knowledge is influenced by one’s social surrounding, grounded in human needs that inform one’s understanding and actions. Habermas’ early work proposed that humans were interested in three particular types of knowledge; the ‘technical’, the ‘practical’ and the ‘emancipatory’ (1972, p. 311).

‘Technical knowledge’, also referred to as ‘work knowledge’, is embodied by the empirical sciences that seek truth in isolation. Habermas likened ‘technical knowledge to the human interest in controlling one’s environment. ‘Practical knowledge’ refers to the human interest of understanding, largely linked to the domain of the interpretive sciences. Finally, ‘emancipatory knowledge’ is seen as the culmination of both technical and practical knowledge for self development.

My framework, ‘how you define is how you design’, proposes that the understanding of ‘unsustainability’ is embodied in the realised design outcome. By default, an ill-informed understanding of unsustainability will lead to ill-defined
sustainable solutions. The correlation between definition (define) and strategy (design) is highlighted in Figure 1.1 How you define is how you design.

<table>
<thead>
<tr>
<th>How You Define</th>
<th>How you Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pollution is the problem</td>
<td>Cleaner Production</td>
</tr>
<tr>
<td>Waste is the problem</td>
<td>Design for Recycling</td>
</tr>
<tr>
<td>Resource Consumption</td>
<td>Design for Efficiency / LCA</td>
</tr>
<tr>
<td>C02 &amp; Climate Change</td>
<td>Carbon Neutral products &amp; Cap and Trade schemes</td>
</tr>
<tr>
<td>Sustainable Development</td>
<td>Green Design &amp; Ecodesign</td>
</tr>
<tr>
<td>‘Meet the needs of the present’</td>
<td></td>
</tr>
<tr>
<td>Product Based Well being Individual Ownership</td>
<td>‘Results focus’ design Product System Services</td>
</tr>
<tr>
<td>Lack of commons, Contemplative time &amp; Proliferation of remedial goods</td>
<td>Design orientated Scenarios &amp; Mainstream the marginalised</td>
</tr>
<tr>
<td>Inconspicuous and Embodied Consumption</td>
<td>GAP</td>
</tr>
</tbody>
</table>

*Figure 1.1 How you define is how you design*

Figure 1.1 presents the defining and designing as a cause–effect relationship, although in practice design solutions are mobilised in response to more than one problem. However, there is a strong correlation framed above between defining and designing. How the framework ‘How you define is how you design’ is mobilised by Habermas KCI’s is now discussed.

Technical knowledge when applied to DfS represents the dominant form of DfS to date, labelled as DfS1 above. This includes Design for Recycling, Cleaner Production and Design for Efficiency. The problem definition and the design response surrounding ‘technical knowledge’ are highlighted in Figure 1.2.

<table>
<thead>
<tr>
<th>How You Define</th>
<th>How you Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pollution is the problem</td>
<td>Cleaner Production</td>
</tr>
<tr>
<td>Waste is the problem</td>
<td>Design for Recycling</td>
</tr>
<tr>
<td>Resource Consumption</td>
<td>Design for Efficiency / LCA</td>
</tr>
</tbody>
</table>

*Figure 1.2 Technical knowledge*

Habermas’ second form of knowledge, ‘practical knowledge’, is ‘governed by binding consensual norms’ (MacIsaac 1996). That is, the study of meaning and value
within society. ‘Practical knowledge’ is closely aligned with the interpretive sciences that seek understanding. In DfS ‘practical knowledge’ favours the ‘social approach’ to DfS2 championed by Ezio Manzini and informed by insight from Elizabeth Shove, who attempt to understand the anthropocentric relationship to unsustainability. The ‘practical knowledge’ seeks to identify the unsustainable within social practices and normality. Figure 1.2 illustrates that there are inadequate design strategies to apply ‘practical knowledge’ as identified by Shove’s inconspicuous consumption. While excellent in illuminating the problem of unsustainability, there is limited transformation into technical design solutions.  

![Figure 1.3 Practical knowledge](image)

The combination of all three ‘knowledge constitutive interests’ inform our practice as individuals and designers. The hypothesis is that Industrial Design is informed heavily by ‘technical knowledge’ to the detriment to ‘practical’ knowledge. The ‘emancipatory knowledge’ would see the totality of approaches informing each other, ‘practical knowledge’ would be informing the ‘technical knowledge’. This is seen to have the potential to move towards DSF3 type solutions outlined previously.

Carr and Kemmis synthesise Habermas’ move to emancipatory knowledge through reconciling the understanding provided from the practical knowledge with the technical causal explanation (1983, p. 137). In relation to the theoretical framework for DfS, a reconciliation is required between ‘How you Define’ (practical knowledge) with regards to understanding the problem, and ‘How you Design’ (technical knowledge) in DfS. A reconciliation of the technical and practical is seen

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4 The relatively new concept of eco-visualisation (for examples see Tiffany Holmes [2008] or Peter Hall’s [2007] work) is a nascent area of design development that draws attention to the inconspicuous consumption of energy, however it is severely underdeveloped compared to the widely practised technical ‘solutions’.
as a way to move towards a critical form of design that can bring about a sustainable society.

1.8  **Research Methodology**

Action research is the methodology used for the project. The position of teacher-as-researcher outlined by Stenhouse (1975), and Carr and Kemmis (1983) was influential in the initial selection of the methodology. Industrial Design has no national certification, national curriculum or objectives that must be taught. Therefore the teacher as researcher has a greater capacity to influence the curriculum design than disciplines like nursing, education or engineering where certification and national curricula are present. The selection of Action Research as a methodology was in part due to the position of the researcher as an Industrial Design Teaching Fellow within the School of Engineering and Industrial Design at the University of Western Sydney. This unique position enabled the trialling of methods and approaches to teaching sustainability within a close time frame, as well as the exploration of ‘real world’ difficulties in teaching sustainable design. The sustainable design program within the Industrial Design course consists of three units, for which there is opportunity to assist in curriculum development through the dissemination of the research findings.

The findings of this research will feed into planning the overall sustainable design structure through the mechanisms of the course development team, of which the researcher is a key member. The unit at the centre of this research project is ‘300306 Sustainable Design: Sustainable Futures’. This unit, taught and developed by the researcher in collaboration with other members of the team, affords the opportunity for students to mobilise their materials education achieved in preceding Sustainable Design units in the generation of conceptual design solutions for complex future scenarios.

<table>
<thead>
<tr>
<th>Unit</th>
<th>Description from 2004 UWS Handbook</th>
</tr>
</thead>
<tbody>
<tr>
<td>300304 Sustainable Design: Materials Technology</td>
<td>This unit introduces basic thermodynamics, properties of fluids as well as mechanical and thermal properties of materials. It covers basic physical and chemical properties of metals, ceramics and plastics and discusses in some detail how these materials are chosen for fabrication of particular products as a</td>
</tr>
</tbody>
</table>
result of their physical and chemical properties. In addition, the manufacturing methods used to produce various products will be described and justified on the basis of the materials used.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>300309</td>
<td>Sustainable Design: Life Cycle Analysis</td>
<td>Designers prescribe the use of our limited materials resources with every product that transpires from their work. With an informed approach to design, based on a sound knowledge of materials from their origins to their disposal as well as manufacturing processes, systems and technologies, a designer can minimise the impact products have on the global community.</td>
</tr>
<tr>
<td>300306</td>
<td>Sustainable Design: Sustainable Futures</td>
<td>“If science and planning march under the banner of “everything is possible”, design culture must know how to point out a path for these potential possibilities, a path that can be completely opposed to that which technological – scientific development has followed up to now” (Manzini 1995, p.237). This unit explores the challenges facing design culture in which the designer must now provide scenarios that visualise some aspects of how the world could be and, at the same, time, present it with such characteristics that can be supported by complex ecological equilibria, which are acceptable socially and attractive culturally.</td>
</tr>
</tbody>
</table>

The ‘sustainable design stream team’ consists of four academic staff who teach into the above sustainable design units as outlined in Table 1.1. The committee allows for incremental changes within the running of the three units to be managed internally, while minor or major course changes are proposed by the ‘stream team’ in the below structure for approval (see Figure 1.4).

![Figure 1.4 Committee structure for course alterations UWS](image)

5 Adapted from McPhail, Riley et al. 2003, p. 5.

Due to the context of the project, action research was selected as the most applicable method. The five stages of action research from Susman and Evered (1978) are outlined below and applied to this thesis:

5 Over the course of the thesis the sustainable design units have evolved from the model outlined in 2004 based on input from the sustainable design stream, including input from this thesis.
1. **Diagnosing**; defining the problem through the inductive research strategy after analysing students’ ‘conceptual design scenarios’.

2. **Action planning**; considering alternate course of actions informed by the theories of both sustainability and education.

3. **Action Taking**; an intervention implementing the changes within the University of Western Sydney Sustainable Design curriculum by working closely with key staff members.

4. **Evaluating**; using content analysis, students’ ‘conceptual design scenarios’ are evaluated to assess the impact of the intervention.

5. **Specifying Learning**: Disseminating the results directly to relevant staff and publishing the results of this thesis.

The project’s duration runs across three years. The research process across four years is illustrated in Figure 1.5 on the following page.
The theoretical and pedagogic intervention as well as the ‘pedagogical framework for Industrial Design Education for Sustainability’ were not planned priori and evolved out of the inductive research methodology.

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*Figure 1.5 Action Research cycle across study*
1.9 **Research Methods**

Three key data sets inform the study as illustrated in Figure 1.4. These are the literature review, content analysis of student conceptual design scenarios and content analysis of Design for Sustainability case studies.

1.9.1 **Literature Review**

To gain an understating of sustainability theory, a rigorous literature review of the scholarly trends was conducted. The review looked at sustainability in the broader sense as well as in relation to industrial design. From the literature review the themes for the content analysis categories were developed to assist in answering the research questions.

1.9.2 **Content Analysis of Student Conceptual Design Scenarios**

Content analysis was used to objectively inform the interventions made into the unit *Sustainable Design: Sustainable Futures*. The inductive nature of the research design allowed the analysis to inform the interventions that took place. The year 2005 formed a pilot year for the study (with no intervention). Student submissions from this pilot were analysed via content analysis. The results of the analysis informed the theoretical interventions made in 2006. The results of 2006, which were interpreted in relation to the additional pedagogical literature, informed the pedagogical interventions for 2007. The results of 2007 were analysed further to provide insight into DfS education that informs the *Pedagogical Framework for Industrial Design Education for Sustainability* proposed in Chapter Nine. The results address two research questions: ‘what DfS approaches are represented in the conceptual design scenarios of Industrial Design students?’ and ‘how are the approaches with the highest sustaining potential integrated into Industrial Design?’.

The sample for the study is all second year Industrial Design students from the University of Western Sydney taking part in Unit 300306 *Sustainable Design: Sustainable Futures*. The sample for analysis is the final Conceptual Design Scenarios submitted within the same unit across 2005–2007. This is a core unit within a core stream i.e. all students enrolled in the Industrial Design or Design and Technology degree must complete these units.
1.9.3 Content Analysis of Design for Sustainability Case Studies

To posit the study in a broader context, DfS case studies from the literature were analysed to provide insight into the question ‘what DFS approaches offer the highest sustaining potential?’. Reputable websites aligned to both the design community and academia that showcase DfS also provided case studies for analysis.

1.10 Thesis

The thesis advanced through this research is that students of Industrial Design can design for sustainability if an appropriate understanding of unsustainability is defined (the problem context), supported by pedagogic processes to transform the understanding into design and justified for real world application for Industrial Design practice.

1.11 Structure of Thesis

The thesis has been structured in ten chapters. The current chapter; Introduction, introduces the research problem: Why are students of Industrial Design unable to design in a way that can contribute in real terms to a sustainable society, economy or ecology? The chapter also provides an overview of the structure of the thesis.

Chapter 2: How You Define is How You Design explores the theoretical background for the study in relation to defining unsustainability, Design for Sustainability practice and Industrial Design Education for Sustainability. The dominance of the popular ‘technically orientated’ DfS strategies and their formation on inadequate narrow definitions of unsustainability are illustrated, and a more refined definition of unsustainability in relation to social as well as technical considerations is proposed. Finally, the chapter explores how Industrial Design education at present is founded on inadequate definitions of unsustainability, compounded by pedagogies that limit Industrial Design students’ ability to generate sound definitions of the unsustainable.

Chapter 3: Conceptual Tools for Analysing the Practice of Industrial Design Education for Sustainability introduces the theoretical concepts used to analyse
students’ design output from Industrial Design Education for Sustainability with this study.

Chapter 4: *Action Research and the ‘Teacher as Researcher’* introduces the methodology of Action Research used within the study following Stenhouse’s (1975) and Carr and Kemmis’s (1983) original intent of the teacher as researcher. The chapter presents how Content Analysis has been used to overcome the threats associated with conducting action research projects (Kock 2004).

The evidentiary chapters (Chapters 5 through to 8) present the analysis of Industrial Design students’ ‘conceptual design scenarios’, which evaluates the theoretical and pedagogical interventions implemented in 2006 and 2007 to enable Industrial Design students to better design for sustainability.

Chapter 5: *Analysis 2005: DfS the Status Quo* presents the problems experienced by students in understanding the scale and complexity of unsustainability supported by design, and transforming this understanding into appropriate design solutions. The year 2005 formed the pilot year for the study and informed the strategies for the theoretical intervention in 2006.

The theoretical intervention of 2006 focused on enabling students to better define and transform unsustainability into Designs for Sustainability. Chapter 6: *Analysis 2006: From DfS Theory to Pedagogy* presents the results of the first intervention, strengthening the relationship between defining unsustainability and designing for sustainability. The analysis of 2006 shifted the focus of the study from sustainable theory to pedagogy. The action plan developed for 2007 was informed by the analysis of 2006 and introduced the pedagogy of Deep Learning, specifically how Student-Centred delivery may engage Industrial Design students to further enable their ability to Design for Sustainability.

Chapter 7: *Analysis 2007: Reconciling Defining and Designing* presents the analysis of the subsequent pedagogic intervention, which assisted in developing students’ capabilities to design for sustainability. The results of the action research process illuminated the challenges for Industrial Design Education for Sustainability, particularly the conflict between the tradition of Industrial Design and the challenges that DfS asks students to confront and respond to. This is returned to in Chapter 9.
Chapter 8: Case Study Analysis and Challenges for Industrial Design Education for Sustainability, while presented out of sequence from the chronological analysis, presents the analysis of case studies collated from the DfS literature. The chapter presents several key findings to the study. First, the chapter confirms the dominance of Ecodesign. Second, the correlations between coding categories indicate that the categories of a ‘Social’ school of thought, combined with ‘functional’ and ‘systems innovation’, have the highest sustaining potential. Third, specific case studies utilising the ‘combined categories of high sustaining potential’ are reviewed to identify contemporary DfS challenges in design for behavioural change and design for the local community which are further explored in Chapter Nine.

Chapter 9: A Pedagogical Framework for Industrial Design Education for Sustainability considers the findings from the evidentiary chapters to present a proposal to allow Industrial Designers to address the more abstract forms of DfS3-type designing, such as designing for behavioural change. The core of the proposal utilises community based social marketing (McKenzie-Mohr and Smith 1999) to design for behavioural change, which may be realised in three vocation variations. It is suggested that Industrial Design Education for Sustainability would benefit from engaging with the vocational variations, which are: first, designers applying their skill set as a concept generator; which is seen as a core role of the traditional Industrial Designer and is particularly relevant to DfS because of the limited availability of ‘to hand’ solutions; second, as entrepreneur; which is applying design’s problem solving skills to new profitable business ventures dedicated to generating sustainability and; third, as a DfS consultant; which applies design’s creativity skills to facilitate individuals, business and communities move to a lower ecological, carbon and energy footprint (the savings from energy and oil would offset the consultancy fee). The chapter supports each mode of vocation with recommendations to integrate into Industrial Design Education for Sustainability.

How this thesis has addressed the research questions and contributed to advancing knowledge for Industrial Design Education for Sustainability is discussed in the final chapter Conclusion.
1.12 Conclusion

The introduction has outlined the research problem of Industrial Design students’ difficulty in Designing for Sustainability. The research design structured around literature review, action research and content analysis has been presented in response to the research problem. The following chapter presents a review of the literature with regards to the theoretical framework ‘How you define is how you design’.
2 How You Define is How You Design

The intention of this literature review is to investigate the theoretical context for the key argument that problematic definitions of sustainability contribute to problematic Designs for Sustainability (DfS). Understandings of ‘unsustainability’ are embodied in realised design outcomes, or ‘how you define is how you design’. The chapter presents a progression in definitions of unsustainability through a historical reading from Ecodesign to DfS, illustrating how Industrial Design has not yet engaged in the complexity of unsustainability through over-consumption as a significant cause of the ecological crisis.

2.1 Presentation

A brief summary of DfS strategies in the initial pages of this chapter provide an overview of the key argument making the link between defining and designing, to illustrate that the dominant ‘tacit’ definitions of DfS are based on a flawed definition of unsustainability.

This is followed by a presentation of the researcher’s understanding of the ecological crisis (a key contributor to unsustainability). This understanding affords a more substantial critique of DfS strategies which makes up the body of this chapter. This includes the most promising approaches to bring about the desired DfS3-type solutions.

The chapter concludes with a critique of the state of Industrial Design Education for Sustainability in light of the argument presented in the literature preceding it.
2.2 An ill-defined foundation

The early focus of Ecodesign and DfS1-type solutions framed pollution as the problem, therefore cleaner production was the solution; waste was the problem therefore recycling was the solution; resource exploitation the problem, therefore life cycle analysis and design for efficiency (Ecodesign) were deemed solutions. These initial strategies represent a ‘technical’ school of thought, in that each of these strategies attempts to solve the problem without recourse to human users and the complexity of everyday social practices which are supported by existing designs. Ecodesign is seen as the dominant form of DfS engaged with by industry to date. The concern is that in isolating problems from social processes, the dominant forms of DfS1 practice are based upon a narrow, non-relational and ill-defined notion of unsustainability. For example, ‘cleaner production’ does not respond to the problem of ‘waste’, and is incapable of bringing about substantial change for a sustainable society.

A progression to more refined ‘substantial’ definitions of unsustainability that incorporates the ‘social’ dimension to guide designers’ in concept generation of DfS2-type solutions has been attempted; for example, identifying Product-Based Wellbeing (wellbeing derived from the individual ownership of consumer products) as a problem (Manzini 2003a) invites solutions that take account of how design informs and supports everyday social practices, such as is attempted by Product System Services which challenge individual ownership. This marks a progression from the end of pipe solutions (waste and pollutions) to the front of pipe in acknowledging consumption. Schmidt-Bleek’s (1999) Material Intensity Per unit of Service (MIPS) presents a strategy that defines inefficient material consumption matched with poor service life as the problem, therefore more efficient ‘matching’ of material input and the use made of these materials become design goals. Tischner’s progressive abstraction (Tukker and Tischner 2004, p.216) is used as a creativity tool to generate solutions from repeatedly asking the question ‘what are we actually

Schmidt-Bleek’s MIPS equation has been appropriated within the thesis as providing a useful means to focus equally on both materials intensity and use life. The focus of use life has been extended by the author to include the largely social dimension of use, like personal ownership or sharing.
aiming for?’. It assists in moving from the underlying problem such as viewing the car as the problem, to viewing the movement of people as the problem, to the need to move as the problem. Repeatedly challenging the problem definition seeks to identify the problem at a more fundamental level. This can be applied to the history of DfS as the ‘tacit’ definitions have progressively moved deeper and deeper to what would be more fundamental causes of unsustainability.

Progressive theorists such as Manzini (2003a) and Shove (2003), who both in different ways account for the social role of industrial design, have proven most useful in understanding the move from treating the symptoms of unsustainability to treating the causes. Manzini defines unsustainability in social terms as a deterioration to what he calls ‘the commons’ and contemplative time. The ‘commons’ refer to those resources that are owned by none and thus all that we have a right to (i.e. water, air, community) (2003a, p. 5). Contemplative time is time to do nothing; time that is unscripted (2003a, p. 6). He posits Design Orientated Scenarios (DOS) as a framework for conceptual development that attempts to restore the ‘commons’ via bringing people together, and assist in the creation of contemplative time.

Shove’s work can be appropriated to define the problem of unsustainability in terms of what she calls 3 C’s: ‘comfort, cleanliness and convenience’ (2003, p. 395). The key idea in her argument is that consumption is a reasonable consequence of the existing options available to people (‘consumers’). Over-consumption is therefore ‘inconspicuous’; it is not directly intentional nor is it understood as such. Existing products, social conventions and practices ‘hold together’ our resource-intensive everyday practices in complex ways that can not simply be reversed by technically efficient design solutions. Inconspicuous consumption and the role of design in supporting this unintentional consumption is defined as the key problem, to which there has been a limited design response.

To bring the above into an educational context, Ramirez’s (2006; 2007) studies of both Australian and international institutions teaching industrial design highlighted that the types of DfS taught are dominated by a technical approach (DfS1) focusing upon end of pipe strategies such as recycling and disposal. Educators defined ‘sustainability as being identical with ecological design or green design, which focuses mostly on ‘minimization of environmental impacts and
usually not covering aspects of promoting equity’ (2007, p. 3). This indicates that pedagogy tends to reflect the dominant technical approaches and need to take a far more active role in reflecting and responding to progressive literature on sustainability. This is problematic for Industrial Design education for sustainability and indicates that an intervention is required to shift the understanding of unsustainability to a more holistic approach. Design education in the form outlined above may be contributing to the broader problem of inadequately Designing for Sustainability.

The concepts and argument presented above will be returned to in detail. Given the first part of the thesis presented in Chapter 1 that ‘students can design for sustainability if an appropriate understanding of unsustainability is defined’, the researcher’s understanding of unsustainability will now be presented to enable a more substantial critique of the DfS strategies later in the chapter. The researcher’s understanding is framed by the complex concealment of resource consumption by design in two key ways: first, the consumption of natural resources is embodied in consumer products in ways that conceal the weight and scale of this depletion, and, second; the consumption of natural resources is made inconspicuous in our everyday lives. These two forms of consumption, one from the production side (embodied consumption) and the other from the demand side (inconspicuous consumption), are both driven by design and are presented as major contributors to the ecological crisis.

### 2.3 Embodied and Inconspicuous Consumption in Everyday Life

The following section reviews over-consumption of natural resources in the light of everyday practices, to present embodied and inconspicuous consumption as two key relevant drivers of the current ecological crisis. Industrial Design’s role in facilitating this consumption in our everyday life is explored, and provides insight into understanding unsustainability. This understanding is critical in informing the interventions that could occur for Industrial Design practitioners to DfS3.

According to the growing body of literature we are living beyond the ecological limits of our planet, with a suggested reduction in resource use of up to
95% for western countries in order to be sustainable (Vergragt 2004). The Club of Rome as early as 1972 published ‘the limits of growth’, which indicated the coming ecological crisis by identifying that continued economic growth dependent on natural resources will lead to a shortage of natural resources (Meadows 1972).

In recent years the debate has shifted focus from the consumption of natural resources to the issue of climate change, which has received unprecedented international attention. The Stern review proclaims: ‘the scientific evidence is now overwhelming; climate change presents very serious global risks and it demands an urgent global response’ of which ‘the benefits of strong, early action on climate change outweigh the costs’ (Stern 2006, p. i). However as there is a causal relationship between carbon dioxide (CO$_2$) production and resource consumption (Lenzen 1998), the extraction, transformation and depletion of natural resources is still of central concern. Climate change is in part a measurable consequence of this activity.

It is not the focus of this thesis to further substantiate the evidence of ecological crisis as a result of human activity; the position is taken that there is sufficient evidence of an ecological crisis$^8$ which is unsustainable, and the remainder of the thesis is presented in light of the above assumption.

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$^8$ Source: Steffen et al. (2004)

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$^8$ For example the WWF 2008 report states: ‘Humanity’s demand upon the planet’s living resources, its ecological footprint, now exceeds the planet’s regenerative capacity by about 30 percent’ (p. 2).
The effect of over-consumption in deteriorating natural resources over the past two centuries is illustrated by Steffen in Figure 2.1. The figure highlights the sharp decline over the past century of rainforests, and a sharp increase in water use and levels of carbon dioxide concentration. The causal relationship between resource consumption and the ecological impact is also illustrated in Figure 2.1. As the rate and scale of human consumption has increased in the past century (i.e. cars and paper), there has been an equal decrease of natural resources (i.e. rainforest and increased carbon).

Tonkinwise (2005) likens the ecological crisis to a ‘death by a thousand cuts’, in that it is the compounding effects of many factors, rather than singular causes, that makes the crisis problematic. Figure 2.2 extrapolates the metaphor by showing that the exponential rise in consumption has occurred on many levels since the turn of the 20th century, which are synergistically related.

<table>
<thead>
<tr>
<th>Population Increase</th>
<th>5 fold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight of good owned per capita</td>
<td>2-3 fold</td>
</tr>
<tr>
<td>Rucksack increase per kilogram</td>
<td>2-3 fold</td>
</tr>
<tr>
<td>Energy Consumption Per capita</td>
<td>2-3 fold</td>
</tr>
<tr>
<td>Only relevant</td>
<td>1/5 of the world’s population</td>
</tr>
</tbody>
</table>

Figure 2.2 Increased resource dependency 1900–1995

The compounding effects of the above Figure 2.2 enable us to see the magnitude of the increase in consumption, not only has the population increase created a higher demand for resources, but the amount of resources (weight) per capita has increased through a dramatic increase in goods owned. Most of the products today are manufactured at a greatly reduced weight to their 1900 counterparts, however in order to achieve this reduction in weight new alloys have been employed. These materials have a higher ecological rucksack than the traditional materials of natural fibres, woods and metal which were the dominant materials at the turn of the 20th century. Matos and Wagner (1998) state that individual consumption of materials per capita in the USA increased five fold from two tonnes to ten tonnes over the period 1900–1995.

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9 Ecological rucksacks are figures indicating the amount of earth and water disturbed to make one unit of material. For example, aluminium’s ecological rucksack of 85 illustrates that 85 kg of earth are disturbed to make 1 kg of aluminium (Schmidt-Bleek 1999, p. 9).
An extrapolation of Figure 2.2 equates to an average twenty-five fold increase in resource use and a ten to fifteen fold increase in energy overall from 1900–1995. Currently the figures apply only to the developed world. If the remaining four-fifths of the world develop in a similar manner to the west, then the forecast resource dependency would equate to a one hundred and twenty-five fold increase in resource use from levels in 1900. So the ecological impact of lightweight materials is to some extent displaced and concealed by the use of advanced materials such as plastics, composite fibres and by the evolution of materials innovation.

The simple extrapolation of potential resource use, although elementary in its working, exposes the premise for targets in resource reduction. The Club of Rome proposed a reduction in resource consumption by a Factor of 4 in 1972 (Meadows 1972); the Wuppertal Institutes proposed a Factor 10 reduction (Schmidt-Bleek 1999) and the Netherlands Government a reduction by a Factor of 20 (Vergragt 2004) These proposed factor reductions in resource use indicate the radical scale of change that appears to be needed. It is clear from the above that over-consumption of our natural resources is a core contributor to the ecological crisis and thus is a key indicator of our unsustainability.

Embodied consumption refers to the natural resources and energy that are embodied within the product during the manufacturing phase of a product’s lifecycle. Embodied consumption can be quantified through ecological rucksacks, for example an average laptop may have a rucksack of 4,000 (Hawken, Lovins et al. 1999, p.50) meaning a 3 kg laptop multiplied by a rucksack of 4,000 has disturbed 12,000 kg of earth in production. Lenzen’s study of primary energy and greenhouse gases in Australia (1998) illustrates that the majority of this embodied energy is consumed inconspicuously in the purchasing of goods and services for the house (see Figure 2.3).

The individual may theoretically connect the relation between their home electricity use and green house gases. However the embodied energy (like the ecological rucksack) in purchased goods is hidden from the end user; it would require relational thinking to recognise this embodied energy and resources. Embodied consumption means the end user is only able to see the tip of the iceberg in terms of the resources that they consume.
Lenzen’s breakdown of greenhouse gas requirements into final consumption categories highlights the embodied nature of everyday consumption. Greenhouse gases directly related to household electricity and car use form only 11% of the greenhouse gas consumed yet can be seen as the focus of the majority of reduction campaigns (1998, p. 505). For example the NSW Department of Environment and Climate Change budgeted a 63 million dollar scheme to retrofit low income earners’ homes to be more energy efficient (2008), which ignores the throughput of goods and services. The results would suggest that a greater focus away from just the end use energy is required, and greater focus to be placed upon the throughput of material goods consumed in our everyday life. Tonkinwise suggests that it is the throughput of goods in the house, and the rapidity of their turn over which is a key indicator of problematic consumption (2005). Tony Fry writes that it is precisely our lack of consumption of the goods that we purchase, use and dispose of that is the problem. The garbage or waste dump is full of items that have not been consumed (1999, p. 109). These unconsumed goods all have embodied energy and greenhouse gases associated with their production.

The vast amount of consumption that occurs in this way is supported by mundane and normal everyday routines and practices. Manzini’s (2003a) work focuses on daily routines with the premise that it is the boring and mundane actions in our everyday life that drive unsustainability. We are unintentionally unsustainable...
in small actions that are repeated everyday in contexts of familiarity and dependence. Elizabeth Shove (2003) provides a nuanced and useful account of the everyday context and the role of design in ‘holding together’ normal, everyday practices. The everyday is an important locus of unsustainable consumption, but as Shove shows, the consuming that everyday practices demand is largely unthought and inconspicuous. Shove’s study of social normality provides insight into consumption practices that push beyond the boundaries of the intentionality of the self-declared green consumer and the ethics of individual choice. Shove’s studies identify the ingrained nature of daily behaviours that contribute to resource dependent lifestyles. The argument so far has identified that over-consumption is at the root of the ecological crisis, and that consumption is embodied in material products which are not in fact effectively consumed. Shove explores how inconspicuous consumption becomes normal and habitual through everyday practices.

Shove (2003) makes three claims in presenting her argument: first; that the everyday consumption of resources is directly related to normal and familiar experiences; second, that the everyday consumption of resources is largely unnoticed or invisible to the end user, for example space heating contributes significantly to the world’s energy demands yet is so ingrained within everyday life that it has become a basic structural feature of our everyday environments; third, the over consuming conventions of the everyday are ratcheting upward in various ways, implicitly demanding more resources which have severe ecological implications. This provides another view of the exponential increases in consumption discussed earlier.

Shove (2003) demonstrates her key claims of changing conventions via the study of three areas, comfort, cleanliness and convenience, which she identifies as important ‘hotspots’ of consumption relating largely to daily practices within the home. Lenzin’s study identified that 48% of CO₂e consumed within Australia is related to the acquisition of goods and services for the house; Shove uses similar statistics such as the 70% increase in domestic water consumption in the last 30 years (Yorkshire water 2002 cited in Shove 2003, p. 396).

Comfort is discussed through the example of air conditioning, which has redistributed the management of one’s own thermal comfort through appropriate clothing to regulated space heating of home, workplace, car and shops. This represents a dramatic shift in the need for personal climatic awareness and
sensitivity. Thermal comfort has been the focus of scientific psychological studies identifying temperatures of the optimum ‘comfort zone’. As no climate in the world meets the scientific ‘comfort zone’ of 22°C, all climates within the world, no matter how mild, have become the potential markets for air-conditioning (Cooper cited in Shove 2003).

The standardisation of comfort across cultures has seen a shift in space design to accommodate 22°C. Clothing is designed for comfort at 22°C; buildings have been hermetically sealed to stabilise the interior climate at 22°C via air conditioning. This is at the expense of the traditional passive building techniques that every civilisation has historically developed to mitigate the harshness of their climate. Even Mexico’s siesta was not spared; once 22°C became normal, air conditioning removed the need to escape the afternoon heat. Shove describes the standardisation of air-conditioning in terms of a ratchet effect, there appears to be no way back and the course of design (e.g. path dependencies of technological innovation) continues to accommodate the standard at the expense of traditional practice.

Cleanliness is explored by Shove in relation to changes in laundering and bathing habits over time. She identifies that today, cleanliness relates not just to the removal of dirt, but as much to the social ideals of practice such as the ‘power shower’ that has developed to freshen up or relax after a hard day’s work. History identifies a major shift in practice from the weekly shower to the twice daily shower with obvious resource implications in potable water usage. The conception of ‘dirty’ clothes has also, Shove shows, been substantially shifted by clothes washing technologies and what they afford. You may not only have enough clothes to wear, but enough clothes to wear that are socially acceptable. The availability of personal ownership of washing machines and driers has dramatically altered washing practices of the past. The washing can now be done at night, or when raining, which leads us to the final convention Shove considers: that of convenience.

Shove (2003) considers how convenience and perceptions of efficiency have allowed products to become a dominant focus within the domestic environment. Convenience is not just simply an efficiency measure, but allows products to purchase or shift time. For example, the microwave allows food to be prepared quicker; the freezer allows you to cook on Saturday so you can store food to be
quickly reheated with a reduced preparation time through the week. Convenience
goods have also shifted from a self-sufficiency model to reliance on outside
production; particularly in time-poor societies involved in the work–spend cycle.\textsuperscript{10} Mass transportation, storage and packaging were necessitated by the model of
centralised supply.

The insights into the normality of everyday practices provided by Shove’s
perspective on inconspicuous consumption are beneficial in defining the complexity
of unsustainability. When inconspicuous consumption is added to the embodied
consumption in goods prior to their take-up in everyday practices, a dire picture is
painted. Embodied consumption suggests that we only see the tip of the iceberg in
terms of the resources consumed in the production of goods, and the refuse entailed
by our ‘unconsumption’, whereas inconspicuous consumption implies that we may
not even be aware of the iceberg at all.

Shove’s insights into the detail of unsustainability help to delineate what Fry
describes as ‘the very ground upon which the unconsumption of unsustainable living
is constructed’ (1999, p. 109). In describing the social construction of normality,
Shove also identifies the social significance of design and its effect upon the
household. Industrial Design’s role in this nexus of normal consumption is discussed
in the following section, drawing upon Fry (1999) who attributes the development of
structured-in unsustainability squarely on the shoulders of Industrial Design.

Industrial Design’s contribution to unsustainability was foreseen by Victor
Papanek in his 1972 publication ‘design for the real world’:

There are professions more harmful than industrial design, but only a very few of
them. And possibly, only one profession is phonier. Advertising design, in persuading
people to buy things they don’t need, with money they don’t have, in order to impress
others who don’t care, is probably the phoniest field in existence today. Industrial
design, by concocting the tawdry idiocies hawked by advertisers, comes a close second

Papanek’s view of consumption implicates advertising design and Industrial
Design’s role in conspicuous consumption, whereby Fry is more strident in his
argument that attributes the damaging consequences of design far beyond the retail
end of consumption. Design also shapes the consuming that is not intentional, that is
structured in to our worlds and activities and rests on legacies of the past. Industrial

\textsuperscript{10} The work–spend cycle is identified by Schor 1992, cited in Shove 2003, p. 11. The cycle is seen to
reduce the available time for self sufficiency, increasing dependency on others.
Design helped to normalise consumption (Andrews 2007; Fry 1999), as Fry (1999, p. 108) describes in response to the household of the 1930s:

The mechanism of the household, for instance, became a complex mix of the development of mechanical services, the rise of the domestic technologies and the arrival of factory processed or produced foodstuffs that often required another technology to store or cook (for instance ice cream demands the refrigerator, tinned soup required a cooker). The impact of these technologies has been profound: mains sewage systems transformed public health; piped potable water enabled laundry to be done at home, while water heaters changed bathing habits; domestic refrigeration changed the patterns of food marketing, storage and purchasing. In turn piped gas and then mains electricity created new domestic cultures via the technologies of light and cooking. Then there have been all the consequences of the rise of the radio, television, video, home computers and a whole host of domestic appliances — vacuum cleaners sewing machines, washing machines and so on. The technologies were forces that transformed not only the home but the very nature of the fabric of social and community life. In many respects, these technologies worked and still do to atomise social life and individualise domestic labour: they altered and still alter, temporal and spatial existence.

Social normality in many ways has been facilitated unintentionally by Industrial Design practitioners as is articulated in the above quote. Fry has stated that resource intensive consumption in the everyday context was set in place from the early years of Industrial Design and that important synergies between products and social practices served to embed this consumption. Industrial Design played an integral role in developing the consumer society via the promotion of goods into the home. For each of the examples outlined by Shove, Industrial Designers developed a range of products to promote comfort, cleanliness or convenience. Early Industrial Designers were opportunistic in the role they played in stimulating the economy of the USA after the Great Depression. By making desirable goods and stimulating spending, increasing consumption was seen as a tool to grow the economy. The early designers applied stylistic, streamlined aesthetics to a variety of manufactured goods from cars to appliances. For the first time, style was affordable to the masses, and matched with rhetoric from all spheres of influence (national and state politics, increased wages at work and a shift in education) that viewed progress as good (Fry, 1999). Andrews summates (2007, p. 58):

Industrial design made mass produced products desirable as a means to stimulate consumption. It set about to clearly define the role of the consumer as a functional unit in what would be an efficient and balanced socio-economic system. It provided industry with the tools to make more products more economically and created a market to consume them. In return for their consensus to buy their products industrial designers promised consumers a prosperous and ordered Utopian end point of material well-being. They explicitly linked happiness to material consumption and constructed, carefully and deliberately, product-based well-being. They created desire and the context for the ever new, establishing an enduring and self-renewing spiral of material consumption that instigated the contemporary environment crisis of over-consumption.
The ecological crisis is in part formed by excessive resource consumption; the drivers for resource consumption lie in the embodied and inconspicuous nature of our daily consumption. Our social normality has driven resource consumption; therefore to address resource consumption a greater, more nuanced understanding of social normality is required on the part of designers.

This above understanding of unsustainability is now contrasted with the dominant definitions of sustainability presented and embodied in Industrial Design practice.

2.4 Problematic Definitions of Sustainability for Industrial Design Practice

The rate and scale of resource consumption, driven by inconspicuous and embodied consumption within everyday life, is identified by the researcher in the previous section as a driver for unsustainability. In light of this understanding, two concepts will be discussed; first Ehrlich’s equation (Ehrlich and Holdren 1972) for consumption and second, the dominant international definition of sustainable development.

Ehrlich and Holdren derived the IPAT equation: Impact = Population (P) x Affluence (A) x Technology (T) in the early 1970s (Chertow 2001). The equation was an attempt to identify and quantify the factors that lead to environmental impacts. The equation highlights that human impact can be viewed as the product of three factors, the number of people (population), the amount consumed per capita (described as affluence) and finally the environmental disruptiveness of technology in producing goods (technology). UNEP (2002) amended the equation to read affluence as units of consumption per head and technology as environmental efficiency, which can be quantified using ecological rucksacks mentioned earlier in this chapter. IPAT states that impact can be curtailed by reducing population, reducing consumption or improving efficiency. For industrial design practice, population is difficult to address, however efficiency and consumption may be targeted.

The second definition, ‘sustainable development’, contrasts with the IPAT equation. ‘Sustainable Development’ from the Brundtland report Our Common
Future is defined as ‘development that meets the needs of today without compromising the ability of future generations to meet their own needs’ (World Commission on Environment and Development 1987 p. 43). The definition is the most cited in international discourse on sustainability, and it is from this recognised definition that separate schools of thought about sustainability begin to emerge. The debate centres on the term ‘sustainable development’, being an oxymoron to many environmentalists and academics (Fry 1994) as development linked to further economic growth, implies an expansion in resource use.

The fact that development is inherently antagonistic to sustainability and the ‘limits to growth’ argument effectively disappears as a concern in the Brundtland definition, which has gone on to inform the declared environmental and sustainability activities of government and industry. Sustainable Development promotes business as usual growth linked to the escalating throughput of goods, (albeit with cleaner, more efficient forms of production). As Wolfgang Sachs (cited in Sessions 1995, p.434).expands:

Even bearing in mind a very loose definition of development, the anthropocentric bias of the statement springs to mind; it is not the preservation of nature’s dignity which is on the international agenda, but to extend human-centered utilitarianism to posterity.

The definition we shall see has only facilitated the exponential internal consumption at the core of unsustainability that we have described as embodied and inconspicuous. Fry (1994) proposed a rephrasing of Ecological Sustainable Development (ESD) into Developing Ecological Sustainments (DES). Developing Ecological Sustainments clearly articulates that it is sustainability that needs to be developed, not development that needs to be sustained.

Robinson suggests that it is from the debate on terminology that two distinct schools of thought with regard to defining sustainability can be generalised: the technical and the social (2004). ‘Sustainable Development’ leans to a ‘technical’ orientation in addressing sustainability as it places faith in the development of technology and science to bring about efficiencies that would support a more sustainable society. The ‘social’ approach of sustainability promotes a change in shared values (cultural change) and everyday behaviour, a social response. This

11 ‘Sustainments are concrete initiatives that aim to promote and sustain change toward more sustainable ways of living and working. No sustainment is, by itself, “sustainable”’. Rather, sustainments are contributions to the development of sustainability as a concept and a realised way of living and working’ (Eco Design Foundation 2005).
understanding of approaches has been identified in DfS theory by Fletcher and Goggin (2001), who suggest that there is a requirement to progress from ‘product focus’ [technical] to ‘results focus’ to ‘needs focus’ [social].

The technical school of thought is interpreted by the author to be orientated to ‘technology’ within the IPAT equation, while the ‘social’ approach is seen to have the potential to reduce the impact of ‘affluence’ through behaviour change to reduce the amount consumed per capita.

The school of thought and definitions on sustainability are of paramount importance in determining the different practices of DfS1–DfS3. For Industrial Designers the above debate is relevant with respect to the proposal how you define is how you design. The practitioner’s position on sustainability, their definition of the problem, inform the solutions proposed and become embodied within designed forms. A brief example of the divide in practice of ‘technical’ and ‘social’ approaches and how significant it can be in terms of design outcomes can be illustrated using the car.

The ‘technical’ approach focuses clearly on developing a more efficient car, such as the Weizacker and Hawken’s ‘Hypercar’ that affords four to ten fold efficiency gains through using alternative lightweight construction materials such as carbon fibre and alternate efficient engines. (Weizsacker, Lovins et al. 1997; Hawken, Lovins et al. 1999). Such a car can be mass produced and sold in a way that complements the economic model of sustainable development. It solves a problem technically without accounting for how that technical solution would get taken up in practices and the impacts of its mass diffusion. It also fails to account for the existing stock of cars which is theoretically made redundant by this new sustainable technology and thus contributes to the ‘unconsumed’ refuse.

The ‘social’ approach focuses more on the car as a facilitator of social services which may be met in alternative ways. This necessarily directs attention to the capacity of design to facilitate shifts in expectation and sustained behavioural change. An example of this is car pooling whereby you carry a passenger with you travelling on a similar route which makes the car twice as efficient; if you have five people in the car you are operating the car five times more efficiently.
The above example illustrates the possible approaches available to Industrial Design practitioners in addressing sustainability. The following section illustrates the dominance of the technical approach within Ecodesign.

### 2.5 Ecodesign: Revealing Inconspicuous Consumption

Industrial Design readily fitted into the Brundtland model by greening rather than changing its practices. Ecodesign (DfS1) fits within a framework whereby the design brief is not questioned, and the focus is on servicing clients’ needs in a manner that is less damaging to the environment. The question ‘what to design?’ or ‘why design?’ is not afforded, as Fletcher and Goggin note this type of Ecodesign is intensely ‘product focused’ (2001). The early focus of Ecodesign (termed green design in the 1980s) was on ‘greening’ products through minimising the environmental impacts of the products that designers produce (Madge 1997).

The early focus of Ecodesign identified pollution as the problem, therefore cleaner production was the solution; waste was the problem therefore recycling was the solution.\(^\text{12}\) As Ecodesign progressed and became more sophisticated, the impact of the product across its entire lifespan came into question, as opposed to just the end of life as described by Blewitt and Cunningham (2004, p. 92):

> … a method for systematically integrating environmental considerations into the designs of products, systems and services throughout their lifetime. It can be argued that eco-design goes beyond simply seeking to minimize waste and pollution effects. Instead, it seeks to look at the entire process over the complete lifecycle, beginning with choice of raw materials, extraction and processing, production use and end of life.

While Ecodesign is criticised for greening as opposed to changing design practice, it has played an important role in terms of how it informs the designer’s intuition. Two key concepts that have emerged from Ecodesign theory can be mobilised to inform a more future oriented and broadly social approach for DfS3; the first is the ‘designer as prescriber of ecological damage’ and the second is ‘lifecycle thinking’. Tischner, Dietz et al. suggest that Ecodesign applies qualitative lifecycle thinking, which differs from quantitative Life Cycle Analysis (LCA) which is detailed, rigorous and often time consuming (2000). Heiskanen suggests that this form of life cycle thinking is the best thing to have come of LCA (2002).

\(^{12}\) A more detailed account of the history of Design for Recycling and Cleaner Production takes place on page 42.
Viewing the designer as a ‘prescriber of ecological damage’ is the rationale used by Lewis and Gertsakis (2001) in promoting Ecodesign: they suggest that 85% of the financial costs of the product and an estimated 70% of the environmental impact of the product are prescribed within the concept development stage (see Figure 2.4). When developing a product for market most industrial designers follow a variation of the product development process, which involves the steps of planning, concept development, detail design, testing and refinement and production ramp up prior to manufacturing the product (Ulrich and Eppinger 2000).

![Prescribed ecological impact v Product lifecycle](source: Lewis and Gertsakis (2001, p. 13))

The second concept that informs Ecodesign is life cycle thinking, in considering the impact of the product from cradle to grave, as illustrated by Brezet’s LIDS wheel in Figure 2.5. The value of life cycle thinking for designers is useful as it makes explicit the *embodied* consumption during production, and attempts to make explicit the *inconspicuous* consumption expected during the use phase, while the end-of-life phase acknowledges that the product may actually be *unconsumed*. Mellick’s Design for Sustainability guide suggests that it is the ‘learning potential of the process rather than the outcome’ (Mellick 2003, p.1) that is beneficial for designers.
The combination of these two concepts is positive in their ability to equip the designer with the ability to respond to the embodied and inconspicuous consumption that the product supports over its lifetime. The ‘operational use life’ of the product lifecycle encourages the designer to consider the use of the product in context. The consumer’s use of the product comes into question, and thus the inconspicuous consumption that has evolved on the basis of existing products becomes part of the problem context being defined. For example the Kambrook Axis kettle used insulation and a temperature gauge to alter the default action of boiling an already hot kettle to reduce energy consumption (RMIT 1996).

Exemplary concepts of Ecodesign proliferate within the DfS literature, and when looked at in isolation appear to be extremely positive, such as the examples listed in Table 2.2, which outlines the application of Ecodesign to products to reduce energy consumption by over 90%.

\[\text{Source: Brezet and Hemel (1997)}\]
Table 2.2 Exemplar Ecodesign Cases

<table>
<thead>
<tr>
<th>Ecodesign Example</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Super Efficient Refrigerator:</strong> The efficient refrigerators, designed by Sunfrost, have been designed to run on 86% less energy than 1972 models by reconfiguring the generator placement. Hawken, Lovins et al. suggest that by using best practice in super insulators and the most energy efficient motors available such fridges could be brought up to 98% or 99%. (1999 p. 106)</td>
</tr>
<tr>
<td><strong>Efficient Appliances:</strong> Replacing all old appliances with new energy- and water-efficient appliances would save water consumption by 59%, electricity by 45% and 70% in Co2 from the appliances used, and decrease nationally greenhouse gas emissions. (Morelli 2001)</td>
</tr>
<tr>
<td><strong>Hydrogen Revolution Hypercar:</strong> through weight reduction (advanced composites) and aerodynamics a car half the weight and 95% more efficient than a conventional car can be produced. (NB. Conventional car mileage was stated as 16L/100 km which appears high.) (Smith, Pinto et al. 2007, p.15)</td>
</tr>
</tbody>
</table>

The examples are promoted as ‘win win’ situations for business as Weizacker explains ‘resource efficiency is usually profitable; you don’t have to pay for the resources that aren’t being turned into pollutants, and you don’t have to pay later to clean them up’ (Weizacker, Lovins et al. 1997, p. 23).

In individual case studies such as those in Table 2.2, Ecodesigned products can reach factor 10 reductions in resources use through particular attention at the concept development stage of the design process in which embodied consumption, and the unconsumed products the innovation is deemed to replace, are factored out. Viewed in isolation, Ecodesign appears to have a great potential to reduce the impact of technology as presented in the IPAT equation.

However this isolation, which appears to bring clarity to the resource saving potential of the design, also negates the compounding impact of the rate and overall scale of resource consumption. rationale that if all energy efficient products were adopted then there would be net gains is true within the limited enframing of Ecodesign. However the electronic industry has increased the capacity of processors on average of 41% each year, while the increase in consumption has reduced the effects of the gains. Consumption continues to outstrip the efficiency improvements, leaving the net consumption levels largely unchanged. This is what Manzini refers to as ‘the rebound effect’.

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13 Factor 10 calculations in the above examples only relate to the use phase, where Schmidt-Bleek states that Factor 10 reductions should be calculated across the entire lifecycle of the product (1999).
Table 2.3 outlines the variety of Ecodesign strategies that can be applied across the lifecycle of the product. In light of the above discussion, the table illustrates the dominance of the technical-focused nature of Ecodesign. Of the 34 Ecodesign strategies identified across all stages of the product’s lifecycle, only four relate to use by the end user (1a, 7b, 7e and 8a). Of all the strategies only one questions the product’s very existence (1a). This is most problematic as it limits Ecodesign solutions to harm minimisation, reduced impact and a continuation of business as usual with a limited agency afforded to the designer. Viewed in light of our earlier discussion of unsustainability driven by what are currently normal social practices, the approach of Ecodesign has limited efficacy. Ecodesign acknowledges the problem of embodied and inconspicuous consumption to a limited degree. However in relying on technical responses to what are complex and relational problems, Ecodesign does not acknowledge the broader social context in which the product is located.

Table 2.3 Ecodesign strategies across the lifecycle of the product

<table>
<thead>
<tr>
<th>1. New Concept Development</th>
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<tbody>
<tr>
<td>a. dematerialisation; does the user actually need a product, could a service be offered instead (PSS)</td>
<td></td>
</tr>
<tr>
<td>b. shared use of product; is the user willing to share the product with others? Is personal ownership important to the user?</td>
<td></td>
</tr>
<tr>
<td>c. integration of Functions; can we combine the functions of different products into one product (multiple uses)?</td>
<td></td>
</tr>
<tr>
<td>d. functional optimisation of product (components); can modular components be used to create an entire product range?</td>
<td></td>
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<table>
<thead>
<tr>
<th>2. Select Low-Impact Material</th>
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</thead>
<tbody>
<tr>
<td>a. non hazardous materials; do the materials selected harm the environment?</td>
<td></td>
</tr>
<tr>
<td>b. non-exhaustible materials; are the materials selected renewable?</td>
<td></td>
</tr>
<tr>
<td>c. low energy materials; are the materials selected energy intensive to produce? Can alternatives be specified?</td>
<td></td>
</tr>
<tr>
<td>d. recycled materials; are recycled materials an option for your design?</td>
<td></td>
</tr>
<tr>
<td>e. recyclable materials; is it possible to use materials that can be recycled?</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>3. Reduction of Materials</th>
<th></th>
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<tbody>
<tr>
<td>a. reduction in weight; can you reduce the weight of the product by using less material or lighter materials?</td>
<td></td>
</tr>
<tr>
<td>b. reduction of transportation volume; can you reduce the volume of the product to optimise transportation?</td>
<td></td>
</tr>
<tr>
<td>c. reduction in the number of materials; can you reduce the volume of the product to optimise transportation?</td>
<td></td>
</tr>
</tbody>
</table>

| 4. Optimise Production Techniques |  |
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41

a. alternative production techniques; are production techniques available that minimise harm to the environment?
b. fewer production processes; can the product be produced using fewer steps?
c. low/clean energy consumption; can we choose cleaner production methods?
d. low generation of waste; is it possible to produce with reduced waste or re-used waste?
e. few/clean consumables; can consumables be reduced in production or non-hazardous consumables be used?

5. Efficient Distribution Systems

a. less/clean packaging; can we remove the need for packaging, or reduce the amount of packaging required, or use less harmful materials?
b. efficient transport mode; have we chosen the most efficient mode of transportation for the product?
c. efficient logistics; can we improve the logistics?

6. Reduction of Environmental Impact During the Use Phase

a. low energy consumption; can the product be made to do without electricity? Can the energy consumption of the product be reduced?
b. clean energy source; is it possible to use a cleaner energy source?
c. few consumables needed during use; can the use of consumables be reduced?
d. clean consumables during use; is it possible to use less harmful consumables?

7. Optimisation of Initial Lifetime

a. reliability and durability; can the product’s reliability be improved?
b. easy maintenance and repair; is the product easy to maintain and repair?
c. modular product structure; is it possible to use standard components to repair the product?
d. classic design; can we improve the fashionable lifespan of the products?
e. user taking care of the product; can we design a product that the user will not likely part from?

8. Optimisation of End of Life Systems

a. reuse of product; is it possible to give the product a second life?
b. remanufacturing/refurbishing; can we fix and reuse the product in an as-new product?
c. recycling of materials; can we recycle the materials used in the product?
d. clean incineration; can the incineration of the product create no harmful emission and waste?

Source: Brezet & Hemel (1997)

The limitation of Ecodesign can be likened to the problem Robinson outlines in relation to ‘technical efficiency’, which he defines as ‘a classic case of a technological fix, which will perpetrate the underlying disease by treating only the symptoms’ (2004, p. 377). As Shove describes ‘there is…a tendency in the sociology of both technology and consumption to pay greater attention to the invention and acquisition of new things than to the way such novelties are subsequently deployed in practice’ (2003, p. 397). The challenging question Ecodesign struggles to engage with is ‘how will this solution contribute to the move towards a sustainable society?’.
Ecodesign fits within a framework whereby the design brief is not questioned, and the focus is on servicing clients’ expectations in a manner that is less damaging to the environment. Even in cases such as RMIT’s relatively groundbreaking EcoReDesign project of the early 1990s, in which clients ‘worked together’ with designers to reduce the environmental impacts of their products, there was still an adoption of the ‘core business’ of the client; the Kambrook Axis kettle (Ryan 1996) is ultimately still a mass-produced electric kettle no matter how elegantly it demonstrated a sensitivity to problems in the use of kettles. This relation to ‘business as usual’ development in the technical approach to defining sustainability underscores a perceived lack of agency on the part of the Industrial Designer to drive the design process. This is discussed below.

### 2.6 Ecodesign and Industrial Designs Agency…or Not

This section discusses the agency, or lack thereof in the ability of Industrial Designers to lead in the conventional manufacturing industries. Industrial Designers help to produce products, which are manufactured *en masse*, which Amit describes as a key role of the profession (2006). What products they produce is a voice that designers do not have (Bohemia 2002) and, further, their ability to determine what actually gets made is severely curtailed (Shove, Watson et al. 2007). The social relationship of the designer and client through history marks a shift from strategic thinkers informing society (such as the profound influence of Industrial Designers in developing the consumer society) to one of client servicing. Andrews suggests that Industrial Designers have lost the agency they once displayed in driving change after the great depression in the USA (2007). Bohemia presents the argument that designers are not change agents within contemporary organisations. His empirical studies of organisations utilising industrial design services suggest that the designer has a more limited influence in industry than the literature might suggest:

The literature suggests that internal and external product integration are key elements that facilitate a successful product development outcome. It also suggests that the industrial designer is well placed to be an integrating force within organisations. However, do organisations use industrial designers as integrators of various functions or do they use industrial designers for other reasons? The results from a survey conducted with Australian manufacturing organisations indicate that these organisations perceive the role as ‘an integrator of various functions’ as being the least important role performed by industrial designers. This suggests that the necessity of industrial
designers to perform in the role of integrator may reflect rhetoric generated from within the design literature rather than organisational reality. (Bohemia 2002, p.23)

Bohemia’s findings present the paradoxical nature of design’s status amongst design clients. On one hand clients rank the design of the product as the most valuable element contributing to the success of the product, but rank the position of the designers relatively low as strategic decision makers.

The power within the relationship appears to be with the client; designers offer a service to the clients in meeting their pre-existing ideas for the product. The designer brings the concept to reality. Who incubates the concept in practice may rarely be the designer. The relationship between the client and practitioner is worthy of investigation in terms of the designer’s ability to innovate outside of the product focus of Ecodesign. The widely cited Interface carpet tiles (i.e. Hawken, Lovins et al. 1999; Dexter Dunphy 2000; Arena and Banks 2004; Surampalli. 2004; Smith, Pinto et al. 2007) are used to illustrate the point. Interface has developed a closed loop system that can recycle their carpet range infinitely by offering a ‘floor covering service’ as a replacement for new carpet. This, combined with carpet tiles that allow replacement for only worn areas; has led to them being able to claim a significantly reduced environmental impact. However, whilst Interface has shifted its business in a way that has made a global impression, the company still relies on making money from floor coverings. Functional innovation may question the need for floor covering at all. Polished concrete is not a solution that would assist Interface carpets. The history of the client’s organisation greatly constrains the ease with which they can innovate on their core business.

Bohemia (2002) suggests that, while designers could take on this role, the industrial reality is that designers are not leaders in integrating new ideas. As Munnecke (2007, p.8) describes:

The majority of companies are locked into top-down strategic process, and do not dare to give designers a real say in the early stages of new business development,—and maybe with a reason, because designers have not had the tools to convincingly do so.

This may suggest why Ecodesign has failed to reach its potential in that designers were not in a position to renegotiate with their clients. The designer provides a service, if he or she does not comply, then business may transfer to a designer who will. Nelson and Stolteram (2000, p.24) contrast this view of designers’ relationships:
A service relationship is a distinct, complex, systemic relationship with a particular focus on the dimensions of responsibility, accountability, and intention that are embedded in the relationship. Designed artefacts, concrete or conceptual, only have value and meaning because of this intentional service relationship. It is through the presence of a service relationship that change and the consequences of change can come to have meaning and give meaning to individual and collective lives. To a designer, a service relationship is the basic ‘cause’ of design. To be in service creates the challenge of designing something desired but not yet fully formed in the imagination of the client or others being served.

While the ability of designers to challenge clients may prove difficult in practice, this is further compounded by what Hawken and Lovin et al. suggest is the inability of existing industrial structures to revolutionarily innovate (1999). They predict that it will be in new industrial contexts that the greatest innovation will be afforded, which would be suggestive that design would seek out and attempt to work with foresightful clients or venture capitalists. In 1999 they cited that it would be the computer industry that would compete against the auto manufacturers in delivering new types of alternate-powered vehicles because of a dramatic shift in technology from internal combustion engine to electronics, and that the historical investment traditional automakers have in steel assets (tooling) would be too great to forego. The production of the electric-powered Tesla motor car in 2008 by venture capitalists in Silicon Valley supports Hawken and Lovin et al.’s view that even technical innovation is difficult within existing industries.

Finally, the economic structuring of time in business is particularly problematic for Ecodesign. The practicality of the project is dependent on the client’s capabilities to expand: their lifecycle thinking, foresight, willingness to take risks, the legacy of their past practices locked into hardware such as expensive tooling which presents a strong argument against change. For example, trains and heavy machinery projects are ideal candidates for weight reduction. Substantial money over time will be saved in running costs (petrol or electricity consumption), and reduced maintenance through a reduction in wear and tear. However, from a business perspective the time required to develop machinery from an alternate process (plastics or glass composites) that is unfamiliar to manufacturers seems unfeasible. The insecurity of additional development time or tooling costs is a deterrent. It is very easy to suggest that such measures represent promising Ecodesign concepts, but substantial investment is required to turn the concepts into reality. Further, the embodied consumption represented by current business practices could be exponentially increased by a complete change in what is made and how it is made.
The above concerns of the agency of Industrial Designers utilising DfS to alter conventional business practices are raised by Walker (2002, p.4), who explains that ‘sustainability seems incompatible with conventional priorities and business norms’. However, exploring ways designers may contribute to sustainability in new forms may be beneficial, and is engaged with later in this chapter with a discussion on DfS3 type solutions. In the interim, the impact of policy shaping Ecodesign is presented.

2.7 All Care Taken but No Responsibility

Policy has potentially (indirectly) legislated an extension of scope for designers via a lifetime responsibility for products, which by default raises questions on the management of the use phase of a product’s lifecycle. While Ecodesign theorists have produced many methods and toolkits to advise designers on how to minimise the impact of the products they design, it has been argued that it was compliance with new environmental policies, rather than forward thinking initiatives on behalf of the designer, that was the driver behind the initial changes in design practice (Andrews 2007, Gertsakis et al. 2001). In direct response to the agenda set by environmental policy, toolkits and strategies were developed such as: Design for Recycling; Design for Disassembly as an extension of Gatenby’s publication *Design for X* (1988); and Cleaner Production, which was formally launched in September 1990 emerging out of the conference on the protection of the North Sea in 1987 in order to ‘reduce polluting emissions’ (Ayres and Ayres 2002, p.38). Such strategies had a heavy technical orientation that viewed the product’s end of life as the problem, hence the solutions attempted to reduce the end-of-life impact.

While initially product orientated and technical in nature, the Ecodesign methods and toolkits have developed to be more systemic, continuing to ask for a broadening scope from the designer. Mcdonough and Braungart are commercial architects and practitioners of DfS. They proposed an upheaval of LCA from *cradle to grave* to *cradle to cradle* (2002) via their critique of Ecodesign as harm minimisation, in that the design challenge should, instead of reducing harm, aim to design: ‘a delightfully diverse, safe, healthy and just world, with clean air, water, soil and power. Economically, equitably, ecologically and elegantly enjoyed’
(McDonough 2005, 05:51 minutes). Cradle to cradle, like industrial ecology or ‘waste equals food’ views the product’s end of one life as a purposeful beginning of the next.

The extension of scope of design responsibility was legislated, particularly in Europe through the adoption of Extended Producer Responsibility (EPR), which began in Germany in 1991. Policies such as Integrated product policy (IPP), the Directive on Waste Electrical and Electronic Equipment (WEEE) passed by European parliament in 2002, and a Framework for Eco-design of End Use Equipment (EUE)\(^{14}\) in 2002 all moved to make the end of life of the products the responsibility of the producer. EPR highlights a limitation of the product-orientated technical solution, products can be recycled, but who takes responsibility for making the recycling happen, the end user or the producer? In EPR it is the producer who, in certain cases, will be penalised if post-consumer waste is found out of place. The legislation focused upon the producer to take responsibility, particularly in Europe via the European Union’s WEEE directive first drafted in 1998 (Castell, Clift et al. 2006). The focus of the legislation raises questions as to who is responsible for the problems contributing to the ecological crisis, the designer or the consumer? The problem definition of unsustainability placed in legislation focused predominately on the production side of consumption; consumption by the end user is largely negated.

The lifetime responsibility for the product designed raises an important question for designers regarding how designers can promote (influence or control) the appropriate use of the product over time throughout its useful life. Time has been a critical factor in forecasting objective targets to avoid an unsustainable future. The Brundtland Commission refers to ‘future generations’, Madge (1999) highlights LCA and EPR as introducing the ‘notion of time and timescale’ in thinking about the lifecycle of the product. Robinson states that ‘sustainability is predicted on a need to think across temporal scales’ (2004 p. 378); similarly Manzini acknowledges the time taken and evolution required to bring about a sustainable society (2003a). Fry identifies the early industrial designers’ failure to identify the temporality of their designed solutions while maintaining their positivist outlook in the belief that there was a perfect solution available as an oxymoron (1999).

\(^{14}\) The legislation, while specific to Europe, has been adopted by companies who export to the European market, thus localised legislation in Europe has had an international impact.
The requirement for insight into temporality of design coupled with the need to give more time to design contrasts radically with the current temporal frameworks of business as usual development discussed earlier. The above thinking is seen to mark a shift in rhetoric within the literature from Ecodesign to Design for Sustainability (DfS). Tischner, Dietz et al. (2000) suggest that Design for Sustainability equates to Ecodesign with a social consideration. This shifts DfS towards strategies focusing more heavily on the use of products, which by default have a more humane element, leaning strongly towards the ‘social’ school of thought on sustainability. According to Robinson, the ‘social’ schools have been ‘slower to emerge’ (2004 p. 376). The shift also challenges consumption in its present form. This chapter will now discuss the DfS2 theories orientated towards the ‘social’ school of thought.

2.8 Challenging Consumption: Social Solutions and Systems Innovation

The thesis thus far has discussed product-focused technical design solutions for DfS and identified their limitations. Manzini focuses on the lesser explored demand side of this which he identifies as Product Based Wellbeing (2003a), that is, wellbeing being derived from the purchasing and ownership of products, which is seen to be ecologically and socially unsustainable. Now the literature review will be shifting focus to the social side of the equation in discussing DfS2 type solutions practices to date.

Product Based Wellbeing identifies individual ownership of products as being the problem, the most prominent design response to which has been put forward in Product Service Systems (PSS), often referred to as a functional economy (Mont 2002).

Morelli (2002) argues that designing PSS is within the scope of designers’ capabilities. PSS have a ‘results focus’ orientation to design. A PSS is a ‘a system of products, services, supporting networks, and infrastructure that is designed to be competitive, satisfy customers’ needs, and have a lower environmental impact than traditional business models’ (Mont 2002, p.241). Instead of looking for a lawnmower you are looking for the end result of a tidy lawn, which provides opportunities for lawn mowing services.
PSS from a sustainable design perspective has the potential to reduce the ecological impact by the move from a product-orientated industrial economy to a service-orientated economy as suggested by the first step in the Ecodesign strategies listed earlier in Table 2.3. The service economy has the ability to reduce environmental impacts as we move from personal ownership to services (Mont 2002). Traditional services such as the Laundromat reduce the need for (or ‘dematerialises’ – see Ecodesign concept 1a discussed above in Table 2.3) the washing machine in the home. The Laundromat operates with quantities of scale that may afford investment in efficient washing machines that would be too expensive in the home environment.

PSS are already successfully practised through leasing schemes that retain organisational ownership of the product and allow control of the product’s entire lifecycle, which correlates well with Extended Producer Responsibilities. Fuji Xerox provides an excellent example of managing product lifecycles in leasing schemes as photocopiers are repaired and re-used. They are disassembled at their end of life, serviceable parts are remanufactured and reused, and unserviceable parts recycled (Kerr and Ryan 2001). The level of control afforded by PSS would be difficult to achieve in the traditional direct sale model. The PSS guarantees that the appropriate strategies are followed at the end of life of the product. To the client, the leasing scheme value adds, as machines are serviced and kept up to date. The economic gains to be made from PSS again can be profitable, as manufacturing profits have been decreasing with respect to services. PSS offer a ‘win-win’ scenario for appropriate businesses.

The benefits of PSS in reducing personal ownership and increasing efficiency appear attractive in the first instance. Christensen (2008) argues however that moving PSS beyond ideology and into action is extremely complex. Four issues are identified that make PSS problematic: first, the intent of business; second, the complexity of people’s need; third, dematerialisation versus rematerialisation and; finally, access-based wellbeing. These issues will be addressed in turn below.

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15 It is acknowledged that Fuji Xerox photocopiers are not a sustainable product, however the management of the photocopier via PSS is a positive model. The photocopier would be an ideal candidate to dematerialise.
PSS for sustainability are most viable when the original intent of the business includes a reduced ecological impact. PSS as a strategy is not inherently sustainable; it is through appropriate application that PSS may become positive contributors. The origins of PSS within the IT industry led to a rapid development and proliferation of products. The shortened development time meant that the traditional product launches and marketing could not get the product to market quick enough. Through expert sales teams selling services, new products are implemented into the market quicker, without the customer needing to understand what the product is, as long as the end function is met (Phillips, Ochs et al. 1999). Ehrenfeld cites examples where services are more materially intensive than stand-alone products, such as waterless toilet urinals. Toilet urinals are most often run by contractors for cleaning and disposal services; BRE patented a chemical and disposable free urinal, however it received little commercial interest as it required no maintenance (Ehrenfeld 2001). A service system alone is not sustainable; it can be as flawed by productivism as poor product design. It is not the model of PSS that is sustainable, but the appropriate application of the model’s potential. The concept of PSS is not unique to design, and has similarities to relationship marketing which focuses heavily on servicing clients needs:

Management must think of itself not as producing products but as providing value satisfactions. It must push this idea (and everything it means and requires) into every nook and cranny of the organization…the organization must learn to think of itself not as producing products but as buying customers, as doing the things that will make people want to do business with it. (Levitt 1970, p. 86)

Mont suggests that 70% of the population is already employed in what would be deemed service industries (2002). This acknowledgement is useful for DfS2 as it frames a way of understanding how pre-existing industries are already framed upon sharing via PSS.

The second problem of PSS is then complexity of people’s needs in relation to sufficiency. ‘Sufficiency, in the context of design, questions the fundamental reason for consuming in the first instance. It explores what people are trying to achieve through their consumption, how these ‘needs’ can be possibly met through other means and how people can be encouraged to see consumption in a different way (Manfred Max-Neef cited in Peet 2006). Max-Neef proposed nine basic human needs that must be met in order to live happily: subsistence, protection, affection, understanding, participation, leisure, creation, identity and freedom. From the nine
needs only subsistence and protection are required to be met through material needs (cited in Peet 2006, p. 415). The complexity of replacing products that satisfies a need is not a matter of substituting the primary need i.e. travel of getting from A to B, but understanding that travel offers freedom, identity, participation and leisure. A greater understanding of what design affords is required. Christensen suggests that even while a car is sitting in the driveway it is still providing a service to the owner as it represents freedom (2008).

The third issue relating to PSS is that simply dematerialising practices and replacing them with services may not always be beneficial (Manzini 2003a; Fry 2004). Fry argues that at times it is rematerialisation rather than dematerialisation that is required. A connection of material responsibility is lost in a service society; you become dependent upon machines that you cannot fix and services you cannot control. The researcher’s own experience with a carbon fax machine in private practice was that you could rewind the carbon roll and use it again several times. The quality diminished but for the purpose of receiving quotes the copies were legible. This contrasts with the researcher’s current institution whereby the printers and faxes never break, the ink is never low because it is changed as part of the contractual agreement within the PSS, making the consumption of the toner even more inconspicuous as it is replaced like magic. I have no control, nor am I afforded control of the system. Ehrenfeld (2001) suggests that services can provide a lack of authentic satisfaction, simply replacing products with services will lead to higher expectations of service.16

Finally, Manzini (2003a) has been critical of PSS as promoting an ‘access based well being’ in that our wellbeing is derived from access to services, while promising in concept when compared to the product-based wellbeing advocated by Ecodesign; he notes that the reality poses many problems. Manzini (2003a) critiques PSS from the perspective that they are often added on top of existing products and services and do not replace them, instead providing a further service that conceals material implications. While PSS provide a non-product-based response to low resource consumption, the social normality of consumption is still not questioned; PSS may in fact facilitate the normality of inconspicuous consumption, which is also

16 The author can not afford to purchase a luxury boat or a Ferrari, however through PSS in boat and car share schemes the affordability of such luxuries is greatly increased, putting items previously unaffordable within reach.
results focused. An alternative approach is focusing on the activity (behaviour) of consumption as the starting point, which Community Based Social Marketing (CBSM) attempts to do.\textsuperscript{17} The benefit of CBSM is that it starts with people’s behaviour (which may include inconspicuous consumption), and works backward to select an effective strategy (intervention) to alter that behaviour (McKenzie-Mohr and Smith 1999, p. 7).

PSS, like Ecodesign, has potential advantages for sustainability, such as the potential value in the ways in which PSS can shift practices and tolerance to sharing, extend appropriate control over products’ lifecycles and greatly reduce material flows. There is a requirement for these to be framed appropriately as Christensen (2008) alluded to, that is, on a substantial definition of unsustainability. The following section looks at DfS3-type solutions that engage in the complexity of unsustainability.

\textbf{2.9 A New Definition of Unsustainability for Industrial Designers}

Ecodesign and PSS have been criticised due to their inability to make a substantial difference to business as usual development enshrined within the Brundtland definition of sustainable development. Manzini is viewed to be relevant in re-orientating designers toward DfS3 in two instances: first, in his unique and socially-oriented problem definition of the un-sustainable; and second, for the strategies he proposes that attempt to re-orientate design practice toward more effective interventions in response. Manzini’s problem definition of unsustainability acknowledges largely that product-based wellbeing is both ecologically and socially unsustainable. He acknowledges the progress that has been made in individual cases of improved policy and product redesign. However, when viewed more broadly, there has been limited improvement due in part to the rebound effect in the proliferation of disposable products but also due to the impacts of this proliferation

\textsuperscript{17} CBSM is a promising psychological theory from outside the discipline of Design. It is discussed in substantial detail in Chapter 9. The core of CBSM is that people’s behaviours may be altered by identifying and overcoming the barriers that are holding these existing behaviours in place. McKenzie-Mohr & Smith (1999) do not acknowledge design’s capacity to hold these behaviours in place, however if design is acknowledged CBSM presents a useful tool for designers to engage in ‘socially’ orientated solutions that challenge existing behaviours and cultural norms.
on social wellbeing. Manzini proposes three hypotheses of the unsustainable: the crisis of common goods, the disappearance of contemplative time and the proliferation of remedial goods.

The crisis of common goods relates to the loss of local common goods (goods that belong to everybody and nobody in particular). Such goods range from air and water, to the civic sense of community, urban and public spaces, to neighbourhood security within a town. Common goods form an important role within human habitat, and Manzini notes that common goods have been deteriorating via privatisation for a period of time (2003a, p. 5).

Manzini proposes that contemplative time has been declining due to a proliferation of goods aimed at both saving time and occupying time. Goods to occupy time take advantage of what may traditionally have been contemplative time (2003a, p. 6). For example Mp4 players allow videos to be watched while commuting, access to news is around the clock and the internet has enabled email to be checked outside of working hours. Manzini (2006, p. 8), explains the correlation between comfort and the lack of contemplative time:

> Comfort as minimisation of personal involvement; the idea that when faced with a result to achieve, the best strategy was always the one which required the least physical effort, attention and time, and consequently, the least of ability and skill to actually bring into play.

Industrial Design practitioners continually design solutions that in delivering comfort and convenience unintentionally degrade the ability of contemplative time to occur. Manzini (2003a) titles this the ‘proliferation of remedial goods’ that make our unsustainability bearable because they work to continually normalise our fractured, individuated and time-poor existence. Security systems enable the replacement of the neighbourhood watch program. Bottled water is predicated on a distrust of municipal water. Food is sold ‘on the go’ due to the lack of time available to prepare and eat in a focused manner. The remedial product covers up the disease of unsustainability.

Manzini is optimistic about the ability of the design industry to re-orientate itself to address the unsustainable via a number of initiatives: first, through participatory visions of sustainable futures presented for discussion in the

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18 Contemplative time is time spent doing nothing that is not meaningless (2003a, p. 6), for example walking, eating, talking or meditative time.
Sustainable Everyday Project (Manzini and Jégou 2003), and second, through mainstreaming marginalised initiatives via the Emerging Users Demand for Sustainable Solutions (EMUDE project).

The Sustainable Everyday Project (Manzini and Jégou 2003), an exhibition to promote visions of sustainable ways of living, used the above hypotheses of the unsustainable, as well as the traditional Ecodesign criteria of low material and energy intensity, to work with communities and designers to develop possible future visions of sustainable ways of living. The ‘scenarios’ attempted to bring communities together into supportive networks and provide the opportunity for contemplative time. The scenarios were presented for discussion, not as utopian visions in final form; they are ‘possible futures that could become real if we are capable of creating it’ (Manzini 2006, p.4). Manzini positions the end user as both actor and client. Participants play an important role in developing and implementing the solutions because their workings are social rather than technical. The interior designer and the architect have a history of dealing directly with the end users. This represents a client relationship in which industrial design has traditionally not been involved. So the Sustainable Everyday Project provides a model for a prospective client–designer relationship that recalibrates the designer’s sense of their own agency.

The EMUDE project looks to find existing promising signs of sustainable living at grass roots level, and then attempts to mainstream these marginalised examples, as Manzini describes (2006, p.5):

We need to re-discover the pleasure of moving on foot, of eating local fruit, of feeling the cycle of the seasons, of caring for things and places, of chatting with neighbours, of taking an active part in the life of the neighbourhood, of gazing at the sunset.

By seeking communities already engaged in the above practices, designers’ communicative and creative strategies can be applied, not to solve problems but to understand how these existing practices are working, flowing into the mainstream and then to enable their enlargement or transfer to other contexts. Manzini proposes two strategies for the designer to do this: observing social innovation as the starting point; and utilising a participatory approach from within the communities to generate possible strategies, as Manzini describes: ‘Participation: they facilitate the convergence of different actors on a common vision that has to act as catalyst in the
network building and in the partnership generation processes. (2003a, p. 3) This focuses design activity in a new direction; it is operating at the level of local community, is participatory and not focused on product-solutions. This approach is the polar opposite of traditional design responding to client-driven briefs.

Manzini’s approach applies the designer’s communicative and creative potential within an alternate client base to visualise DfS3-type solutions. His and Jègou’s approach has the potential to utilise the agency of design that the founders of the discipline so powerfully discovered in assisting to create the consumer society: ‘they capitalised on design’s communicative capacity; its ability to tap into unique contexts for ideas and work on-the-ground; and to engage stakeholders to make things happen’ (Andrews 2007, p. 61).

Manzini states that ‘any attempt we wish or are able to make, to go beyond the models of well-being outlined so far, cannot avoid an in-depth study of the reasons for their existence and their profound implications’ (2006 p. 3). His hypotheses of unsustainability provide a sound example of problem definition that opens opportunities for design interventions that go beyond the context of product design, with alternate clients. While on the fringe of mainstream design practice, Manzini’s explorations assist in formulating the thesis that Industrial Designers can Design for Sustainability, as they provide a vision not only of sustainable futures but also of altered industrial design practice.

2.10 Defuturing; A Philosophy to Reconcile Inconspicuous and Embodied Consumption

With the exception of Manzini (2003a), the strategies thus far have been founded on too-narrow definitions of unsustainability, failing to address the everyday contexts of embodied and inconspicuous consumption, already substantially transformed by design. Tony Fry’s philosophy of defuturing provides a framework for confronting the unsustainable. In A New Design Philosophy (1999), Fry presents valuable insight into how design contributed to our current unsustainability. Through a critical reading of the historical evolution of our unsustainability, insight can be gained into what a possible sustainable future will require. This is also suggestive of the rematerialisation (Fry 2004) touched on earlier, as more ‘sustainable’ past practices
and skills are acknowledged through the process of defuturing that may benefit from being reinterpreted in a contemporary setting.

Fry’s approach of defuturing in ‘a learnt act of critical deconstructive reading’ (1999, p. 11) confronts productivism. Through the critical deconstruction of our history, the theory and practice of sustainability may be learnt.

We need to remind ourselves that the future is never empty, never a blank space to be filled with the output of human activity. It is already colonised by what the past and present have sent to it. Without an understanding of what is finite, what limits reign, we have little understanding of those we need to destroy or those we need to create. (1999 p. 12)

The powerful language used above links design to recognition of relational flows connecting past, present and future. The question of what we want to sustain or destroy becomes a crucial determinant in DfS3 and sets it apart from the DfS we have reviewed thus far. The question of what we want to destroy or what we want to create highlights the thought required to bring about a sustainable society: do we want to sustain product-based wellbeing as described by Manzini (2002; 2003a), or comfort prescribed by Shove (2003)? ‘What is it to be sustained’ forms an important question that has been escaping the practice of DfS to date, as client needs are serviced.

The ontology of design is acknowledged by Fry in the following terms: ‘designers design in a designed world, which arrives by design, that designs their actions and objects’ (1999, p. 6). Fry suggests that a projective impact statement within the concept development phase of the design proposal founded on an understanding of defuturing is needed: ‘the material and cultural impacts of products needs to be added to this picture’ (1999, p. 92). While one cannot predict the future, some assumptions about the widespread proliferation of products can be extrapolated in a reasonably straightforward manner. For example, what will be the impact of the $100 laptop in rural India in five years’ time? The author speculates that the $100 laptop, while designed for India, may proliferate into extremely cheap laptops for western markets. This may encourage individual ownership of laptops for even younger age groups, or make laptops easier to dispose of as their value decreases. Within India the laptop may replace traditional oral learning in the cultures they are seen to assist. Eventually electronic waste will be introduced at the end of life that may not have appropriate infrastructure for disposal. Viewed in context-specific
situations, the $100 laptop may not be the best investment for the intended communities.

Prior to construction of a building, a thorough impact statement may be required, but the lack of defuturing perspective means the majority of products have a free rein to influence behaviours, create new material-intensive ones and destroy previously sustainable ones. This is an expansion of Lewis and Gertsakis’ (2001) determination of designers as prescribers of ecological impact discussed earlier in the chapter.

While Fry (1994; 1999) discusses the Development of Ecological Sustainments (DES), and the destruction of the unsustainable, all prior insights will be important in the eventual solutions for sustainability. Fry’s (1999) work is seen in this thesis as a means to reconcile the social interpretations of unsustainability with the technical means to deliver change by design. His reading highlights Industrial Design’s role in the historical establishment of the consumer society. He confronts the productivist viewpoint that growth is positive and unavoidable, and part of human instinct. Fry substantiates the challenge presented to designers to identify social conditions that are positive, understand how they work and promote these using their design skills as explored in Jégou, Manzini et al.’s EMUDE project (2008). As Fry describes: ‘non modern solutions have to be made socially, politically and symbolically acceptable and exportable’ (Fry 1999, p. 221). In these approaches social innovation precedes technical design; Fry argues that a redirection of practice is required to move towards a sustainable society.

Fry (1999) presents the most thorough approach to defining the problem of unsustainability, and positions the problem not only as ‘how to design’ for sustainability, but engages in the question ‘what to design’ for sustainability. The process of defuturing allows for context-specific definitions of unsustainability to guide what should be designed for sustainability. This approach marks a shift to the extreme front end of problem definition, which will still require the mobilisation of technical know-how and knowledge of the strategies we have explored that reveal the evolution of understandings of ecological design. In Habermas’s (1972) terms this is emancipatory design, appropriated here as technical design reconciled with an interpretive insight of unsustainability.
2.11 The Need to Reorientate Design for Sustainability

This literature review has introduced the scale of the ecological crisis, caused by the over-consumption of natural resources within our everyday lifestyles. Industrial Design’s contribution to the ecological crisis has been defined in relation to its sustainment of the consumer society, via products designed to assist with the carrying out of familiar everyday activities.

In light of the above understanding, sustainability has been examined, and erroneous definitions of unsustainability identified from the dominant discourses on sustainability (i.e. UN, Brundtland Commission) which place exceptional faith in technology as the key contributor to change. Industrial Design’s dominant response to the ecological crisis has been largely through harm minimisation and efficiency at an individual product level. What is required is Developing Ecological Sustainments which place the social context as the driver for products, as opposed to client-driven briefs that do not define why we are unsustainable in the first instance, and in the best case scenario simply reduce the impact of existing products. Fry (1999) and Manzini’s (2003a; 2006) work propose a theoretical framework that is based upon seeking sound definitions of the unsustainable. The hypothesis is that this definition of the problem context is a crucial condition for DfS3 (in the literal sense). To date, this theoretical framework has had a limited application in practice; this thesis attempts to employ this framework in the evidentiary chapters.

To summarise, for Industrial Design to DfS3, an understanding of the following is required:

– History (re-materialisation) in deconstructing the past as a ‘road map’ for the future, acknowledging design’s temporality, relationality and ontology.

– Interpreting unsustainable consumption with regards to both supply and demand i.e. embodied and inconspicuous consumption.

– Understanding how both social and technical innovations are required by design in order to move towards DfS3.

The problems outlined above are not unique to industrial design practice. They are also evident in Industrial Design Education for Sustainability. The following
section discusses the dominant global discourse on Education for Sustainability (EfS) proposals, followed by a review of DfS education as taught to Industrial Design students (how unsustainability is defined within Industrial Design education). This assists in providing insight into the research question ‘why are students of Industrial Design unable to design in a way that can contribute in real terms to a sustainable society, economy or ecology?’

### 2.12 Problematic Definitions in Education for Sustainability

The dominant global discourse on sustainability education is from the UNESCO UNEP International Environmental Education Program (IEEP) (1975–1995). The IEEP has been attempting to institutionalise environmental education globally, most recently in the form of Agenda 21. Sauvé and Berryman et al.’s (2000) discourse analysis of the international proposals highlight two concerns: the proposals are largely dominated by a technical orientation towards sustainability; and the proposals neglect to mention the pedagogic approaches required to implement the proposal.

The technical orientation toward sustainability in the international proposals flows uncritically from the definition of sustainable development by the Brundtland Commission (1987). This has been problematised previously as being pro economic growth and reliant on technology. ‘The proposals, while rapidly acknowledging the importance of social issues, rely heavily on sciences and more specifically environmental sciences and technological transfers as keys to the solutions of environmental problems and thus to environmental education’ (Sauvé and Berryman et al 2000 p. 7). For example, the chapter *Changing Consumption Patterns* states:

Growing recognition of the importance of addressing consumption has also not yet been matched by an understanding of its implications. Some economists are questioning traditional concepts of economic growth and underlining the importance of pursuing economic objectives that take account of the full value of natural resource capital. More needs to be known about the role of consumption in relation to economic growth and population dynamics in order to formulate coherent international and national policies. (United Nations 1992, 4.6)

Agenda 21 does not yet have the capacity to address the demand side of inconspicuous consumption. When contrasted with the chapter *Conservation and Management of Resources for Development of Agenda 21* there are concrete initiatives suggesting how technology and science may protect all sectors of the environment while promoting development. The document recognises consumption
as a problem, but states that more work is required before action can be taken. The implication for EfS sees the dominant proposals neglecting a social interpretation of the crisis.\(^{19}\)

The second concern with Agenda 21 raised by Sauvé and Berryman et al. is the self-reflecting nature of the UN documents that do not suggest pedagogic approaches or schools of thought on how to Educate for Sustainability (Sauvé, Berryman et al. 2000). The documents assert that it is of critical importance to EfS to raise awareness, but they do not provide insight into how this may be approached, referring instead to local authorities:

> Educational authorities should promote proven educational methods and the development of innovative teaching methods for educational settings. They should also recognize appropriate traditional education systems in local communities (United Nations 1992, 36f.)

With specific reference to Industrial Design Education for Sustainability, the Industrial Design Council, the governing body of Industrial Designers, has a strong commitment to DfS (ICSID 2001). The Industrial Designers’ Declaration places DfS as an integral part of future Industrial Designers and DfS in varying capacities is integrated into all Industrial Design schools.

The documents illustrate strong top down support for Sustainability in Education, and specifically to DfS education for Industrial Designers. There has been significant progress made in past decades to place sustainability on the agenda. However, the documents mark the requirement for progression from ‘the need’ to educate for sustainability to ‘how do we’ best educate for sustainability. The following section reviews the current state of Industrial Design education towards sustainability with that in mind.

### 2.13 Problematic Definitions: Industrial Design Education for Sustainability

It is positive that all universities have DfS taught within some capacity; however the scope of DfS taught appears problematic. Mariano Ramirez’s study of universities teaching Industrial Design globally (2007) and within Australia (2006) provides

\(^{19}\) Agenda 21 recognises the crisis of disadvantaged nations and inequality, but neglects sufficient understanding of the developed nations’ consumption patterns from a social interpretation to act.
insight into current educational practice by analysing the strategies and tools used to teach DfS. The worldwide study had a response of 221 design courses, while in Australia all 11 Universities teaching Industrial Design responded. All universities who participated teach DfS in some capacity. Ramirez’s study provides evidence for the global significance of this thesis, and supports the need for change as both the Australian and global study highlighted concerns for DfS education.

The major concern of Ramirez’s work is the interpretation of DfS by staff: ‘most participants seemed to interpret Sustainable Design as being identical with ecological design or green design, which focuses mostly on minimisation of environmental impacts and usually not covering aspects of promoting equity’ (2007 p. 3). The above definition of sustainability is concerning given the proposal of how you define is how you design. If the academic understanding of DfS is related to Ecodesign then there is little opportunity for progressive DfS theories to be taught as advocated in the previous section. The strategies and tools used to teach DfS are reflective of the interpretation of DfS as Ecodesign.

The study illustrates that ‘of the many strategies for designing for the environment, the one most academics used as a focus for student briefs were those addressing end-of-life concerns (design for reuse, recycling and disposal) and the distribution phase’ (Ramirez 2004, p. 2). The end-of-life focus (tailpipe solutions) shows a lag behind the contemporary theory of DfS discussed earlier in this chapter. Ramirez’s study suggests that none of the strategies dominating education radicalise front-of-pipe solutions or attempt to address consumption. The previous section identified that social normality is driving unsustainability via inconspicuous and embodied consumption. The strategies taught do not engage with this interpretation of unsustainability.

The strategies taught in Australian universities highlight an emphasis on the ‘technical’ component of DfS as illustrated in Figure 2.6. There is a lack of strategies designed to reconcile the social components of DfS. The lack of social strategies implies that we are only teaching half of the sustainable design theory within Australian universities. It is also suggestive of a limited understanding of design’s agency to generate change proposals, as previously discussed. This acknowledges that in general we are still in the sphere of Ecodesign and yet to move into DfS.
Chapter Two: How You Define is How You Design

Figure 2.6 Sustainable design strategies and their emphasis

Compiled from Ramirez (2004, 2006)

It is no surprise given the technical definition of unsustainability, and the technical strategies adopted, that the tools used to transfer the definition (how you define) into design outcome (how you design) are used in a technical manner. The tools used to teach sustainable design each have various strengths and weaknesses. On an individual basis the majority of tools lean towards Ecodesign, and their shared aim is in minimising the ecological impact of products they design. MIPS (Material Intensity per Unit of Service) is one tool that can be appropriated to afford consideration for the context of use, however from Ramirez’s results MIPS has a low percentage of use. One can extrapolate that product-focused technical fix solutions dominate the teaching. This is problematic, as the definition of unsustainability taught to Industrial Design students appears narrow and un-relational. The previous section identified that Industrial Design practice requires history; (re-materialisation) in using the past as a ‘road map’ for the future; acknowledging design’s temporality, relationality and ontology; interpreting unsustainable consumption with regards to both supply and demand i.e. embodied and inconspicuous consumption; and understanding how both social and technical innovations are required by design in order to move towards DfS3.

It would appear that this is not yet occurring in Industrial Design Education for Sustainability. The ability of tools outlined by Ramirez to address long term sustainability is limited. This is an issue of the ways in which tools are used; no tool is inherently sustainable or unsustainable, it becomes so through appropriate application. Ecodesign should be the last thing, not the first thing as Fry explains: ‘striving for solutions without having a fundamental grasp and definition of the problem can never advance sustainment’ (2000, p. 4). Technical sustainability is a misnomer that needs to work back from social regeneration for sustainability to answer what is needed here in terms of technical design in light of Fry (1999).
Manzini (2003a) and Walker’s (2002) reorientation of design presented earlier in this chapter. Education’s focus on technical design skills, without adequately defining the problem of unsustainability, negates effective improvements required to move towards sustainability.

The concern of Industrial Design education being overtly focused upon the transfer of technical skills has been identified by the UK Design Council Design Skills Advisory Panel (2007) and Lopes (2006, pp.27-28):

Design education is criticised as being bereft of a culture of research and of being primarily concerned with the transmission of instrumentally practical skills in ‘generating the culture industry in its worst form’, that is, precisely the bringing to reality of the vacuous, superficial commodity dream-world that is critiqued in many discourses and commonly implicated in the problem of over-consumption.

In summary there is a requirement for a broader theoretical understanding of unsustainability within Industrial Design education. Put crudely it appears that we are teaching only half of the available solutions, showing a lag behind the contemporary DfS literature. The concern is not isolated to Australia but appears to be a global problem that should be addressed; compounding the problematic definitions of sustainability in Industrial Design education is the indenture of Industrial Design students through the master-and-apprentice model of the Design Studio.

2.14 Master and Apprenticeship: Indenture in Industrial Design education

The champion subject for teaching designers is often seen to be the Design Studio (Dutton 1987; Graham 2003; Green and Bonollo 2003), whereby students produce conceptual designs in response to a design brief provided by the teacher modelled on a master-and-apprentice model. In seeking to reorientate practice, DfS challenges this traditional model of design education.

The studio has a heavy orientation on ‘how to design’, but the question of ‘what to design’ is not always afforded within the studio. The design brief is previously developed and project criteria fixed (Green and Bonollo 2003). By not engaging students in the question of what to design, or even why to design, there is a limited chance of students understanding the agency of design, and the perpetuation of designer satisfying clients needs (like Ecodesign) is continued. The neglect of
identifying design’s agency as suggested in Nelson and Stolteram (2000) and Fry (1999), may be holding DfS back from realising its potential. What to design with regards to sustainability is a troubling and challenging problem. If briefs within studio subjects are produced on the basis of technical approaches to sustainability (i.e. the design of green gadgets in isolation of their social context), then designers can not engage with the wicked problem of unsustainability.  

The interpretation of unsustainability should be forming the foundation for technical design, i.e. Manzini’s social learning supported by technical design to facilitate sustainability, which is implied by Fry’s Developing Ecological Sustainments (1994). Fry advocates an ecological approach; it is not only the social learning that is missing, it is thinking historically, thinking through design’s agency and thinking through ecological impacts together to form the relational (or ‘emancipatory knowledge’ according to Habermas) approach to unsustainability that is missing from Industrial Design education.

The delivery of Industrial Design education in many ways is restricting a relational approach to design. One of the criticisms of DfS is that designers have displayed a lack of agency in influencing what is designed; designers are servicing clients’ needs that are locked into a productivist framework. The master and apprentice model views the teacher as the client: students do their best to satisfy the client and are rewarded with grades. The parameters of the project are set by staff with the nature of the project, milestones and submission requirements established by staff (Dutton 1987; Green and Bonollo 2003).

The dependency of students on staff within the studio determines an uneasy relationship as ‘a heavy dependency on staff for generation and resolution of ideas’ (Green and Bonollo 2003 p.217) can occur within the studio. This is of particular concern when viewed with Ramirez’s identification of DfS being defined as Ecodesign by Industrial Design staff. If the teachers are relied upon to generate ideas based on ill-defined definitions of the unsustainable, then progressing DfS will be difficult in such an environment.

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20 Horst Rittel adapted Karl Popper’s idea of wicked problems to design theory in the 1960’s, describing them as a ‘class of social system problems where information is confusing, where there are many clients and decision makers with conflicting values, and where the ramifications in the whole system are thoroughly confusing’ (Rittel in Churchman 1967). Note churchman published Rittel’s concept of wicked problems after his lecture series and prior to Rittel’s own 1973 publication Dilemmas in a General Theory of Planning.
In practice, the studio-within-design education is similar to the client–practitioner relationship described earlier, the client-servicing aspect of design could be described as a hidden curriculum within the design schools, not purposely taught, but unless acknowledged and dealt with via equal relationships between student and teacher, the bias of the master–apprentice model will remain (Dutton 1987).

To address this hidden curriculum Dutton suggests equal relationships between students and staff can be generated via reflection upon the curriculum. Dutton’s suggestions are mobilised further in the evidentiary chapters of this thesis where Deep Learning and a student-centred approach to DfS education are introduced in depth in response to the identified shortcomings.21

The implication here is that this model may be implicitly holding in place Industrial Design academics’ inability to challenge the status quo, which more progressive approaches to DfS can be seen to depend upon. There appears to be a powerful correlation between the international proposals such as Agenda 21 and the Bruntland Commission and the approach taken within Industrial Design Education. The question may be asked: if the status quo of policy and practice traditions serve to legitimate education, then how can education serve to challenge the status quo? Sauvé, Berryman et al. encourage educators ‘to take a critical distance from the official proposals’ (2000, p. 19) given that the 30 years of prescribed environmental education has not succeeded in changing the status quo of unsustainable industrial development.

2.15 Summary of How You Define is How You Design

This chapter has presented the complexity of unsustainability via embodied and inconspicuous consumption in everyday life, and illustrated how the dominant design responses via Ecodesign (DfS1) have not fully engaged in this complexity. While DfS2 solutions like PSS attempt to address consumption expressed via product ownership (product-based wellbeing), the move towards a service society may further promote the inconspicuous nature of consumption.

21 The pedagogy of Deep Learning is discussed in detail in Chapter 6 Data Analysis 2006; from DfS theory to pedagogy p. 160.
Industrial Design’s agency in both instances has not been fully acknowledged. The literature identifies a need for DfS to reorient practice as championed by Manzini (2003a) in order to DfS3. Fry’s philosophy of defuturing (1999) is a sound theory for this reorientation that may reconcile a sound definition of unsustainability (how you define) with appropriate design outcomes (how you design).

Industrial Design Education has integrated sustainability into the curriculum in some capacity in all design schools, which is positive. However, like DfS practice, continued effort is required to advance Industrial Design education so that students may be afforded the ability to design for sustainability in a way that could effect positive change as proposed by DfS3. This is seen to require a reorientation in both theory and pedagogy.

Chapter 3 consolidates the literature review into conceptual tools to analyse DfS ‘design scenarios’ in order to position Industrial Design Education for Sustainability. These tools, based upon the progressive DfS literature reviewed in this chapter, challenge existing notions of Industrial Design’s agency and help to clarify and prioritise how a reorientation of practice to
3 Conceptual Tools for Analysing the Practice of Industrial Design Education for Sustainability

If Industrial Designers are to Design for Sustainability, a shift is required to reconcile the social interpretation of unsustainability (how you define) with the ‘technical’ design strategies and tools (how you design). The previous chapter highlighted the desired shift for change in both Industrial Design practice and Industrial Design education.

This chapter introduces conceptual tools for analysing the designed outcomes from Industrial Design Education for Sustainability in order to address shortcomings in the capacity of graduates to DfS. Three theoretical concepts are mobilised as tools to locate and analyse the outcomes of Industrial Design Education for Sustainability: the ‘innovation hierarchy’ based on Brezet’s (1997) four types of innovation; the DfS school of thought derived from Robinson in the previous chapter; and the extent of resource reduction in relation to the Factor 10 and 20 proposed targets also discussed in the previous chapter.

All three tools challenge existing practice in Industrial Design Education for Sustainability in some capacity. This leads to the later half of this chapter being devoted to an analysis of the role of the university, vocational education and implications for changing practice. How these tools are applied to analyse ‘conceptual design scenarios’ is discussed in the following methodology chapter.

22 The role of the university and vocational education in changing practice was identified after the completion of the evidentiary chapters. The discussion has been relocated here, out of sequence of the project’s natural evolution because the concepts add value to the evidentiary chapters.
3.1.1 Brezet’s four types of Innovation

Hanz Brezet (1997), a leading figure in the early development of Ecodesign, proposed four *types of innovation* to enable design solutions with a high sustaining potential (i.e. factor 10 or factor 20). Brezet forecast a move from product improvement, to product redesign, to functional innovation, and finally to systems innovation to enable factor 10 to factor 20-type solutions. While technical solutions have come to dominate as discussed earlier, there has been significant discourse on these forms of innovation since Brezet’s 1997 proposal. This familiarity adds value to utilising the ‘innovation hierarchy’ as an analytical tool in a design context.

The first *type of innovation*, ‘product improvement’ refers to improvements made in existing products to reduce their environmental impact. Lofthouse and Bhamra et al. (1999) suggest that this is achieved by making products compliant, i.e. meeting efficiency standards or legislation such as WEEE (Waste Electrical and Electronic Equipment).

The second *type of innovation*, ‘product redesign’, maintains the original concept of the product, but applies Ecodesign strategies to reduce the environmental impact at one or all stages of the product’s lifecycle, as outlined in the previous chapter.

‘Functional innovation’ is the third *type of innovation* and questions the way in which the function of the product is fulfilled. It aims to offer alternative solutions to fulfil the function with a reduced ecological footprint. Examples of functional innovation include the microwave oven cooking with radiation as opposed to direct heat, email replacing traditional postal service and faxed letters, or a GPS replacing the traditional road map.

Finally, ‘systems innovation’ takes into account the broader production and consumption process, including the physical and institutional contexts, the use of the product by the end user and the product artefact i.e. the entire system (Brezet, Diehl et al. 2001, p. 609). Product Service Systems, as discussed in the literature review, would be classified as ‘systems innovation’.
Brezet’s 1997 proposal as seen in Figure 3.1 has been influential in forecasting the scope of design’s response to sustainability. The proposal has been debated with regards both time and scope. Brezet’s proposal suggests that with regards to time, it may take 20 years before systems innovation solutions arise, which Bhan (2007) questions given the severity of the rate and scale of consumption, suggesting that the leapfrog to sustainable solutions is required as soon as possible. The researcher supports the notion that it would be desirable to achieve the higher types of innovation in a reduced timeframe.

Ehrenfeld (2001) questions the ability of systems design to actually reduce environmental impact, and highlights the complexity required in changing infrastructure and behaviours of the end user (change in user learning). What is relevant from Ehrenfeld’s critique is the need for designers to take far greater account of the context of use and relational thinking on the part of the designer, as suggested in Table 3.1.

Despite these criticisms, Brezet’s 1997 proposal provides a useful schema to prompt the student designer to think beyond product improvements to function and system innovation, conceptually ‘unlocking’ the material product and the services it provides. It therefore forecasts possible roles that design could operate within to move towards the resource reduction targets of factor 10 and factor 20. This marks an important shift from traditional Industrial Design, in which technical solutions...
dominate, to solutions which are far more cognizant of the complexities of context and usage.

Table 3.1 PSS Innovation Categories

<table>
<thead>
<tr>
<th>Category</th>
<th>Change in device concept</th>
<th>Change in infrastructure</th>
<th>Change in user learning</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Process and product redesign</td>
<td>none to minor</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>2 Functional innovation</td>
<td>significant</td>
<td>none to minor</td>
<td>minor</td>
</tr>
<tr>
<td>3 Institutional innovation</td>
<td>none to minor</td>
<td>significant</td>
<td>significant</td>
</tr>
<tr>
<td>4 System innovation</td>
<td>significant</td>
<td>significant</td>
<td>significant</td>
</tr>
</tbody>
</table>

*Source: Ehrenfeld (2001)*

3.1.2 Social-Technical School of Thought

The second conceptual tool is derived from a combination of the author’s framework ‘how you define is how you design’ and Habermas’ theory on Knowledge of Constitutive Interest (1972) as signposted in the introduction, as well as Robinson’s school of thought (2004) from the previous chapter. The schools of thought are defined as ‘Social’, ‘Technical’ and ‘Socio-Technical’. The ‘social’ school of thought refers solely to changes in human end-user behaviour in order to reduce environmental impact; the ‘technical’ school of thought focuses primarily on the product to reduce the environmental impact (i.e. Ecodesign); whereas the ‘socio-technical’ school of thought attempts to consciously alter behaviours by informing the technical design from a social understanding of unsustainability. While not a concrete rule, the DfS1-type solutions discussed earlier are represented by the technical school of thought, while the DfS2-type solutions are closer to the social school of thought.

3.1.3 Scale of Resource Reduction

The third conceptual tool used for analysis is the extent to which outcomes represent the targets of resource reduction as suggested within the literature such as the Wuppertal’s Institute’s Factor 10 and the Netherlands Government’s Factor 20 (Meadows 1972; Gardner and Sampat 1998; Schmidt-Bleek 1999; Vergragt 2004). Table 3.2 presents Gardner and Sampat’s (1998) compilation of target reductions in resource use sanctioned by a range of government and institutional bodies.
Table 3.2 Target Reduction Established

<table>
<thead>
<tr>
<th>Source</th>
<th>Target Reductions</th>
<th>Timeframe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austrian National 1996</td>
<td>10-fold</td>
<td>To be achieved over the Environment Plan next decade.</td>
</tr>
<tr>
<td>Netherlands Government 2004</td>
<td>20-fold</td>
<td></td>
</tr>
<tr>
<td>Swedish Ecocycle 1997</td>
<td>10-fold</td>
<td>Applies to both material Commission and energy efficiency; to be achieved over the next 25 years</td>
</tr>
<tr>
<td>German Environment Ministry 1998</td>
<td>2.5-fold</td>
<td>Applies to non-renewable raw materials; to be achieved by 2020</td>
</tr>
<tr>
<td>Factor 10 Club 1994 Declaration by 16 eminent scholars from 10 countries</td>
<td>10-fold</td>
<td>reductions in materials flows to be achieved over 30–50 years in industrial nations</td>
</tr>
<tr>
<td>UN General 1997</td>
<td>10-fold</td>
<td>Calls for studies; gains to Assembly be achieved over 2–3 decades</td>
</tr>
<tr>
<td>World Business Development and UNEP</td>
<td>10-fold</td>
<td>World wide calls for improvements in Council for Sustainability — eco-efficiency</td>
</tr>
</tbody>
</table>

Compiled from Gardner and Sampat (1998)

While the targets relate specifically to ecological resource reduction, the scale of the targets again supports the proposal that radical approaches to sustainability may be required, which technical sustainability alone has a limited chance of bringing into being.

The three conceptual tools presented mirror the progression of Industrial Design scope that is identified by the literature review, such as Fletcher and Goggin’s (2001) progress from ‘product focus’ to ‘results focus’ to ‘needs focus’. There appears to be consensus that Industrial Design practice needs to be redirected to effectively DfS, as Andrews (2007, p. 62) describes:

To escape the product design brief, the legacy of streamlining, and the imperative to create the ‘next best thing’, industrial design may need to conceive of and develop a new profession. One that does not claim to have the definite answer to solve the ills of the world, but one that makes the necessary connection between stakeholders, and communicates alternative scenarios to make sustainability possible, compelling and practical.

Similarly Manzini states ‘the design activity itself needs to be redefined in order to positively and effectively contribute to the radical change required by the transition towards a sustainable society’ (2003b, p.1). By default, such changes
challenge Industrial Design Education for Sustainability. The conceptual tools imply a shift in the direction of Industrial Design, bringing into question the role of the university in DfS education. They may seem to be quite ambitious tools with which to judge undergraduate student design concepts. However, as will become clear, they serve an important role in both characterising and reflecting upon the nature of design activity as part of the educational experience.

Brezet’s hierarchy challenges students to consider the change agency of design and their role in creating a more sustainable society. The higher forms of innovation imply a more influential consequence of design activity than do those at the technical end of the spectrum.

Empirical evidence suggests that at present Industrial Design (both in practice and education) is dominated by product improvement and redesign. Halila and Horte’s (2006) study of 150 award-winning ‘eco-innovations’ identified that 75% of eco-innovation occurs in what Brezet classifies as ‘product improvement’ and ‘product redesign’, and suggest that, in order to achieve greater reductions in resource use, exploration of ‘systems innovation’ and ‘scientific breakthrough’ would be desirable.

Similarly according to Reynolds, Hay and Camp (1999) 67% of new inventions occur through small business, a business sector that may benefit from stronger Industrial Design relationships. Brezet’s schema also raises questions about the practical and disciplinary contexts of Industrial Design. If Industrial Designers are to offer functional innovations they may have to form different sorts of relationships with new clients who are more open to collaborative problem solving and innovation.

Robinson’s schools of thought also promote a shift in perceptions of design’s agency. The second hypothesis proposed is that design concepts that correlate with the socio-technical school of thought will have the highest sustaining potential because they bridge embodied (supply-side consumption, which is technical) and inconspicuous (demand-side consumption, which is social) consumption. The socio-technical school of thought suggests that Industrial Designers could work in trans-disciplinary contexts where technical and social dynamics can be fully explored and addressed in conceptual development.
Finally, ‘the scale of resource reduction’ also extends significant responsibility to the designer by drawing attention to consequences of design decision-making that go well beyond the product form. To address large scale targets, students would need to apply a socio-technical approach.

These conceptual tools and the results of the status quo analysis available in Chapter 5 imply that Industrial Design education needs to be changed to more appropriately prepare graduates to DfS. The following section explores the role of the university, vocational education and implications for changing practice in light of this need.

### 3.2 The Role of the University

Walker (2002) describes the perceived needs of industry and sustainability at times as appearing to be polar opposites. The insights of Habermas (1971; 1989) are drawn upon in what follows to articulate the balanced role universities could take in educating designers for sustainability.

Habermas states there are four responsibilities of the university: research, in the transmission and production of technically exploitable knowledge; providing the minimum qualification for professional knowledge and skills; the transmission, interpretation and development of cultural traditions; and the development of the political consciousness of the students (1971, pp. 1-3).

Thus, the vocational component of education is only one of four responsibilities of a university. In relation to Industrial Design Education for Sustainability this would require a more relational approach to Industrial Design education. Habermas advocates ‘that under no circumstances can the universities dispense with the three tasks I have mentioned that go beyond reproduction and transmission of technologically exploitable knowledge’ (1971, p. 4).

Similarly, Talcott Parsons (1973) states that the four functions of higher education are as follows: research and training of new scientists and scholars; academic preparation for the professions (technically usable knowledge); general education; and a contribution to cultural self understanding and intellectual enlightenment (cited in Habermas 1989, p 121.). Habermas (1989, p. 100) suggests
that the outcome of the above functions not being embedded in higher education would be that:

The university will end up the functionalism of giant institutes for training and development of specialized scientific and technical expertise. This is why it is crucial to envision...the possibilities of a renewal of the university on the basis of its idea.

Arenas’ (2008) contemporary analysis of secondary education, like those of Habermas (1971, 1989), is critical of the dominant focus on vocations:

The focus on these goals, although important, has meant that other vital areas have not been addressed: namely, how to ensure that vocational education promotes a sense of empowerment, fosters a stronger sense of community, and seeks to protect the natural environment. (Arenas 2008, p. 377)

These ideas on the role of a university education raise questions about ‘what’ should be taught to Industrial Design students and the nature of ‘industry readiness’ in Industrial Design graduates. The expectation of vocational training to provide employment to graduates is a central concern of Industrial Design students. To explore the concept of vocational education John Dewey is drawn upon in the following section, which supports an expanded view of vocational education to accommodate DfS better.

### 3.3 Vocational Education

The emphasis on ‘technical’ skills was identified within the literature review as dominant within Industrial Design education for sustainability. Dewey (1966) would describe this as a narrow view of ‘vocation’. Dewey viewed vocation as more than just the occupation of tasks completed to earn money; vocation includes one’s calling as a family member, as a friend, as part of a community and so on. He states:

We should not allow ourselves to be subject to words as to ignore and virtually deny his other callings when it comes to a consideration of vocation phases of education. (Dewey 1966, p. 307)

Dewey clarifies his point with the example of the artist: an artist who is skilled as a technically proficient painter but who has no subjective matter to critique or story to tell based on life experience or observation, has little chance of succeeding in the vocation. Likewise a designer who is capable of specifying appropriate material for a task, but does not grasp the relational or ontological impact of the design would not be capable of DfS. He continues with the limitation of the singular vocational focus:
We must avoid not only limitation of conception of vocation to the occupation where immediately tangible commodities are produced, but also the notion that vocations are distributed in an exclusive way, one and only one to each person. Such restrictive specialism is impossible; nothing could be more absurd than to try to educate individuals with an eye to only one line of activity. (Dewey 1966, p. 307)

Interpreted with regards to Industrial Design and the emphasis on technical skills, Dewey is advocating the importance of vocation beyond just the skills set by a singular profession. The student is part of a family and society that are equally important, as the danger of vocation education is explained:

There is danger that vocational education will be interpreted in theory and practice as trade education: as a means of securing technical efficiency in specialized future pursuits. Education would then become an instrument of perpetuating unchanged and existing industrial order of society, instead of operating as a means for transformation. (Dewey 1966, p. 316)

Vocation training in preparing students for Industrial Design practice in the present form, with a guarantee of prosperous employment at the completion of the degree, would be falling short of Dewey’s (1966) notion of vocation. The inclusion of a wider understanding of vocation affords the discussion of what society could be, not a replication of what industry is, as Dewey (1966, p. 317) states the emancipatory potential of education:

It does mean that we may produce in schools a projection in the type of the society we would like to realize, and by forming minds in accord with it gradually modify the larger and more recalcitrant features of adult society.

The notion of educating for what society could be, not for what society is, supports Habermas’s (1971) role of the university in the interpretation and development of culture. To date, the requirement for Industrial Design Education for Sustainability to ‘change’ has been expressed by the DfS literature. Habermas (1971; 1989) and Dewey’s (1966) philosophy on education also support a shift in practice toward a more holistic approach to Industrial Design Education that would support Design for Sustainability. For the desired shift to occur, a sound understanding of ‘practice’ and what it takes to shift ‘practice’ in Industrial Design Education for Sustainability is required.

3.4 Changing Practice

Shifting practice is not as simple as recommending that a particular theory be taught: the problem is located within the wider context of Industrial Design Practice and
Industrial Design Education. If the solution was as simple as adopting another theory then there would be no reason for this thesis, as many have 'specified that design needs to reorientate practice, i.e. ‘functional’ and ‘systems’ innovation proposed by Brezet (1997) or ‘needs focus’ design (Fletcher and Goggin 2001). A greater understanding of practice and how practice is changed marks a shift away from presenting sound theoretical proposition on DfS, to exploring how the proposition can come into existence as sound DfS practice.

3.5 **Stephen Kemmis — Knowing Practice**

Stephen Kemmis has written extensively on the issue of what practice is and how it can be changed (2005; 2007). He views practice not only in terms of the individual act of a trained professional, but as an individual working within a professional body, who is influenced by his environment both past and present. Kemmis (2005; 2007) categorises the practice of the individual as being influenced by four key features; discourse; social relationships; cultural norms; and material and economic relationships. Kemmis terms these ‘extra individual’ features. In order to alter ‘practice’, the extra individual features of practice also need to be altered (Kemmis 2005; Kemmis 2007). Like Fry’s defuturing (1999), the ‘history’ of the profession can be read to understand practice by critically deconstructing its traditions. Kemmis’ extra-individual features are explained below, and provide a framework to assist in this deconstruction.

The ‘discourse’ on practice assists to form the expectations of what the practice actually is, what it attempts to achieve, how the practitioner should practise and what the client should expect. Kemmis (2005, p. 399) explains:

> Practices are also shaped by words: by the *discourses* of professions and professionals that name and describe particular things in particular ways, noticing particular aspects of the world as relevant to their work and deflecting attention from others. These discourses guide and inform professional practice, offering ways of understanding how practice can be directed and corrected.

Similarly, the social setting of practice locates the role of the individual amongst a wider network. The social setting of practice acknowledges the relationship that occurs between client and practitioner. Clients ‘are knowledgeable about the relevant practices and know something about how they are to participate within them.’(Kemmis 2007, p. 8). The role of the designer is framed on pre-
conceived ideas of the services that they offer. The problematic cultural norm of the client servicing position of Industrial Design and Ecodesign were discussed in the previous chapter. The material and economic side of practice is easily framed as the business side of practice. Businesses are run as profitable ventures, of which design consultancies are a part. Client and practitioner negotiations are dependent on shifts in the macro economy, i.e. product development funds for design may be less ambitious in times of economic uncertainty. General Motors is reportedly cutting spending on product development due to the recent financial downturn (Associated Press 2008), which will impact on both design departments and design consultancies operating in a traditional design context.

Kemmis acknowledges that all extra individual features of practice are temporary and contextualised in particular situations. Practice cannot be understood in isolation; Kemmis’ (2007 p. 12) example below illustrates how the process of changing what would appear to be a relatively straight forward procedure resonates and requires altered practice to the related extra individual features.

These cultural-discursive, social and macro economic frameworks existed prior to the arrival of these particular people in this encounter, in this setting. To change what I meant and intended by this social practice in this setting may thus require changing not just what the actors themselves think or do, or how they relate, it may also require changes in the language and discourse they use (new development in the theory of how burns should be treated); changes in the relationships between people around the particular practice (for example, changing the ways different people in different roles relate to each other in the burns unit of a hospital, or the values and norms of care and respect that guide their work); and changes in the material economic arrangements of what people do, with what resources, in return for what rewards (for example new ways of treating burns, new technologies like new dressings for burns, or new pay scales for specialist staff working in burns units).

The extra individual features highlight the complex nature of changing practice; as Winter suggests, having ‘correct knowledge’ does not of itself lead to change, attention also needs to be paid to the ‘matrix of cultural and psychic forces’ through which the subject is constituted (1987, p.48). The relationship of the extra-individual features in relation to Industrial Design Education for Sustainability is discussed in the following section.
3.6 **Extra Individual Features of Industrial Design Education for Sustainability**

The process of changing practice, Kemmis argues, cannot be adequately understood without reference to extra individual features (2007 p. 3). In a criticism of past educators he states that:

> ...they inhabit. We should not limit our teaching to instilling professional practical knowledge in the form of technical, craft and personal knowledge, but rather to insist that neophyte and developing professionals should understand how practices are constructed in the social and other dimensions listed. (Kemmis 2007 p. 3)

Like Habermas’ role of the university (1971), and Dewey’s interpretation of vocation (1966), Kemmis (2005; 2007) suggests a holistic understanding of practice that goes beyond seeing the profession in isolation of its lived contexts. From the previous chapter and the UK Design Council Design Skills Advisory Panel 2007 which stated that graduate designers lacked skills beyond technical designing, it appears that Industrial Design education in general overemphasises technical skills to the detriment of holistic understanding. Kemmis (2005 p. 205) suggests that what to teach is broader than these important technical skills:

> [W]hat needs to be known is not just what is in the heads of other or past practitioners; it is also extra-individual: features that exist in discursive and social realms that extend beyond the heads of individuals into the space-time, historically-constituted, social and discursive realms.

For Industrial Design Education for Sustainability, exploration of the extra individual features provides a framework to address the complex challenge of shifting practice. Table 3.3 applies the extra individual features of Kemmis against the current practice of Industrial Design Education for Sustainability informed by the previous chapter’s literature review, and Habermas and Dewey in the previous section of this chapter. The table is not presented as a complete account of the extra individual features of practice, but speculates upon the many small but significant contributions the teacher as researcher may complete (highlighted in green) in the hope of shifting practice. This is influential in clarifying the direction in which the research proceeds.
### Table 3.3 Extra Individual Feature of Practice Applied to Industrial Design Education for Sustainability

<table>
<thead>
<tr>
<th>Extra Individual Feature</th>
<th>Industrial Design Practitioners</th>
<th>Industrial Design for Sustainability Educators</th>
<th>Industrial Design Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discourse</td>
<td>Design for mass production, product focused. Design for style, functionality, cost, efficiency, profitability.</td>
<td>Limited discourse on how to educate Industrial Designers to Design for Sustainability. No requirement to consult alternative discourse on education.</td>
<td>Largely reflective of discourse presented on Industrial Design. Class discussion(^{23}) highlighted that students’ interests went beyond the narrow definition of an industrial designer as product designer i.e. possible desired vocations included gaming, furniture, interiors, management and graphics.</td>
</tr>
<tr>
<td></td>
<td>New discourse on design required.</td>
<td></td>
<td>Flexible required in Industrial Design education.</td>
</tr>
<tr>
<td>Social</td>
<td>The designer services the needs of the client and is not in a position of power. Through education prepare students with skills to negotiate, explore alternate client relationships and practices whereby innovation is invited.</td>
<td>Master and Apprentice relationship modelled in education. Focus on acquisition of technical skills. Unequal relationship between student and teacher Review pedagogy via action research.</td>
<td>University is one of many activities that inform the students, i.e. Dewey’s (1966) vocation. Be inclusive of broader social context that the students bring to their educational experience.</td>
</tr>
<tr>
<td>Cultural</td>
<td>Industry suited to incremental innovation. Explore opportunities to leapfrog incremental innovation.</td>
<td>Emphasis on practical skills over research contribution.</td>
<td>Varies between the institutions or university under study, UWS culture is influenced by the location of students predominately living in the outer suburbs of a global city (i.e. urban sprawl and mortgage belt). Be inclusive of broader cultural context.</td>
</tr>
</tbody>
</table>

\(^{23}\) Class discussion of student interests is an introductory exercise that the researcher practices at the beginning of a teaching session, what is of interest is that the students’ interests almost always go beyond the narrow definition of Industrial Design as product design for mass production. The specific examples given are from the 2007 teaching session.
By attempting to make explicit the extra individual features required to change practice, it is hoped to clarify how this research may contribute to moving practice in a more desirable direction. While this thesis acknowledges the complexity of shifting practice, three specific insights are worthy of further discussion as they inform the direction of the following chapters.

First, the discourse on education for Industrial Design educators (sustainable or otherwise) is identified as slim, compounded by the limited exposure that Industrial Design educators have to alternate pedagogic approaches. These concerns assist to identify a niche to which this thesis may contribute knowledge. However the practice of Industrial Design Education for Sustainability is not only about the production of relevant discourse for DfS, but also a sound dissemination strategy to increase the chance of exposure to and adoption of the discourse. The conclusion of the thesis presents a dissemination strategy based on the work of Foertsch, Miller et al. (1997).

Second, the master and apprentice approach to teaching and the emphasis on technical skills at the neglect of students’ social experiences are identified as troubling historical features of design education. These concerns inform a review of teaching delivery that supports a holistic and student-centred approach to Industrial Design Education for Sustainability which is explored through the practice of deep learning in Chapter 7.24

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24 Deep learning is a student-centred pedagogic approach that encourages students to engage in a deep understanding of the subject matter at hand in relation to society, often through learning by doing.
Third, the culture of Industrial Design practice is largely client servicing, and the future challenges to this culture defined by the material and economic features of practice presents problems that Industrial Design Education for Sustainability needs to explore. Manzini (2003a, 2006), for example, highlights the opportunities available for design operating with an alternate client base, as explored in Chapter 2 above. Further, the challenges for design practice presented by the ecological crisis, depleting oil stocks and more severe CO$_2$e reduction targets, require a proactive, forethoughtful design approach that is aware of design’s influence and is prepared to seek out leadership opportunities both within and outside the traditional scope of design practice.

### 3.7 Changing Practice in Industrial Design Education for Sustainability

Changing practice is complex and requires an understanding of the extra individual features which need to change. As Kemmis (2005, p.413) describes:

> Changing practice requires collective interventions into the social, discursive and practical conditions under which practices are formed, structured and re-structured. In the longer term, changing practices in the richer, individual-plus-social sense of the term requires collective transformation, not just transformation of their individual professional practice knowledge (in the sense of their expertise or knowledge ‘in their heads’).

For Industrial Design Education for Sustainability to change, the extra individual features holding it in place (such as those briefly outlined in Table 3.3 above) need to be understood. This thesis has a small but significant role in attempting to ‘change practice’ by undertaking the highlighted suggestions made in Table 3.3 in its pedagogical interventions. This is attempted by mobilising a position Stenhouse (1975) presented for educational reform, that of the ‘teacher as researcher’, advanced upon by Carr and Kemmis (1983; 2005) and discussed in greater detail in the following chapter. In short, the teacher is viewed to be in a position to negotiate the cultural knowledge that students bring with them, and to offer educational reform from the bottom up.

To reiterate: changing practice has emerged as a critically important concern in this study—not just in terms of the social practices that design contributes to ‘out there’, but also in terms of practices in the education and profession of industrial
design. In encouraging students to develop DfS3 solutions, this study takes account of the extra individual features needed to shift practice and exposes students to these insights in the context of their learning. The interventions ‘test out’ the sound theoretical proposals presented by the likes of Fry (1999) and Brezet (1997) in an attempt to align Industrial Design Education for Sustainability better with the educational theories of Habermas (1971) and Dewey (1966) in which understandings of the role of the university and of vocation challenge the technical focus of industrial design.

### 3.8 Overview

This chapter has outlined the conceptual tools that will now be used to analyse the ‘conceptual design outcomes’ of Industrial Design Education for Sustainability. Each of the conceptual tools is seen to present challenges for Industrial Design Education for Sustainability in that they shift Industrial Designers out of their technical comfort zone. Mobilising Kemmis’ (2005; 2007) understanding of what is entailed in shifting practice, the chapter has positioned the significance of educational practices in developing students’ ability to DfS3.

The following chapter outlines how Action Research and the adopted position of teacher-as-researcher utilises the conceptual tools presented within this chapter to provide a methodology to intervene in and redirect the practice of Industrial Design Education for Sustainability.
4 Action Research and the Teacher as Researcher

This chapter presents an explanation and justification regarding how the methodology of Action Research and the ‘teacher as researcher’ is used with the conceptual tools introduced in the previous chapter to address the guiding research questions of this thesis. To reiterate, the main research question is why are students of Industrial Design unable to design in a way that can contribute in real terms to a sustainable society, economy or ecology? The subsidiary research questions are: What DfS approaches are represented in the conceptual design solutions of Industrial Design students? What DfS approaches offer the highest sustaining potential? How are the approaches with the highest sustaining potential best integrated into Industrial Design education?

4.1 Introduction

The chapter begins with a discussion of the relevant epistemological approaches of sustainable design, industrial design and education. Action Research, which is aligned with these epistemological approaches, is proposed as an appropriate overarching methodology for the primary research component of this thesis. A rationale is provided for site and sample selection. The mid stages discuss the principles and procedures of the data collection, content analysis and the interpretation of results. The chapter closes with an overview of the ethical procedures completed within the study.
4.2 Epistemological Views in Sustainability, Industrial Design and Education

This thesis is a hybrid of three disciplines; Sustainability, Industrial Design and Education. How knowledge is produced within each of these disciplines informs the methodology that has been selected for this study. Therefore before the methodology is introduced, a brief overview of the relevant epistemological views in each discipline is presented.

Sustainability maintains a variety of conflicting definitions, as seen in Chapter 2. Each definition supports particular epistemological viewpoints. The thinking evident in the Brundtland definition can be most closely aligned to a positivist position of technological determinism, in that the narrow definition of the problem is isolated to technical efficiency. The progressive view seen as most relevant to this research is that ‘sustainability is regarded as neither knowledge, knowable nor an end point’ (Fry, 1999 p. 8). Fry’s position is seen by the author to be extrapolated by Manzini as he discusses the transition to a sustainable society:

The result is that not only is it impossible to foresee how and at what pace this transition will take place, but it is even very difficult simply ‘to see the present’, i.e. to recognise how it works today and in which way and where ‘the new’ is appearing. This kind of blindness is not so strange: given to its complexity, the transition towards sustainability will be very far from being a linear evolution. On the contrary, it will be a complex social learning process: a sequence of events and experiences thanks to which, progressively, amid mistakes and contradictions as always it happens in any learning process—human beings will learn to live in a sustainable way. (Manzini 2003a, p.1)

The philosophical understanding presented above is that sustainability presents many unknowns that are complex and unable to be grasped in their entirety. Truth with regards to sustainability would not be objective or absolute. The approach advocated by Fry is that, through an understanding of unsustainability, sustaining knowledge can be generated (Fry 1999). This is viewed as an appropriate approach to DfS3 as it couples developing sustainability with learning rather than technological determinism as articulated by Manzini above. This approach is therefore embodied in the selection of the methodology for this thesis.

Industrial Design as a discipline does not have a position widely debated within the community on what constructs its knowledge base. This is in stark contrast to the sciences where ‘truth’ has been debated since ancient times via Socrates, Plato and Aristotle. ‘Design methods and theories are very recent and still
in their infant stages of consensus, amongst industrial design practitioners themselves, and amongst other professions generally dealing with them’ (Loriot 2003, p.10). What constitutes knowledge in Industrial Design is largely a green-field site; however the following section will present the epistemology of Industrial Design practice from three relevant perspectives: the professional design process; the creative activity of designing; and in relation to ontological design.

The founding Industrial Design practitioners of the 1930s such as Raymond Loewy, Henry Dreyfuss, Norman Bel Geddes and Walter Dorwin Teague presented themselves to industry as the users of analytical positivist methods that led to correct solutions. This was achieved via careful analysis of the market, production methods and scientific principles such as streamlining applied within the design process. The design process as outlined by Bel Geddes (1940 pp. 225–233 cited in Andrews 2007) could be summarised as client meeting, establish objectives (brief), market analysis, concept generation and concept selection, concept refinement, detailed design, production and promotion. The process differs very little from that advocated in Ulrich and Eppinger, a recent text on the design process whereby systematic analysis leads to the ideal design solution (2000). This is the standard design process still taught in design schools today. The design process was portrayed by the early Industrial Design practitioners as systematic analysis; ‘Industrial Design presented its working methods as a science of certainty’ (Andrews 2007, p. 26) in the belief that ‘if the inputs were thoroughly investigated, the output would be the one perfect design solution’ (2007 p. 28).

The design process, characterised as a form of systematic analysis, contrasts heavily with the creative activity of actually designing within this process. The creative activity of generating concept sketches and models was largely kept as a secret or ‘black art’. The talent of the designer to bring together various ideas into one finalised concept was not disclosed by the early industrial designers (Andrews 2007, p. 42). Swann describes the process as ‘intuition, inspirational guesswork and holistic thinking’ (2002, p.51).

Kolakowski (1972, pp. 11–12) describes the most important rule with regards to the ‘positivist’ nature of knowledge is that ‘valid knowledge can only be established to that which is manifested in experience’, which has been widely interpreted to be that which can be objectively observed. Value judgements can not be observed therefore are not ‘valid forms of knowledge’ (cited in Carr and Kemmis 1983, pp. 61–62). The analytical methods of designers are seen as overtly positivist as they comprise of a study of discrete, observable elements and events that interact in an observable, determined and regular manner, the results of which are presented as fact.
The contrast is picked up by Cross (1989), who explores the synthetic process by articulating the difference between design and engineering. He suggests that designers solve complex problems through synthesis in the generation of multiple solutions; many quick solutions are generated until one works. This differs from science or engineering disciplines in which problems are solved through analysis. When industrial design practitioners are observed from the outside it is clear that the creative process of designing (which the literature resists defining) involves synthesis.

The synthetic creative process has been explored by the likes of Schön as continuous on-the-fly ‘reflection in action’ (1991). The problem-solving process that the Industrial Design practitioner follows is likened by Swann to action research: ‘action research and the action of designing are so close that it would require only a few words to be substituted for the theoretical frameworks of action research to make it applicable to design’ (Swann 2002, p.56). While this argument is convincing, the connection is not acknowledged in design practice. The above section outlines competing epistemological views within the practice of designing, in synthesis and analysis: the author acknowledges that at various stages of the design process the designer in reality would move between analysis and synthesis.

However, the following section will briefly detour to consider the relationship between artefact and designer via a discussion on ontological design, to illustrate flaws in an overtly positivist orientated position on the design process.

Ontological Design is the theory that design designs, as Fry describes: ‘designers design in a designed world, which arrives by design, that designs their actions and objects, or more simply: we design our world, while our world designs us’ (1999, p.6). Ontological design draws attention to the ways in which designed artefacts impact upon our lives. For example, attempt to think of one activity completed that is not facilitated by design. This impact of design is not widely acknowledged or studied in Industrial Design. Once ontological design is acknowledged, conflict appears with the strong positivist approach of the design process described above, because the finalised ‘ideal’ solution may ‘in use’ play out completely differently to the original design intent, making it improbable that the one ‘ideal’ solution achieved through systematic design is possible. Artefacts create
Chapter Four: Action Research and the Teacher as Researcher

relational impact across time, while the design process leads to temporary solutions promoted as final.

An ontological perspective on design is central to understanding design’s impact over time and in context. This is important in the selection of methodologies that allow learning over time. The cyclical nature of an Action Research process promotes this learning, which will be shown to be highly important for DfS education.

Within education there is a broad range of epistemological views. The one most relevant to this thesis is that of the ‘teacher as researcher’, largely influenced by Lawrence Stenhouse (1975). John Dewey proposed that educational results are not valid until they have been tested out in practice: ‘they may be scientific in some other field but not in education until they serve educational purposes, and what they really serve or not can only be found out in practice’ (Dewey 1929, p.33). This positions the classroom to be of central importance to educational research.

Stenhouse (1975, p. 142) positions the ‘teacher as researcher’ as follows:

All well founded curriculum research and development, whether the work of an individual teacher, of a school, of a group working in teacher’s centre or of a group working within the co-ordinating framework of a national project, is based on the study of classrooms. It thus rests on the works of teachers...It is not enough that teachers’ work should be studied: they need to study it themselves.

The ‘teacher as researcher’ is seen as central to developing and testing the validity of educational research. The perspective supported in this thesis is that the teacher is in the optimum position to generate educational knowledge for curriculum development: ‘put the teacher at the centre of knowledge production in the professional context of the classroom, school, college or university department’ (Burke and Kirton 2006, p.1).

Stenhouse (1975) advocates that teaching strategies can never be applied a priori, or proposed by outsiders for implementation by the teacher without mechanisms of involvement and feedback. Strategic advice on the curriculum content from academic sources always needs to be tested out in action by the teacher, often with on-the-fly changes. The teacher is the only one in the position to judge the success of the suggested strategies. Like ‘practice’ in the previous chapter, teaching is located amongst social, cultural, historical and economic grounds with which the
teacher must acknowledge and work. The practice of teaching, like design, can be seen as a form of ‘reflection in action’.

The opposite position, in which curriculum is formed from knowledge generated externally to the institution, and which is imposed upon the learning environment from ‘top down’, has been criticised by Stenhouse (1975, p. 14):

> Are we to accept the view that although knowledge is distorted in the culture of the school, outside the school there are reference groups which set standards in knowledge, having as it were a purchase on truth? I don’t think we can in that simple form.

The teacher as researcher generates knowledge from within the school (Stenhouse 1975); this position is viewed as critical for curriculum development within this study. ‘The emergent curriculum must be grounded…in the study of classroom practice’ (Stenhouse 1975, p. 25). Stenhouse argued that curriculum development should be aligned with the betterment of teaching: ‘curriculum research and development ought to belong to the teacher and that there are prospects of making this good in practice’ (p. 142). He outlined how this may be achieved through a ‘process of development…by thoughtful refinement of professional skill…and that skill is generally achieved by a gradual elimination of failings through the systematic study of one’s own teaching’ (1975, p. 39). The process he outlines has strong similarities to the reflective process of action research (which his work predates).

Carr and Kemmis were influenced by Stenhouse’s position of the ‘teacher as researcher’ in education in their work *Becoming Critical*(1983). The intent of this work was to justify and extend opportunities for teachers in research as a legitimate form of critical social science. Their work explicitly introduced Action Research as an appropriate methodology for the ‘teacher as researcher’(Carr and Kemmis 1983, pp179-209).

To summarise the above epistemological discussion on education, Dewey (1929) suggested that knowledge in education is only valid once tested in the classroom; Stenhouse (1975) advocated that the best way of achieving this is via the ‘teacher as researcher’ model, while Carr and Kemmis (1983) advanced this position by introducing Action Research as a capable method of bringing about teacher-led research.
A variety of relevant views on knowledge generation in the three disciplines of Sustainability, Industrial Design and Education have been presented. Sustainability and the ontology of design are interpretive and difficult to study with objectivity, as they take effect over time. Industrial Design relies heavily on synthesis and analysis to a lesser extent at various stages of the design process, while in Education knowledge becomes valid once proven in the classroom. There appears a common thread of learning through reflection over time in all three disciplines to generate knowledge.

To briefly reflect on the theoretical framework of the thesis introduced in Chapter 1, Habermas’s ‘technical knowledge’ is likened to the empirical analytical sciences, ‘practical knowledge’ to the interpretative sciences focused on understanding, and ‘emancipatory knowledge’ as the reconciliation of the previous two types of knowledge. This understanding frames the understanding of DfS practice underpinning this thesis; however it is also beneficial in relation to the methodology, as at various stages of the research project each type of knowledge is drawn upon. Due to the hybrid mix of disciplines and the above theoretical framework, the thesis is not located strictly in one epistemological perspective; instead Action Research enframes a mixed method approach to data analysis. This is introduced in the following pages.

### 4.3 Action Research

Action research ‘is the application of fact finding to practical problem solving with the view to improving the quality of action within it...the focus is on a specific problem in a defined content’ (Burns 1990, p. 253).

Action Research is an appropriate methodology to address the research questions, as it is aligned with the epistemological and philosophical outlook of the disciplines described above. Action Research has a tradition in education (McNiff 1998), and positions the researcher within the field of action, as the ‘teacher as researcher’ discussion above suggests. Action Research also bears a strong resemblance to the design process (Swann 2002). Additionally the ontological approach to understanding design is akin to the open and relational approach of action research.
The selection of Action Research is viewed as an appropriate methodology given the current status of Industrial Design Education for Sustainability. The appropriateness of Action Research is discussed in relation to three perspectives on Industrial Design Education for Sustainability: from a theoretical perspective, a pedagogical perspective, and the perspective of curricula reform.

From a theoretical perspective, it is positive that Sustainability has been successfully integrated into the Industrial Design curriculum in some capacity. The literature review above introduced the position of progressive theorists who argue the need for DfS in Industrial Design practice to be remade (i.e. Manzini 2003a; Fry 1999; Andrews 2007; and Morelli 2002). The indenture of design education via master and apprenticeship approach identified in Chapter 2 would suggest that for practice to change, an intervention in an educational context may break tradition. The agency of how education may contribute to altering practice as proposed by Kemmis has been raised in the previous chapter.

Action Research from an educational context also presents the opportunity to test progressive DfS theories such as ‘defuturing’ (Fry 1999), to identify the problems and opportunities that theoretical migration presents in an overtly practice-driven discipline like Industrial Design.

From a pedagogical perspective there is limited literature on how Industrial Design Education for Sustainability should be taught. Deep Learning is identified as a promising pedagogy for DfS and has similarities to the design studio as currently taught. Standing in the way of this learning is the master and apprentice model of the Industrial Design studio discussed in Chapter 2 in which learning is modelled and imparted from an expert leading to problems of indenture. Action Research and its privileging of critical reflection offers a promising way to intervene in this model and thus stands as an important way to remake Industrial Design education. On the basis of the preceding discussion, action research can be seen as a highly appropriate methodology to propose, test and amend curricula in a reform process.

In relation to curriculum reform the position of ‘teacher as researcher’ has recently been re-evaluated by Kemmis (2005). Kemmis suggests that over the last 20

26 Deep learning is introduced in Chapter 6 below, as it emerged from the inductive learning process that Action Research enables.
years, secondary and tertiary education in many disciplines, including education, has seen the initial intent of Stenhouse’s teacher-as-researcher deteriorate due to the proliferation of objective outcome-based teaching, national tests, state tests and performance measures placed on curricula, which have taken hold in Australia (Carr and Kemmis 2005). This has meant that the environment of teaching practice is not as receptive to the action-oriented model of the teacher as researcher as it once may have been.

This somewhat dire summation of the situation may be accurate within the state schooling systems or within disciplines of higher education such as teaching, nursing and engineering wherein a national curriculum largely dictates what happens in the classroom. However, Industrial Design education is without this curriculum model, and while it has its own traditions and legacies to contend with, academic staff are still largely responsible for curriculum development. While the process of curriculum change in higher education can be slow and bureaucratic, a particularly painful proposition in relation to the paradigm shifts demanded by sustainability, it is still possible for development to come from the bottom up within Industrial Design education.

Further, Action Research is viewed as a particularly important strategy within Industrial Design higher education as there is a distinct lack of educators with teaching qualifications. The process of learning in action and reflecting upon one’s practice and the practice of industrial design as a whole may give teaching staff who have not had a significant opportunity to reflect on their teaching processes some tools with which to do so. Past practice and expertise appear to be the only qualifications necessary to teach design to students. This is problematic due to the tendency to educate in the manner that you have been taught i.e. the master and apprentice model will continue without intervention.

This study was conducted in a way that takes its cue from Stenhouse’s (1975, p. 141) original idea of the teacher as researcher:

Not only is the project a study of teachers who are studying themselves: the application of its results depends of teachers’ testing its tentative hypothesis through research in their own situations. A particular kind of professionalism is implied: research based teaching.

The study has also drawn heavily on Carr and Kemmis’ (1983) original notion of becoming critical, by which the ‘teacher as researcher’ can generate knowledge
through Action Research. This project may be viewed as an example that other Industrial Design teachers may be able to follow in grappling with the challenges of DIS3.

### 4.3.1 Action Research Threats

Action Research has been widely criticised with regards to its validity as a research methodology (i.e. Frideres 1992; Baskerville and Wood-Harper 1996) as well as the impartiality of the researcher (Hoque 2006). Kock summarises the three main ‘threats’ to action research as ‘uncontrollability’, ‘contingency’ and ‘subjectivity’ (2004, p. 265).

The *uncontrollability threat* relates to the researcher’s lack of control in attempting to insert positive interventions within the environment that is being studied. This is particularly relevant when the relationship between the organisation and the researcher is fresh (Kock 2004).

The *contingency threat* relates to the wide body of evidence that is accessible to the researcher from the organisation. In the case of UWS, unit outlines for the past 10 years are accessible, as are the University’s policies. This data is ‘Broad and Shallow’, as opposed to ‘Narrow and Deep’. The contingency threat makes the identification of the causal relationship between the researcher’s intervention and outcomes difficult to establish as there is a wide scope of material that may have contributed to the outcome. The isolation of ‘Narrow and Deep’ evidence is required in order to judge the particular merits of the researcher’s intervention.

The *subjectivity threat* relates to the deep involvement that the researcher has with the project, and the ability for the researcher to introduce personal bias into the research findings. Kock states:

> While deep personal involvement from the part of the researcher has the potential to bias research results, it is inherent in AR because it is impossible for a researcher to both be in a detached position, and at the same time exert positive intervention on the environment and subjects being studied. (2004 p. 269)

The potential for bias is higher when the situation is emotionally charged, or conflict is involved. The subjectivity threat also has the potential to skew the data interpretation via externalisation bias (Kock 2004), in that negative results are viewed to be part of the organisation and not due to the interventions initiated by the researcher.
Koch suggests limiting the three threats of uncontrollability, contingency and subjectivity by selecting *a priori* units of analysis. Planning what it is that you are going to analyse allows the selection of appropriate units of analysis that the researcher has greatest control over, countering the uncontrollability threat. The selection of units of analysis encourages the identification of ‘Narrow and Deep’ areas, as well as encouraging objective analysis, reducing the subjectivity threat.

Multi-iterations of the Action Research cycle are Kock’s final suggestion to reduce the threats, as multi-iterations assist in building compounding evidence from previous iterations:

In a multi-iteration study, the experience gained in previous iterations helps the researcher avoid situations that may jeopardize the AR study and come across to the client as more knowledgeable about the topic being studied and thus more worthy of the client’s trust. While it seems that multiple iterations of Susman and Evered’s AR cycle are advisable, explicit examples of AR conducted through multiple iterations of the AR cycle are difficult to come by, as most AR studies seem to traverse the AR cycle only once. (Kock 2004 p. 272)

Kock’s three threats to action research have been considered in developing the research strategy for this thesis, which will now be outlined. Where possible the recommended antidotes have been integrated.

### 4.4 Research Strategy: Action Research

Action Research provides a mixed method approach consisting primarily of content analysis as the nucleus of the study, as displayed in Figure 4.1 on the following page. Content analysis was applied to data gathered from a variety of sources. The categories for coding were drawn from the literature review and introduced in the previous chapter. How the coding process was completed will be discussed in detail later in section 4.6 *Content Analysis Principles, Procedures and Instruments*, p.100.

The site of the study was the University of Western Sydney’s sustainable design stream as taught to undergraduate Industrial Design students. This was analysed primarily through student ‘conceptual design scenarios’ from second year design students studying the unit 300306, Sustainable Design: Sustainable Futures (SDSF). Best practice examples of DfS case studies were also gathered and analysed

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27 Susman and Evered’s (1978) Action Research Cycle is used within this study, the five stages are introduced in Chapter 1 on page 12.
from leading DfS peer reviewed journals, key DfS texts and DfS websites. The analysed data informs the action research process adopted from Susman and Evered (1978), which comprises the following steps: Diagnosing, Action Planning, Action Taking, Evaluating and Specifying Learning. These were defined in relation to this study and outlined below.

**Figure 4.1 Research strategy within action research cycle**

**Adapted from Susman and Evered’s five stages of action research (1978)**

1. **Diagnosing:** The problem definition would become clear through the inductive learning process and research strategy employed. Content analysis of student ‘conceptual design scenarios’ from the unit SDSF were analysed to initially locate the sample in relation to progressive DfS theory.

2. **Action planning:** Interventions within the unit were planned in discussion with key staff delivering the sustainable design stream. This occurred for implementation in 2006 from the results of the diagnosing phase in 2005, and in 2007 from the diagnosing phase in 2006.

3. **Action Taking:** Implementing the recommendation from the Action Planning Phase within the curriculum was done in close collaboration with key staff members of the UWS sustainable design ‘stream team’, a close knit group of DfS
academics who are responsible for driving change in the DfS curriculum within the Industrial Design program at UWS.

4. **Evaluating**: the success of the interventions made in Phase 3 Action Taking were assessed in relation to the conceptual tools presented in the previous chapter via content analysis. This internally validated the research findings.

5. **Specifying Learning**: The results provide insight for continual improvement and were disseminated first through the Sustainable Design ‘stream team’ discussions, and second via publication of executive summaries in 2005, 2006 and 2007. The dissemination also occurred through publication of papers in conference proceedings (i.e. Clune 2007; Lopes, Clune et al. 2007; Clune 2008 available in the appendix) and finally in this dissertation.

Within the research strategy, specific measures were taken to reduce the three threats of action research discussed above. Planning what was to be analysed in advance, as suggested by Kock (2004), reduced the threat of uncontrollability, contingency and subjectivity via the selection of ‘narrow and deep’ units in ‘student conceptual design’ solutions to be analysed via content analysis.

Content Analysis is defined as ‘analysis of the manifest and latent content of a body of communicated material (as book or film) through classification, tabulation and evaluation of its key symbols and themes in order to ascertain its meaning and probable effect (Krippendorf 2003, p.17) This stand-alone method was selected for analysing the student ‘conceptual design scenarios’ and DfS case studies. Content analysis provides ‘narrow and deep’ data required to produce valid results at the evaluating and diagnosing phases of the Action Research process. By using a rigorous analysis procedure the threat of ‘subjectivity’ has been greatly reduced.

Multi-iterations were used to increase validity as illustrated in Figure 4.2. The study took place over a three year time period, allowing for three iterations.

![Figure 4.2 Action Research cycle across three year study](image-url)
The threat of ‘uncontrollability’ was further reduced by way of the unique position of the researcher as an Industrial Design teaching fellow within the School of Engineering at the University of Western Sydney. The position enabled the trialling of methods and approaches to teaching sustainability within a closed time frame in close consultation with members of the sustainable design ‘stream team’. The position and relationship with key staff largely minimised the uncontrollability threat.

4.4.1 Site Selection

The University of Western Sydney Industrial Design course rated highly in relation to the amount (percentage) of DfS being taught within Industrial Design degrees in Australia (Ramirez 2004). A global study of the percentage of DfS specific units taught within Industrial Design programmes showed 13% to be average (Ramirez 2007). The University of Western Sydney was in line with this percentage. UWS has a history of DfS being taught within the Industrial Design Program, evolving from environmental management introduced in 1997 to Sustainable Design in 2003. The specific unit for analysis, SDSF, is the final sustainable design unit taught within the Sustainable Design sub-major at UWS. The unit is unusual as, rather than being structured in terms of a traditional lecture–tutorial format, it involves two intensive design-focused all-day workshops within which assessment tasks are accelerated, as well as supportive weekly tutorial sessions and online discussions. The results students produce at the end of the unit embody the entirety of the compulsory Sustainable Design curriculum.

SDSF utilises a hybrid model of scenario planning for sustainable futures drawing on a range of theoretical sources (Lopes, Clune et al. 2007). The outcomes of the unit are ‘conceptual design solutions’ produced by students illustrating possible future visions of a sustainability society. The three key theories that the unit was constructed upon are: Strategic Foresight (Marsh, McAllum et al. 2002); Manzini and Jègou’s Design Orientated Scenarios (2000); and Fry’s Philosophy of Defuturing (1999). The literature review identified that, in order to design for sustainability, Industrial Design students require an understanding of history, acknowledging design’s temporality, relationality and ontology, as well as an interpretation of the social context to reveal inconspicuous and embodied
consumption as the defining conditions for design interventions. The hybrid model of scenario planning attempted to engage the design students in such requirements.

Strategic Foresight (SF) is a business tool used to develop fast growing and strategically clever future businesses based on trends analysis and creative, lateral thinking. Foresight practitioner Dominique Purcell (Marsh, McAllum & Purcell 2002) assisted in the initial design of the unit Sustainable Design: Sustainable Futures, and introduced both theoretical and pedagogical tools to the unit. The theoretical tool of SF involves gathering data on emerging trends, analysing the potential consequences of those trends in relation to each other and finally creating pictures of possible future worlds based on this analysis. The process was one the unit utilised as part of the hybrid model of scenario planning. The process was useful as it attempted to reveal the inconspicuous consumption identified as problematic within the literature review of Chapter 2.

Purcell assisted in the design of the day-long workshops as an aid to the intensive and lateral thinking future scenario planning demands. These workshops replaced the traditional weekly lectures within the unit. The workshops use Strategic Foresight to read trends forward or ‘stand in the future’ and ‘backcast’ how to get to this future from the present. The outcomes of the workshops were proposals for probable future visions designed and produced by the students. The conventional use of strategic foresight is to utilise the probable future visions to find profitable business and growth opportunities and when the method was initially proposed for the Industrial Design course, this was the key driver and perceived benefit for strategic design. In stark contrast, scenario development is now wholly aimed at facilitating the sustainability of human communities, uncurtailed by commercial imperatives (though as shall be seen not at the expense of acknowledging the vocational value of acquiring future scenario planning skills).

Facilitating human communities was the objective of the second theoretical context for our hybrid model. Presented by Ezio Manzini and Francois Jégou (2000) the concept of the Design-Oriented Scenario (DOS) expands upon the idea of scenarios as ‘visions’ or slices of future life and sees them instead as ‘concrete hypotheses’ that can be compared and judged much as a range of alternative design concepts might be developed in response to a brief. While SF supports design innovation as the proliferation of solutions customised for individual consumers; the
DOS is strongly system-oriented and emphasised the design of feasible ways to share resources and enhance social and environmental well-being.

Three key aspects to this approach distinguish DOS from other forms of futures thinking: emphasis on the normality of everyday human practice as the focus of sustainability; the afforded agency of design to facilitate change through ‘bottom up interventions’; and the critical notion of interdependent well-being that can only be achieved by thinking communally. From this perspective ‘the client’ is the community whom design serves.

Tony Fry’s (1999) concept and practice of ‘defuturing’ was the third theoretical context informing the hybrid model of future scenario planning. As discussed in the literature review, defuturing presents a solid theoretical proposal to explore the inconspicuous patterns of normal consumption that design unintentionally created. Defuturing as a ‘learnt act of critical deconstructive reading’ (Fry 1999 p. 11) entails ‘reading’ the extent to which any product, system or service contributes to or diminishes future sustainability, Fry (1999, pp. 11–12) explains:

…the future is never empty, never a blank space to be filled with the output of human activity. It is already colonised by what the past and present have sent to it. Without this comprehension of what is finite, what limits reign and what directions are already set in place, we have little knowledge of futures, either those we need to destroy, or those we need to create.

To engage second year undergraduate students in the process of defuturing, the student-friendly interpretation of defuturing was presented within the unit as follows: the present is a construct of the past, therefore the future will be a construct of the past and present, a critical reading of the past in understanding our unsustainability presents a roadmap to reorient for sustainability. The process of defuturing has the potential to assist in defining a sound interpretation of unsustainability (how you define) that will aid in defining what is needed in a given social context (i.e. design criteria) to position students better to be able to Design for Sustainability (how you design).

4.4.2 Sample selection

Based upon the research strategy presented in Figure 4.1 on page 92, data for analysis from the following were used; Design for Sustainability theory; the Sustainable Design stream within the University of Western Sydney’s Industrial
Design Degree; and case studies of DfS. The methods used for sample selection from the population are discussed below.

**Design for Sustainability Theory**
This was largely completed through the literature review in the previous chapter. Peer-reviewed international journals and books formed the context for defining the progressive DfS theory. Journals such as the *Journal of Design Research*, *Design Issues*, *Journal of Sustainable Product Design* and the *Design Philosophy Papers* were reviewed to gain a comprehensive understanding of key contemporary DfS theories.

**University of Western Sydney**
All second year Industrial Design students who completed the Sustainable Design stream at UWS between the years of 2005 and 2007 made up the sample for the study. As the concluding unit of the Sustainable Design core stream, SDSF students were chosen as the sample population, allowing the researcher to analyse data immediately after action had been applied to the delivery of the sustainable design stream. The sample of students completing was 80–100 students depending on yearly intake, the industrial design students sampled were expected to produce 160–200 conceptual design scenarios for analysis each year. Each student is expected to present two ‘conceptual design scenarios’, leading to 160–200 works to analyse. Over the course of the study, the intake within the Industrial Design programme at UWS lowered, therefore a lower number of ‘conceptual design scenarios’ were analysed in later years.

**Case studies of Design for Sustainability**
The DfS literature presented many case studies and inspiring examples of how DfS principles have been applied. Over 100 case studies from multiple sources were analysed from DfS journal articles. Key texts such as ‘Natural Capitalism’ by Hawken and Lovins (1999) and online galleries such the Delfts ‘Re F-use’ (2005) and Jégou and Manzini et al’s ‘Sustainable Everyday Project’ (2008) provided case studies for analysis.

The proposition was that the case studies selected represent the practical application of DfS as presented to the wider design community. Measuring the current practical application of DfS against the broader DfS theory assisted in
answering the research question to what levels are key DfS theories displayed in practice?

4.5 **Data Collection Principles, Procedures and Instruments**

Principles to ensure reliable and replicable data collection were adhered to within the study. This was required as the multi-iterations of the action research project meant that data was collected and analysed over a three-year time frame.

4.5.1 **UWS Industrial Design Student Work**

The primary source of data collection from UWS was that collected from the final assignment within the unit. The data collected for analysis was the students’ ‘conceptual design scenarios’, an assessment attracting 20% of the overall mark for the unit and largely developed within the day-long workshops (see *Appendix V Assessment Tasks*, p. 305). Since all students wishing to pass the unit complete the assignment, it had a strong potential to return a high response in data collection. The ethical procedures for collecting the data are introduced later in this chapter in Section 4.8.

The conceptual design solutions presented by the Industrial Design students were largely visual forms with supportive textual annotations. Therefore an analysis method that can cater for the visual dimension was required. The visual form according to Swann is a ‘means of encapsulating ideas, and indeed some ideas are expressed more powerfully through the visual medium than any other form of communication’ (2002, p 52). Content analysis is a method that can be appropriated to cater to the visual form (Rose 2001) and will be discussed later in the chapter.

4.5.2 **UWS DfS Curriculum**

The course description and promotional material of the UWS curriculum reflects the emphasis placed on sustainability from the institution, with the possibility of locating the program within the sustainable paradigms that emerged from the literature. Course descriptions of some institutions explicitly state industrial design’s
contribution and responsibility towards sustainability. The descriptions of the design courses were available on the Internet, presenting unobtrusive data for analysis.

The University of Western Sydney Industrial Design course teaches sustainability as both stand-alone units with the Sustainable Design stream as well as embedded within the Design Studio unit projects incorporating LCA (life cycle analysis).

Unit outlines were available for the researcher and presented another source of unobtrusive data for analysis. The relationship between the DfS units and the remainder of the Industrial Design course was important and could be analysed for a broader pedagogical perspective on the holistic curriculum approach.

### 4.5.3 Design for Sustainability Case Studies

As previously mentioned the DfS literature presents many case studies drawn from industry and academia that include inspiring examples of how DfS principles have been applied. These were collated through traditional desk research.

### 4.6 Content Analysis Principles, Procedures and Instruments

Whilst the study was largely inductive, elements of the scientific approach to research have been utilised in part to combat the threats detailed above. The credibility of the study in an Industrial Design context was still informed by scientific approaches, following the research principles of reliability, validity, reproducibility and credibility. The following section explains how each of the above principles were integrated into the data analysis via content analysis.

#### 4.6.1 Reliability

Reliability within content analysis comes from limiting ambiguity within the coding categories (Krippendorff 1980). Weber suggests there are three types of reliability; stability, reproducibility and accuracy (1990, p. 17). Stability refers to the ability to code the same material more than once, and produce the same results time and time again, without any inconsistencies. Reproducibility occurs when the content is coded
accuracy is where pre-existing codes are used to analyse new texts. The empirical nature of codes for this thesis makes accuracy irrelevant.

To ensure the data analysed was reliable the following checks for stability and reproducibility were put in place: first, by repeating the coding of the same ‘conceptual design scenarios’ any inconsistencies between the coded materials were noted—this procedure afforded stability; second, when inconsistencies did occur the coding categories were reworked until an appropriate level of stability was achieved; third, by piloting the coding categories with several coders inconsistencies were measured. If inadequacies occurred at each stage, then the codes were revised until stability and reproducibility fell within acceptable levels of repetition. This was measured by using Krippendorf’s R value of 0.85 (1980).

4.6.2 Validity

Content analysis was used to provide solid ‘narrow and deep’ data on which to base the diagnosing and evaluating stage of action research within this study.

To maximise validity within content analysis, questions were developed to assist in the classification of codes. The aim was to classify unmistakably the conceptual design solutions within a category for analysis, thereby maximising validity. In its simplest form the question asked ‘does the [conceptual design solution] generally have the certain attribute [or set of interrelated attributes]…Yes or No’ (Weber 1990, p. 32). This restricted categories to those words (and images) that un-mistakably fit those categories.

4.6.3 Reproducibility

Content Analysis allows for the analysis of data in a replicable manner, within a range of both visual and text based mediums. ‘The key concern for content analysis is the reduction of many words classified into key content categories’ (Weber 1990, p. 13).

Weber’s steps to creating a coding scheme for reliable, valid and replicable data analysis were used as a guide in defining the coding system (1990, p. 21). The
creating and testing of the coding scheme occurred after a thorough literature review of the DfS theories as outlined in Chapter 3. Weber’s steps to creating a coding scheme are:

1. Define the recording units,
2. Define the categories,
3. Test code a sample,
4. Assess accuracy and reliability,
5. Revise the coding rules,
6. Return to step 3 until codes are working correctly.
7. Code all the text,
8. Assess achieved reliability and accuracy.

The application of Weber’s coding scheme for reproducibility in relation to this thesis is outlined in the following section.

1. Define the Recording Units: Due to the highly visual nature of the work analysed, the recording units selected were themes that are best represented in the images to reflect a certain position, which could be positive, negative or neutral (Weber 1990). In order to allow for a qualitative justification of a particular coding category used in relation to a particular image, a comment section was added to the database.

2. Define the Categories: categories were developed to be mutually exclusive (unable to be both true at the same time) either this or that but not both. Any grey areas could be identified within the qualitative comments. In order for the variables not to be mixed up, categories were developed that could be easily distinguished.

The categories were developed from the conceptual tools outlined in Chapter 3 as follows: the DfS school of thought (social, technical or socio-technical); Brezet’s four type of innovation: (product improvement, redesign, functional innovation and systems innovation); and finally the scale of the implied factor X reduction (no reduction, factor 2, 4 or 10). The specific categories and definitions are outlined in Table 4.1.

_table 4.1 Categories for Coding_
<table>
<thead>
<tr>
<th>Main Emphasis / Perspective</th>
<th>Description</th>
<th>Example</th>
<th>Category Defining Question</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>School of thought (Robinson)</strong></td>
<td>Technical</td>
<td>Sustainability brought about through improvement in technology</td>
<td>Hybrid cars, hyper cars</td>
</tr>
<tr>
<td></td>
<td>Social</td>
<td>Sustainability brought about largely through a social response, social change</td>
<td>Car pooling, walking school bus, car sharing</td>
</tr>
<tr>
<td></td>
<td>Socio-technical</td>
<td>Requires social change with the assistance of new technology</td>
<td>Technology to facilitate the ease of car pooling</td>
</tr>
<tr>
<td><strong>Level of approach prescribed by Brezet’s 4 levels of innovation</strong></td>
<td>Product improvement</td>
<td>The improvement of existing products with regards to pollution prevention and environmental care</td>
<td>Products are made compliant, eg. BASIX building code</td>
</tr>
<tr>
<td></td>
<td>Product redesign</td>
<td>The product concept stays the same, but parts of the product are developed further or replaced by others</td>
<td>Increased reuse of spare parts and raw materials, or minimising the energy use at several stages in the product lifecycle. includes Eco-design, green design, LCA, design for environment</td>
</tr>
<tr>
<td></td>
<td>Functional innovation</td>
<td>This involves changing the way in which a defined function is fulfilled</td>
<td>Examples include a move from ‘paper-based information exchange to e-mail, or from private cars to car sharing’, this would include strategies such as dematerialisation, progressive abstraction</td>
</tr>
<tr>
<td></td>
<td>System innovation</td>
<td>In which new products and services arise, requiring changes in the related infrastructure</td>
<td>A change-over from agriculture to industry-based food production, or</td>
</tr>
</tbody>
</table>
and organisations

changes in organisation, transportation and labour-based on information technology, belong to this type of innovation

Does the scenario dematerialise through service systems, altering existing requirements such as transport and labour? Yes = systems innovation

<table>
<thead>
<tr>
<th>Factor X prescribed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negative factor</td>
</tr>
<tr>
<td>factor 0–2: incremental improvement</td>
</tr>
<tr>
<td>factor 2: 50% reduction</td>
</tr>
<tr>
<td>factor 4: 75% reduction</td>
</tr>
<tr>
<td>factor 10: 90% reduction</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Waste hierarchy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avoid</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Reduce</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Reuse</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Recycle</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Regenerate</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

3. Test coding on a sample of text: pilot testing of the conceptual design scenarios was completed several times; the above table represents the finalised
categories. It took several iterations of testing to remove ambiguity in these categories. This process was achieved by following steps 4–8 outlined below.

4. **Assess accuracy and reliability**: Pilot testing occurred by entering data into two separate Filemaker Pro documents. The results were then exported into SPSS and checked for accuracy and reliability using Krippendorf R value of 0.85 as the measure.

5. **Revise the coding rules**: when low reliability occurred (i.e. below 0.85) then the codes and inquiring questions were revised.

6. **Return to step 3**: until the codes worked correctly, steps 3N6x were repeated.

7. **Code all the text**: all the conceptual design scenarios were coded.

8. **Assess achieved reliability and accuracy**: a random selection of samples was coded to assess the accuracy and reliability.

Classifying theoretical concepts through visual imagery proved difficult. Initially there were a far greater number of categories that were attempted to be coded, such as the degree of behavioural change, Fry’s (1999) three positions classifying ecological sustainments, and the recycling hierarchy. However to make the codes reliable these categories needed to be removed or altered, like the recycling hierarchy that failed to generate mutually exclusive categories; therefore this was recorded using an alternative method as will be shown.

### 4.7 Worked Example: Data Collection Instrument in Action

The following section outlines a worked example of the analytical process taken to a student work, from data collection through to final analysis. This tests the process and demonstrates how the process works.

---

30 Fry’s (1999, pp. 8–9) three positions informed the discussion of Developing Ecological Sustainments in Chapter 2. The three positions were: the United Nations’ outlook to modernise all nations via continued development i.e sustainable development, termed the ‘one world order’ position; the position that development and growth are fundamentally at odds with sustainment i.e. reduced development; and the position discussed in Chapter 2 of Developing Ecological Sustainments. Reliably coding the three positions was not possible as a high degree of interpretation was required.
The assessment task was given to students in the first week of teaching in the unit Sustainable Design: Sustainable Futures (see Assessment Task p. 305). The assessment task was completed by students and submitted in the final week of the semester (week 14). Permission to use the assessment task for this thesis was verbally requested at the end of the student presentations, it was stated that there was no connection between the assessment grade received by students and the use of the data for my thesis. The project disclosure statement was handed out (see Appendix IV informed consent p. 304) followed by a permission slip (see Appendix IV informed consent p. 304). An electronic copy of the assessment task was loaded onto a laptop, or a digital photograph of the presented posters was taken at the end of the tutorial depending on the presentation medium.

The digital images in PowerPoint slides or photographs were then cropped and converted to jpegs, and the student names were removed prior to analysis (see Figure 4.3 p. 106).

The image of the conceptual design scenario was assessed against the categories of school of thought, type of innovation, factor X reduction, and recycling hierarchy, as illustrated in Table 4.1. The conceptual design scenario in this case is a car share system.
The car share system required users to adopt a new behaviour by sharing lifts to particular destinations; therefore it was classified as representing the socio-technical school of thought. The type of innovation was classified as ‘functional’ as it meets the function of transport in an alternative way. The potential fold reduction of the system was classified as ‘Factor 4’ as the system has the potential to be four times more efficient in terms of resource use than single person transport, which is taken as the current norm.

<table>
<thead>
<tr>
<th>School of thought</th>
<th>Does the scenario ask the end user to alter their behaviour in any way? No = technical</th>
<th>Does the product ask the end user to alter their behaviour in any way? Yes = social or social technical</th>
<th>Does the scenario incorporate technical design to facilitate the behavioural change? Yes therefore social technical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of Innovation</td>
<td>Does the scenario incorporate product-based incremental improvement to minimise the impact upon the environment? Yes = product improvement</td>
<td>Does the scenario incorporate product redesign based on DfS principles? Yes = product redesign</td>
<td>Does the scenario question the function of the existing product or practice, and attempt to meet that function in an alternative way? Yes = functional innovation</td>
</tr>
<tr>
<td>Factor X Reduction</td>
<td>Does the scenario question the function of the existing product or practice, and attempt to meet that function in an alternative way? Yes = functional innovation</td>
<td>Does the scenario propose a revision in how the function is met through dematerialising existing requirements such as transport or labour? Yes = systems innovation</td>
<td></td>
</tr>
<tr>
<td>Using a quick MIPS Formula, assume the best case scenario:</td>
<td>Quick MIPS formula = The potential fold reduction of resources afforded by the conceptual design scenario (explain working), x the potential fold increase in use life afforded by the conceptual design scenario (explain working).</td>
<td>Negative factor if negative</td>
<td>MIPS = 0-2</td>
</tr>
<tr>
<td></td>
<td>MIPS = 2</td>
<td>MIPS = 4 The car does not reduce resources = 1</td>
<td>The car affords a fourfold increase in use life by carrying maximum passengers = 4</td>
</tr>
<tr>
<td></td>
<td>1 x 4 = 4 fold reduction</td>
<td>MIPS = 10</td>
<td></td>
</tr>
</tbody>
</table>

Table 4.2 Example Categories coded
Table 4.3 Recycling Hierarchy Coded

<table>
<thead>
<tr>
<th>Recycling Hierarchy</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avoid</td>
<td>Dematerialise the product</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Eliminate product or practice</td>
<td></td>
</tr>
<tr>
<td>Reduce</td>
<td>Minimise physical amount of material used</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Use alternate material with lower ecological rucksack</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reduce throughput of materials over lifecycle</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Designed for longer life</td>
<td></td>
</tr>
<tr>
<td>Reuse</td>
<td>Designed from re-used materials</td>
<td>Yes – existing phone and car network</td>
</tr>
<tr>
<td></td>
<td>Designed for re-use (more uses)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Designed for more users</td>
<td>Yes – encourage more users per service</td>
</tr>
<tr>
<td></td>
<td>Front of pipe solutions</td>
<td></td>
</tr>
<tr>
<td>Recycle</td>
<td>Designed from recycled materials</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Designed for recycling</td>
<td></td>
</tr>
<tr>
<td>Regenerate</td>
<td>Restores natural environment</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Restores social interaction amongst people</td>
<td>Yes – potential to encourage social interaction</td>
</tr>
</tbody>
</table>

The car sharing system was classified in the recycling hierarchy (Table [4.3]) to fit into the categories of designed for re-use; through re-using the existing phone networks, cars and road network, and designing for more users per service in encouraging more users per trip. The system was also identified to have the potential to encourage social interaction through personal interaction that may occur within the car trip. The above results and discussion were entered into the File maker data base (see Figure 4.4 on the following page). The results were then exported from Filemaker into SPSS (Statistical Package for the Social Sciences) for statistical analysis.

The above procedure was followed for all student conceptual design scenarios. While all effort was made to create unambiguous categories, the categories are defined in a way that requires thought on the part of the coder. However, the scenarios and case studies were not always easily defined into categories, and on occasion required interpretation by the coder. This interpretation was recorded in the form of comments within the database to explain the coder’s thinking.

The results of the coding would seem to be quantitative once in the analysis stage, yet again these results require a qualitative interpretation to produce results that are ‘valid and theoretically interesting’ (Weber 1960 cited in Rose 2001, p.67).
Figure 4.4 Database entry form used for analysis

Source: The above image is a screen capture taken from the researcher’s computer while entering data.

4.7.1 Data Interpretation of Content Analysis

The primary measure used in analysis was the frequency amongst the categories; this provided the ability to measure the students’ conceptual design scenarios against the progressive DfS theory. The analysis across student years (2005, 2006 and 2007) allowed the interventions (action taking) proposed by the researcher to be analysed in relation to the question ‘what DfS approaches are represented in the conceptual
design solutions of Industrial Design students?’ The targeted focus of analysis across the multi-iterations of the action research cycle ameliorated Kock’s three threats to action research (2004).

To address the question ‘what DfS approaches offer the highest sustaining potential?’, the DfS case studies and student conceptual design scenarios were statistically analysed using the ‘Pearson Coefficient’. The ‘Pearson Coefficient’ is widely used to measure correlation between two variables. This formula identifies relationships between the categories and in this context quantified the approaches to sustainability that have the most probability of offering high sustaining solutions.

The data interpretation outlined above was largely quantitative; however it was the qualitative interpretation of the results that gave meaning to the analysis, as the theoretical discussion on the strengths and limitations of the intervention implemented, the learning from process and the possible reasons behind the results presented in the evidentiary chapters (Chapters 5–7 below) provide insights to address the primary research question of why students of Industrial Design are unable to design in a way that can contribute in real terms to a sustainable society, economy or ecology. In doing so, the action research methodology has not just been used to implement the DfS theory from literature into a curriculum, but has the potential to advance knowledge with the discipline.

4.8 Research Ethics

Throughout the research process, the general ethical principles of voluntary participation, informed consent, risk of harm, confidentiality and anonymity (Trochim 2004) were adhered to. The process for voluntary participation and informed consent are explained in Section 4.7 above. In addition, the unequal power relationship (NHMRC 2007, p.1) between teacher and student as an issue relevant to this study was considered (explained below).

Confidentiality was applied to the students’ conceptual design scenarios by removing student names from digital work prior to analysis. A master document of the original student work is stored on TRIM, the University of Western Sydney’s main archival database.
The ethical principle of anonymity is difficult to achieve within action research (Williamson and Prosser 2002), as the teacher has a professional relationship with the students and is close to the data set. The data set is presented anonymously within this thesis; however it is not possible for the researcher to remove the knowledge of the teaching experience with specific students. The ‘Narrow and Deep’ objective of content analysis ameliorated to some extent the bias from the relationships with participants necessitated by the action research process.

How possible issues regarding the unequal power relationship (fear of reprisal) were addressed is now outlined. Students were required to complete no additional work to be involved within the study, as their already submitted assignments were analysed against a different data set. It was made clear that no assessment marks were awarded for participation in the study. The risk of harm to the students was negligible, as the students’ conceptual design scenarios were already submitted. However, all effort was made not to coerce students as within action research there is ‘an unequal relationship [that] may influence a person’s decision to participate in research’ (NHMRC 2007, p.1). To minimise any fear of reprisal for non-participation, the analysis procedure was disclosed to students. It was explained that the analysis would not be initiated until after their assessment tasks had been marked, therefore non-participation could have no affect on the final grade. Further, being the last assessment task at the end of the session marked the end of the relationship between the student and teacher. Therefore reprisal for non participation was not possible.

Finally the formal ethical approval process for the project was completed and clearance received from the University of Western Sydney Human Research Ethics Committee (approval HREC 05/175). Approval was granted by adhering to the ethical principles outlined above. The ethics application can be viewed in Appendix I p. 295 and approval on p. 300. The process involved minor amendments to the original proposal, separating the informed consent and plain language statement into two documents, as well as being specific in seeking consent only for this research study. These minor amendments were made and approval granted prior to collecting the data.
4.9 Summary

This chapter has justified the methodology and outlined how action research mobilised by the teacher as researcher is used within this study. The epistemological viewpoints of Sustainability, Industrial Design and Education guided the selection of Action Research as the enframing methodology. Content Analysis is the primary analytical method applied to the conceptual design scenarios designed and produced by Industrial Design students. Content analysis internally validates the outcomes of the intervention planned in the multi-iterations of the action research cycle. Through the application of the methodology outlined within this chapter the curriculum was reviewed and reformed, through which knowledge was generated that assisted in answering the research questions.

The following chapters document the application of the methodology to the student conceptual design scenarios in the 2005 teaching year.
Chapter 4 outlined how the data was collected; this chapter presents the analysis of the first of four evidentiary chapters, and assists to address the research question ‘what DfS approaches are represented in the conceptual design solutions of Industrial Design students?’ The year 2005 forms the pilot study for analysis.

In analysing the status quo, the findings of this first stage of the study provided a base line for the pedagogical interventions and validated the underlying guiding hypothesis that students of Industrial Design are currently unable to design for sustainability.

5.1 Presentation

This chapter starts by analysing the results of the data collected from the Industrial Design student conceptual design scenarios presented at the end of the 2005 teaching session within the unit SDSF. The qualitative discussion from this first phase of analysis informs the diagnosing phase of the action research cycle, to identify what areas of the unit may be strengthened to enable students to DfS3. The closing stages of the chapter move to the second phase of the action research cycle, action planning, where the strategies planned for implementation in the 2006 teaching session are outlined, as illustrated by Figure 5.1.

The data is analysed against the core DfS categories identified in Chapter 3. The emphasis as suggested by the title of the chapter was to measure the status quo prior to making any intervention.
5.2 Sample Population

The output of second year Industrial Design students from the unit SDSF at the University of Western Sydney forms the sample for analysis within this chapter. The sample was taken at the end of the 2005 session, and was the last unit of three compulsory sustainable design units. The results should therefore be indicative of students’ progress to date with regard to their understanding of sustainability. The objective of the unit SDSF is as follows:

This unit explores the challenges facing design culture in which the designer must now provide scenarios of sustainable futures that visualise some aspects of how the world could be and which are acceptable socially and attractive culturally. (UWS 2005, p. 2)

The outcome of the unit was for students to develop skills to ‘implement strategic foresight as a tool for contributing positively to sustainable change in a diverse and evolving world’ (UWS 2005, p. 2). The objective and outcomes of the unit are realised in ‘conceptual design scenarios’ presented by the Industrial Design students. Modelled on the DOS explored in the last chapter, these scenarios require the students to situate their design concepts—which could be product-, system- or service-based—within a fully realised visual context. The high rate of return, 98% (n122) is reflective of the data collected being an assessment task that was mandatory.

5.3 Analysis Criterion

The sample for analysis was the final assessment task submitted within the unit. The assessment task (see Appendix V p. 305) consisted of students presenting a group presentation (PowerPoint), visualising a sustainable future for their research portfolio.
(water, energy, food, transport or material consumption) which was embedded with two design conceptual design scenarios each. The conceptual design scenarios were generated after two all-day workshops, whereby students extrapolated contemporary trends research collected throughout the semester to forecast probable future scenarios. The future scenario was then critically examined to strengthen and enlarge by design the positive elements, and eliminate or reduce those elements that are negative for sustainability (see Appendix X p. 322 below for an overview of the workshop theory and structure). A digital copy of the final submissions was analysed.

The explicit assessment criteria for the design solutions within the unit are as follows.

1. The degree to which the designs facilitate sustainable behaviour
2. Feasibility (based on your scenario context in terms of its technological, social or economic status)
3. Design communication (presentation skills in relation to how well you convey three-dimensionality, how the design works, professionalism, and clarity).

The categories analysed in this study differ from the assessment criteria that were given to students. The categories used— the DfS school of thought, Brezet’s type of innovation, and factor X reduction—are more holistic, and embody implicit measures of DfS theory as discussed in Chapter 3, p. 67.

Measuring the current Industrial Design students’ conceptual design scenarios against the broader DfS theory would assist in addressing the research question: ‘what DfS approaches are represented in the conceptual design solutions of Industrial Design students?’ It is viewed that students’ tacit understanding of sustainability was embodied in the conceptual design solutions presented within the unit.

5.4 Results of Content Analysis—Student Design Work 2005

Content analysis was used to measure the student work against the three categories from the DfS theory. The following section provides the results of quantitative analysis of the Student Design work presented in 2005 with regards to the categories,
DfS school of thought, the type of innovation and factor X reduction. The section measures frequency of the results as well as the patterns within the data using the Pearson Coefficient.

### 5.4.1 Frequencies Within the Data 2005

The student conceptual design scenarios collected in 2005 displayed the following results with regards to the category factor X reduction. The majority of conceptual designs were classified to have a relatively small impact in their ability to reduce resources, as 65.5% (n=80) of design solutions had the capacity to reduce resource use by less than 25%. This contrasts starkly to the levels of reduction required by the DfS theory of 90% or factor 10. One third of the conceptual design solutions or 31% (n=38) had the capacity to reduce resources greater than 50%, of which 24% (n=30) had reduced resources by greater than 75% with only 11% (n=13) meeting the reductions required in the DfS literature of 90% (see Table 5.1).

<table>
<thead>
<tr>
<th>‘Factor X Reduction’ 2005</th>
<th>Frequency</th>
<th>Percent</th>
<th>Valid Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negative factor –0</td>
<td>4</td>
<td>3.3</td>
<td>3.3</td>
</tr>
<tr>
<td>Factor 0–2 (less than 25% resource reduction)</td>
<td>80</td>
<td>65.5</td>
<td>65.5</td>
</tr>
<tr>
<td>Factor 2 (50% resource reduction)</td>
<td>9</td>
<td>7.4</td>
<td>7.4</td>
</tr>
<tr>
<td>Factor 4 (75% resource reduction)</td>
<td>16</td>
<td>13.1</td>
<td>13.1</td>
</tr>
<tr>
<td>Factor 10 (90% resource reduction)</td>
<td>13</td>
<td>10.7</td>
<td>10.7</td>
</tr>
<tr>
<td>Total</td>
<td>122</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

The frequencies of the category type of innovation represented in the student conceptual design scenarios from 2005 highlighted that the majority (67.8% n=83) of student work presented was product orientated (22% being ‘product improvement’ and 45.8% being ‘product redesign’). Almost a quarter of work (n=32) presented was classified as ‘functional innovation’ where the students had questioned the function of a product and attempted to meet that function in alternative ways. Only a small percentage 5.9% (n=7) offered designs solution that would be classified as systems innovation (see Table 5.2).

31 The results of the recycling hierarchy have not been included in the evidentiary chapters as the large number of categories did not produce results that were significant. However, through the natural evolution of this study the process of developing the categories produces a useful teaching tool to concisely present the possible ways that DfS may be achieved.
Table 5.2 Frequency ‘Type of Innovation’ in Student Design Work 2005

<table>
<thead>
<tr>
<th>Brezet’s ‘Type of Innovation’ 2005</th>
<th>Frequency</th>
<th>Percent</th>
<th>Valid Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product improvement</td>
<td>27</td>
<td>22</td>
<td>22</td>
</tr>
<tr>
<td>Product redesign</td>
<td>56</td>
<td>45.8</td>
<td>45.8</td>
</tr>
<tr>
<td>Functional innovation</td>
<td>32</td>
<td>26.3</td>
<td>26.3</td>
</tr>
<tr>
<td>Systems innovation</td>
<td>7</td>
<td>5.9</td>
<td>5.9</td>
</tr>
<tr>
<td>Total</td>
<td>122</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

With regards to the DfS school of thought (Table 5.3), the student work analysed had the majority (56.5%, n=69) of students presenting solutions that were classified as technical. One third (32.8%, n=40) presented social-technical solutions, while 10.7% presented purely social solutions. There was a reasonable number 43.4% (n=53) of conceptual design solutions that were classified as socially oriented, as they asked the end user to alter their behaviour. This is positive in relation to the hypothesis that social-technical solutions would address inconspicuous and embodied consumption, as proposed in Chapter 3. However, as the analysis below shows, locating design’s agency in such solutions has appeared difficult.

Table 5.3 Frequency of the ‘School of Thought’ in Student Design Work 2005

<table>
<thead>
<tr>
<th>Sustainable ‘School of Thought’ 2005</th>
<th>Frequency</th>
<th>Percent</th>
<th>Valid Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical</td>
<td>69</td>
<td>56.5</td>
<td>56.5</td>
</tr>
<tr>
<td>Social-technical</td>
<td>40</td>
<td>32.8</td>
<td>32.8</td>
</tr>
<tr>
<td>Social</td>
<td>13</td>
<td>10.7</td>
<td>10.7</td>
</tr>
<tr>
<td>Total</td>
<td>122</td>
<td>100.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>

5.5 Key Results for Further Discussion

The following section may read as an indicator of shortcomings of the Industrial Design students. This is not the position taken by the researcher. The problems discussed are analysed to identify shortcomings in the delivery of the unit, to assess if the delivery has provided the right ‘tooling’ to enable DfS3 (assisting to form the diagnosing phase of Action Research).

From the above quantitative analysis of students’ design work in 2005, two key results are worthy of further discussion: first, the small percentage of conceptual design solutions that resulted in large factor X reduction savings; and second, the
emphasis by students on the product focused ‘solutions’ in the category type of innovation.

The first key result was the problem of students being unable to synthesise the Factor 10 reductions into design solutions. This suggests two possibilities: that students did not comprehend from the DfS theory they were exposed to in the unit the large scale of change that is required, which would indicate that the students’ tacit definition of ‘sustainability’ was based upon minor improvement; or the students may have grasped the large scale change required but lacked the skills to turn the required reduction into design solutions.

The second key result was how the technical and product-oriented focus of design stands in the way of realising concepts that comprehend design’s agency, such as that embodied in the idea that design designs. This would require a sense of temporality—how the design may evolve over time. Some of the concepts attempted to show change over time. However, this was seen to be an underdeveloped aspect of their ‘to hand’ capabilities.

With regard to the proposal ‘how you define is how you design’, the results would suggest difficulty on both sides of the framework. An inadequate interpretation of unsustainability (how you define) is informing the design decision, while students may have difficulty in transforming this understanding into design solutions (how you design).

5.5.1 The Chalk and Cheese of Design for Sustainability Theory Represented in Practice

The literature review in Chapter 2 introduced the ecological crisis of unsustainability as over-consumption, suggesting that large scale resource reduction in the order of factor 10 is required (Schmidt-Bleek 1999). What immediately confronted the researcher in the early analysis was that such a large-scale reduction appeared as almost the polar opposite to the levels of resource reduction that the student design ‘solutions’ actually afforded. To reiterate, this is not viewed to be the fault of the students, the above concern is the starting point for the researcher to investigate and learn more about the challenges in Industrial Design Education for Sustainability, particularly those faced in the SDSF Unit.
While significantly reducing our material dependency is one of many elements required to bring about a sustainable society, and in the first instance may appear simple and mathematic, the analysis of the students’ work presented the starting point to reveal broader issues relating to Design for Sustainability.

Within the unit, each group of students researched a particular portfolio from the defined areas of water, energy, food, transport or material consumption. The first conceptual design scenario presented was by the ‘transport’ group (Figure 5.2), and proposed that to reduce the dependency on transport, it could be arranged to work from home for two days of the week (reducing the requirement of travel to 3/5 days, equating to a reduction of 40% or 1.66 fold in the quick MIPS working for analysis). If ecological resource was the focus then the scale of change acknowledged in the student’s ‘tacit’ definition of unsustainability was low.

If ecological resource reduction was to take precedence, then modification to the ‘work from home scenario’ to more radical alternatives could be made. For example, a strategic plan to facilitate working from home four out of five days per week would increase the implied resource reduction potential of the scenario (reduction of 80% or five fold). This would be assisted by design innovation to overcome communication barriers between employer and employee that were identified by students as the reasons for the cautious approach. The revised scenario would be classified in the coding schema as ‘factor 4,’ ‘systems innovation’ and ‘socio-technical’ school of thought.

![Figure 5.2 Work from home two days per week](source: Industrial Design student conceptual design scenario submitted in 2005 for the unit Sustainable Design: Sustainable Futures at the University of Western Sydney)

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32 The use of identifying barriers draws on the theory of McKenzie-Mohr and Smith’s (1999) Community Based Social Marketing. Overcoming barriers is a key goal in facilitating behavioural change and in this study became a major design directive.
The analysis, while initially focused on ecological resource reduction, quickly identified issues of context, feasibility and social requirements that would need to be addressed to reach the more drastic targets. The above ‘solution’ also raised questions about where design’s agency lies in engaging in ‘social’ solutions: at present the concept of work from home is vague in identifying how Industrial Design may assist in the ‘solution’. This introduces the concept termed ‘no design’ by the researcher, which is identified in the analysis chapters as a problem in relation to determining design’s contribution to more ‘social solutions’.

The second conceptual design scenario, presented by the ‘food group’, was the ‘indoor kitchen vegetable patch’ (see Figure 5.3). This was designed to provide fresh food within the kitchen, and efficiently use rainwater falling on rooftops to irrigate the plants. The design solution presented is positive in terms of supplementing food, but the scale of the solution again is only a minor in its capacity to minimise ecological resource use. When considered in light of Manzini’s rebound effect discussed in Chapter 2 above (i.e. what are the potential escalations in consumption implied by this design?), the indoor kitchen vegetable patch could entail additional

33 The benefits of growing vegetables, such as the owner’s wellbeing, are acknowledged, as is the control offered to guarantee freshness.
regular trips to the shop, as the scale addressed would supplement rather than substitute household needs.

This analysis started to shape the sorts of questions students would need to ask themselves in their designing for sustainability, for example what does this design create, destroy? How can I move my design to enable a higher degree of self sufficiency in fresh food production within the home?

The above examples illustrate that the ‘tacit’ definition of unsustainability embodied in the problems that students were attempting to resolve did not engage fully with the scale of change required to move towards sustainability; the above examples are viewed to be representative of the student ‘solutions’ as evidenced by the small percentage (11% n=13) of students who produced conceptual design scenarios that were capable of reducing resources in the order of factor 10.

These examples and data analysis indicated that students needed to pitch their proposals more radically in relation to the scale of ecological resource use reduction required by more comprehensively defining the problem space and indicating what their proposals offset and generated. There is a conceptual leap that was not afforded by the process within the unit to allow students to visualise significantly reduced material intense ways of living. This was seen to be compounded by a dependency on the ‘techno-fix’, of which Industrial Design has a strong history. This leads to the second concern of the students results, that of largely product-dependent solutions. This is discussed in the following section.

5.5.2 Dependency on the Techno-fix

The large percentage (67.8%) of Industrial Design students’ conceptual design scenarios in 2005 that were product orientated is not in itself problematic. However the problems compound when these concepts are presented as solutions in themselves, in isolation of their social context, or when the product solutions are founded upon an ill-conceived ‘tacit’ definition of unsustainability. When this occurs the unit may be seen to be promoting sustainability via the proliferation of new products, which is not its objective.

This problem of ‘techno fix’ solutions is largely seen as a problem embedded in Industrial Design’s history and the culture of its practices, both educational and
professional. The term technological fix (techno-fix) was introduced by Alvin Weinberg (1966) to describe how technology may be used to respond to human problems that traditionally would be addressed through other processes (i.e. behavioural change through social processes). Techno-fix solutions can be viewed as overtly dependent on technology as an easier approach to confronting fundamentally relational, ‘wicked’ problems. The student examples in Figure 5.4 are presented as examples of techno-fix; neither the ‘road go cart’ nor the ‘water filtration system’ question the problematic behaviours associated with our high dependency on the car and excessive water use—they implicitly treat existing behaviours as the status quo.

![Figure 5.4 Road go cart and water filtration system](image)

Source: Industrial Design student conceptual design scenario’s submitted in 2005 for the unit Sustainable Design: Sustainable Futures at the University of Western Sydney

Possible reasons for the dependency on the ‘techno-fix’ in these early concepts may be attributed to the broader Industrial Design curriculum at UWS, as well as ambiguity in the learning design of the unit SDSF. The compulsory sustainable design stream comprises three out of 24 units that the Industrial Design student must complete prior to graduation. At present sustainability content is not integrated throughout the other units; therefore while three units teach sustainability, 21 unintentionally teach the unsustainable (i.e. expanding market share through improved design being a central focus). SDSF is the first unit where non-product design solutions are encouraged. This suggests that the low amount of function or system innovation being presented may be due to a lack of exposure and practice of this kind of designing in an educational context, as Industrial Design students are conditioned to the product-focused ‘techno-fix’ solutions in their education to date.
Further, a review of the assessment outline (University of Western Sydney 2005 p 2) for the unit showed that students were required to present ‘two design solutions as hand drawn presentation concept renderings describing what the design is, how it is produced, how it works etc.’

Students would understand this wording to mean solutions in the form of physical technical products, as this was all they had been exposed to to date. In fact, the use of the term ‘design concepts’ is ambiguous in the above extract and a careful analysis of the unit content revealed that it actually allows design ‘solutions’ to take the form of products, systems or services, but this is not clearly stated in the assessment outline. Further terms within the assessment brief synonymous with product concepts include ‘concept renderings’ and ‘produced’.34

The focus on product ‘techno-fix’ conceptual design solutions in 2005 represent in part the limitations of the assessment tasks in the unit SDSF. The results suggested that in order to expose students to more progressive forms of DfS (functional and systems innovation) a move away from conventional assessment models that reflect a product focus may be required.

To summarise the major concerns of the 2005 results, first it appears that the major scale of ecological resource reduction required was far from being addressed, in that the conceptual leap to less material-intense ways of living had not been made. Second, the above concerns are seen to be compounded by the dependency on the ‘techno-fix’ to bring about such change. This raises questions about the embedded perception of design’s agency being located in product-based ‘solutions’ rather than in broader social contexts supported by design.

The following section presents a deeper analysis of the above in relation to the cognitive process of designing (which leads on from the ‘epistemological’ discussion in Chapter 4) in terms of critical, relational and creative thinking.

34 Technically, Product System Services are also ‘produced’, however the language is viewed to be product orientated. Terms such as managed, implemented or introduced may correlate better with Product System Services.
5.6 Transforming Understanding into Design Solutions

During analysis of the 2005 material, it was unclear whether the problem of not addressing the scale of unsustainability was located in a poor problem definition, or in the ability of students to transform their understanding of the problem into design solutions. However what was clear was the dominance of ‘techno-fix’ approaches and that the kinds of questions students were asking themselves in their designing needed to shift. In order to develop conceptual design scenarios that may achieve factor 10 reductions in resource use requires critical and relational thinking that the students were largely unpractised in, matched with creativity skills that could help mobilise more traditional ‘synthetic’ processes in service of DfS3 proposals.

The hybrid model of scenario planning discussed in Chapter 4, drawing on Strategic Foresight (SF), Design Orientated Scenarios (DOS) and Defuturing, was developed to address the above skill deficit in terms of designing for sustainability. The model was employed in the two intensive scenario planning workshops which have been a defining structural feature of the unit since its inception and mark its difference from other units in the course. As noted in the beginning of this chapter, the outcome of the first workshop is a 15-year scenario narrative of a probable future. The second workshop develops strategies for how design can intervene in these scenarios to move towards sustainability. The conceptual design solutions presented are the final outcome. The workshops are designed to ‘remove the blinkers’ from current thinking, as the future scenarios encourage students to step outside the constraints limiting contemporary design as they forecast trends to identify the type of society that could be and ‘stand in the future’, to reflect upon how it may be possible arrive at this future, encouraging lateral thinking for a sustainable future (Lopes, Clune et al. 2007).

Strategic Foresight was initially selected to encourage the skills of relational thinking, critical thinking and creativity. Therefore it was surprising given the prior development of the unit that these skills of critical thinking, relational thinking and creativity were not evidenced within the student design solutions to the level required by the DfS theory. A clear explanation, given the previous analysis, is that

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35 For an introduction of the hybrid model of Scenario Planning used at the University of Western Sydney see Chapter 4, p. 95 in the methodology chapter or the full paper included in Appendix X.
these skills were employed in relation to generating product forms that immediately foreclose upon the complexity of problems.

Critical thinking in DfS is most simply engaged by questioning ‘how the solutions will bring about sustainable change’, and ‘how design can assist this process’. Relational thinking can be encouraged by asking ‘what does a design create or destroy?’ This allows one to connect, say, bio-fuel as a ‘solution’ to the ‘problem’ of allocating agricultural land to growing fuel and or land clearing. Relational thinking assists to tease out the complexities of problems; it is problem generating (how you define). ‘Impact assessment’, commonly practised within life cycle analysis, is useful in weighing up those problems to make decisions and is therefore a process of critical thinking related to design judgement. Finally, creative or lateral thinking is seen to assist how you design, in transforming these analytical understandings into synthetic, visual design ‘solutions’. These types of thinking are discussed in relation to the student work below. Then we address how they informed the interventions for the next iteration of the study.

5.6.1 Critical Thinking

Critical thinking is important in assisting students to form a sound definition of unsustainability. As Dewey stated, ‘a problem well put is half-solved’ (Dewey 1998, p.173). Due to the large amount of information surrounding sustainability, with multiple definitions and products being presented as ‘sustainable’, critical thinking assists in arriving as a sound definition of what is and what is not sustainable. Scriven and Paul (2001, p.1) define critical thinking as:

…the intellectually disciplined process of actively and skilfully conceptualising, applying, analysing, synthesising and/or evaluating information gathered from, or generalised by, observation, experience, reflection, reasoning or communication, as a guide to belief or action [or argument].

For sustainability, the question of ‘how does this solution contribute to a sustainable society’ is invaluable as a means to critically discuss the advantages of the proposed solution. Students’ inability to employ critical thinking in the development of sustainable scenarios was evidenced within their design work in several ways: first, the proposed work mimicked solutions available today (see Figure 5.5), such as the rainwater tank and gutter shield, without addressing what is standing in the way of taking up these solutions; second, technical solutions were
presented in isolation of their contextual conditions (see Figure 5.6). The bike and train have been presented as the ‘solution’ to the problem of single occupant car travel.

![Figure 5.5 Gutter shield and tank wall](image)

![Figure 5.6 Motorbike and electric train](image)

Source: Industrial Design student conceptual design scenarios submitted in 2005 for the unit Sustainable Design: Sustainable Futures at the University of Western Sydney

Most notable within pass grade students, taken for granted ‘green’ solutions of today are not being advanced upon. Students reached for existing ideas and relied upon pre-existing notions of sustainability, such as recycling points and hybrid cars. These were accepted and presented without criticism, whilst the critical thinking required depends on questioning the status quo and determining its benefit in relation to bringing on a sustainable society.

The recycling concepts of Figure 5.7 present an example of a lack of critical thinking. While the benefits of recycling in reducing resource consumption by a factor of two is acknowledged as an improvement, it would be desirable to question the benefits of recycling as the design strategy for a long term sustainable solution.
In these examples, today’s best practice is presented as a future solution. Existing technology in some instances was presented with no improvement, indicating a failure to map the contextual dimensions of problems and make the creative leaps to accommodate these insights in concept generation.

To bring critical thinking back to sound problem definition, if the problem is reframed from ‘how can we design sustainable products’ to read ‘how can design encourage the adoption of sustainable practices and behavioural change?’ then focusing on the adoption of promising technology may be beneficial and provide an opportunity for design innovation. There is a problem in that we have many existing ‘sustainable’ solutions all around us that are not being used. Encouraging the adoption of pre-existing promising technical ‘solutions’ relies on a greater understanding of the system and contexts of use in which the products are operating, thus engaging in a level of detail required to think critically. This thinking draws heavily on Manzini’s enabling solution criteria of ‘use what already exists’(2002, p.9). 36

The second concern raised by the data analysis relates to solutions presented in isolation of their contextual conditions. The lack of specific, articulated context disables the student from being able to think through the social implications and relational impacts of a proposed idea which is the basis of the scenario model. Without a point of reference the design ‘solution’ is difficult to assess, as a solution

36 Manzini states his ‘use what exists’ in the following terms: ‘before conceiving something new, re-use and/or reinvent the use of existing resources and infrastructures. This is the most obvious, but also the most frequently forgotten strategy to sustainability.’ (2002, p. 9)
that may be highly appropriate for one location may not be appropriate for another. The student design ‘solution’ of the maglev train for resource-efficient transport illustrates the point (see Figure 5.8). If the student had proposed a maglev train to compete with the airline routes between Melbourne, Sydney and Brisbane, this may have provided a significant reduction in the greenhouse emissions from air travel (if powered from clean energy). On the other hand, if the maglev train was proposed as a suburban railway network in Sydney the shorter distances reduce the attractive time-saving potential of the system. The system is also not compatible with the extensive existing rail network so would require all new infrastructure, making it less favourable against Manzini’s ‘use what exists criteria’ (2002, p. 9).

Therefore to be able to validate effective design solutions, the level of context-related detail needs to increase. Lipman describes critical thinking as ‘skilful, responsible thinking that facilitates good judgement because it: a) relies on criteria, (b) is self-correcting; and (c) is sensitive to context’ (Lipman 1988, p.39). How critical thinking may be strengthened via design criteria and context is discussed later in this chapter.

5.6.2 Relational Thinking

For embodied and inconspicuous consumption as identified in the literature review to be revealed, relational thinking on the part of the designer is required. The
conceptual design scenarios presented in 2005 were linear in their problem definition with the exception of a few. For example, the ‘transport’ group identified the problem as the motorcar, therefore more efficient cars were the dominant solution. The implied relational problems, such as extended commuting hours leading to time away from family in travelling to and from a centralised work place, were not raised. The ‘water’ group identified the problem of over-consumption of potable water in relation to the tap, therefore more efficient home water use utilised timers and savers.

Almost all of the designs relating to water defined the problem as consumption of water within the house (with the exception of designs that related to storage and reticulation). The example of the water time delay switch (Figure 5.9) is typical of the water solutions offered. The design appears to be informed by the ‘every drop counts’ advertising and educational programs that had been running in Australia for many years (i.e. Winters 2000), which has given the act of turning off the tap iconic status as a key water-saving activity. The design is effective in reducing the water use by 25% at the tap. However, in relation to the holistic consumption of water within Australia, the saving is small. For example, the water time delay switch in Figure 5.8 offers a suggested 25% savings of water from the tap. Water from the tap accounts for 1.4% water use nationally (ABS, 2006). This equates to total water savings of 0.35% if adopted by the entire population.

![Figure 5.9 Water time delay switch](image_url)

*Source: Industrial Design student conceptual design scenario submitted in 2005 for the unit Sustainable Design: Sustainable Futures at the University of Western Sydney*
The Australian statistics of water use within the house indicate that the garden utilises the majority of the water, yet no designs focused upon the garden. Such examples suggest that a pedagogical focus on developing opportunities for relational thinking, to question where the problems lie and where design could have the greatest impact, is warranted. If one looks at water use in Australia (see Table 5.4) we find that household consumption equates to 9% of the water consumed (ABS 2006).

Table 5.4 Breakdown of Water Consumers within Australia

<table>
<thead>
<tr>
<th>Breakdown of Australia’s Water Consumption</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Agriculture</strong></td>
<td>67% of total water consumption</td>
</tr>
<tr>
<td>Livestock, pasture, grains &amp; other</td>
<td>33.5%</td>
</tr>
<tr>
<td>Cotton</td>
<td>17.5%</td>
</tr>
<tr>
<td>Dairy</td>
<td>17%</td>
</tr>
<tr>
<td>Rice</td>
<td>12%</td>
</tr>
<tr>
<td><strong>Household</strong></td>
<td>9% of total water consumption</td>
</tr>
<tr>
<td>Outdoors (garden)</td>
<td>46% household water</td>
</tr>
<tr>
<td>Shower and Bath</td>
<td>20% household water</td>
</tr>
<tr>
<td>Kitchen, Drinking and cleaning</td>
<td>16% household water</td>
</tr>
<tr>
<td>Toilet flushing</td>
<td>11% household water</td>
</tr>
<tr>
<td>Laundry</td>
<td>7% household water</td>
</tr>
<tr>
<td>Water supply, sewerage and drainage</td>
<td>7%</td>
</tr>
<tr>
<td>services</td>
<td></td>
</tr>
<tr>
<td>Electricity and gas</td>
<td>7%</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>7%</td>
</tr>
</tbody>
</table>


Relational thinking would lead designers to define the problem of water unsustainability in terms of other areas of consumption, for example of ‘how Industrial Design can reduce/eliminate/substitute the use of cotton’, the production of which consumes 12% of Australia’s water, or ‘how can design reduce the energy and gas consumed within the house?’, which would offer a similar savings to turning off water at the tap.

A more relational approach moves away from the product focus of consumption toward embodied and inconspicuous forms of consumption, where design can have an influence on behaviour and social impact. Lenzen and Foran focused on the embodied water consumed within the household as illustrated in Figure 5.10: applying relational thinking to their findings is challenging for DfS as 48% of water consumed is embodied with the food we eat, 14% embodied within the house and only 11% of the water consumed is through direct in-house water use i.e.
the tap (2001, p.353). Engaging the designer in embodied water use would again shift the design criteria to respond to.

![Figure 5.10 Total water budget within the average Sydney household](image)

In the 2005 teaching session students adhered to the efficiency approach, despite this being contradictory to theoretical content delivered in tutorials which clearly supported the argument that more than incremental improvement and efficiency is required to move toward a more sustainable society. To have a learning approach engaging students with embodied water use would mark a significant shift in understanding the complexity of sustainability within the unit, of which relational thinking is of central importance.

### 5.6.3 Creativity, Lateral Thinking

Radical change requires radical thinking; radical thinking is most closely aligned to creative thinking, lateral thinking or ‘thinking outside the square’—skills which are advertised as core to industrial design practice, as the International Council of Societies of Industrial Design states ‘design is a creative activity’ (2008, p.1). This creative activity is viewed to be the outcome of creative thinking. Therefore it was surprising that the conceptual design scenarios displayed a minimal amount of creative thought as determined by their dependence on existing ‘solutions’ already in wide cultural circulation. The low percentage of functional innovation, 26%, is a
strong indicator of this lack of creativity, as asking how the function can be met in alternative ways is a key creative exercise in itself and a stage of the widely cited Osborne’s checklist (Osborne 1963).  

The freedom given to students within SDSF to come up with ‘radical’ solutions is extensive, viewed to be greater than that in the remaining units of study. The perceived ‘lack of creativity’ is not seen as an indicator of student ability, rather this was interpreted as a problem with the learning environment and assessments. The reasoning behind the lack of creative skills presented may be through the assumption that creativity is inert within the students. Specific strategies to develop creativity within the unit were not present, however it is suggested that creativity can be taught (Craft, Jeffrey et al. 2001). This is discussed in detail below.

The most noticeable omission from the unit that is required for creative problem solutions is a clear problem definition. To reiterate Dewey, ‘a problem well put is half-solved’ (Dewey 1998, p.173). Without a comprehensive understanding of the problems that that need to be turned around by design, it will be difficult for students to offer effective creative solutions.

### 5.7 Strategies for Action 2006

The analysis and discussion of the conceptual design scenarios presented in 2005 informed the ‘Diagnosing’ phase of the action research cycle. This identified key items to address through the teaching session of Sustainable Design: Sustainable Futures in 2006 which were:

- to increase students’ exposure to the scale of reduction required.
- to further integrate methods to encourage critical thinking, relational thinking and creativity displayed by students.
- provided a learning design to encourage students to design solutions outside of the product presented in isolation.

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37 Osborne’s checklist (1963) is a widely used tool to assist in facilitating creative brainstorming sessions, where by a facilitator asks prompting questions around a topic such as how could this solution be adopted, modified, magnified, reduced, substituted, rearranged, reversed or combined. Stating the function of the problem or product is seen to assist in conceiving a wider range of ‘solutions’.
The roadmap for how the key items were integrated within the unit is discussed below; this forms the ‘Action Planning’ phase of the first iteration of the action research cycle. Figure 5.11 assists in following the timing of the planned interventions across the 2006 teaching session.

### Timing of 2006 session plan interventions

<table>
<thead>
<tr>
<th>Week one</th>
<th>Lecture, scale of unsustainability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week two</td>
<td></td>
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<tr>
<td>Week Three</td>
<td></td>
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<tr>
<td>Week Four</td>
<td>Formal in class debates</td>
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<tr>
<td>Week Five</td>
<td>Our unsustainable past - annotated bibliography due + WorkShop one - creating probable futures</td>
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<tr>
<td>Week Six</td>
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<tr>
<td>Week Seven</td>
<td>Our unsustainable past - tutorial presentation</td>
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<tr>
<td>Week Eight</td>
<td></td>
</tr>
<tr>
<td>Week Nine</td>
<td>Formal in class debates</td>
</tr>
<tr>
<td>Week Ten</td>
<td>Tutorial discussion, Manzini and Jegou’s criterion for sustainability</td>
</tr>
<tr>
<td>Week Eleven</td>
<td>WorkShop two - sustainable solutions, A ‘Day in the Life’ scenario, followed by the ‘design brief’ followed by ‘creativity tools’</td>
</tr>
<tr>
<td>Week Twelve</td>
<td></td>
</tr>
<tr>
<td>Week Thirteen</td>
<td>Scenario Narrative + Contemporary Trends Research Final Submission (ongoing from week two)</td>
</tr>
<tr>
<td>Week Fourteen</td>
<td>Presentation of Designed Solutions Reflective learning document</td>
</tr>
</tbody>
</table>

*Figure 5.11 planned timing of 2006 interventions*

#### 5.7.1 Increasing Exposure to the Scale of Reduction

To encourage students to engage in the scale of change required for sustainability, the introductory lecture and ongoing tutorials planned for the 2006 intervention had an emphasis on scale.

The first strategy planned was to ensure that students would be exposed to the reasons behind the requirement for large scale reduction throughout the unit in a rational way. The scale of reduction is explicitly stated in lectures at the beginning of the session through the argument construction shown in Figure 5.11. The argument would be continually returned to at various stages of the session. It was envisioned that such exposure would assist in informing the students’ tacit definitions of unsustainability.
Further, tutorial discussions were planned around existing sustainability indicators from progressive theorists such as Manzini and Jégou’s Scenarios of Everyday Life (2003). The indicators included low embodied energy and low material intensity to the order of factor 10. These would be presented to students in an attempt to normalise the radical reductions required in weekly discussions, aligning better with the scale presented in the DfS literature. Finally indicators would be developed by each group, once they have an understanding of what is unsustainable, then the polar opposite of this forms the beginnings of criteria for sustainability (for example if inconspicuous consumption is the problem, then making consumption conspicuous may be the criterion). The indicators would be carried over into the criteria for their final design solutions, which is discussed in the following section.

Through the implementation of the above strategies it was hoped that students would acknowledge and engage in the challenge of designing for sustainability. Making explicit assumptions and defending the criteria for sustainability against the unsustainable problems would assist in forming a sound problem definition.

### 5.7.2 Critical Thinking, Relational Thinking and Creativity

It was envisaged that the above strategy of explicitly forming criteria for sustainability would provide a solid foundation to assist critical thinking as supported by Lipman (1988) discussed above. The strategies also provide a sound problem and criteria to enable creativity strategies to be applied to develop design ‘solutions’, which will be presented later.

#### Encouraging Critical Thinking

The tutorial plan for 2006 allocated a weekly timeslot for formal debates to be held within the class to analyse current best practices on sustainability. It was proposed that two teams would be established within the class on selected topics such as ‘is the Tesla Roadster an effective transport solution for Sydney?’. The affirmative team
would be briefed with the white papers from Tesla motors (Eberhard and Tarpenning 2006), the cutting edge electric car manufacturer from the USA, outlining the benefits of electric cars to cutting emissions. The negative team would be briefed with urban design and public transport papers, such as Curitiba’s public transport initiatives and the grand Lyon Vélib bike share program. Students would be given 30 minutes to prepare for a 20 minute debate. It was envisaged that through a balanced debate and facilitated discussion, the advantages and disadvantages of particular solutions would arise. These could include the inability of electric cars to reduce traffic congestion and more widespread issues of city planning, exposing the limitations of the techno-fix solutions and the opportunity represented by public transport, walking and biking to contribute to a more sustainable transport mix.

**Facilitating Relational Thinking and Creativity**

To facilitate relational thinking and creativity in defining the problem and concept generation, three ‘human-centred’ strategies were developed. First, a ‘day in the life scenario’ detailing the flow of actions and design interactions that may take place across a day would focus students on individual behaviours in context as a source for design innovation, and provide opportunities for relational thinking in determining hot spots of inconspicuous consumption. Second, behaviours identified in the day in the life scenario could be judged critically in terms of whether they are sustainable or unsustainable. This would help develop criteria for change in the context of a functional design brief. The human-centred functional design brief’s purpose was twofold (see worked example on the following page): first, drawing on ‘progressive abstraction’ (Tukker and Tischner 2004, p.216), a deeper understanding of the problem was attempted by repeatedly asking the question ‘what are we actually aiming for?’. This was planned to assist in relational thinking as students move to the underlying problem, such as moving from the car as the problem, to movement of people as the problem, to the need to move as the problem, allowing for an inclusion of criteria like Manzini’s regenerative potential. The human-centred functional design brief’s second purpose was to provide focus to allow creativity tools to be applied, which was the third strategy.

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38 The Vélib’ bike share, Curitiba’s bus shelters, Tesla motors and walking schools buses are drawn from case studies that the researcher has been collating for analysis as part of the methodology outlined in the previous chapter. A detailed analysis of these case studies is presented in Chapter 8.
Because a clear problem definition had been created through the design brief, it was envisioned that the creativity tools employed would have a greater chance of facilitating concepts realised through creative thinking. A more detailed explanation of these planned strategies follows.

A ‘day in the life scenario’ was planned as an addition to the first ‘scenario planning’ workshop of 2006. The day in the life scenario examines in detail the intricate activities of a particular persona created by the Industrial Design student. The premise for examining the detail of a ‘day in the life’ follows the literature review where inconspicuous and embodied consumption in the everyday was identified as a driver of unsustainability and is further warranted by the findings of the analysis of 2005 design concepts, in which technical solutions dominated. By critically examining our everyday and identifying the relational embodied and inconspicuous consumption connected to the daily activities, it was hoped that students would identify specific unsustainable activities which could be redirected by design.

A template (Figure 5.12) was developed to encourage students to think in minute detail about the environment for which they will be designing. The greater the understanding of the environmental contexts through the activities of an identifiable persona, the clearer the criteria for design would be.

The ‘day in the life’ template would be screened for activities that are sustainable or unsustainable in their nature, according to the criteria of unsustainability articulated in tutorials. To formulate a criterion for sustainability, the polar opposite in unsustainability would be used as a starting point, for example if dependency on the car for transport is identified as unsustainable; then reducing car dependency becomes a design criterion. The criterion for sustainability will then be transferred into a human-centered design brief. Students would be given opportunities to practise relational thinking by connecting daily activities to the broader impacts that they have on society in responding to their briefs.
Once a number of behaviours or activities are identified, the human-centered functional design brief will be completed, as indicated in the example below.

To assist your persona to complete the daily activity of picking up the kids from school within the quadrant comprising of Urban Sprawl/Home Ownership, whilst satisfying the design criteria of: A. low material intensity (less material removed from nature therefore having a smaller environmental impact); B. low energy use in any form — electricity, fuels (solutions must be highly efficient across the life of the product); C. high regenerative potential (enhancing and if possible regenerating environmental and social resources); D. providing a positive experience in that completing the activities is fulfilling and E. reducing car dependency.

In developing the design brief Tischner’s progressive abstraction (Tukker and Tischner 2004, p.216) was employed in an attempt to encourage students to articulate the design problem at a more fundamental level. Once the design brief was identified and the problems located and defined, the hypothesis was that students would then be able to work with the familiar tools of design. The abstract notion of sustainability had been transferred into a straightforward design problem by giving it a situated problem context with existing design and human elements.
For creativity tools to be effective they require well defined problems (Osborne 1963; Shneiderman and Fischer 2005) which the above design brief affords. Even if students are adverse to sustainability, they would now have a brief to work with, requiring the appropriate application of design skills from this point forward.

To assist in fostering creative solutions, a suite of creativity tools were developed to be on hand during the concept generation phase, which follows the development of the functional design brief. The specific creativity tools proposed to be used were Osborne’s Checklist (Osborne 1963), morphological analysis, 20minutes-20solutions, and the ‘think back’ exercise developed by the researcher. A degree of responsibility will be placed with the facilitator to select the appropriate tool for the varying progress speeds of the different groups.

Osborne’s Checklist is a series of questions or prompts that are asked during a brainstorming session. Students are already familiar with the rules of brainstorming from other units. Prompts asked include how the solutions can be adopted, modified, magnified, reduced, substituted, rearranged, reversed or combined (Osborne 1963; Steidle, Harris et al. 1992). Osborne’s Checklist is effective in generating multiple variations on existing concepts, which would be used once initial conceptual design scenarios have been generated and are expanded upon.

Morphological analysis is a tool that is suited to generating a large number of possible solutions very quickly. It is envisioned that the tool will be useful when students are stuck—if there is a lack of ideas flowing from students then morphological analysis is suitable due to its procedural nature, which is outlined below from Zwiggy (1966 cited in Ritchy 1998, p.3).

First; the problem to be solved must be very concisely formulated.

Second; all of the parameters that might be of importance for the solution of the given problem must be localized and analysed.

Third; the morphological box or multidimensional matrix, which contains all of the potential solutions of the given problem, is constructed.

Fourth; all the solutions contained in the morphological box are closely scrutinized and evaluated with respect to the purposes that are to be achieved.

Fifth; the optimally suitable solutions are...selected and are practically applied, provided the necessary means that are available.

The exercise of 20minutes-20 solutions is a strategy planned for use near the end of the day of the second workshop prior to breaks. i.e. ‘there are 20 minutes until lunch time, sketch down 20 possible solutions prior to lunch’. The sheer volume of
Chapter Five: Data Analysis 2005, The Status Quo

solutions in a short time frame encourages solutions to be born without immediate reflection. When solutions are later reflected upon there may be possible concepts worth developing or modifying.

‘Think back’ is a variation of the ‘what if’ question and was developed by the researcher (Lopes, Clune et al. 2007). The ‘what if’ question, such as ‘what if we had no electricity?’, ‘what if we had no water?’ etc. assists students to identify radical solutions through functional innovation by severely limiting the palette of resources they have to design with. For example how could one clean without water? This forces students to search for alternatives (i.e. high air pressure, antibacterial wipes, smell-neutralising powder). The ‘think back’ exercise differs as it involves asking students to think back to a time in history when the current problem they are working with was not an issue of unsustainability as it is currently defined. The exercise supports Fry’s philosophy of defuturing (1999). By acknowledging existing practices, students identify that alternative practices have been in place in the past, and that there is a great opportunity to draw on and re-invent such practices in the present. Students will be asked to ‘think back’ to a time in history when society addressed its needs without electricity, air-conditioners; prepared food without fridges or coordinated social events without mobile phones.

The hypothesis is that the above process of concretely defining criteria for unsustainability, developing a human-centred functional design brief, and applying creativity tools to a well-refined problem would assist students to bring about DfS3-type solutions, as is the objective of the thesis. The process is envisaged to create synergies between sustainability and the traditional design studio, as once the problem is well defined students can mobilise the traditional design skills that drew them to the discipline in the first place in order to develop responses.

5.7.3 Designing Outside the Product

As noted in the discussion above, students perceive the ‘design solutions’ requested as being product related. The assessment task has been amended and now reads as follows:

You are to visualise the system of your future scenario. Your system will require products, systems or services design solutions to move towards long-term sustainability. Two design solutions each are to be presented within the group presentation. Your designs should not be presented in isolation but in the context of use in everyday life,
you need to showcase how your designs facilitate sustainable behaviour (Appendix X, p. 305 below)

Through the reworked assessment task and the functional design brief, it was thought that solutions would look beyond the product, leaning towards functional and systems innovation. By acknowledging the shortfall of solutions (being product focused) it is hoped that the tutors of the unit can intervene by illustrating alternate solutions that would be exemplary of, acceptable and desirable for functional and systems innovation.

5.8 Conclusion

This chapter has provided a detailed analysis of the student design work presented in 2005 forming the diagnosing phase of the action research cycle. Concerns were identified with regard to the students’ ability to engage with a sound problem definition of unsustainability, in particular acknowledging and designing for large-scale change. In addition, the emphasis on the techno-fix product-based solutions in the concepts revealed a significant barrier to the possible range of ‘solutions’ DfS may present. From this diagnosis, an action planning strategy was developed for implementation in the 2006 teaching session for the unit Sustainable Design: Sustainable Futures. The strategy, which was approved for implementation by peers in the Sustainable Design stream team, had two overarching aims: to assist students to critically define unsustainability in their problem context; and to assist students to transform their understanding into more appropriate design proposals.

This progresses the action research cycle to the Action Taking stage in the 2006 teaching session, and will form the basis for the following chapter.
6 Analysis 2006: From DfS Theory to Pedagogy

In Chapter 5, data was analysed against core Design for Sustainability categories, identifying shortfalls in the ability of Industrial Design students to produce conceptual design scenarios that would lead to DfS3-type ‘solutions’ that would bring about real sustainable change. An intervention was implemented in the 2006 teaching session in the unit SDSF. The intervention planned to assist students to develop a sound definition of unsustainability, and apply critical, creative and relational thinking to transform the definition of unsustainability into sound DfS3 proposals. This chapter analyses the effectiveness of those strategies.

6.1 Presentation

The first part of the chapter reviews the strategies put in place for the 2006 teaching session, followed by the analysis of the conceptual design scenarios presented in 2006. The results of 2006 are compared to those of 2005 to internally validate the impact of the intervention and form the evaluation phase of the action research cycle (see Figure 6.1). This is followed by a discussion of the effects of individual strategies in the intervention, to identify what was or was not effective (i.e. specifying learning in Figure 6.1). In this discussion the thesis revisits pedagogy, particularly the approach of deep learning as the most appropriate pedagogy for Industrial Design Education for Sustainability. To summarise, the previous chapter’s intervention was predominately influenced by Design for Sustainability theory (what to teach), the intervention for 2007 resulting from this chapter is largely pedagogical (how to teach). The closing stages of this chapter articulate the action planning phase for the pedagogical intervention in the 2007 teaching year.
6.2 **Review of Strategies in Place**

Prior to the teaching session of 2006 an intervention was implemented involving three key strategies to encourage the students’ conceptual design scenarios to better represent progressive DfS requirements of large-scale change and functional and systems innovation. In summary, the three strategies attempted to expose students to the scale of unsustainability to assist in the formation of a sound definition of unsustainability in an applied context; encourage the application of critical thinking, relational thinking and creativity in the generation of the conceptual design scenarios; and rework assessment tasks to encourage the submission of contextualised conceptual design scenarios that moved beyond product redesign presented in isolation of contexts of use. For a comprehensive review of the strategies see Chapter 5, p. 132.

6.3 **Sample Population**

The sample population for this phase of the study was consistent with the first phase, comprising second year Industrial Design students from the Sustainable Design: Sustainable Futures unit at the University of Western Sydney. The 2006 sample differed in timing, as the data was collected from the 2006 teaching session. The data collected in 2006 was from students who had received the planned interventions outlined in the previous chapter. The sample in 2006 was slightly lower (n=84) than 2005 as the intake of Industrial Design students in the school had fallen from the previous year. Again a high rate of return occurred from the sample, as students consented to the analysis of their assessment task for this study.
6.4 Analysis Criteria

The assessment task collected and analysed was also the same as that for the previous year. This consisted of each student presenting two conceptual design scenarios within a group presentation (PowerPoint) which visualised a sustainable future according to their selected research field. A digital copy of the submissions was analysed. The assessment criteria for the design solutions within the unit were as follows.

1. The degree to which the designs facilitate more sustainable behaviour
2. Feasibility (based on your scenario context in terms of its technological, social or economic status)
3. Design communication (presentation skills [how well you convey 3-dimensionality, how the design works], professionalism, and clarity).

The categories that the conceptual design scenarios were analysed against within the thesis differed to the assessment criteria given to students. The data was analysed using content analysis against the categories of DfS school of thought, Brezet’s the type of innovation and factor X reduction outlined in Chapter 3.

6.5 Results of Content Analysis—Student Design Solutions 2006

The following section provides the results of the quantitative analysis of the Student Design work presented in 2006 according to the categories, DfS school of thought, the type of innovation and factor X reduction. The frequency with which the coding categories was evidenced in the students’ conceptual design scenarios was measured. The analyses of the 2006 outcomes were compared to the analyses of the 2005 data, to validate the results of the intervention implemented between the two years. The analysis indicated that an encouraging shift had occurred in the students’ ability to present conceptual design solutions with higher sustaining potential, while engaging in Brezet’s higher types of innovation.
6.5.1 Frequencies Within Data, Student Design Work 2006

The Industrial Design students’ conceptual design scenarios presented in 2006 mark an improvement over those collected in 2005 with regards to the degree of resource reduction that the scenarios embedded. However while an improvement occurred, in relation to the category factor X nearly half the students’ designs had a relatively minor impact, with 46.4% (n=39) of student conceptual design solutions affording less than a 25% implied resource reduction. Like the analysis from 2005, this is well below the level of reduction discussed within the DfS literature of factor 10 (i.e. Schmidt-Bleek 1999). Slightly more than half of the students presented design solutions with implied resource reduction greater than 50% (n=43), of which 37% percent had reductions greater than 75% (n=32) and 21% (n=18) offering reductions greater than 90% (see Table 6.1).

<table>
<thead>
<tr>
<th>‘Factor X Reduction’ 2006</th>
<th>Frequency</th>
<th>Percent</th>
<th>Valid Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negative factor –0</td>
<td>2</td>
<td>2.4</td>
<td>2.4</td>
</tr>
<tr>
<td>Factor 0–2 (less than 25% resource reduction)</td>
<td>39</td>
<td>46.4</td>
<td>46.4</td>
</tr>
<tr>
<td>Factor 2 (50% resource reduction)</td>
<td>11</td>
<td>13.1</td>
<td>13.1</td>
</tr>
<tr>
<td>Factor 4 (75% resource reduction)</td>
<td>14</td>
<td>16.7</td>
<td>16.7</td>
</tr>
<tr>
<td>Factor 10 (90% resource reduction)</td>
<td>18</td>
<td>21.4</td>
<td>21.4</td>
</tr>
<tr>
<td>Total</td>
<td>84</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

In comparison to the work presented in 2005 there was an improvement within the conceptual design scenarios presented in 2006, evidenced by the ability to achieve higher levels of resource reduction. This is indicated primarily by an increase of 10% in the percentage of factor 10 design solutions presented, and a decline of 19% in solutions presenting resource reductions of less than 25% (see Figure 6.2). The results could be attributed in part to the intervention implemented between the 2005 and 2006 teaching session.
Within the category *type of innovation* the conceptual design scenarios presented in 2006 mark a positive shift from those presented in 2005. The analysis highlights that the majority of student work was still product orientated (53.7% n=45, 12.2% being product improvement and 41.5% being product redesign). Almost a third (32.9% n=28) of the work presented was classified as functional innovation, where the students had questioned the function of a product and attempted to meet that function in alternative ways. Only a small percentage 13.4% offered designs solution that would be classified as systems innovation (see Table 6.2).

<table>
<thead>
<tr>
<th>‘Type of Innovation’ 2006</th>
<th>Frequency</th>
<th>Percent</th>
<th>Valid Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product improvement</td>
<td>10</td>
<td>12.2</td>
<td>12.2</td>
</tr>
<tr>
<td>Product redesign</td>
<td>35</td>
<td>41.5</td>
<td>41.5</td>
</tr>
<tr>
<td>Functional innovation</td>
<td>28</td>
<td>32.9</td>
<td>32.9</td>
</tr>
<tr>
<td>Systems innovation</td>
<td>11</td>
<td>13.4</td>
<td>13.4</td>
</tr>
<tr>
<td>Total</td>
<td>84</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

In comparison to the *type of innovation* from the results collected in 2005, there was a perceived positive shift towards the higher *type of innovation* in systems innovation (increasing 7.5%) and functional innovation (increasing 6.7%). There was also a minor decrease of near 10% in the number of designs within the category of product improvement (see Figure 6.3).
Finally, with regards to the category *school of thought*, the student conceptual design scenarios presented in 2006 had the majority (57.1% n=48) of students presenting solutions that would be classified as purely technical, in that the scenarios had not attempted to alter the behaviour of the end user toward more sustainable practice. Over a third (27.4% n=23) presented social-technical solutions, while 15.5% (n=13) presented purely social solutions applying no new product design. This equates to 43.4% (n=36) of students offering solutions that are socially orientated in some way, in that they encourage the end user to shift towards more sustainable behaviour (see Table 6.3).

### Table 6.3 Frequency of ‘School of Thought’ Student Design Work 2006

<table>
<thead>
<tr>
<th>‘School of Thought’ 2006</th>
<th>Frequency</th>
<th>Percent</th>
<th>Valid Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical</td>
<td>48</td>
<td>57.1</td>
<td>57.1</td>
</tr>
<tr>
<td>Social-technical</td>
<td>23</td>
<td>27.4</td>
<td>27.4</td>
</tr>
<tr>
<td>Social</td>
<td>13</td>
<td>15.5</td>
<td>15.5</td>
</tr>
<tr>
<td>Total</td>
<td>84</td>
<td>100.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>

In comparison to the design scenarios presented in 2005 there is little variation in regard to the category *school of thought*. This is notable as it indicates that the relation between categories may not be as assumed. There was an assumption that a social or socio-technical *school of thought* would increase with the higher frequency of factor 10 and functional and systems innovations, however this was not the case. A preliminary thought is that the results may be suggestive of the lingering ‘techno-fix’ product focus of Industrial Design students discussed in the previous chapter, in that the design opportunities in ‘solutions’ contributing to ‘social’ change is less understood. The results also highlight a complex relation between the coding categories. This correlation between categories is explored in detail in Chapter 8.
Overall the analysis presented suggested a notable shift had occurred through the intervention implemented between 2005 and 2006 in that the students’ conceptual design scenarios moved to challenge the demand side of consumption, as will be shown below. The scale of the shift in results, while positive, were relatively minor and by no means a \textit{fait accompli} in enabling students to DfS, highlighting that the unit faced further challenges in enabling Industrial Design students’ to DfS. The results are now discussed in relation to the specific strategies implemented in the 2006 intervention.

#### 6.6 Reflection on DfS Theoretical Intervention

The intervention implemented in 2006 planned to assist students in developing a sound definition of unsustainability, and to transform that understanding into effective Designs for Sustainability. The concerns raised in 2005 of relational and critical thinking being poorly displayed as presented in Chapter 5 were still present in 2006, although to a diminished degree. While difficult to quantify, the following discussion explores the specific intervention strategies and their perceived impact on the students’ ability to DfS.

##### 6.6.1 Reflection on Defining Unsustainability

The results in 2006 indicated a positive shift towards higher levels of resource reduction, and an increase in functional and systems \textit{types of innovation}. The shift may be reflective of the strategies put in place within the teaching session to expose students to a sound definition of unsustainability.\(^{39}\)

The scale of unsustainability was an ongoing discussion throughout the teaching session. The first lecture introduced students to unsustainability through Tonkinwise’s (2005) ‘death of a thousand cuts’ metaphor (see literature review (Figure 2.2 p. 26). The discussion continued in tutorials when reviewing promising examples of sustainable best practice, in that the scale of change required was constantly referred to. Finally the most formal attempt to define unsustainability

\(^{39}\) At this stage of PhD candidature, an emphasis was placed on scale of resource reduction by the researcher. As the candidacy progressed, the natural evolution of the project shifted to encompass a more relational and holistic understanding of unsustainability.
occurred with a tutorial dedicated to a reading and discussion of Manzini and Jégou’s criteria for sustainability in their text *Sustainable everyday, scenarios of urban life* (2003). The criterion discussed were low energy and material Intensity i.e. factor 10; bring people and things together, reduce demand for transport; share tools and equipments, reduce the demand for products; and empower people, increase participation (Manzini and Jégou 2003, pp. 55-59).

The criteria of low energy and material intensity and factor 10 appeared to be easily understood, as students had previously been exposed to such concepts in the previous unit of study ‘Life Cycle Analysis’. However the criteria of ‘bring people together’, ‘share tools’ and ‘empower people’ (Manzini and Jégou 2003, pp. 55–59) appeared abstract for students to comprehend in relation to their understanding of the Industrial Design as a discipline that designs products en masse for sale. The criteria presented by Manzini and Jégou (2003) challenge the students’ understanding of their discipline. Following this discussion on unsustainability, each group was asked to define why their thematic area of study was unsustainable. This definition of unsustainability was first defended in tutorial discussion by the students, and later transferred into a criteria for sustainability. This criteria was used within the human-centred functional briefs students develop in the second workshop.

The criteria that each group came up with appeared to heavily influence the final design solutions that were presented. The example of a group with ‘energy’ as their thematic area identified within the tutorial that high energy consumption was unsustainable due to the invisible (inconspicuous and embodied) nature of electricity. Therefore to be more sustainable the design criteria that energy use should be made visible was established. This criteria influenced a suite of conceptual design scenarios where the key function was to communicate energy usage. The scenarios included cost calculators that immediately convert energy usage to dollars, high-tech materials that change colour when consuming high amounts of energy, bracelets that change colour and an energy thermometer (see Figure 6.4). The major premise here was that through indicating high energy use, the user would be prompted to take action on that over-consumption.
The relationship between the criteria established by the groups and the influence on the conceptual design scenario outcomes strongly supports the notion of how you define is how you design. This strengthens the premise that for students to DfS a sound understanding of unsustainability is required, as the definition would appear integral to the final design solution.

The process of establishing and defining a criteria for sustainability is in itself a concrete initiative towards critical thinking. The strategies implemented to assist in critical thinking will now discussed.

### 6.6.2 Reflections on Strategies to Assist Critical, Relational and Creative Thinking

The previous chapter outlined the planning of interventions aimed at assisting students to think critically, relationally and creatively. As noted, the exercise in defining and defending the criteria for sustainability assisted in engaging students in critical thinking. Within the teaching session further specific activities were
implemented to engage students to apply critical, creative and relational thinking to their evolving ideas.

First, to assist in critical thinking a series of tutorial debates were conducted through the teaching session, as previously identified. These debates fleshed out the limitations of ‘techno-fix’ solutions, and assisted in exploring the complexity of sustainability, as topics were deliberately selected that positioned techno-fix solutions against behavioural change or social solutions. The outcomes largely advocated a socio-technical approach, and promoted a style of thinking which carried over to the group work employed in the intensive workshop.

With regards to encouraging relational and creative thinking, three specific strategies were implemented: first, a ‘day in the life scenario’ was created in the workshop in an attempt to contextualise the problem of unsustainability; second, the development of a design brief utilising the previously developed criteria for sustainability; and third, an intensive creativity session drawing upon a suite of creativity tools. The merits of each strategy will be discussed individually.

**A day in the life scenario**

The first strategy to encourage creative thinking was the introduction of the ‘day in the life’ scenario. The intent of this scenario was to assist students to contextualise the problem of unsustainability in relation to a day in a particular person’s life, to characterise the everyday as the locus of unsustainability. The personas were fictitious characters that students developed, given an age, occupation, family status and address. Reviewing the minute detail of a day in the life identifies daily activities (as opposed to products) that are unsustainable for the given context. However, context based solutions that were the intended outcomes of the day in the life scenario were not transferred across into the final conceptual design solution presentations as expected, with the exception of a small few.

An exemplary scenario was presented by a transport group that forecast a future scenario whereby urban sprawl within Sydney has continued, with minimal infrastructure for public transport. This was achieved by extrapolating current government-approved developments that are yet to receive commitment for public transport. The Industrial Design students’ conceptual design scenario presented variations of electric scooters to facilitate the use of our existing rail network for
commuting, a low emission solution presented that was context specific to the location described in the day in the life scenario.

However, there were many generic scenarios presented that could be applied equally to any part of the world. In general, the day in the life scenarios did not work as envisaged, as they replicated the problem that occurred in 2005 that the student conceptual design scenarios were presented with no surrounding context (see p. 125). It would be advantageous to find a method that assists students to engage in context specific solutions. The absence of the context specific problem negates the ability to critically design solutions (if critically designing is an extension of critical thinking).

**The Design Brief**

The second tool implemented to assist in relational thinking and provide a solid platform for creative thinking to be applied was the design brief; founded on a suite of criteria for sustainability. The design brief appeared successful in assisting relational thinking, as evidenced by a notable increase in conceptual design solutions addressing the demand-side of the problem. As discussed in Chapter 5, the majority of water ‘solutions’ focused on water coming from the tap. The emphasis on the demand for water saw students more thoroughly question why we use water for so many activities and offered solutions to each of the tasks. This may be attributed to the use of the design brief encouraging functional innovation, viewing activities as opposed to products as the problem. The design brief was implemented at the beginning of the second all-intensive all-day workshop, after the students had completed their day in the life scenarios. The human-centred functional design brief for the water group is presented below, with the designed outcome presented after.

To assist Jim complete the daily activity of brushing his teeth within the quadrant comprising expensive water/home ownership, whilst satisfying the design criteria of: A. low material intensity (less material removed from nature therefore having a smaller environmental impact); B low energy use in any form—electricity, fuels (solutions must be highly efficient across the life of the product); C. high regenerative potential (enhancing and if possible regenerating environmental and social resources); D. providing a positive experience in that completing the activities is fulfilling and E. reducing water use.

The brief produced ‘solutions’ such as textured teeth wipes, while similar briefs within the ‘water group’ produced ‘solutions’ like the waterless ‘handy wash’ (see Figure 6.5). While the solution viewed individually may not account for a great
amount of water reduction, if viewed as a suite of products the group was successful in dematerialising water use within the house.

The ‘solutions’ were favourable as they moved to the demand side of water within the house, as opposed to efficiency in the tap. Hence, the scale of resource reduction represented by the solutions may be significantly higher than focusing on the efficiency of the tap. The suite of ‘solutions’ in Figure 6.5 was seen to address the inconspicuous and habitual nature of water consumption within the house.

![Figure 6.5 A suite of water dematerialising products](image)

Source: Industrial Design students’ conceptual design scenarios submitted in 2006 for the unit Sustainable Design: Sustainable Futures at the University of Western Sydney.

While the scale of water reduction was improved, relational thinking with regards to the rebound effect (Manzini 2002, p. 4) is crucial for a holistic understanding of the potential benefits of the conceptual design scenarios. For example, the water usage associated with the activity of brushing teeth was replaced by waterless textured teeth wipes, which are a disposable product. Relational thinking in the form of a ‘life cycle impact assessment’ to quantify the future impact
of the ‘solution’ would be desirable, to ensure that the ‘solution’ is actually advantageous and not adding to the problem of unsustainability.

The liquid toothbrush (Figure 6.6) presented is a more extreme example of a lack of forethoughtful and relational thinking and articulates the rebound effect (Manzini 2002, p. 4). The toothbrush does not require water, but now requires batteries, which may have a negative impact when viewed holistically, even though water from the tap is being saved.

![Figure 6.6 The liquid brush](image)

Another example of Industrial Design students addressing the demand-side of the problem occurred with the transport group. The design criterion of ‘reducing car dependency’ was established and daily activities in work and education examined. Through functional innovation a suite of scenarios was developed around virtual environments and tele-commuting (see Figure 6.7).

The virtual learning environment (Figure 6.7) is a solution based around online tutorials and lectures that are delivered at particular times. The monitor illustrates which class members are present through cameras on students’ computers. Further promising solutions in the virtual learning environment included drawing tablets that could be used within the virtual design studio to communicate ideas between student and teacher. The tele-commute ‘service solution’ was presented as a business that specialised in work-from-home solutions, with experience in negotiating and overcoming the barriers between employee and employer in the adoption of the
virtual office such as reduced face to face communication, time management and supervisory concerns.

The above examples highlight how the human-centred functional design brief, founded on a context-specific criterion for sustainability assisted to move to demand-side solutions. The criteria for sustainability embedded in the design brief further supports the thesis that ‘students can DfS if an appropriate understanding of unsustainability is defined (the problem context)’ or how you define is how you design. The examples illustrate that redefining the problem of unsustainability leads to alternate designs for sustainability. A greater emphasis would be desirable in ensuring that students have every opportunity to develop a sound complex, relational definition of the problem.

While the above ‘solutions’ were seen to be effective in reducing the demand side of transport and water, it is important to locate their worth in relation to the broader issues of sustainability. The ‘social’ element of sustainability, such as issues
relating to isolation in home office needs to be carefully considered, particularly in relation to the transport solution. Questioning the impact that the virtual/telecommuting environment has upon the social activity of worker and student raises important questions for discussion. This positions the proposals in line with Manzini and Jégou’s argument for Design-Orientated-Scenarios, in that they are probable hypotheses for discussion (2003). The forethoughtful question ‘what if they were adopted, what will be the possible impacts?’ is critical for DfS, and inherent in Fry’s model of defuturing (1999). The discussion of the rebound effect (Manzini 2002, p. 4) of the perceived positive solutions would further engage students in critical thinking. A sound problem definition of unsustainability is integral to DfS, but developing forethoughtful thinking in relation to potential impacts on the other side of a designed intervention adds further rigour to the critical thinking process that has been displayed thus far by students.⁴⁰

**Creative Brainstorming Session**

The third strategy to assist with creative thinking was the creative brainstorming session that followed the development of the design brief in the second all-day intensive workshop. The session drew upon a suite of creativity tools that the workshop facilitator directed students to in order to assist in creative concept generation to resolve the design brief. It was envisioned that this session would be most familiar to students due to the designerly nature of the task. It represents the first time that the unit SDSF asked students to draw upon their creative design skills.

The creative brainstorming session in action had mixed results for several reasons. First, students were conservative in the number of solutions generated; there was a perceived tendency for students to stop once a plausible solution had been identified, as opposed to the continual generation of multiple solutions, or exploring further design opportunities surrounding an identified concept. Second, the researcher perceived the session to generate fascinating novel ideas at the workshops, but the ideas were then not developed into the final conceptual design scenarios presented. This problem is what the researcher earlier termed ‘no design’. Examples of creative concepts generated within the workshop that were not realised are discussed below.

³⁰ How the relational impacts of products are addressed most substantially in this thesis is in Chapter 9, however the later stages of this chapter present strategies to encourage reflection on the product’s design which to a lesser extent promote thinking about the relational impacts of products.
The transport group identified the ‘walking school bus’ as a possible solution to reduce the demand for car and bus travel. As a concept the solution has high sustaining potential. In the creative brainstorming session, the facilitator questioned how the walking school bus could be a profitable business venture: this led to the concept of senior students ‘driving the bus’ to earn money, which would benefit the peer-support network within the school and provide a solution that would be ‘cool’ for young students to walk with senior students, as opposed to volunteer parents. The facilitator’s probing questions such as ‘how would you make the scenario safe?’ led to concepts generated around security and communication networks. The researcher perceived that the solution had great potential to locate design opportunities within ‘systems innovation’, yet at the end of the session the concept of the ‘walking school bus’, void of the potential design opportunities that was assumed to be validated at the workshop was presented as the final scenario. This supports the idea of ‘no design’ in that students appeared to lack confidence and practice in visualising social ‘solutions’.

The second example that portrays what is seen to be unrealised potential of the brainstorming session is that of the energy group, who were discussing how to keep the necessary power tools charged at a building site. The facilitator prompted the students using the ‘think back’ tool as presented in the previous chapter to question why we need power tools on site. The question of how we built buildings prior to power tools prompted students to identify traditional building techniques like Japanese buildings that used very simple hand planes and saws and were constructed with no fasteners. The question of whether the traditional techniques could be recreated with advanced technology or material prompted the concepts of homes that are CNC machined and flat-packed, and with interlocking shapes that do not require power tools for assembly. While not a ‘no design’ solution, the students reverted to an obvious product-orientated solution for the final presentation.

The researcher was pleased with the alternate direction that the concept generation was heading, yet the final conceptual design scenario presented was a solar-powered battery pack and generator fitted to a work vehicle (see Figure 6.8). While reducing emissions in the use phase of tools on construction sites, this

41 Prompting questions from facilitators in ‘brainstorming’ sessions to stimulate participants is a technique that is widely recommended (Osborne 1963).
solution does not question the current building practices, which had been such a fruitful part of the brainstorming session.

![Solar Power Battery Pack and Generator](image1)

![Sustainable Kit Homes](image2)

**Figure 6.8 Home construction solutions**

Source: Industrial Design students’ conceptual design scenarios submitted in 2006 for the unit Sustainable Design: Sustainable Futures at the University of Western Sydney.

The final example of creativity being undeveloped occurred from a group aimed at reducing consumption. The concept proposed that the virtual online game ‘Second Life’ could be a possible place where conspicuous consumption could occur. Individuals could live and consume to destruction online, while preserving the earth. Putting aside the ontological implications of such a proposal, again the solution was not developed further, as the researcher perceived that the students were struggling to make the connection between an interesting concept and a designed outcome. A conservative product-orientated three-in-one appliance was presented as the final conceptual design scenario for this group.

Between the final workshop and the end of session presentation it was felt that students returned to conservative scenarios. The creative brainstorming session is viewed to have been theoretically sound. Students had a clear design brief, understood the criteria for sustainability, and to a degree applied brainstorming techniques that should have generated multiple concepts that would then be refined by students for the final conceptual design scenario. Yet it seemed that momentum from the workshop was not carried over into the final weeks of the session. How the creativity that appeared to be present in the workshops could be sustained and transformed into design solutions was a problem presented to the researcher.
There was an extreme instance of a student asking the week after the workshop ‘what should I design for the final presentation?’ and ‘where do I come up with the design solutions?’ There was an assumption from the researcher that the process was sound, clear and understood. Students would take the work to date and develop the concepts further and finetune concepts and how they fitted within the quadrant. The task at hand appeared to not be clearly understood, there seemed to be a disconnect—quite a radical one—between the engaging process and the designed outcome.

On reflection the above difficulty encountered from the creative brainstorming session formed a decisive moment in the researcher’s own learning. The focus of the thesis thus far had been heavily focused on ensuring that students were presented with the appropriate theory and methods to DfS. Why the student conceptual design scenarios did not progress (possibly regressed) from the creative brainstorming, but remained entrenched in rather obvious product-orientated or ‘no design’ solutions led the researcher to seek out pedagogical theory, as a possible way to increase student engagement in the process, as there was a belief that underlying DfS theory was sound.

### 6.6.3 Reflections on Strategies to Move Beyond the Product

The final strategy implemented for reflection was that of encouraging Industrial Design students to design functional and system innovations. The human-centred functional design brief was developed to encourage students to focus on activities as opposed to products, which may have assisted in the positive shift towards functional and systems innovation identified in the analysis of the conceptual design scenarios in 2006. Rewording the assessment task to ask for products, systems or services also potentially widened the scope of options that the students had available to them, even if plagued by the concept of ‘no design’.

There were scenarios that were predominately system ‘solutions’ such as leasing plans for photovoltaic panels, to offset the large upfront costs, supported by contracts for the consumer to purchase a fixed amount of electricity at a particular price.

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42 The four quadrant method of Strategic Foresight is explained in detail in *Appendix VII* p. 316.
6.7  Evaluating Data Analysis 2006

The intervention implemented in the 2006 teaching session provided insight in addressing the research question ‘why are students of Industrial Design unable to design in a way that can contribute in real terms to a sustainable society, economy or ecology?’ The analysis provided insight into the thesis that ‘students can DfS if an appropriate understanding of the unsustainability is defined’. The analysis presented an encouraging shift in the students’ conceptual design scenarios’ ability to afford higher sustaining potential and higher \textit{types of innovation}. One may conclude that to alter the students’ ability to DfS, they would benefit from an altered definition of sustainability.

The focus of the intervention implemented in 2006 relied heavily on DfS theory, which shifted the results of the students. On reflection it appears that the level of students’ engagement with the process could be increased. The creative brainstorming session in particular seemed dependent on the facilitator to assist in generating potential concepts. The students’ inability to transform these sound ideas into conceptual design scenarios is seen to reflect the pedagogical problems of Industrial Design being largely client-serving and product-oriented design, but also in terms of problems of visualising social solutions, which was part of the initial driving impetus behind scenario development. To reflect on the theoretical framework presented in Chapter 1, there appears to be limited correlation on the students’ part between Habermas’s (1972) ‘technical knowledge’, represented by the ‘techno-fix’, and ‘practical knowledge’ in a socially determined understanding of unsustainability.

The literature surrounding education theory was revisited at this time to address the above concerns, and identified that the delivery of the unit may be described as ‘teacher-centred’, with a heavy reliance on the teacher for ideation. As was problematic in the master-and-apprentice approach to the design studio it may be desirable to move to a student-centred model of teaching. In what follows we revisit the pedagogy of deep learning, prior to suggesting how the implementation of this theory was planned.
6.8 **Diagnosing 2006, From Design for Sustainability Theory to Pedagogy**

The focus to date of the thesis has been on what DfS knowledge and tools students should be exposed to. In 2005 areas were diagnosed from the data analysis as being weak with regard to key DfS theories; the intervention implemented in the teaching session in 2006 attempted to strengthen the student conceptual design scenarios in relation to these theories. While the analysis from 2005 to 2006 indicated a positive improvement with regards to the analytical categories, the results still maintained a large gap between what the progressive DfS theories suggest in factor 10 solutions and Brezet’s higher *types of innovation* and the results displayed by students.

When the thesis was initiated, the researcher assumed that the problem was defined within *what students should learn* as opposed to *how students should learn*. The thought was that DfS needed to be more effectively integrated and dispersed within existing pedagogical formats that represent Industrial Design: put crudely, the researcher assumed that students were not being taught the appropriate material. However from the analysis to date it is clear that *how students learn* is influenced by the learning design of the course, which may be influencing Industrial Design students’ ability to design for sustainability. The inability of students to articulate DfS solutions may be attributed to the course design and the performance of the teacher, in the words of Lev Tolstoy:

> Every teacher must...by regarding every imperfection in the pupil’s comprehension, not as a defect of the pupil, but as a defect of his own instruction, endeavor to develop himself the ability of discovering new methods. (1967 cited in Schön 1991, p. 65)

To gain insight into how the learning design and environment may be affecting the results to date, the assumed pedagogy appropriate for teaching DfS was revisited in Deep Learning.

6.8.1 **Deep Learning, the Pedagogy for Industrial Design Education for Sustainability**

There is general agreement that education for sustainability, not education about sustainability, is required in delivering effective EfS programs (i.e. Fien, Scott et al. 2002; Tilbury and Adams 2004). Awareness of sustainability issues does not necessarily equate to more sustainable modes of behaviour (McKenzie-Mohr 2000),
therefore sustainable issues cannot be presented in isolation from practice and must be integrated.

If action is to follow awareness, students must not only become aware of issues but also gain skills of analysis and investigation, learn about effective remedial strategies and develop an in-depth understanding of the underlying concepts (Warburton 2003, p. 50)

The pedagogy of deep learning is recommended to enable Education for Sustainability (i.e. Benn 1999; Fien, Scott et al. 2002; Fletcher and Dewberry 2002; Warburton 2003). As Warburton (2003, p. 46) explains:

Deep learning is particularly crucial in the case of sustainability education, where holistic insight and an ability to organise and structure disparate types of information into a coherent whole is central to the whole exercise.

It was assumed that the relevance of deep learning in Education for Sustainability would correlate as the appropriate pedagogy in Design for Sustainability Education, as the skills listed by Warburton above largely resemble the skills identified in the literature that are required to DfS.

Deep learning refers to learning with understanding, while surface learning refers to more temporary learning (Williams, 1992, p45 cited in Beattie, Collins et al. 1997). Wanting students to be engaged, enthusiastic, understanding and appreciative of the subject matter implies a deep approach to learning (Lublin 2006, p.2). An overview of the characteristics of Deep and Surface learning is provided in Table 6.4.

Table 6.4 Characteristic of Deep v Surface approach to learning

<table>
<thead>
<tr>
<th>Characteristics of the deep approach to learning</th>
<th>Characteristics of the surface approach to learning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actively seek to understand the material / the subject</td>
<td>Try to learn in order to repeat what they have learned</td>
</tr>
<tr>
<td>Interact vigorously with the content of particular teaching materials</td>
<td>Memorise information needed for assessments, without distinguishing any underlying principles or patterns.</td>
</tr>
<tr>
<td>Make use of evidence, inquiry and evaluation</td>
<td>Make use of rote learning</td>
</tr>
<tr>
<td>Take a broad view and relate ideas to one another, a desire to think conceptually rather than amass detail</td>
<td>Take a narrow view and concentrate on detail</td>
</tr>
<tr>
<td>Are motivated by interest, meaningful engagement in and enjoyment of learning</td>
<td>Fail to distinguish principles from examples</td>
</tr>
<tr>
<td>Relate new ideas to previous knowledge, relate concepts to everyday experience</td>
<td>Stick closely to the course requirements, apply the minimum effort to at least meet prescribed course requirements.</td>
</tr>
<tr>
<td>Tend to read and study beyond the course requirements</td>
<td>Are motivated by fear of failure</td>
</tr>
</tbody>
</table>
Deep learning is closely aligned to the constructive approach to knowledge, in that the teacher cannot hand out knowledge; knowledge is created through the learner via the transformation of personal experience (Dewey 1963; Kolb 1984). From an understanding of pedagogic approach used in Industrial Design education, the discipline appears to educate students in a manner that would clearly resemble deep learning as Fletcher and Dewberry (2002, p. 39) state:

The Association of University Leaders for a sustainable future...stresses the importance to sustainability education of skills and knowledge pertaining to defining problems holistically and analysing them from multiple perspectives. Likewise, design pedagogy can employ approaches which include: creative, solutions-focused learning, self-directed teamwork; learning by doing (commonly ‘live’ projects); iterative refinement and reflection; and developing research and interpretation skills drawing on multiple sources. The level of similarity of these two approaches perhaps suggests that an entirely new pedagogy need not be developed for the learning and teaching of design for sustainability.

Industrial Design would appear to be in an advanced position with regards to deep learning, as the constructivist approach of ‘learning by doing’ is a staple in design courses: Industrial Design almost teaches Deep Learning by default. ‘Learning by doing’, a process where the design problem took preference over the lecture and became the vehicle by which architecture was taught, was introduced into art and architectural education at the École Nationale et Speciale des Beaux-Arts in Paris in the 1890s (Milton 2003 p.2). The design studio in Industrial Design mirrors the design studio approach of architecture, appropriating the approach to relate to the nuances of Industrial Design (Green and Bonollo, 2003). The pedagogy outlined above places Industrial Design well to educate DfS, as studio subjects have traditionally taught in what appears a style of deep learning without formal acknowledgement.

The reading of Beattie and Collins et al. (1997) on the implementation of Deep Learning in accounting education is pertinent, as the approaches that are advocated are strongly inherent in Industrial Design education. Deep learning as a pedagogic approach appears to contrast with the teaching in traditional disciplines of science,
and challenges the traditional structure of lectures, tutorials and exams, which have been suggested to encourage rote learning. These structures are not prominent in Industrial Design education.

This raises a concern for this study in that deep learning is advocating largely what already appears to be implemented in the teaching of Industrial Design students. Schön’s (1991) theories of deep learning were based on the study of architecture’s design studio, and apply equally to Industrial Design education. Yet the analysis of the Industrial Design students’ conceptual design scenarios, when compared to Lublin’s (2006, p. 2) description of students being engaged, enthusiastic, understanding and appreciative of the subject matter would indicate that deep learning was not occurring in the unit Sustainable Design: Sustainable Futures.

The problem is perceived that Industrial Design education delivers deep learning opportunities in the ‘traditional’ learning design, but, as will be shown, is ultimately compromised by the master and apprentice model.

Warburton’s article ‘Deep Learning and Education for Sustainability’ presents principles to encourage deep learning and is summarised in Table 6.5 (2003 p. 48). Warburton’s principles are compared to the strategies already applied in the delivery of the unit Sustainable Design: Sustainable Futures. The comparison indicates clear possibilities for improving the students’ engagement with the task at hand and highlights that the unit could be delivered with a more student-centered approach. With the exception of ‘combining knowledge and understanding through the personal experience of the student’ (Warburton 2003, p. 48), the remaining seven strategies to encourage deep learning are to some degree already in place (see Table 6.5).

Warburton’s ‘useful principles to encourage deep learning’ as summarised in Table 6.5 highlights that the oversight of ‘combining knowledge and understanding through personal experience of the student’ (2003, p. 48) may be significant. This will be addressed in the strategies for action in 2007. The literature review identified that the master and apprentice approach to design education was problematic. This suggests that a student-centred approach to Industrial Design Education for Sustainability may be beneficial in engaging the student experience. The delivery of
the unit in 2005 and 2006 appears to correlate with the remaining strategies for deep learning as indicated in the right hand column of Table 6.5.

Table 6.5 Deep Learning Strategies in Education for Sustainability compared to strategies employed in Sustainable Design: Sustainable Futures

<table>
<thead>
<tr>
<th>Strategies to Encourage Deep Learning in Education for Sustainability</th>
<th>Evidence of strategy in place Sustainable Design: Sustainable Futures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combine Mastery learning and discovery learning; in Mastery learning student responsibility and involvement are encouraged, but the teacher controls curricular planning and sequencing. In discovery learning, self directed learning by students is encouraged with teacher as facilitator.</td>
<td>The assessment task: explain in historical terms why the present is unsustainable.</td>
</tr>
<tr>
<td>Combine knowledge and understanding through personal experience of the student</td>
<td>No strategy in place!</td>
</tr>
<tr>
<td>Promote concepts and principles as opposed to hard facts, view these concepts and principles across the triple bottom line of sustainability, debate concepts and principles through real examples</td>
<td>In-class debates around current best practice, and the advantages and disadvantages with regards to sustainability. Criteria for sustainability are based upon principles developed within the class</td>
</tr>
<tr>
<td>Use conceptual frameworks, mind map relationships between key concepts</td>
<td>Relational thinking prompted by the matrix method of strategic foresight (see Appendix XI) and our hybrid model of scenario planning</td>
</tr>
<tr>
<td>Stimulate deep learning through asking questions (student or teacher), make predictions, and develop explanations</td>
<td>Strategic foresight workshops in developing future scenarios ask prompting questions, require students to make predictions supported by explanations</td>
</tr>
<tr>
<td>Build individual awareness as opposed to rote learning facts. Problem Based Learning</td>
<td>Final design solutions are a form of problem-based learning</td>
</tr>
<tr>
<td>Curriculum action research</td>
<td>Already employed by the researcher in this thesis</td>
</tr>
<tr>
<td>Emphasise how to achieve behavioural change, raise awareness as well as learn about effective remedial strategies</td>
<td>Focus of the unit is on how the conceptual design scenarios make our default everyday practices more sustainable</td>
</tr>
</tbody>
</table>

Source; Warburton (2003, p. 48)

6.8.2 Teaching Strategies to Complement Deep Learning

To complement the pedagogy of deep learning, Chickering and Gamson’s (1987, pp.3-7) seven principles of good teaching were used as a practical guide by the
The principles appear to complement many aspects of deep learning and the student-centered approach to delivery outlined above by Warburton (2003). For example principle three, that good teaching ‘encourages active learning’ from Chickering and Gamson (1987) reads similar to ‘combine knowledge and understanding through personal experience of the student’ from Warburton (2003, p. 48). The seven principles assisted in identifying areas of teacher delivery that may be strengthened. For example the time on task (clear, focused time spent on task) can be clarified for students, previous students’ work can be used to communicate high expectations, peer review and group work can be used to strengthen and enhance cooperation amongst students and provide prompt feedback. A more detailed account of the intervention to implement deep learning is described in the following section.

6.9 Action Planning 2007: Understand and Engage in the Student Experience

The intervention planned for 2007 would be largely pedagogical, aimed at encouraging deep learning within the unit Sustainable Design: Sustainable Futures. The emphasis in developing the intervention focused on the unintentional oversight

researcher in developing the pedagogic intervention planned for 2007. The seven principles are outlined below:

1. Encourages contact between students and faculty. Frequent student–faculty contact in and out of class is the most important factor in student motivation and involvement.

2. Develops reciprocity and cooperation among students. Learning is enhanced when it resembles a team effort rather than a solo race.

3. Encourages active learning. Learning is not a spectator sport. Students must talk about what they are learning, write about it, relate it to past experiences, and apply it to their daily lives. They must make what they learn part of themselves.


5. Emphasises time on task. Time plus energy equals learning. There is no substitute for time on task.

6. Communicates high expectations. If teachers expect more they will get more.

7. Respects diverse talents and ways of learning. There are many roads to learning. Students need the opportunity to show their talents and learn in ways that work for them.
of ‘combining knowledge and understanding through personal experience of the student’.

The practical approach of putting oneself in the students’ shoes, while novel, highlights the practical limitations to the adoption of deep learning. This approach proved insightful in planning the pedagogic intervention for 2007. For example, when students are overworked they reorder priorities so that the most immediately urgent things get done, which limits the opportunity of deep learning (Lublin 2006). If multiple assessment tasks are due at the same time then students may not engage in a deep approach to learning. Suggesting minor changes in assessment timing may alter the outcomes produced by the students with no alteration in teaching delivery. The interventions for 2007 were divided into two categories: removing ambiguity by altering the way key concepts were scaffolded through the course to provide a more concise structure; and revising assessment tasks in an attempt to adopt a student-centred approach to learning.

6.9.1 Removing Ambiguity, Keeping to the Task at Hand

The phases of the past, present and future represent key theoretical concepts of Fry’s defuturing (1999) that provide the overriding methodology for the unit Sustainable Design: Sustainable Futures. In the 2005 and 2006 teaching sessions the unit structure had phases of Fry’s defuturing operating concurrently (see Figure 6.9).
For example, students were attempting to answer the tutorial question ‘what are the historical reasons why we are unsustainable?’ (focusing on the past) while at the same time collating contemporary trends research (focusing on the present). There was perceived ambiguity in not having a clear focus to the task at hand from the student’s perspective, which may have reduced the capacity of Industrial Design Students to fully engage in articulating an understanding of the problem (unsustainability). Figure 6.9 illustrates the perceived ambiguity to the task at hand.

It is proposed that a less ambiguous structure can be afforded, allowing for devoted time on the key concepts within the unit. A more logical scaffolding of concepts and assessment timeframes was proposed for 2007. The unit would be divided into three distinct sections to provide a clear structure in the past, present and future. Streamlining the unit planned to allow for greater time to be devoted to each concept, allowing the theoretical underpinnings of each theoretical concept to be explored. Figure 6.10 represents the revised session structure.
The revised timeline was also planned to alleviate the pressure that occurs towards the end of the teaching session; by bringing the ‘contemporary trends research final submission’ forward, a more evenly spaced workload for the students was arranged. Previously, assessment tasks were focused towards the end of the session, despite formative weekly assessments; the final weeks of the session were stressful for the students.

The planned scaffolding of the phases also ensured that Workshop One had students better prepared, as the contemporary trends research final submission is due the morning of the workshop. This would allow for all relevant trends research to be at hand and fresh in the students’ minds. The follow-on effect envisaged is that the scenario planning that takes place in Workshop One will occur on a stronger foundation. The key theoretical concepts in the past and the present are understood, prior to moving towards the future. Embodying Fry’s (1999) philosophy in that the present is a construct of the past, therefore the future will be a construct of the present (and past).
The specific timing and brief explanation of the revised session plan is provided in Figure 6.11. An explanation of the unit, each individual assessment task and the phase of defuturing that has been made more student-centred is explained in the following section.

6.9.2 A Student-centered Revision of Tasks

The planned changes for a student-centred approach to teaching are outlined below in relation to the three phases of defuturing ‘Past’, ‘Present’ and ‘Future’. Before the specific phases and tasks are discussed, first the changes planned in the front matter of the unit will briefly be presented.

In 2007 the themes that the unit would be based on were altered from the broad portfolios of water, energy, transport and consumption to more targeted thematic areas in the domestic environment of the house in: garden, entertainment, kitchen, bathroom and laundry. The alteration was due in part to the significance of the ‘domestication’ of practices (i.e. Shove 2003) which relate to inconspicuous consumption, but also to the fact that so much Industrial Design is focused on the home environment. As a case in point, IKEA Australia displayed interest in strengthening relations with colleagues at the University of Western Sydney, and the possibility of exhibiting exemplar future scenarios at the completion of course was presented.43

It was envisaged that the interest from IKEA would strengthen the perceived credibility of the unit by students. The selection of themes by students would be according to individual interest, which would be the basis for the formation of groups. Within the introductory tutorial the students’ desire to study Industrial Design and their dream vocations would be discussed. The plan was to encourage group discussion as soon as possible on the relevance of strategic foresight for sustainability, but equally for the impact on future vocations.

Past
In 2007 the first task required of students was to explain the historical reasons why we are unsustainable in relation to their chosen domestic thematic area (such as the

43 IKEA is not the client for the project, and the delivery of specific solutions for IKEA is not the intention: the revised themes will provide design scenarios related to housing. The final outcomes will then be presented to IKEA. This differs from traditional client-driven briefs where the client specifies what they would like designed.
throughput of waste in the kitchen) and how design has contributed to this unsustainability (e.g. designing appliances that facilitate the ease of convenience dinners that support the throughput of waste). The task would be completed through two assessment tasks in an annotated bibliography, and a group presentation. While a similar task had been undertaken in 2006, for 2007 the timing of this task was altered and the brief revised. For 2007 the timing was moved forward after a review of second year students’ assessment dates showed a bottleneck of tasks all due in week four. The task was moved from week five to week three, relieving pressure from the students to submit multiple tasks in the same week, in accordance with Lublin’s suggestion (2006). In order to facilitate the shortened time frame, readings were placed on WebCT for student access. Previously students were asked to locate two suitable articles to annotate. However by providing the readings it was planned that students would be directed to readings deemed most relevant to answering the question.

Students previously have illustrated a sound capability to review the concepts presented within the annotated bibliography task, but the ability to relate the concepts presented to ‘why we are unsustainable’ was perceived by students to be difficult. A review of assessment tasks highlighted that it was not explicitly asked of the students to make the connections. For 2007 the assessment tasks were reworded to encourage the required relational thinking, by specifically stating the questions to be answered within the annotated bibliography brief as outlined below:

- A. Who is the author and what are the key points in the article?
- B. Are the key points valid, how do they contribute to your understanding of why your thematic area is unsustainable?

The modified assessment criteria were planned to encourage relational and critical thinking by causing students to mine their responses more deeply in analysing texts. The second part of the assignment, the group presentations, saw students in 2005 and 2006 having difficulty as they appeared unable to answer the question ‘from a historical perspective why are we unsustainable?’. Reworking the annotated bibliography questions attempted to remove ambiguity limiting the completion of this task, and as such, may benefit students’ understanding in the ‘past’ phase of defuturing.
Present

Starting in week five in 2007, the students’ focus progressed from the past to the study of the present. Students were required to complete contemporary trends research, to identify present trends that would then be extrapolated for their future impact on a sustainable society (positive or negative) in the years to come. Weekly magazine, newspaper and journal articles were collected and analysed in relation to their selected topics as well as the broader impact that this may have on a sustainable society. The study of the contemporary trends took place between weeks five and nine and saw three changes to encourage a student-centred approach. First, the condensed period of time devoted to the ‘present’ in contemporary trends research. The second period involved the peer review of the weekly contemporary trends; and the third period uses empirical research gathered in another unit, Sustainable Design: Life Cycle Analysis, to identify trends relating to the students’ personal experience.

The contemporary trends research asked students to identify the key themes/trends within articles collected and draw connections to the impact that this trend will have upon a sustainable future. Previously the task in checking the trends had been heavily tutor driven. The strategy for the 2007 session was to move away from the tutor as key, and enable group participation engaging with the weekly topics. Through peer assessment within the group, the students offered feedback based upon a set criteria. The benefit of peer review is twofold: student receive feedback highlighting areas to improve upon in their own work prior to final submission; and they learn via critiquing their peers’ work as they develop a greater understanding of the expectations of the unit.

The first half hour of the tutorial was devoted to the individuals in groups assessing each other’s work, followed by a discussion of the key trends and the recording of weekly trends by the group. A class discussion between groups closed the trends research tutorial. The peer review process for 2007 was planned to keep passive time in tutorials to a minimum, previously in 2005 and 2006 the weekly markings of work was reliant on the tutor viewing class/group members each week individually, this time was viewed as unproductive for groups waiting for feedback. The condensed time frame and peer review was planned to maximise time on task.

Following the identification of trends, students were encouraged to develop small hypotheses to prove or disprove the nature of the trend (positive or negative
for future sustainability) and see if the trend is increasing or decreasing through debate.

The final strategy was to combine knowledge and understanding through the personal experience of the student. In the preceding unit of study Life Cycle Analysis, a ‘Mystuff’ journal was collated, which involved students auditing all of their possessions, as well as their consumption of resources (food, water, energy) and production of waste for two weeks. The collation of this work presented the opportunity to reflect on trends apparent within an individual’s lifestyle, and to compare these trends to others based on the ‘experience’ of the students. It was planned that this exercise would bring the context of sustainability and unsustainability closer to home. Utilising the previous units of study in an alternative way also may strengthen the connection between units, and encourage reflection on what had been done.

The collection of empirical trends research is particularly relevant to the location of the student body at UWS. The majority of students live and study in an area of urban sprawl, in the suburbs on the fringes of a global city. This presents challenges to DfS in the author’s view that have not been adequately addressed in the majority of the design solutions presented by professional practice to date.

The European focus of DfS has been on solutions orientated for dense city living. However solutions that apply within a high density city do not always apply within the dispersed suburban networks where students live; the recent trends toward larger dwellings in new developments that are not well supported by public transport tend to make car dependency the norm. Acknowledging and working within the context of the students’ experience is necessary if we are to address solutions for a sustainable society. The ‘use what exists’ criterion of Manzini (2002, p. 9) is important to confront the less-than-desirable urban sprawl. It is expected that trends identified within the UWS student body would differ from institution based in the higher density city centres.

Improving the quality of the trends research in the ‘present’ phase was planned to directly impact on the final area of study the ‘future’. The focus of students’ cultural knowledge was carried through to the future scenario. In 2007 the personas that the students develop for their day in the life scenarios must be based upon a
friend or family member that they knew intimately and also based on a suburb that they had local knowledge of. 44 This was planned to encourage context-based solutions in the final conceptual design scenarios.

**Future**

For the future phase of defuturing in 2007, several changes were planned to encourage a student-centred delivery. These included revising the process of the scenario planning workshops through to final presentation; encouraging reflective thinking between the end of the workshop and final submission, and altering the format of the final submission.

Previously how the workshops contributed to the final presentation had not been clear to students, as discussed previously within this chapter. The revised process was planned to assist in the communication of clear objectives for each workshop, and their contribution to the final conceptual design scenario. The revised ‘streamlined’ process would be discussed throughout the session so that the *task at hand* is clear. The 2007 revised workshops are summarised below.

1. **Workshop One.** Aim is to forecast a probable future based on extrapolating contemporary trends research. The outcome will be the draft scenario narrative.

2. **Scenario Narrative.** Aim is to explain ‘a day in the life’ of the probable future developed in Workshop One.

3. **Mid Workshop Tutorial.** Aim is to develop sustainable criteria and critique the scenario narrative developed to identify areas that are unsustainable.

4. **Workshop Two.** Aim is to develop conceptual design scenarios that intervene in the ‘day in the life’ to move towards sustainability. This is achieved by resolving the functional human-centred design brief.

5. **Reflect.** Aim is to reflect on and progress the outcome of the workshop to refine solutions for presentation.

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44 Previously the ‘day in the life’ scenario was developed around fictitious characters, and saw personas of characters like merchant bankers or highly paid executives that the students could not relate to. This was seen to deteriorate the original purpose of providing context for specific solutions.
6. Exhibit. the refined ‘conceptual design scenarios’ are presented in the final class.

By presenting the expectations of the workshop a priori, and then clearly outlining action required by students after the workshop, it was envisaged that student understanding of the process would be enhanced. It was expected that the students as designers would reflect and build on what had happened within the workshop, and in the process encourage learning as a designer.

To encourage reflective learning (a component of Deep Learning) Bourner (2003) proposes that the key is in providing a suite of reflective questions and providing opportunities to practise them. Schön (1991) places great emphasis on the reflective thinking in action that occurs within the design process, through reframing the problem and looking at the problem from alternative perspectives. Through this process solutions that fit better are found.

Rather than assessing reflection on the unit as a whole at the completion of the unit, as occurred in 2005 and 2006, in 2007 it was planned to create a reflective process modelled on Schön’s (1991) reflection in action. The students would leave the workshop with almost complete conceptual scenarios, they were then expected to develop the most promising solutions prior to final submission. By asking and assessing reflective questions of the concepts prior to this final submission, it was envisioned that they would learn the reflective process. Examples of Bourner’s (2003) reflective questions are:

- What happened that most surprised you?
- What patterns can you recognise in your experience?
- What was the most fulfilling part of it? And the least fulfilling part of it?
- What does the experience suggest to you about your values?
- What happened that contradicted your prior beliefs? What happened that confirmed your prior beliefs?
- How do you feel about that experience now compared with how you felt about it at the time?
- What does the experience suggest to you about your strengths?
- What does the experience suggest to you about your weaknesses and opportunities for development?
- How else could you view that experience?
- What did you learn from that experience about how you react?
- What other options did you have at the time?
- Is there anything about the experience that was familiar to you?
- What might you do differently as a result of that experience and your reflections on it?
- What actions do your reflections lead you to?
The above reflective questions of Bourners were reworked for the unit Sustainable Design Sustainable Futures, to enable students to reflect on, and alter their final conceptual design scenario prior to submission. The reworded questions were:

- If you had not gone through the workshop do you think that you would have developed the same concept?
- Why have you selected your particular concept?
- Does the concept selected fit with your criteria for sustainability perfectly?
- If it does not fit, what is it that makes the concept desirable?
- How can you modify your concept so that there is a better ‘fit’ with the criteria?

The final strategy to encourage Deep Learning is through altering the final assessment tasks. By modifying the final submission the form of a story board was used. This was planned to provide a medium to allow students to visualise and communicate more ‘social’ solutions that were identified in the workshops but not carried over into the final design ‘solutions’. It was also thought this would cause students to think through the scenarios in greater detail because storyboards by nature place the scenarios in context.

![Sample storyboard](image)

*Figure 6.11 Sample storyboard*

Source: Compiled by the researcher from a range of submissions presented in 2005 and 2006 as a showcase example of a storyboard

A digital template was provided for the storyboard (see sample storyboard, Figure 6.12). Students would be asked to attach with the poster 250 words about why
their scenario was sustainable in relation to the criteria that students established previously in tutorials.

6.10 Overview

The chapter has evaluated the intervention that took place in 2006, which focused on encouraging Industrial Design students to explicitly define unsustainability by exposure and discussion of key sustainability theories, and transform the understanding of unsustainability into designs for sustainability through a revised development process. The analysis (evaluation phase) highlighted that the 2006 students cohort based their conceptual design scenarios on altered definitions of sustainability, which was an encouraging improvement on the results presented in comparison to the previous year, validating the notion of how you define is how you design.

However, some elements of the 2006 intervention did not materialise in student ‘solutions’ as planned, such as the move towards more creative solutions. The solutions outlined by students were either obvious product-orientated solutions, or social solutions that involved ‘no design’, as the connection with design to facilitate social change was not made. This marked a key point in the researcher’s learning, and an exploration of education theory was undertaken to explain why a sound theoretical process did not materialise the desired outcomes.

The second half of the chapter marked a shift from the theory of design for sustainability (what should be taught) to the pedagogy of sustainability in (how it should be taught). On reflection, the pedagogy of Deep Learning was proposed for a ‘pedagogical intervention’ in 2007, focusing on delivering the unit to ‘combine knowledge and understanding through personal experience of the student’. By students engaging in deep learning it was proposed that a ‘deeper’ understanding of unsustainability would occur, which would transform into altered Designs for Sustainability through the proposal how you define is how you design. To accomplish this is a student-centred mode of delivery was planned for 2007, which is presented and analysed in the following chapter. Figure 6.13 presents a visual of action research cycle at the completion of this chapter.
Figure 6.12 Action Research cycle at the completion of Chapter 6
Chapter 6 outlined the planned pedagogical intervention for 2007 to encourage deep learning. It is envisaged that through the pedagogy of deep learning students will engage in a greater understanding of the socio-technical complexity of unsustainability. By default this would have a positive effect on the designed outcome through the proposal ‘how you define is how you design’, which recalls Dewey’s comment ‘that a problem well put is half solved’ (1998, p. 178). The pedagogical intervention was implemented in the ‘action taking’ phase of 2007 (see Figure 7.1). The intervention focused on a ‘student-centred’ mode of delivery in the unit Sustainable Design: Sustainable Futures, as well as on revising the unit structure to remove perceived ambiguities in the flow of theoretical concepts and practical tasks as explained in Chapter 6.

![Figure 7.1 Chapter 7 in relation to the Action Research cycle within the thesis](image)

### 7.1 Presentation

This chapter analyses the conceptual design scenarios presented by Industrial Design students who participated in the unit in the 2007 intervention. The analysis assists in
addressing the research question ‘how are the approaches with the highest sustaining potential integrated into Industrial Design education?’, which is informed by insights gained in addressing the question ‘what DfS approaches are represented in the conceptual design solutions of Industrial Design students?’.

The first part of the chapter analyses the conceptual design presented in 2007. A discussion of the analysis from the pedagogical intervention illustrates the development in Industrial Design students’ ability to Design for Sustainability in relation to the research question. The chapter concludes with a discussion of the challenges that Industrial Design Education for Sustainability faces in relation to motivation and vocation. This completes the action research cycle for the study ‘Developing Sustainable literacy for Industrial Designers’ (see Figure 7.1).

### 7.2 Overview of Intervention Strategies

The intervention implemented in 2007 was focused on encouraging deep learning by the Industrial Design students. The specific intervention strategies are shown in Table 7.1, however the strategies fall into two broad areas: an increased emphasis on a student-centred approach to teaching, to apply students’ knowledge and understanding throughout the unit; and ambiguity in the task at hand was removed from the structure of the unit Sustainable Design: Sustainable Futures.

<table>
<thead>
<tr>
<th>Strategies encouraging a student-centred mode of delivery</th>
<th>Results of Implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Planned Intervention Strategy</strong></td>
<td></td>
</tr>
<tr>
<td>Engage the student’s perspective. Why are they studying Industrial Design, what are their vocational aims?</td>
<td>Opening questions within the unit, focused on career aspirations and past experience of sustainability. Followed by a discussion of why we are unsustainable from their perspective and how unsustainability will affect their future career.</td>
</tr>
<tr>
<td>Use empirical data collated from LCA journals in previous units of study to make relevant scenario planning as a tool of change by highlighting the lack of immediate ‘quick fix’ solutions that will actually bring the desired changes.</td>
<td>In-class discussion highlighted how hard it was for students’ behaviours to be more sustainable without systemic support or design intervention. E.g. commuting to UWS by public transport can take four times longer than driving, it therefore is not viable. This highlighted that scenario planning’s relevance in making systemic alternatives work.</td>
</tr>
<tr>
<td>Use empirical data collated from LCA journals in previous subject to personalise trends analysis</td>
<td>A tutorial was devoted to data collected from the previous unit, data was collated to identify trends within the UWS student body,</td>
</tr>
</tbody>
</table>

Table 7.1 Overview of intervention strategies 2007
contextualising the individuals’ unsustainable behaviour. This was not to polarise the students’ behaviour, but to present the design challenge that the unit would engage in.

<table>
<thead>
<tr>
<th>Peer assessment of trends research</th>
<th>Intensive tutorials were held wherein students peer reviewed team members’ submission of trend analysis from week six to week eight.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use personal experience and knowledge to base the scenario narrative on someone they know intimately</td>
<td>Scenario narrative guidelines delivered in the first workshop to base their ‘persona’ on a person and location they know intimately.</td>
</tr>
<tr>
<td>Drawing on Schön’s reflections in action, the intervention was to ask reflective questions between concept generation and the final assessment to make reflection a more conscious designerly activity</td>
<td>Reflective questions (detailed in the previous chapter) were asked of the students after the second workshop.</td>
</tr>
<tr>
<td>Self-assess final designs against sustainable criteria established within the tutorial</td>
<td>Implemented in part as a component of the reflective questions. In the final assessment students defended their ‘solutions’ against the criteria for sustainability they developed.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Strategies to remove ambiguity from the unit structure</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Planned Intervention Strategy</strong></td>
</tr>
<tr>
<td>Revised structure of unit into key theoretical concepts; past, present and future to allow for condensed focus on key concepts.</td>
</tr>
<tr>
<td>Revised timing of assessment tasks to evenly distribute tasks throughout the unit, and remove instances where multiple assignments are due simultaneously in different subjects.</td>
</tr>
<tr>
<td>The structure of the unit, and the progress of students through the unit was communicated openly and frequently to students.</td>
</tr>
<tr>
<td>Reworked the assessment task to reflect the historical significance of unsustainability.</td>
</tr>
<tr>
<td>Final presentation strategy in the form of a storyboard, to encourage contextually sensitive design solutions and practise visualisation oriented to social ‘solutions’.</td>
</tr>
</tbody>
</table>

The impact of selected strategies will be discussed in detail later in this chapter.

To see the development of the strategies see the previous chapter, p. 160.
7.3 Sample Population

As per the action research iterations of 2005 and 2006, second year Industrial Design students from the Sustainable Design: Sustainable Futures unit at the University of Western Sydney formed the sample for analysis in 2007.

The presentation of the final assessment task was altered from previous years and consisted of students presenting two design concepts each: two A3 posters with two 250-word blurbs describing the advantages of the design solution from a sustainable perspective. A digital photograph of each submission was analysed. The theoretical content of the assignment was the same as in previous years.

The assessment criteria for these final design solutions were as follows.

1. Degree to which the designs facilitate sustainable behaviour
2. Feasibility (based on your scenario context in terms of its technological, social or economic status)
3. Design communication (presentation skills [how well you convey 3-dimensionality, how the design works], professionalism, and clarity).

The poster format was an alternative to the group PowerPoint presentations in previous years. The poster was presented in an exhibition layout so that students could freely share their work with others. The same categories were used to assess the conceptual design solutions as in previous years. The analysis informs the question ‘what DfS approaches are represented in the conceptual design solutions of Industrial Design students?’.

The number of works collected in the sample (n=88) was lower than that forecast in the methodology chapter due to a decrease in enrolments.

7.4 Contents Analysis: Student Conceptual Design Scenarios 2007

As detailed in the last chapter, there was a positive minor shift in results from 2005 to 2006 in relation to both factor X reduction and DfS school of thought but not in types of innovation. The largest development from the results of the pedagogic intervention in 2007 was the evidenced increase in students’ ability to design for ‘systems innovation’ as determined by Brezet’s model. To validate the pedagogic intervention, the analysis of 2007 is compared to those of 2005 and 2006.
The following section provides the results of quantitative analysis of the Industrial Design student ‘conceptual design scenarios’ presented in 2007 with regards to the categories, *factor X reduction, types of innovation* and the *DfS school of thought*.

### 7.4.1 Frequencies Within Data, Student Conceptual Design Scenarios 2007

The analysis of the *factor X reduction* category continued to be of concern from an ecological perspective, in that the large scale resource reduction required was not being represented in the students’ conceptual design scenarios.

From the Industrial Design students’ conceptual design scenarios presented in 2007, 44.9% (n=40) were classified as affording less than a 25% implied resource reduction, a relatively minor reduction in comparison to the levels of reduction stated within the DfS theory of 90%. Slightly more than half (51.7% n=46) of the students presented conceptual design scenarios with implied resource reduction greater than 50%, of which 34.8% (n=31) had reductions greater than 75% and 19% (n=17) afforded reductions greater than 90% (see Table 7.2).

<table>
<thead>
<tr>
<th>‘Factor X’ Reduction 2007</th>
<th>Frequency</th>
<th>Percent</th>
<th>Valid Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negative factor –0</td>
<td>3</td>
<td>3.4</td>
<td>3.4</td>
</tr>
<tr>
<td>Factor 0–2 (less than 25% resource reduction)</td>
<td>40</td>
<td>44.9</td>
<td>44.9</td>
</tr>
<tr>
<td>Factor 2 (50% resource reduction)</td>
<td>15</td>
<td>16.9</td>
<td>16.9</td>
</tr>
<tr>
<td>Factor 4 (75% resource reduction)</td>
<td>14</td>
<td>15.7</td>
<td>16.7</td>
</tr>
<tr>
<td>Factor 10 (90% resource reduction)</td>
<td>17</td>
<td>19.1</td>
<td>19.1</td>
</tr>
<tr>
<td>Total</td>
<td>89</td>
<td>100.0</td>
<td>100</td>
</tr>
</tbody>
</table>

The analysis of the conceptual design scenarios presented in 2007 displays similar results with regards to the category *factor X reduction* as those generated in 2006, as indicated in Figure 7.2. The solid bar represents the shift in comparison to the analysed results of 2005, while the outline represents the results of 2006 in comparison to 2005.
The category *type of innovation* highlighted a significant development in students’ conceptual design solutions from the previous years. In 2007, almost two-thirds (60.2% n=53) of students’ conceptual design solutions were classified as either functional or systems innovation. Over a quarter (28.4% n=25) was classified as functional innovation where the students had questioned the function of a product and attempted to meet that function in alternative ways. Nearly one third (31.8% n=28) was classified as systems innovation, which is a significantly higher percentage than previously displayed in industrial design student work. Only a small percentage (19.1%) offered design solutions that would be classified as product improvement (see Table 7.3).

<table>
<thead>
<tr>
<th>‘Type of Innovation’ 2007</th>
<th>Frequency</th>
<th>Percent</th>
<th>Valid Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product improvement</td>
<td>8</td>
<td>9.1</td>
<td>9.1</td>
</tr>
<tr>
<td>Product redesign</td>
<td>27</td>
<td>30.7</td>
<td>30.7</td>
</tr>
<tr>
<td>Functional innovation</td>
<td>25</td>
<td>28.4</td>
<td>28.4</td>
</tr>
<tr>
<td>Systems innovation</td>
<td>28</td>
<td>31.8</td>
<td>31.8</td>
</tr>
<tr>
<td>Total</td>
<td>88</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

The significant increase was evidenced by a 25.9% increase in student work classified as systems innovation from 2005 to 2007, and an 18% increase from 2006 to 2007 (see Figure 7.3). The pedagogic intervention implemented in 2007 appears positive with regards to Brezet’s *types of innovation*. The increase in systems innovation also appears to correlate with an increase in conceptual design scenarios classified as social-technical in the *DfS school of thought* which is discussed below.
In 2007, for the first time, the majority of students presented work that was socially orientated in some way (63.1% n=52); it was classifiable as either ‘social’ or ‘social technical’ in relation to the school of thought. However a large proportion of students (40.9% n=36) still produced conceptual design solutions that were classified as ‘technical’ in that they treated design in isolation of end users and did not require any behavioural change (see Table 7.4). The shift in classification of students’ conceptual design scenarios is illustrated in Figure 7.4.

The significant increases in frequency of conceptual design solutions displaying a socio-technical DfS school of thought and functional and systems type of innovation are notable and a most desirable result for the unit, suggesting that social innovation has framed the criteria for the technical design. Chapter 3 noted that the categories selected for analysis were relevant to Industrial Design Education for Sustainability as it was suggested that they represent a progression in how the design students view their future role as designers. The hypothesis was presented
that functional and systems innovations inherently attribute a greater agency to the designer. Likewise the increase in socio-technical solutions in this iteration go some way to ameliorate the neatness of a division between social and technical solutions that were identified in the literature review in Chapter 2 and the theoretical framework in Chapter 1. The pedagogic intervention is viewed to have assisted students to contextualise ‘technical’ solutions, which has by default caused students to consider people and their practices as part of their designing. The specific strategies from the pedagogic interventions that can be attributed to the shift in results are discussed in the following section.

7.5 Discussion Arising from the Results of the Pedagogical Interventions 2007

As the results indicate, a significant shift occurred towards ‘socio-technical’ designs as well as ‘systems innovation’. To reiterate, socio-technical designs are categorised as incorporating technical design to facilitate behavioural change (which is social). An example, the sustainable systems communicator, is presented in Figure 7.5.

![Figure 7.5 Sustainable communication system](image)

Source: Industrial Design students’ conceptual design scenarios submitted in 2007

In this example, the student identified the misinformation surrounding sustainability as problematic, therefore the sustainable systems communicator puts
individuals in touch with community experts on sustainability for tailored strategic advice to assist in shifting to more desirable behaviours and practice.

Systems innovation was categorised in Chapter 4 as scenarios presenting broader systemic change that alters existing infrastructure and organisation. Examples of systems innovation scenarios from the 2007 sample included moving to a decentralised water supply, and reticulation systems utilising the garden and decentralised farming, combined with food ordered online, delivered to car-free communities.

The possible reasons for such a significant shift are discussed in relation to the pedagogic intervention in offering a student-centred approach to the unit delivery as well as a course structure that removed ambiguity. The results indicate that the students engaged in a further shift towards social interpretation of unsustainability (people’s actions, not products), highlighting the importance of pedagogy for Industrial Design Education for Sustainability.

From the strategies implemented to encourage a student-centred approach and remove ambiguity, five specific strategies appear to have made a significant impact on students’ development and will be discussed in detail:

1. the revised themes of study;
2. drawing on students’ knowledge and experience to frame unsustainability;
3. rescheduled timing of assessment tasks to remove ambiguity;
4. a revised workshop strategy;
5. a revised presentation strategy.

### 7.5.1 Revised Thematic Areas of Study

In 2007, students’ tacit understanding of their problem definition appeared to shift to a more social interpretation of unsustainability. This may be due to the altered thematic areas of study that made palatable the DfS theory presented within the unit. The thematic areas of study evolved from broad categories of energy, water, transport and resource consumption in 2005 and 2006 to domestic areas of kitchen, bathroom, laundry, entertainment, garage and garden in 2007. The specific areas

45 The social interpretation of unsustainability saw students drawing heavily upon Manzini’s and Jégou’s criteria of ‘bring people together’ and ‘share’. Doing so is seen to increase the MIPS potential of products and environments as they have more users.
made the connection between behaviours and design more immediate. The kitchen is full of appliances that have altered behaviours throughout history, assisting in the connection being made to how design facilitated (responded to) changing social practices in the kitchen over time. The new thematic areas provided a frame of reference to understand inconspicuous consumption (due to convenience) as explained by Shove (2003), and the proliferation of remedial products as proposed by Manzini (2003a) that compensate for our lack of time, or ability to cook. As such, design ‘solutions’ like the communal kitchen presented in Figure 7.6 attempt to restore individuals’ ability to cook with the assistance of technical aids, while also restoring the ‘commons’ (Manzini 2003a).

The DfS theory for students to make the connection to the revised thematic areas was provided via the first assessment task, the preparation of an annotated bibliography, presenting students with readings on inconspicuous consumption. By providing the students with key readings (see Appendix VI Suggested readings for the annotated bibliography in 2007, p. 314) with practical references to the thematic areas of the house, students were exposed to important theoretical insights into unsustainability and the connection of design and behaviours to resource
dependency. The altered thematic areas were perceived to make the theory of ontological design and inconspicuous consumption easier to frame and apply.

**7.5.2 Combining Knowledge and Experience of the Student**

The second notable strategy implemented in 2007 was the student-centred approach to unit delivery. This attempted to use the students’ personal knowledge and experience to frame unsustainability. The preceding unit Sustainable Design: Life Cycle Analysis asked students to compile a personal audit of their consumption. The data was reframed in the unit Sustainable Design: Sustainable Futures (the following unit) to identify contemporary trends within the student body. The trends discussion quickly identified car dependency as a key problem for the student cohort. The reasons why students are dependent on cars were discussed, as well as why the alternatives (walking, riding and public transport) are not used. A typical response was that it takes four times longer to commute by these modes than to drive to university. The students speculated on the problem of the systemic nature of unsustainable transport in Sydney, as well as on the campus. In this discussion students were exposed to the complexity of the problem and the difficulty in immediately ‘fixing’ it (e.g. zero emissions or factor 10) due to this complexity. This was important as it enabled the introduction of strategic foresight and scenario planning as potential methods that could resolve the issues the students faced, and allowed complexity to be engaged with, and scenarios to be presented that may allow students to study in a sustainable manner over time.

The discussion also validated the methodology used in the unit as the benefit of strategic foresight and scenario planning was introduced in context, in that it combined the ‘knowledge and understanding of the student’. This was seen as a major omission from previous iterations of the unit in the context of Warburton’s (2003) deep learning framework as presented in the previous chapter.

The forms that ‘solutions’ may take were quickly speculated on by students, and examples from previous years’ work and best practice in the design of transport-friendly cities were provided by the researcher. The virtual study solution’

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46 The best practice case studies were drawn from the analysis of DfS case studies that have been analysed over the course of the study, such as Curitiba’s bus shelters and the Paris Vélib which are presented in Chapter 8.
presented in 2006 questioned the practice of coming to university, and raised complex social issues that were discussed such as social isolation. The concept of designing cars specifically for sharing quickly identified issues with the concept of personal transport, individual ownership and trust issues in society (trust in sharing individually owned goods with others). Value adding to public transport systems in an attempt to redesign public transport as a fun social activity to make desirable an extended time of travel was proposed as a potential solution by students, while bike share schemes that could ‘plug the gaps’ for UWS students travelling between the train station and campus were appropriated from the real-world case study Paris Vélib’ (discussed in detail in the next chapter). An attempt was made to create an environment that made such examples acceptable challenges for industrial designers to engage in, framed by the problems that students experience.

7.5.3 Removing Ambiguity Through Assessments Timing

Rescheduling the timing of assessment tasks and workshops for 2007 allowed for a logical scaffolding of Fry’s defuturing concept (1999). The past, present and future were presented as key theoretical phases in an attempt to remove ambiguity for students as the task at hand was made clear. The roadmap for where the unit was going was easier to present to students throughout the session (see Figure 7.7). Details of interventions made within each phase are discussed below.

Past; why are we unsustainable, how has design contributed?

The time given to complete the first assignment (two annotated bibliographies) was reduced in 2007 by two weeks in comparison to 2006. To compensate for the reduced timeframe, a reading list was provided for at least one of the annotated bibliographies. The decision was made by the sustainable design stream team that the emphasis for the first assignment was not to develop students’ research skills in finding appropriate documents, but on bringing students up to speed on critical knowledge, in key concepts and authors relevant to defining unsustainability. By providing a reading list, assignments could be completed in a shorter time frame, with the knowledge that the readings were validated as relevant and important.

The quality of the student assignments, given the reduced period of three weeks, appeared not to differ to previous iterations in 2005 and 2006 when students had five weeks to complete the assignment.
Present; what trends of today will influence the future?

Previously a session-long exercise on trends research was conducted by gathering weekly articles from popular sources to identify contemporary trends and their impact on future sustainability or unsustainability. In 2007 this was consolidated into a four-week exercise. Intense tutorials were held from Weeks 6 to 9 which focused on trends research. During these weeks, students collected and annotated four articles per week identifying the key trend and the impact the key trend may have on a sustainable future, in 100 words. Peer review and group work were introduced within this task as part of the student-centred delivery.

In the final week prior to the workshop the most important trends were identified by the group in the tutorial in preparation for the first workshop. The major benefit of consolidating the contemporary trends research into an intense timeframe was that it allowed for a redistribution of tutorial time in the earlier weeks. Previously in 2005 and 2006, each week the tutor would check that everyone
had two annotations, record students’ marks and check for key themes. The process became repetitive and was dependent on the tutor’s personal communication with the majority of the students. Incorporated with the revised intensive program was a peer review marking sheet for group work within the tutorial (see Appendix VIII, p. 318). Class discussions were held around the trends identified, as group implications for a sustainable future were thought through. The simple question ‘does this lead to sustainable future?’ was asked of students to force them to critically think through and take a position on the potential impact of each trend.

The peer review of students’ work assisted not only in identifying errors within the individual student work, but also in encouraging transparency in relation to the marking procedures within the unit, leading to a clearer understanding of expectations for their submitted work—both receiving feedback for correction and giving feedback to enhance their critiquing skills is of benefit to the students. Finally, the major benefit from peer review was seen in the reduced role the tutor played via the student-centred approach to learning, leading to a more equal power balance within the class. This was seen to be desirable as a possible means to reduce the master-and-apprentice model in Industrial Design Education outlined as problematic in Chapter 2.

**Future; what could a sustainable future be?**
The rescheduled timeframe meant the workshops were moved towards the end of the session. This afforded students a more focused preparation period in which they could locate their newly formed understandings of unsustainability (informed by past design decisions [such as the freezer and microwave-supporting convenience foods] and present trends [such as longer work hours and obesity]), prior to questioning the future. Making the assessment for contemporary trends research due the day of the workshop ensured students were fully prepared with their trends analysis fresh in their minds.\(^{47}\) This enabled a more focused strategy within the workshops as students could focus on the task at hand as the ‘present’ trends research was drawn upon to forecast possible future scenarios using the four quadrant method of strategic foresight (see Appendix VII, p. 316). The outcome of the first workshop was a 2022 future scenario, which the students then developed into a scenario narrative describing ‘a day in the life’ of the scenario.

\(^{47}\) In previous iterations, the trends research that was used in the workshop was not complete.
The scenario narrative submission was due between the first and second workshop. In Workshop Two the students designed conceptual design scenarios based on the human-centred functional design brief (discussed in the previous chapter) that was responsive to unsustainable activities within the above scenario narrative.

The clarity of the *task at hand* in the revised process produced results that have progressed further than previous years in their ability to address unsustainability. The retiming of assessment tasks to more logically scaffold activities (phases of defuturing) had a significant impact, as evidenced by an increase in socially orientated design solutions. The theoretical material delivered within 2007 was the same as 2006, yet minor changes within the timing and scaffolding of assessment tasks enhanced the comprehension of DfS theory and its application into conceptual design scenarios.

### 7.5.4 Workshop Two Strategy—Designing the Utopian Solution

The third notable strategy was the altered delivery of the second workshops which differed slightly from before. The timing of the workshop noted above was one change. Further changes included the optimisation of the process students were taken through in the workshop to generate concepts to resolve the human-centred functional design brief. The most significant of these was the request of students to design utopian solutions that perfectly resolve their design brief. Table 7.5 shows how the most recent iteration of the sustainable futures workshop proceeded in 2007.

<table>
<thead>
<tr>
<th>Time</th>
<th>Workshop Two tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.55</td>
<td>Write down the criteria for sustainability specifically for your thematic area of the house. Prior to the workshop students were required to submit an assignment explaining the historical reason for our present unsustainability and how design has been implicated. This presentation encouraged students to dig beneath the surface of our daily habitual actions to seek why these actions take place, and unearth the role that design has had in creating the habitual actions. Core themes were exposed as to why we are unsustainable, for example, dependence on convenience food, singular ownership of not often used goods etc.</td>
</tr>
<tr>
<td>9.55</td>
<td>Apply criteria for sustainability against your scenario; flag both the sustainable and the unsustainable A scenario from Workshop One was presented based on trends research; this is a probable forecast into the future based on contemporary trends. Flagging occurrences of unsustainable practices in everyday life, it attempted to contextualise the problems at hand.</td>
</tr>
</tbody>
</table>

*Table 7.5 Workshop Two Run Sheet*
<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
<th>Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.10</td>
<td>Formulate Design Brief surrounding daily activities (problem definition—clear objectives) p. 132</td>
<td></td>
</tr>
<tr>
<td>10.20</td>
<td>Break</td>
<td></td>
</tr>
<tr>
<td>10.40</td>
<td>Share Design Briefs</td>
<td></td>
</tr>
<tr>
<td>10.55</td>
<td>Visualise the ideal solution (product, system or service) that satisfies your Design Brief (this is to be utopian: i.e. the most optimised version of your design intervention and may be a development from positive concepts presented within your scenario)</td>
<td><strong>rationale</strong> Asking for the ideal design solution that meets all criteria forces students to think beyond incremental innovation, to perfectly meet the criteria of extremely low water or energy intensity across the product’s life. An example would be designing for a community that shares as much as possible once singular ownership of products has been identified as a contributor to unsustainability.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Annotate the Barriers to enabling the ideal solutions, what must be overcome for this to occur by 2022 Following Doug McKenzie-Mohr’s community based social marketing (2000), it is not always the innovation of a completely new product that is required, but the ability to gain acceptance of existing products and ideas. For example, walking has been around since day one, but creating solutions that make walking a desirable and feasible option in the community requires that the barriers to why people do not walk are (a) identified and (b) overcome.</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>rationale</strong> Visualise (refine and add to) your solution to overcome the barriers Constant sketching assists designers to reflect in action according to Schön (1991)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Annotate the implications for your ideal solutions, are these desirable? If the final design arrives within society, what will be the follow-on effects from successful adoption? What will change? Futuring our current design solutions so that we are not continuing to design the unsustainable is a check that designers do not typically confront.</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>rationale</strong> Visualise, (refine and add to) your solution to address the implications Normalising the design solution ensures that the solution is comfortable within society. The experience has been that students tend to sway towards government intervention or restriction—which again manifests a perceived lack of agency for design to promote change. Visualising how one may live with adopted design solution may highlight that they are not desirable, which becomes a locus for further design intervention.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Visualise, (refine and add to) It is expected that as you visualise the barriers, implications and feasibility you gain a richer understanding of what your solution should entail, and the systemic process that must be addressed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>You may present multiple variation of your concept</td>
</tr>
</tbody>
</table>

The above process was integrated into the second workshop with the aim of adding complexity to initial design ‘solutions’. Asking students to come up with an ultimate ideal design solution to the unsustainable problem context they had defined encouraged them to dream and think big to overcome aspects of unsustainable daily behaviour. The strategy was to loosen the constraints of their thinking so that they did not necessarily pay homage to current ways of doing things.
The ‘ultimate’ solution encouraged conceptual designs such as the scrub suit (Figure 7.8). The scrub suit is a waterless form of cleaning based upon microorganisms embodied in fabric that clean the skin. The fabric is biodegradable and provides nutrients back into the soil once its useful life as a towel is finished. The radical rethink was a result of looking for the ultimate utopian solution in waterless cleaning that has a low material intensity. The solution questions how we bathe and offers an alternative that substantially reduces the amount of water consumed in comparison to the most efficient showerheads that have been offered as solutions in previous years.

The solution is viewed to be successful in overcoming the concern raised in the previous chapter of more ‘creative’ concepts not being pursued, suggesting the intervention for this purpose was appropriate. However the ‘solution’ in the ‘scrub suit’ drastically alters the experience of cleaning, and is viewed by the researcher to present further design challenges for the student in how this ‘solution’ could become socially acceptable.

![Figure 7.8 Scrub suit](source: Industrial Design students’ conceptual design scenarios submitted in 2007 for the unit Sustainable Design: Sustainable Futures at the University of Western Sydney.

The request of students to design utopian scenarios was one that the researcher did not make lightly. There is a danger in how utopian visions have previously been used by the design community. Early Industrial Designers presented utopian visions from a top-down perspective as grand scenarios that were devoid of people, or the
foresightful consequences of their adoption. The danger in such scenarios was that they may (and did) in some cases become reality (Andrews 2007; Fry 1999). Such dangers were acknowledged within sustainable design by the researcher, and countered by several measures. First, by having an excellent understanding of why we are unsustainable through the defuturing exercise grounded the utopian solutions. Students’ visions of future societies were not formed on a blank canvas; they were responsive to a probable scenario narrative based on a well thought through criterion for sustainability. Second, by eventually presenting the solutions in the context of use by people attempted to reduce the techno-fix nature of utopian visions; and third, checking the vision with regards to barriers, desirability, implications and normalising capacity assisted students to think through whether they were in fact desirable and beneficial.

Returning to the workshop structure after the altered process described above was implemented, the remainder of the workshop was delivered in the same manner as in 2006. The students applied creativity tools to the solutions generated thus far to refine variations of their conceptual design scenarios.

The question of how to bring such radical solutions to normality formed the next stage of the process after the workshop. The visual representation (in fully formed installations) of radical ideas is one avenue that previous designers utilised to normalise radical solutions, such as the streamlining movement and future exhibitions at the New York World Fair (Andrews 2007).

In 2007 the medium of the storyboard was integrated as an appropriate medium with which to communicate the conceptual design scenario as a hypothesis of future practice. Like the New York World Fair, the storyboard attempts to communicate the ‘experience’ and ‘believability’ of potential ‘solutions’.

7.5.5 Story Boards and Poster Presentations

The last minor changes that appear to have reaped large rewards in the 2007 intervention was the implementation of storyboards for the final presentation of concepts. An example poster presentation of a car pooling scenario was presented to students as seen in figure 7.9.
Accompanying the poster, students were asked to provide a 200-word description of how the scenario facilitated sustainability. An example annotation and poster was provided for the students:

The ‘EZE’ pooling system addresses the unsustainability of the future via several mechanisms. First by reducing single person travel and maximising the full seats in the car greatly reduces the number of cars on the road. This drastically increases the efficiency of our travel. Second, the ‘EZE’ pooling system utilises existing infrastructure of the road and telephone network; instead of designing new cars the systems ‘uses what already exists’. Retrofitting existing cars to electric and modifying (stretching) the cars enhances their car-pooling potential. The Falcon is a prime candidate for modification due to its high availability and low cost on the second-hand market.

The feedback mechanism like eBay’s system allows for the reputation of the users to be recorded, encouraging appropriate behaviour of the sharer and driver. No money is exchanged directly, the user’s account is debited a standard amount depending on the number of people within the carpool, and this discourages theft or ‘EZE’ pool car bolts.

The poster above is compiled from a combination of previous years’ student work. Storyboarding assists in explaining the context of use for the conceptual design scenario, quotation bubbles are effective in highlighting the benefits of the system.
Providing a benchmark/exemplar also familiarises the students with the expectations for their submitted work. In doing so, the details of how the final conceptual design scenario operates in context is thought through. In previous years the conceptual design scenarios were presented in isolation as stand-alone products with no connection to the outside world, even when an emphasis was placed within the assessment brief to present solutions in their context of use, which suggested a gap in enabling students to make the leap to depicting their design in action.

How the use of storyboarding assisted to explain the details of a PSS operating in the student scenario is illustrated by the example below ‘clothes man’ in Figure 7.10. The provided template encouraged students to focus on the ‘task at hand’ of communicating sustainability in everyday life. The time spent by the student developing an attractive template and corporate strategy was reduced in this assessment via the use of the template. The template also assisted in presenting a professional corporate identity in the final exhibition/presentation.

The above strategies altered how the DfS material was delivered to the Industrial Design students, and had a substantial impact on the type of conceptual design scenarios presented by students, as shown in the results section of this
The results of analysis in 2007 were surprising in the first instance. The on-the-ground feel from the sustainable design stream team was that the results within the unit had come a long way from previous years. However, the analysis of the results showed that while there had been positive gains in increasing the instances of ‘systems innovation’ and ‘social-technical’ school of thought, the factor X reduction in resource use did not shift from the previous iteration. The assumption of the researcher was that ‘systems innovation’ and a ‘socio-technical’ school of thought would lead to higher factor X reductions. At first glance without checking the Pearson Coefficient this does not seem to hold true. The results plagued the researcher for a time, yet they indicate a possible divide between ecological resource reduction and social well being. Conceptual design solutions that focus on social issues, in bringing people together or restoring the ‘commons’ in Manzini’s words (2003a) are far more difficult to quantify in terms of resource reduction.

Ecological resource reduction is presented by products that are efficient across all stages of their lifecycle including use phase, presenting overall low material and low energy intensity. The solutions are easy to calculate in terms of resource reduction using quick MIPS, such as the dual-use toaster in Figure 7.11. Waste heat from toasting the bread is used as a small hot plate to cook eggs and heat water. The co-location is implied to be twice as efficient as a traditional stove and toaster.
On the other hand, the community rooftop garden is used as an example that is difficult to quantify. The community rooftop garden has the potential to offer ecological resource reduction in several ways: it may offset mass food production and transport; heating and cooling costs of the buildings if designed appropriately; it may reduce the energy consumption of buildings depending on the systemic design inclusion in the architecture; if well designed the ability to replace air conditioning within such buildings is a possibility; and rainwater run off is reduced.

On the other hand, while the social benefits of the community garden are substantial, they are more difficult to quantify in a meaningful way. If the green roof is used as a shared living space or community garden then it has the potential to bring people together. The psychological effects of green spaces and gardens have a long history, and fresh produce may have an impact on the health of the end user. The content analysis of students’ conceptual design scenarios appears skewed to favour eco-efficiency, as this is quantifiable. The process of content analysis may not have done justice to the social wellbeing-orientated ‘solutions’ that students have attempted to design. This analysis goes some way to revealing the non-fit between the quantitative and qualitative modes of sustainability, and in some sense finds a way to bring them together in the following chapter.

The fact that students have attempted to design for social wellbeing is an achievement in itself, as it shows that they have started to question what it is to be sustainable, beyond just resource reduction. Fry’s line of questioning (1999, p. 12)
was used throughout the unit in terms of ‘what is it you want to sustain?’, ‘what is it you want to create?’ and ‘what is it you want to destroy?’ In response, the students’ tacit understanding of why we are unsustainabe (the problem context) in 2007 is seen to be more relational as it was transferred into context specific conceptual design scenarios.

The better design solutions within the unit were able to find points of contact for design within the presented social solutions. These points of contact require the foundation of Ecodesign (product improvement and product redesign) to be applied within the higher level functional and systems innovation in the social-technical school of thought. The design solutions that attempted to do this are described in the following section.

7.7 Promising Conceptual Design Scenarios 2007: Reconciling, Defining and Designing

The level of thinking displayed in several scenarios showed progression from previous years, suggesting that the pedagogical tools had appropriately facilitated contextually responsive design activity. It was evidenced in the progression from conceptual design scenarios in 2005 and 2006 that presented sharing or community activities as the scenario, to attempts in 2007 to facilitate such activities by design.

Sharing
Notable scenarios were the ‘Pod Pad’, ‘Mod-U-home’ and various community gardens, all of which engaged in the complexity of design to encourage sharing. In previous years sharing was presented as the design solution, in 2007 sharing was presented as the problem, and designerly responses were offered to overcome the many barriers to effective sharing that have resulted from the embedded conventions of individual ownership.

Pod Pad (Figure 7.12) is a purpose-built communal living system. The pod pad system focuses on sharing to reduce the material–energy intensity of our lifestyles. A well thought through incentive program and community display board encourages peer support in saving electricity and water. If electricity and water use targets are met, rewards are generated via a community social activity account. Live feedback
comparing energy usage between peers within the pod pads encourages competition in lowering energy use.

Figure 7.12 Pod pad

Source: Industrial Design student conceptual design scenario submitted in 2007 for the unit Sustainable Design: Sustainable Futures at the University of Western Sydney

Trend research was extrapolated to justify the Pod Pad’s existence such as: changing family structures. the convergence of the digital age. the requirement for denser living to reduce transport distance. and rising energy costs. While the Pod Pad is a more socially oriented ‘solution’ it still shows many of the hallmarks of ‘isolation’ design. The design is presented as a completely new community, and has not indicated how it is integrated within the existing housing stock.
The Mod-U-home (Figure 7.13) applies a common industrial design tool of modular design and upgradeability to architecture. The scenario is responsive to a minor yet growing trend in ‘downsizing’, whereby people make a conscious decision to live with less, which may include moving to a smaller house. Normally this would require a move to a smaller location (from a freestanding house to a flat or unit) once the children have left home. The Mod-U-home caters for downsizing by providing the ability ‘to pass the bedrooms on to the kids’. The design visualises what sustainable design could be, temporary solutions that can be upgraded or downgraded depending on need, making better use of our limited resources. Temporality is designed into the solution.

Figure 7.13 Mod-U-Home
Source: Industrial Design student conceptual design scenario submitted in 2007 for the unit Sustainable Design: Sustainable Futures at the University of Western Sydney

The above student example shows confidence in visualising a shift in thinking. In the previous chapter the creative brainstorming session identified a disconnect between ideas generated in class and actual radicalised outcomes.

Community gardens provided a popular solution for the garden groups in 2007. The real insight from 2007 was that the sharing solutions progressed when the solution became the problem i.e. how can we make this actually work? The better resolved designs focused on how design can facilitate the use of community gardens. Figure 7.15 shows a scenario that has attempted to facilitate sharing within the
community garden: a checkout ‘trolley’ logs work put into the garden for food taken, to keep a balance of who has contributed to and taken from the garden. The trolley assists to keep the tools orderly and also transports compost from the home to the garden. The concept shows the student grappling with design’s product-orientated (note the lack of people) legacy in an environment where such solutions seem foreign.

*Figure 7.14 Community garden*

Source: Industrial Design student conceptual design scenario submitted in 2007 for the unit Sustainable Design: Sustainable Futures at the University of Western Sydney

**Regenerative Solutions**

Promising student conceptual design scenarios in 2007 dealt with rematerialising past sustaining practices such as Do-it-Yourself (DIY) and cooking, which were identified as practices worth enlarging. The ‘DIY tutor’ future scenario is a virtual assistant that offers advice and instruction on DIY projects at the place of work in the garage. The student’s tacit problem definition was the perceived lack of knowledge to complete such projects, a legacy of the transfer of know-how to technologically sophisticated design.
The final example presented from 2007 (Figure 7.17) is the ‘programmable stove’, which was viewed to be particularly good. The social research conducted by students in the first assessment ‘why we are unsustainable with regards to the kitchen’ identified that our cooking habits are informed by a lack of knowledge of how to cook from base ingredients, and an over-reliance on the convenience of microwave and frozen foods. Therefore the conceptual design scenario attempts to remake the convenience of frozen microwave dinners by way of traditional meals and seasonal food. This is achieved by redesigning the oven interface, which operates in a manner similar to a microwave; if you want to simmer food for five minutes you program the stove top to simmer for five minutes, after which the stove turns off. The scenario was presented in conjunction with a smart fridge which has a database of food in stock, allowing possible menus to be suggested and selected (see Figure 7.17).

The product also has the ability to rematerialise past activities as the interface guides you through the necessary steps to prepare and cook your meal. In doing so, it regenerates the lost art of cooking and assists the user to learn. The programmable stove has the potential to dematerialise existing kitchen appliance such as microwaves, toasters, kettles, rice cookers, fry pans and steamers. By

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*Figure 7.15 Virtual DIY tutor*

Source: Industrial Design student conceptual design scenario submitted in 2007 for the unit Sustainable Design: Sustainable Futures at the University of Western Sydney

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48 Re-materialisation as a solution poses many benefits (Fry 2004), however these benefits are unable to be quantified in the analysis of the product using the coding categories within this study. This may go some way to explaining why systems innovation rated highly within the returned analysis, but the level of resource reduction remained the same.
encouraging traditional cooking techniques, these appliances become surplus (an issue not dealt with by the concept).

Figure 7.16 Programmable stove

Source: Industrial Design student conceptual design scenario submitted in 2007 for the unit Sustainable Design: Sustainable Futures at the University of Western Sydney

The design of the stove from a purely technical perspective is also well considered. The student has applied traditional Ecodesign techniques in the programmable stove as it is as efficient as possible through induction cooking, the interface minimises the ability to leave the stove on or overcook, thus minimising electricity consumption, while at the same time dematerialising current electronic cookware. The concept is viewed to be progressive in that it has reconciled a social interpretation of unsustainability to inform the technical Ecodesign. More than the concept itself, what is revealed is an elegant evolution of relational thinking and creative application.

Despite this progress, the design itself illustrates the complexity of DfS3 for the author. The programmable stove is efficient and has the potential to assist the user to learn to cook from fresh base ingredients, possibly increasing the health of the user. On the other hand the design conflicts with Manzini’s ‘use what exists’ criterion as the replacement of a variety of appliances by a new device is problematic. If the design is viewed in two different contexts then the benefits of the design vary. If the ‘programmable stove’ was purchased for a new kitchen as the only appliance, then it is of greater benefit than replacing a stove in an existing
kitchen fitted with a variety of appliances, in which case retrofitting the existing stove may be more appropriate.

To conclude, the design examples shown present a shift in thinking in that students are bringing the Industrial Design ‘language’ of technical design to social contexts. Given ‘no design’ of the previous chapter, the revised process in looking at the ‘solution’ as the ‘problem’ saw the experimental concepts assist to reveal and help students to practise relational thinking. This is an important difference that is of value to what they are doing in this unit. The examples also illustrate the legacy of product-orientated solutions that at this stage can not be escaped; this legacy is discussed in detail in the following section.

7.8 Challenging Industrial Design Education for Sustainability

The analysis of the conceptual design scenarios highlights that positive progress has been made on the work presented in 2005 and 2006, with students presenting a more developed social understanding of unsustainability. The analysis also indicates that while progress has been made, there is still a proportion of students’ work that has not evidenced Designs for Sustainability that will contribute to a sustainable society. The example of poor relational thinking in substituting electricity usage for water within the bathroom was still evident in some conceptual design scenarios, even after discussing Lenzen and Foran’s distribution of embodied water (2001) in tutorials illustrating that one can save almost an equal amount of water by saving electricity. Despite this, the overall assessment of 2007 was an improvement on previous iterations. While improved, DfS still presents challenges for Industrial Design Education.

The programmable stove presented above is a tangible product to which the Industrial Design students can relate. The above transformation of a social interpretation of unsustainability did not always lead to a clear designed outcome. The challenge of designerly outcomes is discussed below.
7.8.1 Design for Sustainability and Industrial Design Culture as Knowledge

To accept the discipline of learning what appears to be useless for the present in the trust that it will serve in the future—appears likely to commend itself to only a small minority of pupils (Stenhouse 1975 p. 9). Stenhouse’s above observation captures harshly the challenge of educating Industrial Design students for sustainability. The challenge for Industrial Design Education is presented on two fronts: the relevance of DfS solutions with high sustaining potential differs considerably from the cultural expectations of what industrial design is; and the progressive theory of DfS as presented by Fry (1999: 2004) challenges the cultural norms of students as individual members of society.

The challenge in relation to expectations of Industrial Design vocation is perceived as follows. Students understand that there is a problem that needs addressing in unsustainability; they understand the possibility of irreversible climate change if action is not taken. However students are presented with a perceived conflict between conceptual design scenarios that best represent Designs for Sustainability, and their future vocation as Industrial Designers, where they imagine they will be designing mass products for sale. Therefore what is best for DfS does not have a clear relationship to the students’ future vocation.

The walking school bus from previous chapters is used to illustrate the point. The walking school bus, from a sustainability perspective, can be perceived as an optimum way a child may arrive at school as it requires minimum resources and energy, offers exercise for children and has potential social benefits. Yet for an Industrial Design student the correlation to their vocation is distant. One can quickly arrive at desirable Designs for Sustainability, but this directly challenges Industrial Design perceived as the designing and making of goods for sale, which can be seen in concepts like the programmable stove above.

How designers may resolve ‘problems’ without the ‘solution’ being the proliferation of products is not clear, particularly in relation to vocational applications. Dewey (1966) and Habermas (1971) support education as a projection of the type of society we could be. In this respect it is worth engaging in the challenge of how Industrial Design may operate without a proliferation of products. Ezio Manzini’s (2003a) work was presented in Chapter 2 as a model for engaging designers in community problems modelled on a more participatory approach in the
resolution of such problems. The following chapters engage further in the issue of vocation.

The second challenge is the confrontational nature that is presented by sustainability in its more radical form. Fry’s sustainments (1994) are viewed to be representative of DfS3 type solutions that may bring about a sustainable society; however such solutions challenge what was seen as progressive in Ecodesign a decade ago. Making the more progressive philosophies on sustainability palatable to students is a challenge that the author believes Sustainable Design: Sustainable Futures has not yet resolved. The student-centred approach to teaching implemented in the pedagogic intervention assisted in the critical reflection from students on their individual lifestyles. This is viewed to challenge what Stenhouse describes as cultural knowledge (1975). Cultural knowledge is formed via the public traditions, what students know is formed through social locations and function. DfS3 challenges this cultural knowledge. The University of Western Sydney is physically located in the working class, car dependent, mortgage belt of a major city. Cultural knowledge and traditions within this milieu are challenged by Sustainability Education.

To return to the Stenhouse quote that opened this section ‘learning what appears to be useless for the present in the trust that it will serve in the future’ (1975, p. 9), Design for Sustainability education can slip into being presented as a moral responsibility as opposed to an opportunity. From the perspective of education, the challenge of motivating and engaging students is a continuing problem. For DfS this is seen to be compounded due to the Greenfield nature of DfS.

7.8.2 The Greenfield Nature of Design for Sustainability Education

Re-iterating Dewey’s statement of educating for a ‘projection in the type of the society we would like to realise’, (1966, p. 317), the challenge for Industrial Design Education for Sustainability is that the ‘type of society’ we would like to realise is not clear.

Bruner (1960, p.31) proposed that an ‘unconnected set of facts has a pitiful short half life in memory’ and that the best way to make a subject worth knowing is to create interest. If the connection for DfS in application is not clear, then there may
be a limited chance of students retaining knowledge, and they may not be fully engaged in and motivated by the subject matter. When educating students for the more progressive DfS theories it appears to be at times a theoretical argument as there are limited supporting case studies for what is being asked. Strengthening the vocational connection of DfS in Industrial Design practice is supported by reflection across the three iterations of the action research cycle. Over the course of three years the teaching has been made easier by presenting previous years’ work as concrete examples of possible outcomes, as well as drawing upon the case studies that the researcher has compiled (as presented in the following chapter). Providing examples of conceptual design scenarios graded at High Distinction level familiarised the students with the expectation of the unit. It also appeared to assist in connecting the application of Industrial Design skills to DfS.

To date very few outcomes acknowledge or embrace design’s agency in spite of readings suggesting its responsibility for the current crisis. In the wider media, climate change looks to be addressed by efficiency and carbon credits; not design’s potential influence upon consumption, despite the widespread influence that design does have.

7.9 Conclusions from 2007

This chapter presented the significant improvements made to DfS education by a focus on the pedagogical delivery of Industrial Design education. The pedagogic gains presented within this chapter are equal to the gains made in the previous year that focused on integrating DfS theory, justifying the importance of pedagogy in Design education. Students achieved a marked improvement in the ability to design for social scenarios incorporating technical design. The higher-achieving students reconciled the theoretical frames of ‘how you define’ in their interpretation of unsustainability with ‘how you design’ in practical technical design outcomes. These solutions displayed a high level of relational thinking, that was not always rewarded in terms of the selected categories against which the solutions were measured.

For the researcher, the chapter strengthened the requirement of context-dependent solutions for DfS, as the concept of ‘rematerialisation’ when contrasted against ‘use what exists’ can only be validated in context for its sustaining potential.
Despite the advancements made in the students’ displayed ability to design for sustainability, there was a perceived difficulty within the unit related to the ‘real world’ justification of the scenarios in relation to future employment opportunities. The challenge facing the unit is to prepare students for scenarios that are likely to develop; however such scenarios are on limited display in practice by Industrial Design practitioners. The following chapter explores what designs have the highest sustaining potential with a global analysis of the results to date. This is followed by a detailed case study exploration of the designs that offer the highest sustaining potential, suggesting that the conceptual design scenarios presented by students do have real world application. It is argued however that this vocational opportunity has not been made clear in DfS education and is a significant feature of what remains to be done.
So far, this thesis has focused primarily on Industrial Design students’ conceptual design scenarios. This chapter analyses the practical case studies and scenarios as presented by the Industrial Design DfS literature in order to draw comparisons between the global perspective on DfS and the localised action research study.

While the chapter is positioned chronologically after the analysis of student work, the collation and analysis of case studies was ongoing from the start of the study. The process of collating the data for analysis served a double purpose: case studies have been an invaluable resource of examples that have informed the researcher’s own learning and have been drawn upon in teaching; and they have assisted in exploring the correlation between categories in addressing the research question ‘what DfS approaches offer the highest sustaining potential?’.

The research project has collated over four hundred (n=402) design scenarios, from both student conceptual design scenarios and practical examples presented in the DfS literature. This number allows for a statistical analysis to explore the relationships between categories and to assist in answering the above research question.

### 8.1 Presentation

The chapter begins with the analysis of the case studies from the DfS literature. This is followed by a statistical analysis of the categories across all years of the project to address the question ‘what DfS approaches offer the highest sustaining potential?’. This is followed by an in depth discussion of the cases studies that matched the
Chapter Eight: Case Study Analysis and Challenges for Industrial Design Education for Sustainability

description of having the ‘highest sustaining potential’. The chapter concludes with a reflection upon the challenge the case studies present to Industrial Design Education for Sustainability.

8.2 Sample Population

The DfS literature presented many inspiring examples of Design for Sustainability in the actual products or systems on the market as fully realised designs. Over the course of this study, whenever such examples were presented within the literature they were collected and analysed, following the same process as the students’ conceptual design scenarios. Over one hundred (n=108) case studies were analysed from multiple sources including; DfS journal articles, key texts (e.g. ‘Natural Capitalism’ by Hawken and Lovins (1999) and Brezet and Hemel’s (1997) ‘Ecodesign: a promising approach’) and credible academic online galleries such as the Delft’s ‘Re F-use’ (2005) and Jégou and Manzini et al.’s ‘Sustainable Everyday Project’ (2008). The proposition is that the case studies selected represent the practical application of DfS as presented to the wider design community.

From the above sources, the most promising cases studies will be discussed in detail after the quantitative analysis, these include: the Beddington Zero Energy Development in England; Curitiba’s bus shelters in Brazil; Jégou and Manzini’s Sustainable-Everyday Project and the Paris Vélib bike share program.

8.3 Content Analysis of Case Studies

As with previous chapters the data is analysed against the categories factor X reduction, Brezet’s type of innovation and the DfS school of thought. The second part analyses the entire database of over four hundred (n=402) scenarios to explore the relationships between coding categories.

8.3.1 Frequencies Within Data: Case studies

From the case studies collected in relation to the category factor X reduction exactly half (n=54) of case studies presented less than a 25% resource reduction in comparison to a similar product. The results are surprising for the researcher, it was
assumed that the case studies would align better with the significant scale of change that is acknowledged in the DfS literature (e.g. factor 10 Schmidt-Bleek 1999). Half the case studies presented design solutions with resource reduction greater than 25%, of which 41.7% (n=45) had implied resource reductions greater than 75% and 28.7% (n=31) afforded reductions greater than 90% (see Table 8.1). These results are not dissimilar to the levels afforded in the Industrial Design students’ conceptual design scenarios throughout the project. This may be attributed to the limited potential to reduce the amount of natural resources over a product’s lifecycle to the scale of factor 10 without systemic change.

The DfS case studies presented within the literature overwhelmingly focused on types of innovation that were product orientated. Of the case studies, 81.5% (n=88) were product orientated, with 28.7% (n=31) classified as product improvement and 52.8% (n=57) classified as product redesign. Only 12% (n=13) of the case studies selected fell into the category of functional innovation where the designer had questioned the function of a product and attempted to meet that function in alternative ways. A particularly small percentage 6.5% (n=7) offered design solutions that would be classified as systems innovation (see Table 8.2).

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<th>in Case Studies</th>
<th>Frequency</th>
<th>Percent</th>
<th>Valid Percent</th>
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<td></td>
<td>31</td>
<td>28.7</td>
<td>28.7</td>
</tr>
<tr>
<td>Product redesign</td>
<td></td>
<td>57</td>
<td>52.8</td>
<td>52.8</td>
</tr>
<tr>
<td>Functional innovation</td>
<td></td>
<td>13</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>Systems innovation</td>
<td></td>
<td>7</td>
<td>6.5</td>
<td>6.5</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>108</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>
The results collected are similar to those of Halila and Horte (2006, p.371), which showed 75% of eco-innovations to be product focused. The improvements made from the pedagogical intervention in Chapter 7 appear significant in light of these results, as students were capable of displaying systems innovation (31.8%) and functional innovation (28.4%). While hypothetical concept generation is very different to an actual product or working example, if Lewis and Gertsakis’ (2001, p. 13) concept of the designer as prescriber of ecological damage is reiterated, 70% of the damage is prescribed in the concept generation phase.

The final category for analysis appears to correlate with technical product orientated solutions, as the case studies were overwhelmingly classified as technical (81.5% n=88). The technical classification was allocated to designs that did not ask the consumer (end user) to alter their behaviour in any way, this is in comparison to the remaining results that encouraged the end user to alter their behaviour and were classified as being socially orientated: either social (12% n=13); or social technical (6.5% n=7) within the category school of thought (see Table 8.3).

Table 8.3 Frequency count ‘School of Thought’ in Case Studies

<table>
<thead>
<tr>
<th>School of Thought in Case Studies</th>
<th>Frequency</th>
<th>Percent</th>
<th>Valid Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical</td>
<td>88</td>
<td>81.5</td>
<td>81.5</td>
</tr>
<tr>
<td>Socio-technical</td>
<td>7</td>
<td>6.5</td>
<td>6.5</td>
</tr>
<tr>
<td>Social</td>
<td>13</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>Total</td>
<td>108</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

The results suggest that the analysed DfS case studies present to the design community a heavily product-orientated approach to sustainability, which confirms that technical Ecodesign is the dominant form of DfS in practice. The redesign of products that fail to encourage the end user to alter their behaviour is of concern. This suggests a lack of understanding of the agency of design to influence behaviours in mainstream design. A technical understanding of what design is capable of influencing severely limits what can be creatively achieved. As Fry states, ‘technology is less than half the sky in terms of the solutions’ (1999, p. 4).

While the majority of the DfS case studies represented the dominance of technical Ecodesign, there was a smaller percentage of case studies that did engage with functional or systems types of innovation, as well as potentially offering high
levels of ecological resource reduction. The specific examples will be discussed later in this chapter.

**8.3.2 Patterns Between the Coding Categories**

The results presented so far in this chapter have only presented the frequencies that occurred from analysis of the design case studies. To explore the interconnections amongst the coding categories the following results analysed all 402 student conceptual design scenarios across all years (2005, 2006 and 2007) as well as the case studies. The Pearson Coefficient has been used to analyse these interconnections. By exploring the relationship between categories, insight into the research question ‘what DfS approaches offer the highest sustaining potential’ can be quantified.49

The Pearson Coefficient is widely used to measure correlation between two variables. A value of 1 or –1 indicates a perfect relationship, while a value nearing 0 (less than 0.05 for example), indicates that there is no relationship between the two variables (Moore 2006). The analysis was completed using SPSS.

Between the categories *type of innovation* and *factor X reduction* a positive relationship was identified with a Pearson Coefficient of .213. The linear relationship can be seen particularly well in two categories: Factor 0–2 and Factor 10 resource reduction (Figure 8.1). The percentage of ‘Factor 0–2’ reductions in the graph indicates that small resource reductions have a higher frequency in the category ‘of product improvement’. This is evidenced by 65% of the case studies and student conceptual design solutions being classified as offering less than a 25% resource reduction. The percentage of instances of Factor 0–2 reductions in correlation with the higher types of innovation with systems innovations presented the lowest instances of small scale reduction.

The percentage of Factor 10 cases was highest in the category of systems innovation, with a frequency of 36.5%. The percentage of instances of Factor 10

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49 It would have been desirable to have the information from this analysis at the beginning of the research project. However for the correlation to be effective a higher sample size was required to be valid. The hypothesis of Chapter 3 stated why the categories for coding were selected and their perceived worth, which informed the interventions aiming to achieve an increase in the higher levels of each category. The collection of the case studies was concurrent with the early teaching sessions allowing for the promising case studies to be used as examples within the teaching sessions.
declined in functional innovation and was equal in the product orientated types of innovation.

From the analysis using the Pearson Coefficient one could deduce that functional and systems innovation offer a higher chance of producing designs with a higher sustaining potential than product-focused innovations in relation to resource reduction. However this is not a fixed or concrete rule, as both categories (product improvements and product redesign) were capable of producing results affording Factor 10 reductions.

The weakest relationship between the categories was in *school of thought*, and *factor x reductions* with a Pearson Coefficient of 0.148. There was a suspected link by the researcher between the categories, in that social-technical solutions would offer a high sustaining potential. The previous chapter discussed the connection of social wellbeing and ecological resource reduction, in that the potentialities of social wellbeing may not be quantifiable, and may explain this weak correlation.

The strongest correlation in the data analysed was between the categories *type of innovation* and *school of thought* with a Pearson Coefficient of 0.408. The strongest relationship saw product improvements being almost purely technical in nature, as seen in Figure 8.2. Surprisingly, examples of product redesign had a high percentage of socio-technical approaches, in that the redesign of the product had attempted to facilitate some type of behavioural change in the end user. An example from the case studies collected would be the previously mentioned Axis kettle. This design attempted to reduce electricity in the use phase (which is social), by reducing the tendency of the end user to re-boil a hot kettle. This was achieved through insulation and a temperature indicator on the kettle, visually prompting the user not
to re-boil (RMIT 1996). The focus on user action classifies the solution as social, while technical design skills assist to achieve the desired behaviour (hence socio-technical), however the product still has all the characteristics of an existing kettle, therefore being classified as a product redesign.

The category ‘functional innovation’ had a relatively even support of the various schools of thought with a high percentage of technically orientated solutions, which was unexpected with regards to the original proposition. This is largely due to products whose alternative functions demand no significant change in the behaviour of the end user.

The category of ‘systems innovation’ displayed the highest incidence of solutions categorised as ‘social’ with only 18% of the solutions within the systems type of innovation being categorised as technical.

![Figure 8.2 ‘Type of innovation’ v ‘school of thought’](image)

### 8.3.3 Combination of Categories to Yield Higher Results

Individually the categories are not judged to be significant in their capability to bring about solutions of high sustaining potential, however if the school of thought and type of innovation approaches are combined then the relationship between categories and their sustaining potential increases quite significantly.

The combination of the categories school of thought and type of innovation presented the approach that can offer the greatest sustaining potential with regards to implied resource reduction, as illustrated by Figure 8.3. When the categories of ‘social’ school of thought and ‘systems’ innovation were combined, 58% of incidences yielded solutions with an implied resource reduction greater than
Factor 10 (see Figure 8.3B). This is followed by the combination of a ‘social’ school of thought and ‘functional’ innovation which, when combined, yielded Factor 10 solution in 35% of incidences.

The results strongly suggest that the combination of categories offers the highest sustaining potential. With the understanding of the above it is imperative that Industrial Design Education for Sustainability explores how it is best able to operate within functional and systems type of innovations combined with a social school of thought. As we saw in the previous chapter, Industrial Design is still heavily reliant

Figure 8.3 Combination of ‘DfS school of thought’ and ‘type of innovation’ against ‘factor X reduction’
and driven by technical- and product-oriented solutions to complex problems of unsustainability, even where a more comprehensive understanding of the problem was evidenced. The following section discusses in detail examples from the case studies collated that fit within the above categories.

8.4 Cases Studies with High Sustaining Potential

The combination of categories that offers the greatest chance of sustainability from an ecological resource reduction perspective is that of the social or socio-technical DfS school of thought combined with systems or functional type of innovation. The following cases fit within those categories: the BedZed Development in the United Kingdom, Transport Initiatives in Curitiba, Jégou et al.’s Sustainable Everyday Project and the Paris Vélib bike share scheme.

8.4.1 BedZed Developments

The first case study for discussion is the Beddington Zero Energy Development (bedzed) by Bill Dunster architects (known as Zedfactory). BedZed has been selected for discussion because of the depth the designed solutions go to in negating the impact of associated lifecycles of the residents and because the design of the building from existing materials is a best-practice example of Manzini’s ‘use what exists’ (2002, p. 4) principle.

There are numerous architectural case studies of super-efficient buildings that use considerably fewer resources throughout their life than the average building. However by the inclusion of associated lifestyles within boundaries of the architectural design, a systems approach has been afforded, and the ontology of the design as a living building has been thought through. It is indicative of the forethought required to DfS3 as discussed within the previous chapters.

As such, Dunster’s approach and systems innovation assist the BedZed apartments in making the default actions of the residents more sustainable, as Dunster (2007, p. 1) continues:

ZED factory is an innovative practice specialising in low energy, low environmental impact buildings and associated lifestyles. Within the wider context of sustainable development we are committed to good quality design based on careful analysis of end user needs.
The Zed factory’s philosophy acknowledges that the carbon footprint of UK individuals consists of roughly one third housing, one third transport and one third food. Their systems approach attempts to cater to all three areas. Transport is addressed largely through the use of mixed use developments, co-locating work and home where possible. Streets are pedestrian friendly, there is good access to public transport as well as a locally run car share scheme to assist in reducing the carbon footprint generated via transport. The systems approach has been highlighted by Olivier Jolliet (2005) in his system-wide LCA of a pharmaceutical business: traditionally businesses focus the majority of their initiatives on production and energy initiatives, and exclude travel of staff and sales reps. When included, travel overwhelmingly produced the greatest CO₂ of any business activity, followed a distant second by packaging. This highlights the limitation of LCA in boundary definitions. The example illustrates the importance of broadening the scope in problem definition, allowing for design to engage in the more relational aspect of inconspicuous consumption.

The second initiative that is promising is the use of local materials or reclaimed materials where possible (using what already exists). It was attempted to construct the buildings from materials sourced within a range of 20 miles, reducing the ecological footprint of transport in the development. Not only the construction of the building uses local materials but the energy production on site utilises local waste as
biomass. The ability of the development to acknowledge the inconspicuous consumption of associated lifestyle and ‘use what exists’ (Manzini 2003a) in local materials are two principles that industrial design practice has difficulty in employing.

The principles of local materials, manufacturing and reuse are worth exploring for industrial design, particularly with respect to peak oil and climate change that may challenge the previous foundation of design based on cheap raw material and transport. Local material and reuse contrasts severely with the status quo of design education’s ‘hidden curricula’ (Gordon 2006)\(^{50}\) that assumes virgin material and mass manufacture in the majority of design briefs. The principles of Industrial Ecology or ‘waste equals food’ are seen to progress somewhat the idea of reuse to commercial levels, which may be beneficial to design thinking.

The Bedzed development assisted in affirming the notion of how you define is how you design as broadening the scope of the problem definition significantly shifted the designed outcome, which has informed the design interventions made in previous chapters.

\subsection*{8.4.2 Curitiba Brazil: the Model City}

Often labelled as the most sustainable city in the world (Fong 1999, p.109), Curitiba, Brazil has a socially focused governing body that has facilitated the implementation of many design-related projects that have transformed the city on many levels, including environmental initiatives, public transport, education and social welfare. The case study is relevant for both the designed artefacts produced and insight into the design process for DfS. Central to this transformation was Mayor Jamie Lerner’s team from the Urban Research and Planning Institute of Curitiba (IPPUC)—Institutode Pesquisa e Planejamento Urbano de Curitiba (Hawken, Lovins et al. 1999).

From the IPPUC’s many initiatives, it is the humble bus shelter (see Figure 8.8) that has been selected as an important case study for analysis. By addressing the key barrier to slow bus travel in boarding and exiting the bus, shelters

\footnote{The ‘hidden curricula’ refers to the unintended curriculum (Gordon, 2006) that may be taught unconsciously in not being formally acknowledged, for example after four years of university specifying virgin grade plastics in assignments with no alternative presented, the assumption may be that this is standard practice.}
were designed that operate in a similar way to a train platform. Because you pay before you enter the shelter, cash transactions are eliminated from the bus, allowing for speedier boarding and exiting. The use of existing roads allows the system to operate in a manner similar to a subway at a greatly reduced cost to the city. From an ecological perspective this has great merit as it ‘uses what already exists’ in a far more efficient manner. This small initiative greatly improved the efficiency of the public transport system, which in turn facilitates sustainable behaviour through increased ridership and reduced single occupancy vehicle trips.

![Figure 8.5 Curitiba bus shelters](source: Hobbs (2006))

While Curitiba has benefited from a well-designed master plan and near 40 years of stable leadership (Macedo 2004), the element from the case study that is most interesting is the agency that design has had in transforming the city. The innovation in the bus shelter is one of many designs resolved by the IPPUC. The buses are colour-coded via travel distances and routes, making them easily understood by city commuters. The buses have some of the largest carrying capacities in the world, and there are social incentives in rewarding positive community behaviour in waste collection with travel coupons. The solutions (particularly the bus shelter) display design-driven lateral thinking to context-specific problems that is encouraging to present to students, communicating the transformative agency of design.

The second inspirational aspect to the case study is that of Jamie Lerner’s declared attitude towards change in that ‘we need transformations that happen now, and not the ones which take 20 years to happen. It is important to make it happen now, and then we take the time to improve’ (Lerner 2005, p.47). There is an urgency in Lerner’s attitude for action on the proposed concepts, which is seen to align with Manzini’s (2003a, p.1) outlook on sustainability that:
it will be a complex social learning process: a sequence of events and experiences thanks to which, progressively, amid mistakes and contradictions as always it happens in any learning process—human beings will learn to live in a sustainable way.

The approach Lerner has taken acknowledges that time is an important element in bringing about sustainability. This has assisted to inform the researcher’s proposal in the following chapter where design interventions take effect over time in an action-research-like process.

Curitiba as a case study is valuable for both of the designed outcomes that the IPPUC produced, which are seen to be beneficial in challenging the traditional structure of where design may operate.

### 8.4.3 Emerging Users’ Demand for Sustainable Solutions

The ‘sustainable everyday project’ compiles case studies of promising social innovation: ‘showing examples of social innovation from all over the world developing original solutions promising in terms of sustainability’ (Jégou, Manzini et al. 2008, p.1). The project has provided several of the case studies for analysis in this study such as the walking school bus, car share schemes and the furniture re-design workshop presented in Figure 8.6.

As a teaching resource, the sustainable everyday project was useful in the later teaching iteration of 2007, as it questioned students’ assumptions or cultural knowledge in that how they live, socialise, shop, and purchase goods is the only valid model available. The sustainable everyday project has collected important information on social innovation upon which design could expand. The project is seen to re-iterate John Thackara’s advice that ‘designers should go out into their community, identify existing cases of promising social innovation and ask if they can help’ (2007 pers. comm., 10 July). When such a stockpile of alternative solutions is viewed it is a powerful tool, illustrating to students the potential markets to apply design skills to, which is most often overlooked.
Chapter Eight: Case Study Analysis and Challenges for Industrial Design Education for Sustainability

Figure 8.6 Sustainable Everyday Project case studies, Milan car sharing, walking school bus and the furniture re-design workshop

Compiled from Jégou and Manzini et al. (2008)

The examples provide a useful base to discuss Fry’s (1999) concept of ‘what is it we want to sustain’, ‘what is it we want to create’ and ‘what is it we want to destroy’. Do we want to sustain conventional business and social norms, even if the models are intrinsically unsustainable, or may we sustain or create practices that are intrinsically more sustainable to begin with? The strength of the sustainable everyday project for the researcher is in locating and clarifying practices that could be strengthened by design.

While positive, the project is also seen to mimic two concerns that the evidentiary chapters have raised: the designlessness of social solutions and the limited perceived vocational prospects for the design of ‘social’ solutions. In the evidentiary chapters of 5 and 6, examples of social innovation were presented, but the immediate connection to the traditional practice of Industrial Design in designing goods for sale (even the application of technical design skills in making things with a useful purpose) is not evident. It is worth noting in relation to ‘no design’ that the probing strategies that turned what was once seen as a solution (e.g. virtual university, community garden) into a problem assisted in generating design opportunities in 2007.
The second concern is the lingering question that the researcher has in how a designer makes a living designing in this context, particularly when the examples given seem to be based on a *lifestyle choice* with no obvious design intervention supporting the practices. This concern has been raised in the previous evidentiary chapter as the vocational prospects for students engaged in ‘social innovation’ is not clear. The following chapter attempts to address the above two concerns.

The BedZed development and Curitiba use design’s normalising capacity to reduce reliance on sustainability as a conscious *lifestyle choice* by making default actions more sustainable. The final case study presented is the Paris Vélib bike share system, which is seen to take the ‘promising social innovation’ that the sustainable everyday project has collated, and reconciles this with technical design to implement sustainable solutions on an unprecedented scale.

### 8.4.4 Vélib, Paris

The Paris Vélib is a bike share scheme that facilitates the ease of cycling throughout the city. The scheme provides an alternative to public transport or driving for short trips. It incorporates bike stands spaced at key destinations through the city, matched with a purpose-designed bicycle for sharing (which was coded in our analysis as systems innovation and a socio technical school of thought, leading to potentially Factor 10 savings in its comparison to private car travel).

What makes the Paris scheme so promising is not only the concept (which has been tried and tested multiple times in various locations), but also the resolution of the Paris Vélib from a design perspective that makes the scheme so impressive. The bicycles are designed specifically for sharing.

Doug Mckenzie-Mohr’s (2000) early stages of Community Based Social Marketing concerns the identification and resolution of barriers as a critical stage in enabling change to more sustainable modes of behaviour. If this principle is applied to the Paris Vélib bike share scheme one realises the depth of the designed solution.

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51 The most notable bike share scheme is the ‘white bike plan’ introduced in Amsterdam that had mixed success (Shaheen and Rodier 2007), as the scheme was plagued by theft and maintenance issues.

52 The process of community based social marketing (CBSM) is discussed in detail in Chapter 9.
Theft is resolved through GPS modules monitoring the location of the bikes, locks and alarms designed into the bike and stations, as well as economic incentives that ensure that if the bike is not returned, the user’s account or credit card is debited a substantial amount i.e. the price of the bike. The hassle of personal ownership is overcome in that the problem of storage space is negated, as is the difficulty of carrying bikes on public transport. Repair and maintenance is resolved through a series of checks that the bike performs before it is released, keeping only working bikes in use and notifying maintenance staff of problems. Timely travel is encouraged through financial incentives, as the first half hour with the bike is free. Peak loads at key stations are overcome through the monitoring of bikes via GPS and the ability to move bike stations if required (Bennhold 2007; Steigrad 2007).

The design of the bike and stands from an aesthetic perspective is well resolved, with subtle curves sloping backwards on the bike stand, and neatly integrated chain guards and protective covers concealing the internal hardware of the bike to prevent disassembly (see Figure 8.8). The development of the bike fits well into traditional Industrial Design practice in that, although the case study is a ‘system’, the core component of that is product specific. It is an excellent example of Industrial Design facilitating behavioural change.

Figure 8.7 Paris Vélib bike share scheme

The success of the Paris Vélib is also seen in the diffusion of bike sharing schemes in multiple cities such as Barcelona, Brussels, Oslo and Vienna (Bryant 2008, p.8) with discussion of the scheme being replicated in cities such as Buenos Aires, Portland and Sydney. Because of the strong inclusion of Industrial Design practice, the author rates the Paris Vélib above promising sharing schemes such as ‘Go-Get Car share schemes’ that are in operation around major cities. This is not dismissing Industrial Designers’ technical skills being of strategic merit in developing sustainability, but suggests that the approach of goods being designed for sharing scaffolds on the designer’s traditional skills set. For example, the car has not altered in layout for the past century, specific cars designed for sharing or car pooling such as those presented by students in the previous chapter present opportunities for design to facilitate what otherwise becomes a largely social initiative void of any traditional object-orientated design, leading to ‘no design’. Such a design intervention has the potential to ‘use what exists’ in the existing road infrastructure at far greater efficiencies.

This thesis proposes that, like the Paris Vélib, the technical language of design can contribute to facilitating social innovation (i.e. sharing) by reconciling technical design skills with social innovation. By enabling and enlarging the pre-existing forms of social innovation such as compiled by the sustainable everyday project, sustainable behaviour may be facilitated.
8.5 Summary of Presented Case Studies

The close analysis of case studies of high-sustaining potential provides insight that DfS3 can be achieved and has been influential on the researcher’s own learning. The agency of design to influence change towards a more sustainable society is illustrated in the presented case studies, and is valuable to communicate in teaching supported by real world evidence. From the presented case studies there are two key elements that stand out for the researcher: first, the context specific nature of the solutions, this understanding has been transferred into the preceding chapter’s interventions to encourage contextualised solutions; and second, the case studies validate that social innovation can be a driver for effective, appropriate technical design.

While the final outcome presented in each case study is promising, the process of how social innovation was transformed into conceptual design solutions is unclear when compared to the traditional Industrial Design process. Being able to replicate such outcomes as presented in this chapter is seen to be dependent on an understanding of this process in an educational context. The next chapter proposes a process that will assist in making design’s contribution to this area of high-sustaining potential but apparent low design input more explicit.

8.6 Case Study Analysis Conclusion

The detailed analysis of case studies with the highest-sustaining potential identified the agency of design to facilitate behavioural change for sustainability; the case studies selected have had a substantial impact on the researcher’s own understanding of what DfS means, which in turn has permeated through into the previous chapters. The exemplar case studies presented social innovation enabled by appropriate technical design. That is, an understanding of DfS2 solutions was supported by DfS1 technical design, presenting cases that come closest to DfS3 solutions that potentially bring about fundamental change towards sustainable practices.

The quantitative analysis of case studies highlighted that technically focused DfS1-type solutions have been dominant. The author speculates that the prevalence of DfS1-type solutions is a logical conclusion in that this type of designing doesn’t challenge industrial norms; it is green business as usual and therefore perceived as
realistic. The categories of functional or systems innovation, combined with a social orientation, were shown to have a greater probability of achieving scenarios with a high-sustaining potential, based on the analysis of both Industrial Design student conceptual design scenarios and DfS case studies.

The frequency of case studies with the combined categories of high-sustaining potential was low, as socially orientated designs focused on altering human behaviours were marginal. This suggests that exploring the process of design’s agency to facilitate behavioural change maybe worthy of further exploration to better enable Industrial Design students to Design for Sustainability.

This chapter presented case studies of designs that addressed behavioural change, highlighting that DfS engagement with social solutions is not a matter of ‘no design’ but rather design that is appropriate, context driven and wholly aware of what exists. The following chapter proposes a pedagogical framework to engage designers in behavioural change, utilising social theory that can inform a new sort of Industrial Design.
This chapter proposes a pedagogical framework for Industrial Design Education for sustainability that attempts to ameliorate many of the outstanding concerns that have been presented in the previous chapters. There are three major areas that this chapter attempts to cover: first, a process to replicate design solutions that facilitate behavioural change is proposed; second, the vocational applicability of DfS for Industrial Design students is revised in light of the evidentiary chapters and the above proposal; and third, how the above two areas may be used to mobilise Industrial Design Education for Sustainability is presented. Each of the three points will be briefly introduced in turn.

The process of designing solutions that facilitate desirable behaviour is seen as a critical form of design in relation to the theoretical framework presented in Chapter 1. The theoretical framework proposed that reconciling ‘practical (social) knowledge’ with ‘technical knowledge’ would lead to ‘emancipatory knowledge’. Emancipatory knowledge is suggested to drive a critical form of design, which the examples from the previous chapter, such as the Curitiba bus shelters and the Paris Vélib are seen to evidence, as do the more promising student examples in Chapter 7. The point about design exhibiting relational thinking can also be made in relation to evidence of emancipatory thought i.e. they show a form of interpretation that is deeper than most design solutions. In such examples design engaged in facilitating behavioural change and designing at a local level, but with a strong element of traditional design activity turning technical skills toward supporting socially oriented initiatives. Designers are now not designing ‘things’, or all in one ‘solutions’ but ‘enablers’ and ‘prompts.’ This chapter provides a clear methodology for how this
kind of designing may be supported, drawing on McKenzie-Mohr and Smith’s (1999) Community Based Social Marketing.

The second area that this chapter attempts to ameliorate is the disconnect between DfS and possible career vocation for Industrial Design students. This was proposed as being problematic in Chapter 7 where the pedagogic intervention resulted in Industrial Design student conceptual design scenarios that were responsive to a more socially orientated problem context, constructed on an understanding of how normal everyday behaviours contribute to unsustainability. The final scenarios presented focused on facilitating sharing and alternative behaviour by embracing social and community initiatives. However these were perceived by students to have a tenuous connection to future employment opportunities in Industrial Design. Similarly, Jégou and Manzini’s Sustainable Everyday Project in Chapter 8 presented excellent examples of potential sustainable solutions, but where the designer may generate income from such solutions was not clear.

Any attempt to further enhance designers’ skills to design such solutions outlined above may be in vain, unless the reasons why job-seeking Industrial Design graduates would apply these skills is explored. There was an assumption on the part of the researcher that the need for DfS skills, and the opportunities these would provide, would become apparent through the process. However, a key finding of the study, which was not anticipated, was that this issue needs to be explicitly addressed throughout the unit otherwise sustainability education risks being perceived as irrelevant within mainstream industrial design education.

The role of the university discussed in Chapter 3 was critical of Industrial Designs emphasis on vocation, which was articulated by Habermas to be one of four roles of the university. However with regards to DfS the opposite is true, as the possible vocational roles for Industrial Design students to utilise DfS have lacked clarity. Strengthening the link to vocational aspirations is needed to increase the chance of students retaining the ability to DfS and to be engaged and motivated, particularly in relation to the more abstract application of DfS such as facilitating behavioural change. This chapter expands on the existing case studies to clarify the vocational relevance of DfS for Industrial Design students.
From a pedagogical perspective, presenting sustainability as an opportunity, not a responsibility in design education, is beneficial. It undoes the sense students may have of sustainability as purely a moral obligation or rhetorical stance. However, as a vocational career it may not seem plausible. If the vocational role appears improbable to students, then it may be perceived as irrelevant, particularly in a client-serving, brief-driven discipline like industrial design. Stenhouse (1975) suggests what is not seen as relevant is disregarded, the polar opposite to the objective of educating Industrial Designers for Sustainability.

9.1 Presentation

This chapter is presented in three sections: first, a clear theoretical process to enable Industrial Design students to design for behavioural change is presented, drawing on Community Based Social Marketing (CBSM) from McKenzie-Mohr and Smith (1999). This theory helps to identify design opportunities by drawing on traditional design skills that can help foster sustainable behaviour, and provides pathways into untapped vocational areas. A proposal for possible vocational roles for designers facilitating behavioural change that draws on existing opportunities is then presented. Finally, the implications of the proposed vocations for Industrial Design Education for Sustainability is reviewed in the context of the University of Western Sydney and suggestions proposed in the light of what has been learnt during this study.

9.2 Design and Behavioural Change

In the analysis of over 400 conceptual design scenarios, and the combined categories of high sustaining potential, this study has found that facilitating sustainability is dependent upon design encouraging sustainable behaviour. If we acknowledge the dependency on behavioural change for the successes of DfS then it is worthwhile for design to explore effective ways to contribute to positive behavioural change, as focusing on technical design alone is seen to present only half of the possible solutions (Fry 2006). This study has shown that behavioural change for sustainability is not something that must happen only ‘out there’ in society, but also in the classroom (i.e. it demands self-reflexivity).
Chapter 2 ‘How you define is how you design’ identified that design’s engagement with the more socially orientated school of thought has not been as dominant: ‘there has been little theorizing about a model of product design for social need’ (Margolin and Margolin 2002, p.24). Margolin goes on to suggest the potential of the social designer is similar to the social worker who collaborates with key stakeholders to intervene in unacceptable social situations. If we take this approach to sustainability, we can see that while ‘inconspicuous’ in Shove’s terms, consuming excessive resources can be considered socially irresponsible behaviour which requires positive intervention by the designer. This might be considered a particularly apt responsibility given that designer’s have been responsible for creating products and services that facilitate this consumption.

This chapter appropriates psychologists Doug McKenzie-Mohr and William Smith’s process for behavioural change, Community Based Social Marketing (1999) for DfS3 in the context of industrial design. As shall be seen, CBSM provides an assistive process for design to address socially irresponsible behaviour i.e. inconspicuous consumption.

CBSM explores the psychology of behavioural change, suggesting ‘most programs to foster sustainable behaviour continue to be based upon models of behavioural change that psychological research has found to be limited’ (McKenzie-Mohr 2000, p. 543). There is often a tacit understanding presented in large-scale advertising campaigns that attempt to promote sustainable behaviour (for example the tap-focused ‘every drop counts’ campaign discussed in Chapter 5) that raising awareness alone will lead to behavioural change. The psychology of behavioural change proposed by McKenzie-Mohr and Smith (1999) challenges this assumption; there is a profound difference, they claim, between what we know and what we actually do. This is supported by recent design literature, for example Stewart and Lorber-Kasunic’s (2006) Akrasia identifies a discrepancy between what one knows is right and what one does in everyday routines. McKenzie-Mohr and Smith (1999) argue that people require practical assistance in order to change habitual behaviours. There is a critical connection to be made here in relation to design, both as the ‘thing’ that supports the unsustainable activity in ‘what one does’ (like

53 ‘We know that we should respect the complexity and fragility of life on our planet, we should reduce energy and material consumption…in many cases we actively desire to do right in such matters. But for the most part we fail.’ (Stewart and Lorber-Kasunic 2006, p. 1)
inconspicuous consumption), but more importantly the potentiality of design to make our default actions more sustainable.

It should be noted that the CBSM process does not include or formally acknowledge the ontological agency of design. However, as will be shown, design is tacit in the process as it is design that frequently and inconspicuously holds the unsustainable behaviours in place. CBSM has been written for executing effective socially based marketing campaigns. However there are strong correlations to Industrial Designers’ skill sets which will be discussed as the four steps of CBSM are introduced in the following section drawing on examples from this study. Jeff Howard (2004) has previously made the connection for the potentiality of design’s application of CBSM, although within a participatory design framework.

The specific process outlined by McKenzie-Mohr in CBSM focuses on altering behaviours by directly encouraging positive behaviours, and eliminating or deterring the undesirable behaviour by removing internal and external barriers. This psychological principle is seen to be central in assisting designers to design for behavioural change and is discussed in detail in the following section.

9.3 Community Based Social Marketing for Industrial Design for Sustainability

The process of CBSM requires a clear mandate from the project leader (designer) for what behaviours you want to change (McKenzie-Mohr 2000). The researcher suggests that the process of clearly defining the problem of unsustainability, as presented in the evidentiary chapters, would be a good starting point from which such a mandate could emerge. The more specific the targeted behaviours the easier it is to tailor an intervention.

McKenzie-Mohr’s (2000) system of CBSM involves four stages: (1) identifying barriers and benefits; (2) designing effective strategies; (3) piloting; and (4) evaluating. A brief overview for the relevance of design sees the first stage of CBSM assisting designers in identifying a sound problem definition for why the desired behaviours do not take place, the second stage provides psychological tools to assist the designer to resolve the problem in their conceptual solution to encourage the desired behaviour, the third stage involves testing the proposed conceptual
solution prior to full scale implementation, while the final stage reflects on (and disseminates) the process. The four stages present strong similarities to the Action Research process that has been used throughout this thesis.

9.3.1 Stage One: Identifying Barriers and Benefits

McKenzie-Mohr and Smith (1999) present one approach to identify why the desired behaviours are not taking place, which involves identifying the barriers and benefits to the desired behaviour in three steps: literature review, participatory research, and survey. The literature review of trade magazines, reports, academic literature and favourable authors is linked to traditional desk research, to provide insight into why the desired behaviours may or may not take place.\textsuperscript{54} Participatory research using focus groups and observation is recommended, as focus groups identify people’s perception towards the desired behaviour, while observation validates their actual action. The final recommended stage is a survey, to quantify if the results gathered are widely applicable or location specific, as well as to identify the characteristics of participants that have changed their behaviours, or are most likely to change or not change. This is likened to the tradition in design of establishing a target market.

McKenzie-Mohr and Smith (1999) present a generic research design in literature review, focus groups, participatory observation and surveys with the objective of identifying the barriers to desirable behaviours. The researcher argues that this first stage could be met by numerous context-specific design research methods, as long as the core issue of identifying barriers and benefits to particular activities are identified.

In SDSF the literature review phase is likened to the contemporary trends research that students completed. The participatory observation and survey phases can be related to the consumption data students gathered in previous units, quantified and reflected upon in SDSF for unsustainable behaviours (p. 188 above). This is drawn upon later in this chapter in relation to a community consultation model of vocation applying CBSM and Design. To assist in the first phase, design methods

\textsuperscript{54} For example, if attempting to identify why walking and bike riding is not as widely supported as desired in the city of Sydney’s CBD, Gehl, Mortensen et al.’s (2007) publication commissioned by the city, \textit{‘Public Space Public Life’}, provides comprehensive designerly research identifying external barriers to easily moving on foot or bike through the city.
such as those proposed by IDEO (2002) method cards may be appropriate and familiar to designers to further strengthen this phase.55

9.3.2 Stage Two: Designing Effective Strategies Based on Effective Tools

Stage Two uses effective physiological strategies to facilitate behavioural changes by accentuating the benefits of positive behaviours and eliminating the barriers identified in Stage One. The strategies are commitments, prompts, norms, incentives and the removal of barriers (McKenzie-Mohr 2000). Of the psychological strategies, three are easily appropriated by Industrial Design. These are prompts, norms and the removal of external barriers.

‘Prompts’ follow the principle that we need to be reminded at the most opportune time how to act. Prompts should be noticeable, self explanatory and near the point of action to encourage the desired behaviour. Prompts provide a most promising strategy for design activity. In his book *Psychology of everyday things* (1990), Donald Norman discusses the importance of prompt-like tools in the user interface of products, called affordances, that ‘provide strong clues to the operations of things...plates are for pushing, knobs are for turning, slots are for inserting things into’ (Norman 1990, p. 9).

Affordances may direct the user toward the correct use of a product. For sustainability, designers may attempt to ensure that the desired behaviour is the most likely default action because affordances have helped to nudge the action in the right way. The prompts could be visual or verbal reminders designed into the product. The tendency to boil a kettle, then forget it has boiled and then re-boiling it (the ‘double-boil’ syndrome) was identified and overcome by a temperature indicator and insulated kettle redesign in Kambrook’s Axis kettle, prompting the user at the point of action to encourage appropriate behaviour i.e. not re-boiling a hot kettle (Ryan 1996). The semantic principles outlined by Norman provide an opportunity for design to practically prompt the appropriate default behaviour.

55 The IDEO methods cards present 51 designedly research methods in four categories: Look, Learn, Ask and Try. Such methods are valuable in understanding people’s’ behaviours, for example the empathy tool encourages designers to try activities simulating the end user, doing so may identify limitations to the desired behaviour.
The second strategy that clearly links to the practical creativity of industrial designers is that of the ‘norm’. A norm is a visual display of ‘normal’ behaviour, for example if you approach a house and see shoes outside the door it is indicative of a ‘norm’ and prompts you to take your shoes off. Elizabeth Shove (2003) identifies the role of design in changing social norms around the three Cs that contribute to our increased embodied and inconspicuous consumption. As our standard of living constantly improves over time, what becomes normal has changed, e.g. increased showering as standards of cleanliness in personal hygiene were raised and facilitated by continuous access to hot water, or the increase in air-conditioned environments which are embedded in aspects of our everyday life. To enable norms for behavioural change, McKenzie-Mohr (2000) suggests that we need to make new sorts of norms visible; the hidden, positive actions for sustainability need to be made visible and desirable as a social norm that can be followed and belonged to.

Creating norms though visualising possible futures is a strategy used within this thesis and has a history of use in Industrial Design (Andrews 2007; Fry 1999). The visions presented by early industrial designers of possible futures conditioned our normality and paved the way for the visions to become material reality. The hybrid model of scenario planning developed by Lopes and Clune et al. (2007) used within this study utilises Design Orientated Scenarios (Manzini and Jègou 2000) to present possible futures as hypotheses for discussion.

The final strategy is the identification and removal of ‘external barriers’. External barriers are constraints that make the logistics of completing an activity difficult. This could be for any number of reasons such as safety, distance, image, cost or Shove’s three C’s (2003). McKenzie-Mohr (2000) concedes that the removal of external barriers may not always be possible as the original intention of the strategy of CBSM was to develop effective community campaigns. However, for design the removal of external barriers is seen to be where the most significant contribution may be made, as design has the capacity to effect change on the physical environment, removing by design the external barriers. This activity connects with Manzini’s criterion of ‘use what exists’ (2002, p. 9), as there is a need for a strong contextual focus to identify what needs to be created, or modified. None of these strategies could be undertaken if design is seen in isolation.
The Paris Vélib discussed in the previous chapter is used as an example as the external barriers to riding, such as convenience, theft, maintenance and parking, have largely been overcome by design. It is easier, cheaper, and more convenient to make a sustainable choice to ride for short-distance travel. Doing so makes the default actions more sustainable.

The technique of design removing external barriers dates well back in design history. The introduction of the phonograph was successful once packaged as furniture, which removed the external barrier of fear of new technology and machines in the home (Barnett 2006). The number five car of Bel Geddes was so radical in styling that five models were produced to gradually accustom customers’ taste to remove the external barrier of radical styling (Fry 1999).

Within the final iteration of teaching SDSF, identifying barriers to the adoption of desired behaviours (and the adoption of their promising concepts) was used in the second workshops (see workshop schedule p. 189) as a concept generational tool. The programmable stove example of the previous chapter attempted to overcome the barriers to a lack of knowledge in preparing meals from fresh ingredients by utilising an assistive display, as well as the barrier of inconvenience by making the cooking instruction programmable like the microwave.

Many of the student solutions engaged in the barriers to sharing and came up with novel solutions; such as the finger-scanner to assist in overcoming the identified barrier of security for the Community Gardens as well as making the garden equitable, as work completed and produce taken is recorded (p. 200). The Mod-U-Home (p. 199) overcame the physical barrier to sharing via a modular home that allowed sections of the house to be handed down to the kids, and in doing so addressed further barriers to enable such a concept to be realised such as cost and convenience (empty nesters needing to downsize). As the examples illustrate, the removal of external barriers by design is a viable tool to assist in concept generation for DfS.

McKenzie-Mohr warns that it is only through the effective identification of the barriers that they may be overcome. For design, inaccurate assumptions of why people do not change behaviours may lead to ineffective solutions. In some respects

56 This can be contrast against the Chrysler Airflow (1934–1937), whose streamlined shape largely failed in the market due to the radical styling.
this is likened to the framework *how you define is how you design*. If the problem identification of unsustainability is not accurate, then the designed ‘solution’ will be ineffective.

### 9.3.3 Stage Three: Piloting the Strategy

McKenzie-Mohr recommends piloting the campaign (or concept for design) on a small scale until the desired results are achieved and then implementing the program. The cost of trialling a program may be small in comparison to running an entirely ineffective campaign. This stage, McKenzie-Mohr suggests, is often overlooked yet has the potential to increase the adoption of sustainable behaviours.

The relevance to pure Industrial Design is not as distant as it once was. Kyffin (2007, pp. 43-71) discusses Phillips’ case study of the ‘experience assessment’ trialling new ‘lifestyle designs’ products within the home for an extensive period of time at great expense to refine the design prior to production. In relation to the Paris Vélib of the previous chapter, the scale on which the system was able to be rolled out was due largely to the sound planning and smaller trials in the Lyon Vélo’V prior to full-scale installation, when they increased at a rate of 500 bikes per week.

The pilot stage is important for DfS; even if unsuccessful, the phase offers a learning opportunity for sustainability in an important social context. There are synergies between the reflective processes of action research which highlight that any change proposal needs to be managed and reflected upon: this becomes critical in the community consult vocation introduced later in this chapter.

### 9.3.4 Stage Four: Evaluating

Stage Four, evaluating the strategy once it has been implemented, is a stage that McKenzie-Mohr (2000) highlights as being poorly completed. This concern is paramount within the field of DfS, as it is how the design plays out in action that is most critical. As Lerner suggested, ‘it is important to make it happen now, and then we take the time to improve’ (Lerner 2005, p. 47). The Sustainable Everyday Project has gone some way in attempting to critically evaluate the success of implemented projects (Jégou, Manzini et al. 2008). The dissemination and evaluation of sustainable case studies is critical if we are to enable healthy reflection on current
DfS strategies. The lack of critical reflection in Industrial Design literature leads to a state whereby it is difficult to learn from others’ mistakes, and restricts the intellectual growth of the discipline (Swann 2002). Monitoring and reflecting strategies across time may be facilitated by design’s new requirement to manage the product over the lifecycle.57

For Industrial Design Education for Sustainability the last phase, evaluating, is critical. Sustainable design cannot be embodied in a one-off solution, it has to succeed and adapt over time with continual reflection in what Manzini describes as ‘social learning process’ (Manzini 2003a, p.1). Sharing the reflections on sustainable design (both successes and failures) is required to build knowledge as it is possible to ‘become more sustainable but [we] can never become fully sustainable’ (Fry 1999, p.289). Embedding reflective practice within academic institutions is challenging, and is discussed later in this chapter, after the possible design-related vocational applications of CBSM are introduced.

9.4 Vocational Applications of Design for Behavioural Change

Design informed by the behavioural change tactics of CBSM is proposed as a sound way of enhancing Industrial Design students’ ability to DfS. The employment of CBSM in practice by Industrial Design practitioners is foreseen in several ways and will be presented as three possible vocational variations for Industrial Design students. The need to clarify the possible vocational roles emerged from the evidentiary chapters which saw a perceived mismatch between the conceptual design solutions and how the solutions would be employed by Industrial Designers in their future careers. The findings from Chapter 8 advanced this position as the most promising case studies for sustainability differed from the tradition of technical Industrial Design as currently taught.

The three variations of possible design vocations for students are: first, designers applying creativity skills to generate DfS product concepts (most similar to traditional Industrial Design practice) for enabling behavioural change; second, 57 For example the Integrated Product Policy, Waste Electrical and Electronic Equipment and Extended Producer Responsibility legislated the responsibility for the product’s life with the producer (Castell, Clift et al. 2006).
designers extending their skill set to manage entrepreneurial ventures for sustainability; and third, designers operating as specialised DfS consultants. The variations of the possible design vocations are presented, and will be followed by a discussion of how Industrial Design Education for Sustainability pedagogy may cater for these vocational destinies better. The variations of vocation are not entirely new, they are based on existing vocations that Industrial Design pedagogy may benefit from embracing, and making explicit.\textsuperscript{58}

\textbf{9.4.1 Community Based Social Marketing as a Concept Generation Tool}

The first vocational possibility of applying CBSM by designers is in utilising their creativity skills to generate alternative concepts in the traditional Industrial Design process. This model represents an ‘over the fence’ model whereby a sound definition of unsustainability and social innovation briefs feed into traditional Industrial Design projects.

CBSM clarifies the process of designing for behavioural change, providing clear tools for practical problem-definition by Industrial Design students, and assists in generating conceptual scenarios that draw on psychological strategies for behavioural change. The process could also be applied to product redesigns, in encouraging default actions in the use phase of the product lifecycle to be more sustainable. When looking at the traditional product development process, CBSM appears to fit within the problem identification and concept generation phase.

The vocational opportunity for DfS presented by CBSM is to mobilise its tools in concept generation in the familiar environment of Industrial Design practice. These tools significantly differ from Ecodesign as the conceptual outcomes forgo the techno-fix of product-based solutions. Rather, they are based on an altered definition of unsustainability, and strategically target altering the behaviours of the end user. The focus on barriers implies a contextualised local understanding that is not always present in technical Ecodesign. For example, the Axis kettle re-boil syndrome of the use phase was effectively addressed, however making the kettle for recycling lacked

\textsuperscript{58} Habermas (1971; 1989) noted that vocational preparation for professions was one role of the university. For DfS the university has a role in \textit{generating} these vocations, through industry sponsorship of scholarships and piloting projects.
this contextual understanding as there was no infrastructure to collect these kettles at end of life.

The potential application of CBSM to design ‘in practice’ can be seen to: introduce sustainability concepts to the uninitiated client and enhance the use phase of product redesigns, as well as present opportunities for entrepreneurial ventures in the development of taking the concepts to market. This is the next variation of vocation presented in the following section.

The model of vocation in generating sustainable concepts does have inherent problems in relation to how these concepts may be managed over time. Ideally the trial and evaluation phases of CBSM may occur in less costly ways than traditional design. It is common for designs to be improved over time, but this is a hugely materials–energy intensive process as it is tested by the market. Each iteration is ‘tested’ without recourse to ecological impacts.\footnote{The existing community forum’s ‘fostering sustainable behaviour’ (McKenzie-Mohr 2009) that supports CBSM is a model that design may benefit from emulating in appropriating CBSM’s trial and evaluation phases. The CBSM forum constantly presents cases of use, questions, potential projects that can be learnt from online from around the world.}

\subsection*{9.4.2 Entrepreneurial Ventures}

The second vocational proposal utilises CBSM to identify entrepreneurial opportunities for product, systems and services development. This may be seen as an extension of the first vocation in developing concepts, as many of the conceptual design scenarios presented by students in the evidentiary chapters have the potential to be profitable business ventures. The specific examples of the Walking School Bus, Newtown Car Share and Paris Vélib bike share scheme that were analysed as case studies in Chapter 8 are viewed as entrepreneurial opportunities responsive to unsustainability. Gartner and Carter (2004, p. 195) describe entrepreneurial behaviour as:

\begin{quote}
...the activities of individuals who are associated with creating new organizations rather than the activities of individuals who are involved with maintaining or changing the operations of ongoing established organizations.
\end{quote}

The process of CBSM and the interventions of previous chapters enable Industrial Design students to Design for Sustainability, which may include innovative and entrepreneurial concepts. The UK Design Council Design Skills Advisory Panel found specific areas where designers’ professional skills need to be
improved. These include ‘entrepreneurial business skills to help designers set up, develop and manage their own enterprises, and leadership skills to grow them’ (2007, p.27). Further, the US Bureau of Labor Statistics states that over 30% of Industrial Designers end up in self-employment. It is then suggested that entrepreneurial skills, while of value specifically to DfS, are immediately applicable as they increase the capacity of the designer to capitalise on their innovative potential.

Small business offers a higher chance of being amicable towards innovation, developing 67% new inventions, according to Reynolds, Hay and Camp (1999). Similarly, small firms are seen to be 2.45 times more productive than large firms with regards to innovation (Acs and Audretsch 1990, p.24). Providing designers with the skills to operate with entrepreneurial small business is seen to assist DfS to innovate and realise its potential.

The above understanding is of value in garnering support for the integration of entrepreneurship in the context of Industrial Design education programs. How this vocation may be made relevant and strengthened for DfS through pedagogy is discussed in Section 9.5 below.

9.4.3 DfS Consultants

The third vocational possibility for designers is in utilising their skills in the position of DfS consultants, to advise individuals, businesses or communities about interventions they may make to reduce their energy and materials intensity (ecological footprint), or enhance social wellbeing. Intervening to encourage behavioural change by making their default actions more sustainable is seen as integral to this consultation vocation.

For the vocation of DfS consultants to be successful, it is viewed that they are dependent on demand for the above service.60 The current climate presents a relatively new incentive for consultation that may be linked to the behaviour change imperative. Contemporary trends such as carbon trading, rising energy costs, peak oil and to a lesser extent triple bottom line reporting are seen as incentives for

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60 There is a history of green consulting in design, for example the Ecodesign Foundation’s work helped to shift ESD from theory to actual implementation in Sydney in the 1990s (see EcoDesign Foundation website www.changedesign.org for Green Olympics cases such as Fry’s 1998 report ‘Greening the Games? Why they were not more Sustainable’.)
business to operate in a less energy- and material-intensive way. In 2006 carbon trading was a $25-billion-a-year global market (Capoor and Ambrosi 2006); at present carbon trading is not established in Australia but is planned for the near future (Garnaut 2008). If the price structure for a cap-and-trade carbon scheme is appropriate it will add further economic incentive to reduce the ecological footprint of business and stimulate innovation (Grubb 2004). This presents an opportunity for the proposed DfS consultants, as economic incentives make relevant this vocational opportunity. Moving to a less carbon-dependent society is frequently presented as an economic cost to both business and the consumer (i.e. Gailey 2008). Such costs are calculated on maintaining the social and business norms that are in many ways responsible for the ecological crisis. Industrial Design with an understanding of inconspicuous consumption, and a focus on behavioural change, is argued by the researcher to be in a capable position to substantially mitigate such costs if behaviours are focused upon. The virtual office consultant proposed in Chapter 6 is seen to represent the above argument. The tele-commute has the potential to substantially reduce transport costs associated with work. Such a scenario is seen to be an ideal candidate for the CBSM process to be applied, as there are many external barriers to the successful implementation of such a scheme.

The potential for DfS consultants above is made without the consideration of the perceived benefits in social wellbeing that may accompany such change. The advantage of consulting from a DfS perspective is that the solutions do not always have to be new products made from virgin materials. The consultant, through strategic advice, may specify existing products to fulfil the requirements, suggest no-build options, re-use or retrofit, all of which become possible within this environment. The BedZed Development case study of the previous chapter is seen as a model for this form of consultancy in action.

Design has a history of consulting practices specifically in interior design and architecture to all levels of clients: individuals, businesses and communities. McDonough and Braungart are prominent DfS consultants who have successfully consulted to business (even if with a strong technical orientation). Recently Industrial Design firm IDEO consulted on a purely theoretical level (no design) to bike component manufacturer Shimano on ‘what to design’ (Moggridge 2008).
The levels at which DfS consultants operate could vary from one-on-one with individuals, to businesses trying to reduce material and energy intensity, to the local community as the client. The differing levels will now be discussed.

The first level is dealing with clients on a one-on-one basis. While novel for Industrial Design, this is common practice with design’s sister disciplines architecture and interior design. These disciplines frequently consult directly with the end user, as opposed to Industrial Design where consultants generally deal with the manufacturing company, not the end user. While the aim of this activity is usually a negotiation to please the client (end user or otherwise), there is an assumed advantage in dealing with the end user by specifying customised solutions to alter behaviour. At present the opportunity of individual sustainability consultants seems distant because it is so far from the Industrial Design model of client communication. However, the above environment of rising energy costs may provide strong economic incentives to move to low-energy-intensive lifestyles, which can be facilitated by design. This may allow consultants to make the cost benefit of design proposals a selling point.61

The second level is consulting to businesses to reduce the ecological footprint of its own practices and/or that of customers. This level is seen to closely resemble models like McDonough and Braungart or the Rocky Mountain Institute, but with a higher inclusion of design for behavioural change as the two consultancies focus almost entirely on technical solutions. It is assumed that this is the most familiar mode of consulting, and students in their conceptual design scenarios identified such opportunities as the tele-commute consultant in Chapter 6. In their concept a consultant was seen as the best way to engage in the context-specific barriers each business would face in shifting to virtual office space.

The final client for DfS practice is the community. Designing for the community was prevalent in the best-case examples outlined in the previous chapter, such as Jégou et al.’s sustainable everyday project (2008). This is consolidated by McKenzie-Mohr (2000), who suggests that behaviour change best occurs at the level of local community, for issues as grave as climate change, individuals can feel

61 Cost benefits have always been a consideration. However, in the current climate of increased energy and fuel costs, matched with raised public awareness, cost benefit is viewed as a possible tipping point. For example, Sydney has seen an unexpected move to increased public transport use on the back of high fuel costs.
daunted as to how they can respond, but community initiatives present a shared response, supporting the creation of new norms and the removal of external barriers.

Within Australia, municipal councils are already committed to many positive initiatives to improve the local environment. The Mayors’ Asia-Pacific Environmental Summit saw 100 municipal councils commit to making cities more ‘sustainable’ (McKeown 2006). Many Australian municipal councils have pledged to be carbon-neutral communities by 2020 and Brazil, New Zealand, Norway and Costa Rica are committed to becoming carbon neutral prior to 2040 (Nuttall, Bisset et al. 2008). Maribyrnong City Council states that the council’s community engagement framework is to:

Actively engage the community in the decision-making activities of Council, particularly in decisions that directly impact on how citizens live, recreate, work, study, use services and do business. (Maribyrnong City Council 2000)

Further, the council’s commitment to sustainability is outlined by its Corporate Plan 1999–2000, which defines sustainability as ‘forms of development and activity which improve the quality of life and enhance the quality of our natural and social environment’ (Maribyrnong City Council 2000, p.2). The cited council is viewed as typical. To the researcher, councils would benefit greatly from what designers could provide; but they are unaware that designers can help deliver this. Again an opportunity is presented for skilled designers to assist in facilitating the commitments that local communities have made. Howard (2004) speculates on the possibilities for integrating CBSM with methods of participatory design:

One approach, for example, would be CBSM-style programs to encourage laypeople to engage in sustainability-oriented PD projects (e.g., consulting with local manufacturers on the energy efficiency of their consumer products)—and, simultaneously, to encourage technologists (e.g., industrial designers) to facilitate their doing so.

A process similar to Howard’s notion of CBSM and participatory design is presented as a model for consultative vocation. It is proposed that the methodology of Participatory Action Research (PAR) may assist this new designer consultant to operate. PAR differs to the Action Research used in this thesis in that the participants are given a strengthened role in identifying and implementing solutions. The process of community engagement has been established by the social sciences. PAR is

62 The literature review identified a causal relationship between carbon production and resource consumption. Carbon is viewed as one aspect to unsustainability, but can be leveraged to assist in the move towards more sustainable behaviours.
advocated as an approach to engaging with and creating positive change for the community (Howard 2004). The inclusion of design within this process could be seen to value-add to the social sciences as the designed outcome equates to action within the PAR process, a stage that social science struggles to achieve. Allen (2005, p.137) coined the term ‘designer-facilitated participatory design’ to identify how the designer may engage with participants, as the designer ‘stimulated, interpreted and synthesised participants’ ideas in the form of sketches and models to more accurately articulate their needs’.

Swann (2002) has previously noted the strong correlation between PAR and the design process, suggesting that the process should be familiar to designers (see Figure 9.3).

The envisioned plan of how the above process may work is likened to the case study of Curitiba and the Paris Vélib of the previous chapter, where collaboration occurs with councils for the implementation of projects, with an emphasis that innovation is the starting point, not the endpoint. This is distinguished in many ways from the Industrial Design consultancy tradition that ends the project once the product is on the market, neglecting the important reflection stage. As Curitiba’s mayor understood, solutions need to be open to change and improved over time.

The three vocational possibilities allow Industrial Design Education for Sustainability to be positively framed as an opportunity, not just a responsibility. The
models provide an avenue for DfS education to overcome the challenges presented in the literature review of designers lacking change agency both in terms of their own perceptions of what design is and can do, and in terms of the skills they are taught. The three vocational modes draw heavily on the existing skill set of the Industrial Designer, yet present alternative destinations for the Industrial Design student. Doing so is seen to educate in the manner advocated by Dewey (1966, p. 317), presenting:

A projection in the type of the society we would like to realize, and by forming minds in accord with it gradually modify the larger and more recalcitrant features of adult society.

Like Manzini and Jégou’s Design-Orientated-Scenarios (2003), the vocational opportunities are concrete hypotheses presented for discussion, by both students and the Industrial Design community. A recommendation is in place in the future teaching of the unit Sustainable Design: Sustainable Futures that students utilise their learnt forecasting skills to envisage their own future careers that DfS may present. Scenarios of vocational futures are an important form of reflection for students, and can be modelled in the existing structure of storyboards in SDSF (i.e. the altered relation between client and designer can be thought through and communicated).

What has been presented are plausible opportunities without ‘flesh’, i.e. they are problems to engage with, not solutions. They need specific cases and contexts in order to be worked out, researched and trialled. How this is attempted within the context of UWS is presented in the following section.

### 9.5 Integration of Design for Behavioural Change Within Education

CBSM provides designers with a series of practical tools in order to address behavioural change, which is viewed to be a key component of DfS3-type solutions. The three vocational possibilities are suggestive of directions that require attention and further research for design to engage in behavioural change (including research that can start in SDSF via Scenario Planning mentioned above). This is imperative,

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63 This recommendation was enacted upon in 2008 by the researcher. While this is outside the realm of this Action Research study, the Student Feedback on Unit survey from this teaching session for the statement ‘I was able to see the relevance of this unit to my course’ increased from 4/5 in 2006 and 2007 to 4.5/5 in 2008.
as the old culture of industrial design cannot be supported into the future (is not sustainable) even if substantially greened (via DfS1). Even if students don’t know it yet, altered vocational futures need to be confronted for the sake of the future of Industrial Design. How the three hypothetical vocations may be integrated into Industrial Design Education for Sustainability is discussed in the following section via a case study of Industrial Design education at UWS.

9.5.1 Concept Generation

The DfS vocation that fits most easily (and is most readily understood) in the Industrial Design Curriculum and industrial practice uses CBSM as a concept-generating tool for DfS3 proposals. ‘What to design’ is developed using the theoretical framework of defuturing and the processes outlined in Chapter 6 of this thesis. CBSM is then used to locate design opportunities in facilitating sustainable behaviour, which are finally transferred into technical Ecodesign (DfS1). The ‘over the fence’ strategy develops the agency of designers to identify ‘what to design’ based on a sound understanding of the unsustainable.

This model has been employed at UWS as a result of this thesis. As identified with the DfS literature, social innovation (DfS2) should be driving technical design (DfS1), leading to DfS3. A rearrangement of the content taught within the sustainable design stream has allowed this to happen. The scenario narratives that are developed within the Sustainable Design: Sustainable Futures were used as starting blocks within the preceding unit Sustainable Design: Life Cycle Analysis.

Initially Sustainable Design: Life Cycle Analysis, the unit that precedes Sustainable Futures, was limited to a redesign activity, where students disassembled an existing product, completed an LCA and then redesigned the product for lower embodied resources across the entire lifecycle. This limited the unit to incremental improvement incapable of leapfrogging to sustainability (as the re-design brief severely curtailed creative leaps).

The revised structure implemented as a finding of this thesis altered the starting point from the redesign of an existing product to a future scenario narrative, which asked students to identify what should be designed to enable sustainability in this context, and empowering students with the question of ‘what to design’. Once this
was identified, traditional technical Ecodesign techniques were then applied to identify the lowest material-intensive solutions. This re-arrangement has social innovation leading the technical design.

The DfS3 approach focuses very much on ‘what should’ be designed, while traditional design studio subjects focus on ‘how to’ design. It may be possible to create a transition between ‘what’ is developed in DfS units being passed across into the ‘how’ of studio courses. This is of importance in relation to the problem cited in Chapter 5, p. 119 of the remaining traditional Industrial Design units, which, in teaching ‘how to design’, are in some respects merely sustaining the unsustainable. This model utilises the existing Industrial Design skill set to resolve ‘sustainable briefs’. For example, the Paris Vélib required bicycles specifically redesigned for the task. Technical briefs could be set within studio units which have nonetheless been generated by careful DfS3 research.

The first model fits within the existing practice of Industrial Design. Caution should be taken when educating Industrial Design students to prevent a proliferation of products that are said to be meeting the demands of a sustainable society, as in Manzini’s rebound effect (2002, p. 4): by reducing the barriers to particular activities they may substantially increase offsetting the ecological gains. The forethoughtful thinking of impacts is raised in Chapter 6, p. 146, when discussing the potential impact of the conceptual design scenarios by questions such as ‘what if they were widely adopted, what will be the possible impacts’ may assist in restraining a proliferation of products.

9.5.2 Integrating Entrepreneurial Ventures

The second proposed vocational direction for DfS graduates, designer as entrepreneur, is not as easily integrated into the existing Industrial Design curriculum. Industrial Design students graduating to start up and run businesses is a career path previous graduates have taken. However, on reflection, one sees that the skills required to operate entrepreneurial start ups or small business are ill-supported within Industrial Design curricula in Australia.64

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64 There are exceptions to this rule, such as programs like the double degree of Bachelor of Design (Industrial Design)/Bachelor of Business offered at the University of Swinbourne that are assumed to address such shortcomings as a lack of business skills.
A lack of business skills in design graduates has been cited as problematic. As Robertson (2007, p.1) states on behalf of the Design Industry of Australia, graduates display a ‘lack of preparation for participation in the business environment, either in an employment situation or in self employment’, and ‘commercial relevance’ is the number one criticism of Industrial Design education.

If an Industrial Design student has an excellent concept that they would like to take to market, the strategic process to bring the concept to reality is not readily taught. Skills such as securing financing through business loans, government grants (of which there are many with regards to sustainability), approaching venture capitalists or even the most elementary business skills in invoicing clients can be absent. Figure 9.3 presents fourth-year examples highlighting the need for concept generation and entrepreneurship to be supported by education. The examples need business understanding to move beyond the hypothetical, which the students lacked. An unfortunate result is that DfS3 concepts appear idealistic rather than starting points. CBSM like processes are applied to honours fourth year projects within the Industrial Design course at UWS and product solutions eventuate that attempt to remove barriers to desirable activities like commuting by bicycle. The images outline how product design has been used, to varying degrees of success, to overcome barriers to the desired behaviours. However, to realise the above solutions, an increased understanding of business would be required.

Adrian Whittaker (2007)
Attire Flyer

Barrier: logistics of riding to work, how to avoid arriving at work with a laptop and a crinkled business suit.

Solution: bag designed to hold shoes and laptop and assisting to fold work clothes in a particular way to avoid creasing.

Barrier: shopping is dependent on conveniently carrying goods home, for which cars make a fantastic ‘trolley’

Design Solution: expandable bag that can be wheeled from shops to home, removing the need for cars to shop

Sebastian Bratt (2006)

Kiss Solar Tiles

Barriers to solar adoption: Photo Voltaic solar is dependent on specialist skills, long waiting lists, expensive panels and labour

Design Solution: Panels designed as replacement tiles, DIY install then call electrician to connect to grid

Nicholas Herling (2006)

Car Sharing Carry All

Barriers: car sharing is seen as impersonal, cars are poorly equipped with personal effects that make a car ‘comfortable’

Design Solution: Bag/seat cover to add personal styles and carry personal effects

Dena Fam (2007)

Dry Flush

Barriers: of composting toilets being unpleasant, and unfamiliar and ‘hippy’ aesthetic

Design Solution: modern aesthetic, clean look, retain flush mechanism to dispense pine bark rather than water

Figure 9.2 4th Year Design Project UWS, overcoming barriers

*Compiled from UWS fourth year ‘Widevision’ exhibition catalogues 2004, 2006, and 2007
This would suggest that there are fundamental principles that Industrial Design students would benefit from learning. Garavan and O’Cinneide (1994) suggest that entrepreneurship skills can be taught. They argue that entrepreneurship, when taught with factual information about business in managing employers, finance and taxation, is not an education model that encourages entrepreneurship.

A ‘learning by doing’ framework is recommended by Garavan and O’Cinneide (1994) as an appropriate model for entrepreneurship education. The ‘learning by doing’ framework of entrepreneurship education can be found in some business schools, initiatives such as Youth Achievement Australia within secondary schools have an applied approach, resulting in an increase in perceived desirability and feasibility of starting a business, according to Peterman and Kennedy (2003). Educating for entrepreneurship drawing on such initiatives in a learning-by-doing framework is viewed as favourable for students as they are given confidence in their ability to manage business.

It is envisaged that the Design schools would not need to develop their own curriculum for entrepreneurship, but could access units taught within business schools as sub-majors in entrepreneurship. Students who see entrepreneurship as appealing can be advised of the appropriate subjects to take for a sub-major in entrepreneurship. Internally the Industrial Design school can frame entrepreneurship as a viable vocation, for example within the unit Sustainable Design: Sustainable Futures students may be presented with and encouraged to locate for themselves promising examples of entrepreneurial ventures in DfS. Students can also be made aware of established businesses that provide assistance for start up businesses, and the grants that may fund the commercialisation of innovation (see Appendix IX p. 319 for available funding schemes in Australia).

Within the University of Western Sydney, a sub-major in entrepreneurship for Industrial Designers has been proposed drawing on four units taught within the School of Business (see Appendix XII Proposed Entrepreneurial Sub-Major, p. 349). The proposed sub-major consists of an introductory management course (MG102A), which is a prerequisite for entrepreneurial units, followed by two theoretical entrepreneurial units focusing on Entrepreneurial Management (200142) and Innovation (51277), and finally an applied unit (200609). The final unit has a learning by doing framework, whereby students work on live projects—an
appropriate pedagogy to encourage entrepreneurship. The above sub-major is a context-specific solution to UWS that may take effect in a short period of time, one that the author can suggest within the bounds of this Action Research study. Alternative solutions like establishing design in business schools, or scaffolding entrepreneurial and business skills throughout the entire Industrial Design curriculum are valid, but require a greater amount of planning and collaboration than can be implemented as a result of this study.

Entrepreneurial skills are seen as important to Industrial design graduates in several ways: from a pedagogical perspective educating Industrial Designers for Sustainability and promoting the conceptual design scenarios concurrently with entrepreneurial skills presents as an opportunity to clarify the future vocational relevance, which has motivational merit. This may lead to students taking a greater control of their own careers in promising new destinations for DfS. While of significant importance for DfS, the focus on entrepreneurial skills would also appear to be welcomed by industry and may ameliorate some of the concerns raised by both the Australian and British Industrial Design bodies.

9.5.3 DfS Consultant

The third vocational variation is the ‘DfS consultant’, which is seen to be the most confronting for Industrial Design Education as consulting to the community, as the client completely alters the balance of power inherent in the ‘hidden curriculum’ of the master—apprentice model of Industrial Design education. There is a delicate balance between future employment and the change agency required to alter the actions of standard industrial practice. Victor Papanek’s moral position that it is sometimes better for designers to do nothing (1972), is a stance that university graduates may not have the luxury of pursuing in a junior role within their first position of employment. However, acknowledging the broader application of DfS presents greater opportunities for the graduate designer to capitalise on their sustainability knowledge (via current trends such as the carbon reduction imperative outlined above).

The three suggested clients for DfS consultants were the individual, business or community, all which have slightly different requirements. The DfS consultant working with individuals or businesses as clients is viewed to be a customary
business relationship. However, consulting to the community appears to be abstract in the restricted context of typical Industrial Design vocations. The typical Industrial Design vocational destinations are seen to be those advertised by the Design Institute of Australia as manufacturing companies, design consultancies, designer/maker workshops, research and development departments, and self employed (Robertson 2007).

The process of community consultancy is strongly related to Participatory Action Research (PAR). The process of PAR in education has been advocated as an approach that engages students in their learning and empowers them to make a difference within their community (Mordock and Krasny 2001). For PAR to be taught effectively, an introduction to the theory of PAR is required, matched with a deep learning (learning-by-doing) pedagogy (Mordock and Krasny 2001). For PAR to be effectively taught to Industrial Designers as a model for community consultancy, two notable inclusions are suggested: education in collaboration, and education for reflection (Clune 2007).

**Education for Collaboration with Community**

Community collaboration has been suggested to increase motivation and engagement from students in an education-for-sustainability context (Mordock and Krasny 2001; Douvlou 2006). To understand how collaboration with the community in a learning-by-doing framework may be integrated into Industrial Design education, UWS is again used as a case study. The most immediate short-term possibility is by acknowledging the student body on campus as a micro-community, as universities generally display traits of larger communities.

The student body therefore presents an accessible ‘community’ for collaboration on behavioural change projects. This may include live projects to encourage sustainable mobility around campus, or the virtual learning that was identified in Chapter 7 as being a solution to overcome the barrier of car-dependency amongst UWS students. How this may be implemented is shown in Table 9.1 below.

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65 These concepts of community collaboration and education for reflection have been presented in the paper ‘Sustainability Literacy for Industrial Designers through Action Research’, which is available in Appendix X, p. 328.
Table 9.1 Internal community collaboration for Industrial Design Education

<table>
<thead>
<tr>
<th>AR Phase</th>
<th>CBSM Phase</th>
<th>Class activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plan</td>
<td>Identify Barriers and Benefits</td>
<td>Similar to the class discussion in Chapter 7, students identify key behaviours and activities that are unsustainable as a group from their individual consumption audit. Problem defining is refined using methods outlined in Chapter 6 to locate the problem at a deep level. Once an activity is selected, the first phase of CBSM in identifying barriers and benefits previously outlined may be completed. Skills required such as interviews or observations to identify barriers and benefits could be achieved internally through role play, whereby students move between the role of researcher and the sample population.</td>
</tr>
<tr>
<td>Act</td>
<td>Design effective Strategies</td>
<td>Following the CBSM guide presented earlier in this chapter, students identity designerly ways to remove the barriers and encourage the benefits of particular activities.</td>
</tr>
<tr>
<td>Observe</td>
<td>Trial</td>
<td>The most challenging of the stages is seen to be in being able to simulate and trial the strategies for behavioural change in the short time period available in a modern teaching session. Quick and Dirty prototyping (IDEO 2002) would be ideal to trial and observe the success of such strategies.</td>
</tr>
<tr>
<td>Reflect</td>
<td>Reflect</td>
<td>In an academic environment with the above process the reflection could take the form of final assessment documents, which would include the required alterations to the trial intervention to increase the chance of success.</td>
</tr>
</tbody>
</table>

The more desirable long-term direction to be developed is to expand partnerships with local communities and industry partners to trial collaborative projects over time at the level of local community. For example, as part of UWS’s community engagement commitment, it is developing links with local municipal councils. This may be expanded upon for live projects, engaging students with sustainable issues that they (preferably collaboratively) identify in the local community.

The published results and reflection from one year would inform practice for the following year, allowing for ongoing projects over time that can increase in complexity as outlined in Table 9.2. This second model is seen to be more aligned to Mordock and Krasny (2001) and Douvloú’s (2006) concept of community collaboration that they suggest has the additional benefits of students viewing themselves positively as contributing members of the community.
Table 9.2 External community collaboration for Industrial Design Education

<table>
<thead>
<tr>
<th>AR Phase</th>
<th>CBSM Phase</th>
<th>Class activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plan</td>
<td>Identify Barriers and Benefits</td>
<td>Unsustainable activities in the local community would be identified, further problem defining would be refined using methods outlined in Chapter 6 to locate the problem at a deep level. Once an activity is selected the first phase of CBSM, identifying barriers and benefits previously outlined, may be completed.</td>
</tr>
<tr>
<td>Act</td>
<td>Design effective Strategies</td>
<td>Following the CBSM guide presented earlier in this chapter, students identify designerly ways to remove the barriers and encourage the benefits to particular activities. The proposals may then be pitched back to council for a small-scale trial.</td>
</tr>
<tr>
<td>Observe</td>
<td>Trial</td>
<td>The observation of the small-scale trial is seen to take place by the following year, with the succeeding class responsible for amending and enlarging the system. A revision of the first two phases may assist in modifying the trialled ‘solution’.</td>
</tr>
<tr>
<td>Reflect</td>
<td>Reflect</td>
<td>The reflection phase again would take place in the following year and encompasses the important dissemination phase, critically reflecting on the three phases in terms of the ability to lead to more sustainable behaviours. The phase may include further amendments and expansions of the system.</td>
</tr>
</tbody>
</table>

Education for Evaluation and Reflection

It is easy to criticise the broader design community for lacking meaningful reflection or futuring from the DfS case studies analysed in Chapter 9. However, within academia it is apparent that the education of current industrial design students may not be supporting students appropriately to ‘reflect-in-action’. The structure of academic institutions is such that assessment techniques leave ‘little time for reflection in a timely fashion’ (Grauerholz 2001) with regards to the design studio, where designs are rarely resolved beyond the conceptual stage (this limitation applies equally to concept generation vocation). Nor are they implemented, which curtails reflection, as the students only get to try things once, not work on them and refine them to make them work. Therefore design is assessed prematurely and theoretically, which could be contributing to the lack of meaningful reflection within industry (Clune 2007, full paper in Appendix X).

Within the unit Sustainable Design: Sustainable Futures an attempt has been made to encourage reflection and collaboration as valued outcomes and key skills required in designing for system-wide change. To encourage reflection, submissions from one unit of study (the scenario narratives from Sustainable Design: Sustainable Futures, and the personal consumption audit in Sustainable Design: Life Cycle Analysis) are analysed by student teams as empirical evidence in the following unit.
of study, completing the PAR cycle of observe and reflect (the final two stages of the PAR cycle of plan, act, observe and reflect). Further, the key to developing reflective learners lies in developing a repertoire of reflective questions and providing opportunities to practice them (Bourner 2003) as illustrated in Chapter 6, p. 165 via questions such as: does the concept selected fit with your criteria for sustainability perfectly? What might you do differently as a result of that experience and your reflections on it? What actions do your reflections lead you to? Exploring the submission of previous units and the underlying assumptions they hold encourages such reflection.

The timing of reflection is also crucial. Schön’s argument that designers reflect in action (1991) suggests that reflection occurs throughout the development process, whereby standard assessment practice is to submit a reflective document at the end of the session, often with questions such as ‘what did you learn?’, which suggests that learning can be easily quantified in isolation of an applied context, rather than being continuous and relational. To tune a designer’s reflection in practice would be more appropriate than to reflect as a final assessment task. The timing of this assessment within Sustainable Design: Sustainable Futures has been reorganised upon these principles in Chapter 6.

‘Reflection in action’ is different to ‘reflection on action’. ‘Reflection in action’ refers to the micro-level cognitive development of design students as they generate multiple variations of concepts to solve a given problem. ‘Reflection on action’, however, refers to the bigger questions of ‘how is this contributing to a sustainable society?’ and ‘if effective, what could be the ramifications?’ This is reflection at a philosophical level. The latter question begins to bring defuturing into action. Such questions, if integrated across the Industrial Design curriculum, may continue to engage students in DfS. It is particularly significant in Education for DfS because it requires forethought and is related to previous discussions of impact analysis (in Chapter 6, p. 165) and relational thinking (in Chapter 5, p. 128).
9.6 Three Vocations and Benefits for Industrial Design Education for Sustainability

This chapter presented a model for design to address behavioural change, following the key point of the previous chapter, that DfS is not a matter of ‘no design’ but rather design that is appropriate, context driven, wholly aware of what exists and what now needs to be designed to support more sustainable lifestyles in the lowest materials–energy intensive way possible. CBSM is a useful social theory that can inform this new sort of industrial design because it provides clear prescriptive tools that designers can respond to in order to shift undesirable behaviours. How this kind of designing challenges existing Industrial Design vocational roles was speculated upon, and three DfS vocational directions were presented: first, operating in a traditional industrial design setting, utilising design for behavioural change as a concept generation tool; second, designing for behavioural change generating entrepreneurial opportunities; third, designing for behavioural change via DfS consultancy, the most challenging example being consulting at the level of the local community.

The benefit for Industrial Design Education for Sustainability of clarifying the vocational variation through appropriate pedagogy is that it provides a useful basis to shift away from the undesirable features of design practice outlined in Chapter 3. The entrepreneurship and consultant vocations encourage students to make their own careers, enabling the growth of the discipline based on an appropriate sustainment of industrial design skills. Doing so challenges the culture of the designer as an occupation that services clients needs, as implicit leadership roles are present in the entrepreneurial and consultancy vocations. Finally the master and apprentice relationship in Industrial Design education is fundamentally challenged by these vocational proposals, and may be further ameliorated if the student-centred pedagogical approach is adopted.

To summarise the findings thus far in relation to the thesis presented in Chapter 1, the implemented interventions progress the thesis that ‘students can design for sustainability if an appropriate understanding of the unsustainability is defined (the problem context)’. The results of Chapter 6, after students explicitly defined unsustainability, support the connection between defining and designing. The second part of the thesis is that students can Design for Sustainability ‘if
supported by pedagogic processes to transform the understanding into design’, which was identified in Chapter 7, highlighting the important role that pedagogy has in influencing the development of Industrial Design students’ capacity to DfS. The third part of the thesis is ‘students can Design for Sustainability if their Industrial Design skill sets are justified for real world applications’, which has been advanced by this chapter. The visions of what DfS could be as a vocation have been proposed, supported by a theoretical framework for integration into Industrial Design Education for Sustainability.

In order to DfS, designers need to be able to generate concepts in response to complex problems, reflect, communicate, inform and teach. They need to lead not follow, which the proposals in this chapter attempted to explore by presenting viable opportunities to DfS that will bring real change for a sustainable society. If not unprecedented, it is certainly unfamiliar ground in traditional Industrial Design education.
This thesis has investigated ‘why are students of Industrial Design unable to design in a way that can contribute in real terms to a sustainable society, economy or ecology?’ addressed through the subsidiary questions:

– What DfS approaches are represented in the conceptual design solutions of Industrial Design students?
– What DfS approaches offer the highest sustaining potential?
– How are the approaches with the highest sustaining potential integrated into Industrial Design education?

In addressing these questions, the thesis has contributed to a better understanding of the complexities involved in enabling Industrial Design students to Design for Sustainability.

### 10.1 Presentation

This chapter presents a summary of the thesis findings: first, an overview of the thesis findings is presented chapter by chapter; followed by the limitations of the study; the main overall findings and how they contribute to new knowledge in Industrial Design education for sustainable futures. Finally, future directions for this research are discussed.
10.2 Summary of the thesis

The thesis stated in Chapter 1 was: students of Industrial Design can design for sustainability if an appropriate understanding of unsustainability is defined (the problem context), supported by pedagogic processes to transform the understanding into design and justified for real world application for Industrial Design practice. An overview of how this thesis has been validated by the study is presented in the following section.

A significant finding of the thesis is the validation of the thesis that the definition of the unsustainable problem being worked with strongly determines the quality of the design outcome in terms of DfS (how you define is how you design). To enable Industrial Design students to design for sustainability, a sound, targeted definition of unsustainability is first required, a task that has been previously neglected in Industrial Design Education. The approach shifts the focus of the design concepts from one of harm minimisation (the characteristic of DfS1-type solutions) to concepts that may positively contribute to more sustainable ways of living.

The thesis how you define is how you design was explored in this study by refining the definition of unsustainability in an explicitly Industrial Design frame: inconspicuous and embodied consumption were shown to be critical factors linking products to people and how they utilise resources indirectly in modest, everyday practices. Both of these forms of consumption showed there is enormous scope for design to contribute to DfS knowledge if it learns to reflect on the socio-technical processes of unsustainability, which was identified as having limited support in Industrial Design practice and Industrial Design Education to date. This focus provided a fresh approach to exploring Industrial Design’s agency in generating more sustainable outcomes: rather than showing up the limitations of Industrial Design solutions, it sought to validate industrial design’s contribution by remediating the vagueness around sustainability that was evident in the literature. This provided a firm foundation upon which to critique both the sustainable literature (Chapter 2) and the designs presented by students within the evidentiary chapters (Chapters 5–8).
While a more targeted problem definition was shown to be critical, transforming this understanding into design outcomes for sustainability within Industrial Design Education required more than just a revision of the problem definition, it requires a reorientation of practice, both educational and design practice (which Chapter 3 explored). Many authors have called for such a reorientation of design practice, however exploring how design education may actually contribute to this shift in design practice guided the study. Drawing on Kemmis (2005; 2007) for insight on how to change practice, this action research study mobilised the ‘teacher-as-researcher’ model to enable the unit Sustainable Design: Sustainable Futures to become a micro experiment in raising change criteria and effecting incremental change across both practical and theoretical domains.

Transformative processes were developed to apply theories such as Fry’s Defuturing (1999) to practical design applications, which had not been previously documented in Industrial Design education in Australia. The pedagogy of deep learning and a student-centred approach to teaching were found to be profoundly effective in progressing students’ understanding of unsustainability and transforming this understanding into designs for sustainability. A brief overview of the progression of the study in this regard is outlined below.

The analysis of the 2005 study highlighted significant problems in students’ tacit understanding of unsustainability. The key problem was the prevalence of ‘techno-fix’ solutions that plagued all the evidentiary chapters as students relied overtly on product-orientated solutions that were poorly integrated into explicit social contexts. Taken as a whole, techno-fix can be read as symptomatic of the lack of Industrial Design exemplars from the more socio-technical side of Brezet’s regime, and a standard against which the validity of solutions are reflexively judged. One might consider, for example, that the crowning moment of the graduating Industrial Designer is the end of session exhibition, in which design is compelled to take product form

The Action Plan for 2006 was largely focused on ameliorating techno-fix via tools and processes to assist students to critically define why we are unsustainable in a specific context. A key innovation of the chapter is the transformative tools that were developed, such as the ‘day in the life’ scenario and revised ‘design brief’ that attempted to focus designs students skills on our everyday unsustainable actions.
These tools were validated in the results of the 2006 intervention (Chapter 6) in which the design outcomes saw students moving to the demand side of the problem and grappling with the complexity of socio-technical change. Unsustainability had been more appropriately defined, however this was not met by the ‘design’ side of the equation. It was strongly apparent that students struggled to see how design could facilitate real change towards sustainability. This was most pronounced in the ‘no design’ concepts in which students presented social innovation solutions devoid of explicit design. This phase marked a key turning point in the research, as the study shifted focus from DfS theory to educational theory in order to address why developments in design outcomes had not been achieved.

The action plan for 2007 therefore relied heavily on the pedagogy of Deep Learning, specifically a student-centred approach which focused on ‘combining knowledge and understanding through personal experience of the student’. This emphasised real-world examples of how design facilitates our behaviours. (The 2007 intervention delivered the same theoretical material as in 2006, but with an altered schedule (such as the scaffolding of assessment tasks) to remove perceived ambiguities from the unit. The results of the above intervention (presented in Chapter 7) validated and quantified the importance of pedagogy, being equally as important as DfS theory, as the student-centred approach assisted students to design for social scenarios incorporating technical design. The divide between technical and social solutions was reduced as students displayed improved relational thinking. A significant finding for industrial design pedagogy in this phase of the research was the importance of probing questions in workshops: once a ‘solution’ had been apparently determined, it became a starting point for further exploration turning what was seen as a solution into an expanded problem field. This successfully helped students to locate further appropriate industrial design opportunities.

The major challenge the chapter revealed for Industrial Design Education for Sustainability was the conflict in the practical application of the more progressive DfS3 solutions for the traditional paradigm of Industrial Design practice (partially explaining the dominance of techno-fix solutions). This was shown not only to be a matter of concern on the side of education, but also in terms of students’ perceptions of Industrial Design as a profession. The lack of socio-technical exemplars also
stood for an actual lack of relevance: To students, the relevance of DfS for their future careers had not been made clear outside the limits of Ecodesign (DfS1).

If Industrial Design students are to be motivated and engaged in DfS, sustainability needs to be presented as more than a responsibility; students need to see clear, feasible, future vocational opportunities for design for sustainability. The results of Chapter 8 indicated that the combined categories of a ‘social’ school of thought with functional and systems innovation had the highest sustaining potential. The specific ‘real world’ case studies illustrating these ‘combined categories of high sustaining potential’, such as the Paris Vélib and Curitiba’s bus shelters actually indicated vocational possibilities that were elaborated on in Chapter 9. In terms of Habermas’s (1972) KCIs, an understanding of DfS2 solutions (practical knowledge) was supported by DfS1 eco design (technical knowledge), presenting cases that come closest to DfS3 solutions required to bring about fundamental change towards sustainable practices (emancipatory knowledge). In Chapter 9, three vocational possibilities supported by the methodology of Community Based Social Marketing and the real world case studies of viable DfS3 were identified and explored. The point of these possibilities was to ameliorate the outstanding concerns of the evidentiary chapters, and to provide viable vocational horizons for students to strive toward centred around a replicable process for design to engage in behavioural change as required above. The three related vocational roles projected DfS beyond the limits of the university: radical concept generation, entrepreneurial activity and consultancy could all be identifiable in the real world case studies explored in Chapter 8. The vocational variations were supported by recommendations for integrating these vocations into Industrial Design Education for Sustainability: in conducting future scenario planning, students can also give shape to their own future as Industrial Designers by envisioning new client-designer relationships.

Habermas (1971: 1989) stated that to prepare students for employment is one of four responsibilities the role of the university (presented in Chapter 3). Industrial Design education was criticised for placing too great an emphasis on vocation. However, the reverse is true with regards to education for sustainability, as the vocational possibilities for DfS were largely perceived as missing by the students. The approach to defining unsustainability as a more socially orientated problem context (presented in Chapters 6–7) assists students to fulfil the other responsibilities
that Habermas (1971, p. 4) discussed, such as developing an understanding of culture through a critique of our everyday activities, developing knowledge and becoming politically engaged. Likewise Dewey (1966) proposed that vocations are more than just the specific skills applied for paid money; that being a member of society is also a vocation. The vocational proposal of DfS consultant for the community blurs this boundary and is seen as the most promising area for further research.

10.3 Limitation and Delimitations

Three significant problems emerged with the research design over the course of the study: first, the isolated focus of the study on one unit from one university excluding a wider sample; second, the exclusion of stakeholders from industry within the study and; third the selected coding categories’ ability to fully capture the merit of DfS solutions. The following section addresses the concerns raised through the course of the study.

10.3.1 Unit-Specific Study

The first identified limitation is that the focus of the study was on one individual unit, to which the author had full access. The unit is one of three that make the core of the sustainable design curriculum at the University of Western Sydney, and one of 22 that students are required to complete prior to graduating with a Bachelor of Design/Industrial Design.

The suggested limitation of the study is that it is too localised. The focus of one unit in one Australian institution, as opposed to a national or world wide study, may not produce results that are representative of the global concerns of Industrial Design education.

This was considered in the original research design of this study prior to commencement, which had planned to locate the state of Industrial Design Education for Sustainability within Australia by conducting interviews with educators from the eleven institutions then teaching Industrial Design. However, the preliminary literature review identified Ramirez’s (2004) study of Australian institutions as sufficient to outline that the state of Industrial Design education with
regards to DfS was not ideal. The rationale for the singular unit of study was extrapolated from Ramirez’s findings, indicating that the concerns arising from teaching DfS at UWS were actually national, as opposed to local.

On completion of the thesis, there was value in improving the teaching of DfS within one unit, the findings of which may be transferable to other institutions. The research design implicitly validated the alternative status of DfS, rather than just transitioning sustainability into mainstream design education, however the proposal that the theoretically bereft ‘how to design’ units could benefit from being driven by ‘what to design’ of DfS is viewed as a valid proposal emerging from this study.

10.3.2 Exclusions of Industry

The second limitation of the study arose from the dissemination of research findings at research conferences; where the research design was questioned with regards to the exclusion of stakeholders from industry.

The initial rationale for the exclusion of industry at the outset of the project was that if students can not display the visions of Design for Sustainability that contribute in real terms to a sustainable society, economy or ecology in an academic context, then once in practice they would have even greater difficulty with the additional pressures of time, economy and industry tradition such as the history of design servicing client’s needs.

On completion of the thesis, the researcher is more comfortable in including industry in further research, as there are clear hypotheses for discussion of how Industrial Design may operate within existing and new industries. The analysis of case studies with the ‘combined categories of high sustaining potential’ has also directed the researcher towards promising case studies that clarify the new industries within which DfS may operate. Educating students for new possible DfS3 vocations is the outcome of Chapter 9. This was not anticipated at the outset of the thesis, illustrating a significant learning through the thesis of what Industrial Design could be. The recommendation for further research from this thesis is a testing out of the proposed DfS3, which would involve a closer collaboration with new and existing industry.
10.3.3 Selection of Categories for Coding

The final suggested limitation of the study came out of the evidentiary chapters, in the inability of the categories selected for coding in Chapter 3 to fully capture the skills inherent in DfS3 type solutions, and a perceived bias in categories towards ecological resource reduction.

To design DfS3-type solutions, there are inherent skills required such as a deep understanding of the problem context, brought about by critical, relational and reflective thinking.

The ability of the coding categories to validate the merits of social innovation within the analysed solution was limited, as the value in solutions that catered towards wellbeing, or that brought people together were not well represented in a quantifiable way.

The categories for coding were developed prior to the study being carried out, in order to improve the validity of Action Research and Content Analysis. On reflection, alternate coding categories and metrics may have been used to capture the above limitation better and to allow for more variation and evolution. However, this limitation was ameliorated to a good extent by the research design, as the qualitative analysis of selected conceptual design scenarios and case studies revealed these less quantifiable values. It was only through the process of analysis that the skill sets required for DfS were learnt and validated.

10.4 Findings and Contribution to Knowledge

In addressing the research question ‘why are students of Industrial Design unable to design in a way that can contribute in real terms to a sustainable society, economy or ecology?’, assisted by the subsidiary research questions, this thesis has contributed to a better understanding of the complexities involved in enabling Industrial Design students to better Design for Sustainability in real terms. The findings and contribution to knowledge are outlined below.
10.4.1 How you define is how you design

The theoretical proposal ‘how you define is how you design’ has been used within the thesis to advance Industrial Design Education for Sustainability in two instances: first, the historical reading of the DfS literature for the progression of unsustainability presented an original angle upon which to establish the thesis; second, ‘how you define is how you design’ was used in the development of the theoretical interventions (Action Planning from Chapter 5: Analysis 2005, the status quo) by assisting Industrial Design students to explicitly define unsustainability. The results of the intervention presented in Chapter 6: Analysis 2006 from DfS theory to pedagogy indicated that developing a sound definition of unsustainability influenced the Industrial Design students’ ability to Design for Sustainability i.e. ‘how you define is how you design.’ This was further mobilised in Chapter 9’s proposals as the benefits and barriers analysis from CBSM enables clearly prescribed criteria upon which to found technical design proposals. Explicitly defining unsustainability addresses a critical omission from the dominant DfS theory and practice to date; as Manzini has indicated, the criterion of ‘use what exists’ is one of the most undervalued design strategies (2002, p. 9). This can be extrapolated to the thesis how you define is how you design, as it causes one to reflect on the foundations of their knowledge and action before acting.

10.4.2 Action Research for Industrial Design Education

The methodology of action research and the teacher-as-researcher applied within Industrial Design Education for Sustainability is timely, and viewed to be significant given the lack of a national curriculum for Industrial Design, affording teachers the desired agency to alter curricula. This agency of the teacher has been written off by the early advocates of Action Research in educational contexts such as Carr and Kemmis (2005), as curriculum reform was centralised.

However, a key finding of the thesis is that smaller disciplines like Industrial Design that have escaped top-down curricula can apply Action Research as originally intended, generating educational knowledge from a careful reflection of classroom practice.
Kemmis (2006a) suggests that Action Research strategies within education have been ill-used to implement curricula within the secondary schooling system by governments, as Action Research is used uncritically as a vehicle for the implementation of externally determined improvements, a far cry from what Stenhouse’s (1975) and Carr and Kemmis’ (1983) original position on what the ‘teacher as researcher’ was intended to do. Kemmis raises the argument that the original intention of his work ‘becoming critical’ was to evoke emancipatory research within education that not only changed the classroom, but influenced the practice and society within which the education is located (2005; 2006b). Research should influence what Kemmis describes as the extra individual features of practice: society, discourse, culture and economy (2005, pp. 393–422). It should not be used to simply implement policy.

This thesis does not (yet) have an emancipatory influence on practice or society as Kemmis is suggesting, nor was it this study’s original intention to do so. The original question of ‘why are students of Industrial Design unable to design in a way that can contribute in real terms to a sustainable society, economy or ecology’ was addressed through the methodology of Action Research. To validate the findings, ‘narrow and deep’ information was collected from students for analysis. The emancipatory nature of the study was not a priority. However, Table 10.1 summarises each of Kemmis’ criticisms from ‘examples of inadequate action research’ (2006a, pp. 460–461) and refutes the main criticisms with regards to this thesis.

<table>
<thead>
<tr>
<th>Kemmis’ Concerns of Inadequate Action Research</th>
<th>Thesis in response to Kemmis’ Concerns</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Action Research is aimed at improving techniques of teaching; it takes the internal goals set for projects for granted; it does not question the project’s role in broader education theory nor how project may lead to better society.</td>
<td>The project was initiated out of a passion for bettering society with regards to sustainability; education was seen as a promising outlet for this to happen. The goal of improving teaching could be said to be secondary (although extremely important) to the initial intent of the research on commencement, which was to enable Industrial Design students to DfS.</td>
</tr>
</tbody>
</table>
2. **Action research is aimed at technical efficiency in improving practice, excluding the extra individual features of practice.**

The ambition of the thesis was to improve the ability of Industrial Design students to Design for Sustainability to bring about real change. This was identified as problematic in the initial inquiry which located a large gap between the theory of sustainability and the embodiment of that theory in design solutions.

On reflection, one could say that improving the technical efficiency of design, but in the direction of DfS, was the underlying aim. However, the extra individual features of practice were not excluded from the study. How this thesis addressed in a small but significant way those extra-individual features is discussed in Chapter 3.

3. **Action research used merely as a vehicle for implementation of externally determined improvements, which are uncritically accepted under serving the potential of the method.**

This thesis has attempted to critically examine what it is we should be designing for, via the literature review presented in Chapter 2.

4. **Action research sees improvement in practice only from the perspective of professional practitioners. It excludes the voices of active participants (students, communities, industry).**

This thesis is heavily focused on the perspective of the professional practitioner (i.e. Industrial Design Educators for Sustainability) in an educational context.

The decision made early on in the study for a limited voice of the people (students) was on the premise that designed goods are outcome based.

When you test drive a new car you do not know who designed it, you reflect on the product as an object in itself. The framework *how you define is how you design* suggests that students’ tacit understanding is placed within their resolved ‘solutions’. The exclusion of industry will be discussed in detail later in this chapter.

5. **Action research is conducted by individuals rather than in open communities with other participants.**

The thesis was conducted by the individual, rather than in open communities. However its findings can be extensively shared and learning processes modelled in other contexts. The researcher learnt how to research but also how to learn. These requirements add complexity to Kock’s requirement of ‘narrow and deep’ analysis to validate Action Research. The research design for this thesis for submission is seen as appropriate given the initial research questions.

To summarise Table 10.1, Kemmis (2006a) has suggested that Action Research has not been emancipatory enough. While the objective of this thesis was not to be emancipatory, the above table illustrates that this thesis has used Action Research in a critical and appropriate context specific manner, conducive to Stenhouse’s (1975) original intent of the teacher-as-researcher.
Through the application of the Action Research cycle over the three iterations, the students’ ability to Design for Sustainability developed markedly. As evidenced by the continual improvement displayed in the conceptual design scenarios analysed in the evidentiary chapters 6: Analysis 2006 from Theory to Pedagogy and 7: Analysis 2007, Reconciling Designing and Defining, the practice of the teacher as researcher also provided a useful basis to investigate the problems identified within the literature on Industrial Design education in the master-and-apprentice, teacher-centred mode of delivery. The Action Research process assisted in identifying alternate pedagogies that engaged in a student-centred approach to teaching (e.g. Deep Learning).

From the researcher’s perspective (who has no formal teaching qualifications), Action Research is invaluable in bettering one’s own teaching via a careful reflection on one’s own practices. The position of limited educational training is viewed to be consistent with Industrial Design educators; therefore Action Research as applied in this research has shown to be an effective way for design educators to engage in reform to enhance the desired outcomes from DfS theory.

### 10.4.3 The Importance of Pedagogy in Industrial Design Education for Sustainability

Action research assisted to illuminate the significant role of pedagogy in Industrial Design Education for Sustainability, which appears to be undervalued in the DfS literature. The results of the pedagogic intervention in 2007 had a significant impact on students’ engagement with the process of DfS, clearly validating the shift from ‘what to teach’ to ‘how to teach’.

The strategies implemented included a student-centred approach to teaching, and a restructured assessment timeline. The results were surprising in that the same theoretical material, delivered in a more scaffolded way, had an impact on the students’ ability to deliver conceptual design scenarios that exhibited technical design solutions founded on a more socially orientated problem context. The work in 2007, after the pedagogic intervention, displayed elements of the ‘emancipatory knowledge’ outlined in the theoretical framework in Chapter one, where ‘practical [social] knowledge’ would be informing the ‘technical knowledge’.
Statistically, the gains of the pedagogical intervention were equal to or greater than the gains made through revising the theory delivered within the first intervention. This validated the proposal that ‘how you teach’ is of equal importance to ‘what you teach’.

10.4.4 **The Development of Transformative Processes and Tools**

The development of transformative processes and tools to reconcile the interpretation of unsustainability into designed solutions through the theoretical and pedagogical intervention have not been previously used in this context, and have proved to be valid.

A pedagogical application for Fry’s defuturing (1999) was developed through the interventions (see Chapter 6), providing an applied theory to enable Industrial Designers to engage with defuturing. This presented a sound theory to interpret unsustainability, but the process of how designers are able to transfer the abstract concepts of unsustainability into realised solutions was unclear.

The tools developed, such as the human-centred functional design brief and the criteria for sustainability (p. 134), provided a process to clarify the transformation of interpretation to practice, which the evidence validated. The theoretical proposals of Chapter 9 (pp. 235–239) outline how Industrial Design students can design for behavioural change utilising transformative tools and processes.

10.4.5 **Quantifying Categories of High Sustaining Potential**

The study identified the categories of ‘socio-technical’, ‘functional’ or ‘systems’ innovation to offer a higher probability of producing Factor 10 resource reduction scenarios, evidenced by the analysis of DfS case studies using the Pearson Coefficient in Chapter 8 (pp. 211–217). Further analysis of these cases with high sustaining potential assisted to refine the qualities of designs that would lead to fundamental change for a sustainable society, by designs that are appropriate, context driven and wholly aware of what exists. Stand-out features of the case study analysis were design for behavioural change, and design at the level of local community, ventures in which Industrial Designers tied to the commercial product economy have traditionally not engaged.
10.4.6 Opportunities in Design for Sustainability

Chapter 7 showed that the moral responsibility of sustainability was understood by students. However, the opportunities and vocational application that DfS skills present were not clear, with a potential impact on students’ engagement with the topic. This thesis has contributed to clarifying the vocational opportunities that DfS may offer Industrial Design students. The relevance of DfS associated with the future career vocations is an important finding, because, if the students are unable to see the relevance of the course of study to their future practice, then the content is deemed irrelevant (Stenhouse 1975). This was supported by the teaching experience as the traditions of Industrial Design conflicted with the conceptual design scenarios that students presented in the evidentiary chapters.

The role of the university was discussed in Chapter 3 in the context of Industrial Design education; to prepare students for employment is just one of many responsibilities, however it was a responsibility that with regards to Design for Sustainability lacked clarity. The proposal in Chapter 9 presented three vocational variations, clarifying the possible application of DfS by Industrial Design graduates. The vocations were supported by a clarified process to design for behavioural change.

These vocational variations ranged from concept generation within a conventional design process to entrepreneurial design, which would require the acquisition of specific complementary skills and DfS consulting. These present opportunities for designers to move beyond the current role of client servicing to taking more of a leadership role, an emerging need in a climate-changed future. The implication for Industrial Design education is paramount as it has the possibility to expand the discipline into non traditional fields. These vocational proposals are viewed as starting points that need to be fleshed out by industry relations, and further research.

10.5 Implications for Policy and Practice

Chapter 3 identified that, in order to change practice, extra-individual features such as the discursive, cultural and macro-economic features of practice (Kemmis 2005;
2007) must also be altered. These features were speculated upon in relation to Industrial Design Education for Sustainability. It was identified that these research findings have a potential impact on three broad areas: Industrial Design students (as future practitioners); Industrial Design Education; and, to a lesser extent, professional Industrial Design practice. Each will be looked at in turn.

The first area that the thesis has had an impact on is the Industrial Design students’ ability to design for sustainability. Over the course of this study students from the unit SDSF (particularly those participating in the later interventions) displayed an improved capability to DfS. Graduate designers continuing to engage in the problems of DfS have the potential to positively shift the professional practices within which they are working, a small but significant contribution. The macro-economic opportunities of DfS for Industrial Design students (the vocational variations presented in Chapter 9) have been integrated into the unit SDSF at the University of Western Sydney as of 2008, further strengthening the viability of DfS as a profession to students that may be realised with time.

With regards to Industrial Design Education, Australia is in a unique position as there is no governing body dictating what or how Industrial Design should be taught. Stenhouse’s (1975) ‘teacher as researcher’ model was therefore utilised as a driver for educational reform. The results of this at a local level have been the internal dissemination of research findings at UWS, via the sustainable design stream team, which has led to interventions being adopted in the specific unit of study SDSF, as well as alteration made to the complementary unit Sustainable Design: Life Cycle Analysis.

In the broad educational context, the Industrial Design Educators Network of Australia is a network that includes the majority of Industrial Design educators within Australia. There is an electronic mailing list for the group, allowing for design educators to be directly targeted. This is a useful medium to establish a discourse with Australian design educators on DfS to disseminate the findings of this thesis, from both a theoretical and pedagogical perspective. The methods and findings employed here could be made available for others to trial and generate further feedback via these networks. As McKenzie-Mohr (2000) has shown, awareness does not lead to behavioural change: change needs to be designed. Foertsch, Miller et al. (1997) suggest that personal contact is effective in the dissemination of education
reform. Personal contact is viable in Australia due to the small number of institutions teaching Industrial Design. This is viewed to be the most effective dissemination strategy, as tailored solutions can be developed to each institution, with the above network an accessible forum to continue and grow discussion.

The traditional dissemination strategy of publishing conference and journal papers is also seen as a way to strengthen the discourse on Industrial Design Education for Sustainability. Strengthening the pedagogical discourse is viewed to be particularly important, which this thesis has identified as limited.

The third area upon which the thesis may have a limited impact is in the professional practice of Industrial Designers. As mentioned above, students becoming professional practitioners may alter practice over time if they continue their engagement with the DfS skills taught; however there are two further ways that this thesis could be disseminated in an attempt to alter practice: first, using the professional body of the Design Institute of Australia to establish a discourse on the proposed vocational variations with practising Industrial Designers via online publications, followed by face-to-face forums as part of the DIA seminar series; and second, by testing out the proposed variations of vocations, which is the recommendation for further research presented in the next section.

10.6 Recommendation for Further Research

The problem of unsustainability presents many opportunities for Industrial Design Education, as suggested by this thesis. The pedagogical framework for Industrial Design Education for Sustainability’ presented in Chapter 9 proposes alternative vocational visions for Industrial Design Students that need development and detailed problem space evolution. The development of vocational visions is viewed as the responsibility of the university, and a topic for further research. This may be completed in the pending Australia Learning and Teaching Council project ‘how can Industrial Design respond to a climate-changed future?’ which aims to ‘set a consensual agenda and develop implementation strategies for industrial design curriculum development for a climate-changed future’ (Allen, Andrews et al. 2008, p. 1). The development of DfS vocations is seen to hold an important position within such a study.
The identified limitation of this thesis in the exclusion of industry is an area that may be ameliorated. The inclusion of industry in the new DfS opportunities presents an area for scholarly research. The testing of the proposed vocations is seen as a logical step to advance the work of this thesis to enable Design for Sustainability to become paid work. One desirable approach is to again advance the work of Tony Fry (1999) concerning rematerialisation. Fry suggests for sustainability we may need to seek out sustaining practices that are susceptible to disappearing, and reorientate (redesign) such practices as naturally drying clothes, or more self-sufficient means of local food production. Making such practices attractive to the cultures in which they were once embedded reveals viable sustainable alternatives, and provides a starting point to test the vocations presented in Chapter 9.

The nature of this study has dictated an overtly western focus on unsustainability inherited from the institution with which the study was conducted, a progression for the researcher is in taking a more global approach. Of interest is the variety of cultures (particularly the developing world) that provide a plethora of traditional sustaining practices. The ‘think back’ exercise developed by the researcher (Lopes, Clune et al. 2007) in asking how society got by without electricity, air conditioning or refrigerators is exemplified in traditional cultures, which can be repositioned from being backward in a development scenario to being forward in a futuring scenario. The challenge for Design for Sustainability is in reinventing and remaking these past (present) sustaining practices to make them viable, competitive and attractive in the context of the unsustainable everyday. This approach challenges the traditional sustainable development strategy which imposes western solutions on traditional cultures. The approach outlined attempts to learn from the sustainable elements of traditional cultures, which, like Jégou, Manzini et al.’s Sustainable Everyday Project’ (2008), identify potential areas for design innovation with which to engage. The outcomes may feed any of the three proposed vocations for Industrial Design presented in Chapter 9.

One proposed research design for how the above project may be realised is via supervision of Masters or PhD students in sustainability. Table 10.2 outlines the four phases of the project, which mirror the reflective phases of CBSM and Action Research.
Table 10.2 Proposed research design framework for further research

<table>
<thead>
<tr>
<th>Phase</th>
<th>Description</th>
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<tbody>
<tr>
<td>Phase One</td>
<td>Students seek out ‘non-modern solutions from traditional practices that have sustaining potential’ (Fry 1999, p. 217) from their own culture, via the use of defuturing as a methodology.</td>
</tr>
<tr>
<td>Phase Two</td>
<td>The practices are transferred into design briefs focused on making ‘non-modern solutions socially, politically and symbolically acceptable and exportable’ in a modern context (Fry 1999, p. 217), drawing on the transformative tools from the evidentiary chapters such as the human-centred functional design brief.</td>
</tr>
<tr>
<td>Phase Three</td>
<td>Realising the briefs through the application of design skill, which are then communicated back to the community they were taken from in a mode similar to the DfS3 community consultant of Chapter 9, a participatory approach is viewed to be paramount in this case as the communities hold vital knowledge required for successfully implementing such practices.</td>
</tr>
<tr>
<td>Phase Four</td>
<td>Reflecting and communicating the results to a wider audience, via online exhibitions which provide a communication strategy that could sustain and grow educational cases.</td>
</tr>
</tbody>
</table>

The above project is seen to advance the discussion on Design for Sustainability presented within this thesis.

10.7 Conclusion

This thesis has illustrated that Industrial Design students could Design for Sustainability if they developed a sound understanding of unsustainability, supported by pedagogic processes to transform their understanding into design solutions, and if they can recognise the vocational reality of DfS for Industrial Design practice.

The thesis has projected a vision of possibilities for Industrial Design Education for Sustainability to enable students to design in a way that can contribute in real terms to a sustainable society, economy or ecology. It has found that DfS is not defined by the poles of techno-fix or ‘no design’, but rather design that is appropriate, context driven, wholly aware of what exists and what now needs to be designed to support more sustainable lifestyles in the lowest materials–energy intensive way possible.

Industrial Design Education for Sustainability has a critical role in exploring and enabling this sort of design activity for the future.
Appendix I Human ethics application form

The following is a copy of the Human Ethics Application form sent to the UWS Human Ethics Research Committee on the 25th August 2005.

1. Developing sustainable literacy of Industrial Designers
2. Chief Investigator (Student Applicants) Stephen Clune, 98106888
   Ph 9852 5074 Doctor of Philosophy, School of Engineering and Industrial Design
2.4 Student Applicant 79 Birdwood Avenue, Winmalee, 2777 NSW
2.5 Student’s Supervisor Dr Erik Bohemia, School of Engineering and Industrial Design
3. Anticipated Duration of the Project Proposed commencement date: 2004
   Proposed completion date: 2008
4. Funding
4.1 Is the research project the subject of an application to an internal or external grants body, or will it be granted other funding support? No
4.4 Is this research a joint staff/student funded project? No
4.5 Are there any constraints placed on the release of research data by the funding body? No
4.6 Do the researchers have any affiliation with, or financial involvement in, any organization or entity with direct or indirect interest in the subject matter or materials of this research? No
4.7 Do the researchers expect to obtain any direct or indirect financial or other benefits from conducting this project? No
4.8 Are there any further ethical considerations that you wish to raise? For example have conditions been imposed upon the publication or ownership of the results? No
5. Lay Summary of Project
The project aims to explore the relationship between the gap in the theoretical knowledge on sustainability and the practice of educating the rising generation Industrial Designers, an area which has had little exploration.
6. Description of Project
6.1 Aims
This action research study aims to explore and investigate the alignment between the sustainability literature and the sustainability curriculum in the Industrial Design program delivered at UWS. Considering the fundamental question of what are the key aspects of sustainability that the students should be exposed to.
6.2 Rationale – Background to research issues
The possibility of irreversible change to our planet through the use of resources in a manner that can not be sustained has been a topic of many publications in recent years (e.g Meadows 1972; Schmidt-Bleek 1999; Manzini 2003; Robinson 2004; Vergragt 2004). According to this growing body of literature we are living beyond the ecological limits of our planet, with a suggested reduction in resource use by up to 95% for developed countries in order to meet the above definition of sustainability (Brezet 1997; Weizsacker, Lovins et al. 1997).

In response to the above issue of resource reduction much has been written on sustainability, with literature examining how industry, community and government practice (e.g. World Commission on Environment and Development 1987; United Nations 1992) should change to enable the future to be sustained. Numerous texts have also been written for the Industrial Design profession on how to minimize the ecological impact of the products they design (e.g. Brezet 1997; Brezet and Hemel 1997; Ryan, Lewis et al. 1997; Tischner 2000).

However, the literature makes little reference to the teaching of sustainability with regards to what should be taught, or the pedagogical approach to teaching, particularly with regards to Industrial Design. The ramifications of the lack of discourse is illustrated by Ramirez’s study of Industrial Design courses within Australian universities, indicating that rules of thumbs (prescriptive toolkits) were frequently taught as a method for sustainability (2004). This is concerning as Tilbury and Adams (2004) highlighted the weakness of using prescriptive toolkits within industry to implement sustainability. The lack of discourse on sustainable pedagogy could be contributing to the situation where ineffective approaches to sustainability are being taught within the Industrial Design courses. Therefore, research is required to synthesize sustainability for Industrial Design with regards to what students should learn.

6.3 Research Questions
The research questions relevant for ethical approval are listed below
How is sustainability currently being taught to Industrial Designers within the University of Western Sydney?
 a. What key themes are being taught?
 b. To what depth are the key themes taught?

6.4 Expected Outcomes, Value and Benefits
The results will have intellectual significance via illustrating the themes of current sustainability literature. The global significance of this will provide insight for design educators and policy makers to tighten the gap between theory and educational practice.

As an action research project Industrial Design at UWS stands to benefit significantly insuring sustainable design is at the forefront. It is possible that by producing graduates with a relevant understanding of sustainability we will be placing knowledge within industry that may transform practices.

7 Research Design
In order to answer the research question, how is sustainability currently being taught to Industrial Designers within the University of Western Sydney, what key themes are being taught and to what depth? Discourse analysis will be used on a variety of mediums being;
A. Industrial Design Course promotional material
B. Unit outlines of units teaching sustainability within industrial Design at UWS
C. Student Assignments
D. Semi-Structured Personal interviews with unit coordinators.

Student assignments will be completed twice within the research design, once prior to alteration to the curriculum and once after the curriculum has been amended.

7.1 Human Participant Description

7.1.1 Discourse Analysis - Using assignments as a mode of analysing student understanding; The sample participants are Second year students from University of Western Sydney, Industrial design degree participating in Sustainable Design futures unit.

7.1.2 Semi-Structured Personal Interviews; Staff member from the School of Engineering and Industrial Design.

7.2 Aboriginal or Torres Strait Islander Participants, NO

7.3 Child Participants, NO

7.4 Sample Size

7.4.1 Discourse Analysis - Using assignments as a mode of analysing student understanding; = 80 second year students

7.4.2 Semi-Structured Personal Interviews; minimum 4 participants, maximum 7. Sample includes unit co-coordinator/s of each sustainable design unit within Industrial Design Course and the Head of Program Industrial Design.

7.5 Exclusion Criteria

Have you designed criteria to ‘exclude’ particular humans from this project? Using the space provided detail the criteria and explain your rationale. N/A

Recruitment methods to access human participants and their involvement

7.5.1 Discourse Analysis - Using assignments as a mode of analysing student understanding

(a) How will the participants be recruited? Sustainable futures contains the sample population required for the data collection.

(b) Will participants receive any financial or other benefits as a result of participation? No

(c) If this research is targeting a particular ethnic of community group has this been done in consultation with a representative of this group N/A

7.6.2 Semi-Structured Personal Interviews

(a) How will the participants be recruited? A formal Invitation will be posted to the relevant unit co-ordinators of sustainable design units and head of program of Industrial Design, identification of sample is through researcher’s position as a teaching fellow and staff sample being work colleagues.

(b) Will participants receive any financial or other benefits as a result of participation? No

(c) If this research is targeting a particular ethnic of community group has this been done in consultation with a representative of this group N/A

7.7 The Method of Data Collection

7.7.1 Discourse Analysis – Using assignments as a mode of analysing student understanding, a 500 word assignment on “articulate your understanding of Industrial Designs position with regards to sustainability”.

7.7.2 Semi-Structured Personal Interviews – have been selected to provide an opportunity to answer checklist of topics that have been prepared, but also allow
Appendix I Human ethics application form

insight from people directing the course of sustainability within the institution. The interviews will be conducted after the discourse analysis of unit outlines; the discourse analysis will provide a base to develop further specific interview questions. However, the expected interview questions would be:

- What is their understanding of sustainability?
- How does the course provide an opportunity in teaching notions of sustainability?
- Does the institution or school have a preferred definition of sustainability?
- What are the key objectives you are aiming to teach within subjects with notions of sustainability?
- How is sustainability incorporated into the degree, specific curriculum, embedded in research projects?
- Where do you see ID’s position with regards to sustainability?

7.8 The Method of Data Analysis

Discourse analysis will be used to analyse both the student responses to the understanding of sustainability as well as interview transcripts. Triangulating the key themes identified through the unit outlines, semi-structured personal and student assignments.

8 Consent Process

8.1 Discourse Analysis - Using assignments as a mode of analysing student understanding; a tick box on the relevant assignment coversheet will be provided for students to accept or decline the use of the assignment for research purposes, this will be accompanied by a brief written overview of the research purpose, as well as a verbal overview encouraging students to accept.

8.2 Semi-Structured Personal Interviews: The invitation will include consent forms and return envelopes including possible dates for the interviews to be conducted. This will be followed by a follow up phone call if no formal response has been received.

9 Risk Management - Evaluation of Potential Harm or Risk of Harm from Research Procedures

9.1 Researcher Qualifications

The research should only be conducted or supervised by persons with experience, qualifications and competence appropriate to the research. Provide the detail relevant to this project.

9.1.1 Discourse Analysis – Using assignments as a mode of analysing student understanding, minimal research involvement in gaining consent for assignment to be used for research, once assignments are submitted it becomes an unobtrusive research method.

9.1.2 Semi-Structured Personal Interviews

9.2 Vulnerability of the Participants

Are the participants placed in a position of vulnerability by the conduct of or by participating in the research. No

9.3 Balance of Burden/Benefit to the participants

Demonstrate how the researcher/s will ensure that the balance of burden/benefit to the participants is justifiable.

9.4 The possibility of physical stress/distress, discomfort to the participants N/A

9.5 The possibility of psychological/mental stress/distress, discomfort to the participants. N/A

9.6 Deception of participants at any stage of the project. N/A

9.7 The use of drugs, natural/complementary therapies or invasive procedure, such as therapeutic devices N/A
Conducting a Clinical Trial  N/A

10.2 Research Category Codes

<table>
<thead>
<tr>
<th>Type of Activity</th>
<th>(a) %</th>
<th>RFCD Code</th>
<th>(b) %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strategic</td>
<td>50</td>
<td>330299</td>
<td>100</td>
</tr>
<tr>
<td>Applied</td>
<td>50</td>
<td>330299</td>
<td>100</td>
</tr>
</tbody>
</table>

11 Data, Storage, Publication and Dissemination

11.1 Data Storage

11.1.1 Discourse Analysis – Using assignments as a mode of analysing student understanding; Student Numbers are recorded against responses, enabling access to UWS record archive if required. Student responses are submitted electronically and will be stored on the Universities Data Base.

11.1.1 Semi-Structured Personal Interviews – transcripts of the interviews will be stored electronically on the Universities Data Base

11.2 Publication and Dissemination

Results of the research finding will be published in the researcher’s Thesis, and possibly disseminated into conference papers. To insure confidentiality names are removed from participants when used within the study.

12 Privacy of Information

Personal Information of individuals held by government, State and Federal as well as other private organisations should not, in most instances, be accessed without the consent of the person whose information is held on. If the researcher answers yes to any of the below questions they should be aware of and agree to abide by Privacy Principles in dealing with personal Information as set down in Federal and State Privacy Legislation. * Further detail is noted in the Guidelines.

1. Does your research involve the use of existing records, which are not in the public domain? NO

13. Ethics Approval from another Institution  N/A

14 Conducting Research Overseas  N/A

15.1 Chief Investigator Declaration (Student)

I certify that the information given in this application is correct to the best of my knowledge. I acknowledge that I must notify the Committee if there is any ethically relevant variation or if the project is discontinued prematurely. I have read, and agree to abide by the relevant codes of practice for research involving humans. I undertake to submit the mandatory reports required on the progress of my research and at its completion.

Chief Investigator (student) Signature;

Signed................................................
Date................................................

15.2 Student Supervisor Declaration (must be signed when applicant is a student)

I certify that I have reviewed this application and it complies with Ethical Principles in the conduct of research with humans.

Supervisor’s Signature;

Signed..........................................................
Date................................................

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Appendix II Ethics approval and clearance conditions

The letter on the following page is the UWS Human Research Ethics Committee’s response to the ethics application issued October 21st 2005. The committee recommended minor amendments to be made for ethics approval relating to separating the plain language statement from the consent form, as well as specifically disclosing that the data collected will only be used for HDR relating to this thesis, not any research. Figure AII.1 is a copy if this transcript and highlights these alterations that were required for the project to satisfy HREC prior to the commencement of data collection. The changes recommended have been made and are shown in Figure AII.2. Details of the plain language statement and separate consent form are provided in Appendix III and Appendix IV. This was completed prior to the first round of data collection in 2005.
21 October 2005

Stephen Clune
79 Birdwood Avenue
Winmalee NSW 2777

Dear Stephen

Re: HREC 05/175 Developing sustainable literacy of Industrial Designers

The Committee has reviewed your application and advises that the following issues require responses and the project will then be considered for approval.

National Statement Principle 1.7 – 1.12 Informed Consent
1. You are advised that it is inappropriate to ask the participants to agree to the research data being used for any purpose. The consent should indicate that the information gained is only for this particular research.

2. The Information sheet for the research project should be on a separate form to the Assignment Cover sheet and also the consent form should be separate as well.

The Committee requires a response to the outstanding issues within a 3 month period. You should only address the specific issue raised and your responses should be forwarded to Kay Buckley and will be accepted via Email to k.buckley@uws.edu.au. Please ensure that you note the name of the project and the registration number in your response. This project should not commence without full ethics clearance.

Yours sincerely

Associate Professor Christine Halse
Chairperson
UWS Human Research Ethics Committee
Cc Dr Erik Bohemia

Figure AII.1 Ethics approval and conditions
Dear Kay,

Please find amendments for ethics clearance RE: HREC 05/175 Developing Sustainable Literacy for Industrial Designers.

As per your review the following amendments have been made:

1. Consent indicates that the information gained is used only for the research project “Developing Sustainable Literacy for Industrial Designers”.
2. The information sheet for the research project is separate from the consent form, a standard school assignment cover sheet will be used which is also separate. Please see attachment.

Kind Regards,

Stephen Clune

PhD Candidate, Teaching Fellow
School of Engineering & Industrial Design
College of Science, Technology and Environment
University of Western Sydney
MOSAIC University of Western Sydney Building 1797 | Penrith South DC NSW 1797
Contact: Telephone 0422 0674 | Fax 9352 0744 | a.clune@uws.edu.au

Figure AII.2 Correspondence of alterations to comply with ethics
Appendix III Plain language statement

**Developing Sustainability Literacy for industrial Designers**

The relationship between the gap in theoretical knowledge on sustainability and the practice of educating the next generation of industrial designers is an area which has received limited scholarly attention. This is concerning given our current climate, which suggests that society needs to move towards sustainable practices.

This research study aims to explore and investigate the alignment between the sustainability literature and the sustainability curriculum in the Industrial Design program delivered at UWS, considering the fundamental question of ‘what are the key aspects of sustainability that students should be exposed to?’

By comparing the key themes of sustainability that students have been exposed to over the duration of the sustainability stream at the University of Western Sydney, against the key themes of current sustainability literature, valuable insight will be gained, the results of which will have global significance for design educators and policy makers, but importantly allow for the University of Western Sydney to maintain a sustainability stream that is both current and relevant.

Stephen Clune is a PhD Candidate / Teaching Fellow with the University of Western Sydney in Sustainable Design, with a background in Industrial Design.
Appendix IV Informed consent

300309 Sustainable Design: Design Futures
Permission to use your assessment tasks

We would be very grateful if you could please grant us permission to use the work you have submitted in this unit for the research project “Developing sustainable literacy for Industrial Designers”. Results of which may be published in higher degree thesis and scholarly journals.

Your Privacy
Work published will have all identification removed before it is displayed.

What we need
Photographs or Digital copies of your design solutions.
Originals or copies of your scenario narrative.

Please read the statement below, sign and return it if you agree.

<table>
<thead>
<tr>
<th>I, ...................................................................................................(your full name) agree</th>
<th>Please Tick</th>
</tr>
</thead>
<tbody>
<tr>
<td>For Stephen Clune to <strong>photograph</strong> my design solutions if not submitted in a</td>
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<td>Industrial Designers”</td>
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<tr>
<td>For Stephen Clune staff to <strong>copy my original</strong> design solutions presentation for</td>
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<td>use in the research project “developing Sustainable Literacy for Industrial Designers”</td>
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<tr>
<td>For Stephen Clune to <strong>retain my original</strong> scenario narrative for use in the</td>
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<tr>
<td>research project “developing Sustainable Literacy for Industrial Designers”</td>
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<td>For Stephen Clune to <strong>copy my original</strong> scenario narrative for use in the</td>
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<td>research project “developing Sustainable Literacy for Industrial Designers”</td>
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</tr>
</tbody>
</table>

Your signature: ...............................................................

Date: .................................................................
Appendix V Assessment task alterations

The following pages present the assessment tasks from the unit handout for Unit 300306 Sustainable Design: Sustainable Futures at the University of Western Sydney in the years 2006 and 2007. The timing of the assessments has altered to present a more streamlined unit to emphasise the task at hand. For discussion on the changes see Chapter 6, *from theory to pedagogy*.

10.8 Assessment Tasks 2006

Assessment of the subject is based on the completion of the following components:

**Part A Research Portfolio** 20%
- Shared Trends Research (Group + Individual) 20% Due Friday, Week 13
  - Submitted within tutorials

**Part B Our Unsustainable Past** 30%
- Annotated Bibliography (Individual) 20% Due Friday, Week 5
  - Submitted via Web CT
- Presentation of tutorial question (Group) 10% Due Friday, Week 7
  - Presented during tutorials

**Part C Sustainable Solutions & Scenarios** 50%
- Scenario Narrative (Individual) 20% Due Friday, Week 13
  - Submitted via Web CT
- Design solutions (Individual) 15% Due Friday, Week 14
  - Presented during tutorials
- Presentation (Group) 10% Due Friday, Week 14
  - Presented during tutorials
- Reflection on Learning & Peer Assessment 5% Due Friday, Week 14
  - Submitted via Web CT

Groups of 4–5 will select a research theme based on categories carried over from the My Stuff Journal in Sustainable Design: LCA. Groups will investigate:
- Sustainable WATER futures
- Sustainable TRANSPORT futures
- Sustainable ENERGY futures
Sustainable CONSUMPTION futures
Sustainable FOOD futures

Students should note that final marks and grades are subject to confirmation by the School and College Assessment Committee, who may scale, modify or otherwise amend the marks and grades for the units as may be required by University Policies. Based on the outcomes from the first workshop, students will individually write a sustainable future scenario of 2000 words that describes the future in depth with reference to trends researched in the research portfolio assessment. Each student will also develop design concepts (described in their scenarios) that are to be showcased in the group presentation which serve to visualise a sustainable future according to their research field (transport, water, consumption, energy & food).

Part A Research Portfolio 20%
Shared Trends research 20%
Each student collects 12 articles from popular and academic sources over the semester related to their chosen trends research topic. These will be checked throughout the semester by your tutor. The articles are to be annotated (100 words) and put into a group research portfolio for other students to draw upon for their long-term scenarios.

The research portfolio must be brought to each tutorial wherein trends will be discussed. The idea is to research trends (sustainable and unsustainable) in the present that will impact upon these fields over the next 15 years (by 2020). Each student should track trends directly related to their main theme and other categories that will impact upon them, including: technology, lifestyle, politics, the economy, law, public opinion and morality and science. Each group member is to be assigned two categories to investigate.

The annotation is a paragraph of word-processed text attached to the original article that provides the full reference for the article and briefly explains the trend(s) discussed in the article and how it impacts upon the broader research theme. For example, a new development in nanotechnology could potentially reduce water consumption in the future.

The research portfolio is due in Week 13 and must be segmented into sections clearly marked with the name of each student and the research categories they are responsible for. It must also contain a summary spreadsheet of the trends (template provided on web CT).

Assessment Criteria
- relevance of articles,
- range and quality of sources, and
- Quality of annotations (referencing, spelling, grammar, explanations).

Each week that articles and annotations are due, your tutor will check that you have completed the work: half a point will be deducted from the Research Portfolio assessment for each missing article throughout the semester. If you are absent without documented cause, points will automatically be deducted.

Part B Our Unsustainable Past 30%
Tutorial Question (Group) 10%
As a group, you are to present a response to the following questions (based upon your group’s research field) in a 15 minute presentation to your tutorial group in Week 7.

- Sustainable WATER Futures
  What are the historical bases for the current unsustainability of NSW’s water supply and demand? How is design implicated in this unsustainability?

- Sustainable TRANSPORT Futures
  What are the historical bases for the unsustainability of NSW’s transport system? How is design implicated in this unsustainability?

- Sustainable ENERGY Futures
  What are the historical bases for the unsustainability of NSW’s energy supply and demand? How is design implicated in this unsustainability?

- Sustainable CONSUMPTION Futures
  What are the historical bases for Australia’s overconsumption of material products? How is design implicated in this unsustainability?

- Sustainable FOOD Futures
  What are the historical bases for the unsustainability of Australia’s supply and demand of food products and eating habits? How is design implicated in this unsustainability?

Assessment Criteria
- Strength of argument
- Evidence of comprehensive research
- Clarity of presentation
- Entertainment Value

Annotated Bibliography 2000 words (Individual) 20%
Each student is to carry out research in order to answer the group question. Each student is to write an annotated bibliography covering 4 sources not being used by other members of the group. These sources must include one refereed journal article of at least 2500 words and one academic book chapter. Details on how to write an annotated bibliography will be provided in your first tutorial in Week 2. Sources must be checked by your tutor in Week 3.

Assessment Criteria
- Quality and relevance of sources
- English Expression
- Demonstrated understanding of the source’s main arguments and findings

Scenario Narrative 20%
A draft version is required in the Week 11 tutorial: submission of the draft is mandatory. You will receive feedback in Week 12 so that suggestions can be implemented before final submission in Week 13.

From the Week 5 Workshop, you will have been assigned a quadrant of the matrix and have a good idea of what this world looks like: you will have a series of bullet points based on certain and uncertain trends analysis and a timeline up until the year 2020. In the second workshop in Week 10, we will treat each matrix quadrant as a ‘map’ within which we will find design intervention points based upon the identification of positive and negative trends analysis (positive and negative in terms of long term sustainability). These intervention points will form the basis of your
Appendix V Assessment task alterations

Design brief to either buck negative trends or enlarge positive ones and will be the basis for design concept generation. This is where we get to apply design skills to bring about feasible, sustainable futures and to creatively generate sustainable design concepts.

What happens when trends are analysed, elaborated, mixed with other trends and bucked or enlarged is described through scenario narratives: a creativity tool to develop and communicate alternative futures. Scenarios are creative because they remove us from the ‘blinders’ of current ways of thinking, allowing us to imagine things differently. But they are not idealistic or extremely bad: they must demonstrate an understanding of the dynamics of change and be based upon sound trends research (which you are assembling in your group research portfolios). The analysis and elaboration of your certain trends within your matrix should help keep the narratives real: there are certain trends that will not go away and that you must work with, for example: climate change, water scarcity, and population growth.

Format: a story, all text, with footnotes referring to your group’s trends research (the group portfolio’s articles). For each thing that happens leading up to or in 2020 that you describe, you need a footnote referring back to the original trend the elaboration is based upon. It can be a movie script, a TV show, a letter to a friend, a newspaper article, a short story. It should contain a protagonist (hero/anti-hero), other actors, a setting, back-casting (explaining the history leading up to 2020) and sustainable design concepts being used to support sustainable behaviours. These ideas must be designable: do not rely on government policy interventions, tax reform or ‘awareness raising’ techniques: you must focus on design as behaviour-changing (i.e. you cannot buck a negative trend by wiping it away with policy or posters: acknowledge design’s agency). It should centre around your group’s research theme: WATER, FOOD, CONSUMPTION, ENERGY, TRANSPORT but can also integrate wider sustainability.

Assessment Criteria
- Creativity:
  - Ability to think relationally (how well you elaborate on the mixing of trends and really think through the potential consequences of individual and mixed trends according to first, second & third order trends)
- Narrative style (entertainment value)
- Adeptness at finding design intervention points
- Feasibility, Based on trends research, and an understanding of the dynamics of change (we won’t all become hippies overnight nor will NSW become a totalitarian state by 2020)
- Clarity of English expression
- Write complete, grammatically correct sentences; proof read your work; use a consistent footnoting system; choose a legible typeface etc.
- Demonstrated understanding of sustainability and behaviour change through design
  - How well you have used this exercise to come up with designs that facilitate sustainable behaviours.

Design Solutions 15%
You are to visualise the system of your future scenario, your system will require products, systems or services designed to move towards long term sustainability.
Appendix V Assessment task alterations

Two design solutions each are to be presented within the group presentation. Your designs should not be presented in isolation but in the context of use in everyday life, you need to showcase how your designs facilitate sustainable behaviour.

Your design solutions should be hand drawn presentation concept renderings describing what the design is, how it is produced, and how it works etc. Tip: do a good hand perspective sketch; scan it into Illustrator, type in the text, use text and arrows to highlight design features. If it is a system, do a system diagram in Illustrator and then story board how the user uses the system. Please propose your presentation strategy to your tutor well in advance of submission. It is OK to embed the design solutions within the group’s Powerpoint presentation as long as it is clear who did what. 3D CAD generated images are not allowed.

Assessment Criteria
- Degree to which the designs facilitate sustainable behaviour
- Feasibility (based on your scenario context in terms of its technological, social or economic status)
- Design communication (presentation skills (how well you convey 3-dimensionality, how the design works), professionalism, and clarity).

Group Presentation 10%
Visualise and verbally present a sustainable future scenario for your research theme in a 10 minute PowerPoint* presentation. Present a sustainable everyday scenario based on the year 2020 supported by your design solutions: make it desirable, realisable and as close an approximation as possible to what it would be like to live in this way.
*Please feel free to negotiate alternate modes of presentation

Assessment Criteria
- Art direction: clarity, how well you set the scene, visual congruence
- Entertainment Value
- Desirability and feasibility of the future in terms of long term sustainability
- Peer Assessment of Group Participation & Reflection on Learning 5%
- Details available on Web CT, for Submission week 14

10.9 Assessment tasks 2007

Part A Our Unsustainable Past 30%
Annotated Bibliography (Individual) 20% Due Friday, Week 3
Submitted via Web CT
Presentation of tutorial question (Group) 10% Due Friday, Week 4
Presented during tutorials

Part B Present: Research Portfolio 25%
Shared Trends Research (Group + Individual) 25% Due Friday, Week 10
Submitted within first workshop

Part C Future Sustainable Solutions & Scenarios 40%
Scenario Narrative (Individual) 20% Due Friday, Week 11
Submitted via Web CT
Reflection on Learning & Peer Assessment 5% Due Friday, Week 13
Submitted via Web CT
Design solutions (Individual) 20% Due Friday, Week 14
Exhibited during tutorials

Part A. Tutorial Question – Our Unsustainable Past 30%
Part A is linked to the following learning outcomes associated with this unit:
Develop the capability of strategic foresight as a creative and practical means of solving novel problems
I. Annotated Bibliography, 1500 words 20%. Submitted prior to midnight Thursday Week 3 Submitted via WebCT (Individual)
In this assessment, students will learn about the relationship between sustainability and design history through ‘backcasting’.

Each student is to write three annotated bibliographies; two annotations from the provided list and one annotation found through your own research. The sources must be either a refereed journal article of at least 2500 words or an academic book chapter. Details on how to write an annotated bibliography will be provided in your first tutorial in Week 2. Assessments that do not include appropriate referencing or that are from sources that do not meet the above criteria will be returned for resubmission.
The annotation must articulate:
- The key argument and or findings from the article
- How the article assists in answering the tutorial question (see part II)

Assessment criteria
- Clarity of English expression. Write complete, grammatically correct sentences; proof read your work; use a consistent referencing system; choose a legible typeface etc
- Demonstrated understanding of the source’s main arguments and findings.
- How well you have related the findings to the research question.

II. Tutorial Question 10% Friday, presented during tutorials Week 4 (group presentation)
In this assessment, learning objectives relate to back casting, sustainability and managing group work
Based on your group’s research field, you are to respond as a group to the following question within a 15 minute presentation;
‘From a historical perspective, why are we unsustainable, how has design contributed to this unsustainability?’
You should answer the above question in relation to your spatial area of the house.

Assessment Criteria
- Strength of argument
- Evidence of comprehensive research
- Clarity of presentation
- Maintain Engagement with Audience

Part B. Present: Research Portfolio 25%
Part B is linked to the following learning outcomes associated with this unit:
Develop the capability of strategic foresight as a creative and practical means of solving novel problems.
Submitted in person 9am Friday Week 10 (individual work presented in group folder)
In this assessment, learning objectives relate to trends research and analysis. The research portfolio’s purpose is to identify current trends within today’s society, and think through how the present trends may impact upon your research field and a sustainable society over the next 15 years (by 2022).

I. Individual 15%
You are to collect 16 articles from popular and academic sources over weeks 5–10 in relation to your chosen research field. The articles are to be annotated (100 words) and will contribute to your group research portfolio. The annotation is a paragraph of word-processed text attached to the original article that provides the full reference for the article. The annotation briefly explains:
- the trend(s) discussed in the article
- how the trend may impact upon long term sustainability

In week 7 and week 8, 4 articles and annotations must be brought to the tutorial for discussion.

Assessment Criteria
- Quality of annotations (referencing, spelling, grammar, explanations).

II. Group Component 10% Due in Week 10
In this assessment, Learning objectives relate to managing group work. As a group you are to compile a research portfolio complete with trends table (available on WebCT). You are to insure that your research portfolio has a balance of articles from the following areas:
- Technology, Policy and legislation
- Consumption, Families and relationships
- Health, Work and leisure
- Biophysical environments

The portfolio must be segmented into sections clearly marked with the name of each student and the research categories they are responsible for. It must also contain the completed trends table (template provided on WebCT).

Assessment criteria
- Relevance of articles,
- Range and quality of sources,
- Participation in weekly peer assessment and tutorial discussion

Part C. Future Sustainable Solutions & Scenarios 45%
Part C is linked to the following learning outcomes associated with this unit: Implement strategic foresight as a tool for contributing positively to sustainable change in a diverse and evolving world.

Based on the outcomes from the first workshop, students will individually write a sustainable future scenario of 1500–2000 words that describes the future in depth with reference to trends researched in the research portfolio assessment.

I. ‘A Day in the Life’ Scenario Narrative 20% Thursday, Week 11 Submitted via WebCT (Individual)
In this assessment, learning objectives relate to sustainability and strategic foresight, back casting, trends analysis, scenario development and product concept development.

As a continuation of the week 10 workshops, you are to describe a ‘day in the life scenario’ of your persona in the year 2022 based upon your matrix. From the workshop you will have a good idea of what this world may look like; you will have
a series of bullet points based on certain and uncertain trends analysis and a timeline up until the year 2022.

Scenarios are a creativity tool to develop and communicate alternative futures. They are creative because they remove the ‘blinkers’ of current ways of thinking, allowing us to imagine things differently. What happens when trends are analysed, elaborated, mixed with other trends and described? Scenarios should not, however, be overly idealistic or extremely bad: they must demonstrate an understanding of the dynamics of change and be based upon sound trends research (which you are assembling in your group research portfolios). The analysis and elaboration of your certain trends within your matrix should help keep the narratives real: there are certain trends that will not go away and that you must work with, for example: climate change, water scarcity, and population growth.

Format: a story, all text, with footnotes referring to your group’s trends research (the group portfolio’s articles). It can be a movie script, a TV show, a letter to a friend, a newspaper article, a short story. For each thing that happens leading up to or in 2022 that you describe, you need a footnote referring back to the original trend the elaboration is based upon.

**Assessment Criteria**
- Creativity: Ability to think relationally (how well you have thought through the potential consequences of first, second and third order trends)
- Narrative style (entertainment value)
- Feasibility based on trends research, and an understanding of the dynamics of change (we won’t all become hippies overnight nor will NSW become a totalitarian state by 2022)
- Clarity of English expression. Write complete, grammatically correct sentences; proof read your work; use a consistent footnoting system; choose a legible typeface etc.

**II. Reflection on Learning 5% Friday, Week 13 Submitted within tutorial**
In the second workshop you developed a variety of sustainable design concepts. You are to reflect upon the selection of your design solutions, and develop the solutions further based upon those reflections. A guide is provided on WebCT to assist in your reflection.

**Assessment Criteria**
- Depth of Reflection
- Clarity of English expression. Write complete, grammatically correct sentences; proof read your work; choose a legible typeface etc.

**III. Design Solutions 20% Friday, Week 14 Presented during tutorials (individual, presented within group presentation)**
In this assessment, learning objectives relate to sustainability and strategic foresight, scenario development and product concept development.
You are to present two design solutions (products, systems or services). The design solutions are to be presented in the context of use in everyday life, you need to showcase how your designs facilitate sustainable behaviour. The design solutions are to be presented within one of the templates provided on WebCT.

**Assessment Criteria**
- Degree to which the designs facilitate sustainable behaviour
- Desirability and feasibility of the future in terms of long term sustainability (based on your scenario context in terms of its technological, social or economic status)
- Design communication (present)
Appendix VI Suggested readings for the annotated bibliography in 2007

The references below were provided to students in 2007 on WebCT (UWS online teaching interface) as suggested readings for the first assessment task, the annotated bibliography. The timeframe to complete the assessment task had been reduced from five weeks to three, therefore the suggested reading assisted students to locate quality articles in a shortened timeframe.

**Kitchen—How has technological innovation and convenience changed the kitchen?**


http://www.cric.ac.uk/cric/events/kitchens/programme.htm

**Laundry—How have laundry practices changed, why is the laundry so energy and water intensive?**


Bathroom—How have cleaning habits changed over time, why does the bathroom consume so much?
Appendix VII Four quadrant method of strategic foresight

Outlined below is the process for the ‘four quadrant’ method of strategic foresight that was used within the unit Sustainable Design: Sustainable Futures to generate probable future scenarios in the first of two intensive day-long workshops. The purpose of the method is to present a cumulative snapshot of possible worlds in 2020.

The key trends identified prior to the workshop (compiled from contemporary trends research) are separated into certain and uncertain trends (Step 1). The two most crucial ambiguous trends are selected (Step 2), the extreme opposing ends of the continuum are identified (Step 3). Students are required to justify their decisions by asking five why questions and finally create a sentence describing each of the opposing trends identified (Step 4)

<table>
<thead>
<tr>
<th>Step 1. Housing Certain and Uncertain Trends</th>
</tr>
</thead>
<tbody>
<tr>
<td>Certain</td>
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<tr>
<td>- Ageing population</td>
</tr>
<tr>
<td>- Higher incomes</td>
</tr>
<tr>
<td>- Expensive energy</td>
</tr>
<tr>
<td>- Increase in homes/capita</td>
</tr>
<tr>
<td>- Increase in population in NSW</td>
</tr>
<tr>
<td>- Longer work hours</td>
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<table>
<thead>
<tr>
<th>Step 2. Selection of Two Crucial Ambiguous Trends</th>
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<td>- Longer work hours</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Step 3. Opposing Ends of Critical Trends</th>
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<tbody>
<tr>
<td>High Density Housing vs Urban Sprawl</td>
</tr>
<tr>
<td>Home Ownership vs Renting</td>
</tr>
</tbody>
</table>
Step 4. Explanatory sentence

‘High density housing has increased in popularity, with a steady increase of people migrating to the city centres.’

The future impact of the opposing ambiguous trends is extrapolated (Step 5). For example, urban sprawl and increase in home ownership may lead to larger house sizes in new developments which result in increased car dependency, but may also offer greater possibilities for decentralised onsite production of energy, water and food because of the greater amount of land owned.

Step 6 then imports the remaining contemporary trends that students have gathered to see how they ‘play out’ differently in each quadrant. This process is seen to lead to four probable but very different future worlds. The following step is for students to develop a future ‘scenario narrative’ for one particular quadrant explaining a ‘day in the life’ of the quadrant.
The template below was provided to students in the 2007 intervention to assist in the peer review process of their contemporary trends research.

<table>
<thead>
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<th>Article one - topic</th>
<th>Quality of annotations (referencing, spelling, grammar,) on a scale of 1-5, see guiding scale below</th>
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<td>2. Annotation handwritten summarising key themes</td>
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<td></td>
<td>3. Good: Word published, writing may be more articulate or refined (i.e. after reading eight annotations it becomes repetitive)</td>
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<tr>
<td></td>
<td>4. Very good: Almost excellent word published but may be missing something for full marks</td>
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</tr>
<tr>
<td></td>
<td>5. Excellent: Word published, Perfect full citation, easy to read, articulate, perfect spelling and grammar, written in full sentences</td>
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<tr>
<th>Relevance</th>
<th>On a scale of 1-5 how well does the annotation identify the key theme of the article</th>
<th>___ /5</th>
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<td>From 1-5 how well does the annotation identify the impact for long term sustainability and or your topic area</td>
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<td>On a scale of 1-5 how well does the annotation identify the key theme of the article</td>
<td>___ /5</td>
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<tr>
<td></td>
<td>On a scale of 1-5 how well does the annotation identify the impact for long term sustainability and or your topic area</td>
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<td>On a scale of 1-5 how well does the annotation identify the key theme of the article</td>
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<td>From 1-5 how well does the annotation identify the impact for long term sustainability and or your topic area</td>
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<td>Relevance</td>
<td>On a scale of 1-5 how well does the annotation identify the key theme of the article</td>
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<td>From 1-5 how well does the annotation identify the impact for long term sustainability and or your topic area</td>
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<th>Article five topic</th>
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<td>On a scale of 1-5 how well does the annotation identify the key theme of the article</td>
<td>___ /5</td>
</tr>
<tr>
<td></td>
<td>From 1-5 how well does the annotation identify the impact for long term sustainability and or your topic area</td>
<td>___ /5</td>
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</table>

<table>
<thead>
<tr>
<th>Article Six - topic</th>
<th>Quality of annotations (referencing, spelling, grammar,) on a scale of 1-5</th>
<th>___ /5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relevance</td>
<td>On a scale of 1-5 how well does the annotation identify the key theme of the article</td>
<td>___ /5</td>
</tr>
<tr>
<td></td>
<td>From 1-5 how well does the annotation identify the impact for long term sustainability and or your topic area</td>
<td>___ /5</td>
</tr>
</tbody>
</table>
The table below illustrates present businesses that support innovation within Australia that may be of assistance in realising the entrepreneurial proposals presented by Industrial Design students. Government grants that support environmental innovation are also presented. The table is a resource that may be drawn upon in presenting the vocational variation of DfS entrepreneurship to students.

*Table AIX 1 Schemes and grants to support innovation*

<table>
<thead>
<tr>
<th>Business or Scheme to Encourage Innovation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ausinvent Innovation Advisory Services</td>
<td>For free innovation advice and referral to help develop your bright idea, please contact your nearest Innovation Advisory Service listed below. Provide an Internet service to promote innovation and stimulate the development of new products and business expansion. AusInvent Innovation Services is an electronic marketplace of innovation services.</td>
</tr>
<tr>
<td>The Australian Institute for Commercialisation</td>
<td>The AIC is a national, not-for-profit company dedicated to enhancing Australia’s ability to commercialise its research and development (R&amp;D) in the global marketplace. The AIC is supported by federal and state government agencies, research organisations, business, industry and service providers to deliver national programs for commercialisation success.</td>
</tr>
</tbody>
</table>
### Community Builders
Looking for funding for your community project? Here's a list of funding programs from federal, state and local government, as well as institutions, philanthropic trusts and companies. All NSW Government grants are currently being added to this site, but only selected grants from other types of funders will be available here.

### Business Angels
An Australian matching service for private firms and private investors. Business Angels Pty Ltd provides a central register for private investors and businesses. The needs of the business are matched with the private investors’ criteria on a fee-for-service basis.

### Entrepreneur Business Centre
A niche small business site specifically targeting people who are in the process of starting or developing a small business.

### Knowledge Commercialisation Australasia
The peak body representing organisations and individuals associated with knowledge transfer from the public sector. Assists in development and maintenance of skills associated with knowledge transfer (the process for transferring knowledge and technology to the commercial sector) from public sector organisations.

### Industry Capability Network (ICN)
An independently managed, non-profit organisation financially supported by State, Territory and Commonwealth Governments. The Network provides companies with a sourcing service to identify competitive local sources to meet procurement and project needs, irrespective of the business.

### Innovation Exchange Network
The first-ever knowledge exchange network to provide a secure, managed environment for the exchange of insights and opportunities between firms, universities and governments.

### Australian Government Schemes for Innovation

<table>
<thead>
<tr>
<th>Scheme</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austrade</td>
<td>The Australian Trade Commission (Austrade) helps Australian companies win overseas business for their products and services by reducing the time, cost and risk involved in selecting, entering and developing international markets.</td>
</tr>
<tr>
<td>AusIndustry</td>
<td>Assists businesses in conducting research, growing small businesses, undertaking manufacturing and production, commercialisation and venture, applying for tax or duty concessions, gaining access to science resources and checking eligibility.</td>
</tr>
<tr>
<td>Backing Australia’s Ability</td>
<td>The Commonwealth Government’s commitment to innovation—Backing Australia’s Ability—is about harnessing collective talent, energy and resources by generating new ideas and bringing them to life as exciting new Australian products, processes, services and businesses.</td>
</tr>
</tbody>
</table>
**Australian Technology Showcase**  
A promotional and networking government program targeted at small and medium sized Australian business enterprises with innovative, cutting edge technologies. It aims to encourage exports and increase employment by promoting member technologies on the domestic and international markets.

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### NSW Government Environmental Grants

<table>
<thead>
<tr>
<th>Program</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Climate Action Grants program, NSW Greenhouse Office</td>
<td>Funding is available for projects that reduce greenhouse gas emissions, or help the NSW community to adapt to the impacts of climate change.</td>
</tr>
<tr>
<td>Energy Savings Fund, Department of Energy, Utilities &amp; Sustainability</td>
<td>Grants are available for projects that reduce peak demand and overall electricity consumption, and reduce related greenhouse gas emissions in NSW.</td>
</tr>
<tr>
<td>Environmental Education grants, NSW Environmental Trust</td>
<td>The Environmental Education program supports educational projects or programs that develop or widen the community’s involvement in protecting the environment.</td>
</tr>
<tr>
<td>Environmental Research grants, NSW Environmental Trust</td>
<td>The Environmental Research program supports research projects that help address environmental problems in NSW.</td>
</tr>
<tr>
<td>Green Business Program, Department of Environment and Climate Change</td>
<td>Supports projects which will save water and/or energy in business operations in NSW.</td>
</tr>
<tr>
<td>Renewable Remote Power Generation Program (RRPGP) in NSW, Department of Energy, Utilities and Sustainability</td>
<td>RRPGP provides rebates for eligible renewable generation equipment installed in remote areas of NSW.</td>
</tr>
<tr>
<td>Urban Sustainability program, NSW Environmental Trust</td>
<td>The Urban Sustainability program supports projects of significant environmental benefit to NSW.</td>
</tr>
<tr>
<td>Water Savings Fund, Department of Energy, Utilities &amp; Sustainability</td>
<td>The Water Savings Fund provides grants for water saving and recycling projects within Sydney Water’s area of operations.</td>
</tr>
</tbody>
</table>
Appendix X Dissemination of findings in peer reviewed conference papers

Three peer reviewed conference papers have included the research of this thesis:


Conference Paper 1: Future scenario planning as a tool for sustainable design education and innovation

The paper on the following pages was presented in 2007 at the Connected International Conference on Design Education. The paper was presented with colleagues from the Sustainable Design Stream Team from the University of Western Sydney. The paper highlights the dissemination of strategies developed in Chapter 5, such as the human-centred functional design brief and creativity tools, while providing the theoretical background to the approach taken within the unit 300306 Sustainable Design: Sustainable Futures, which was the unit that provided the sample for this thesis.
Future Scenario Planning as a tool for sustainable design education and innovation

Abby Mellick Lopes, Stephen Clune, Tara Andrews
University of Western Sydney, Penrith, NSW, 1797, Australia

ABSTRACT

Industrial design education has traditionally focused on the development of material product solutions that best serve requirements and criteria set by a client. Design innovation commonly results in shortened product lifecycles, which supports the net escalation of resource consumption and waste. It is proposed that the context of sustainability, fundamentally at odds with this tradition, requires innovation not only in terms of the nature of the design solutions provided, but also in terms of the ability of aspiring designers to critically address, and generate design criteria in response to new problem contexts. Ultimately sustainability challenges the perceived role of design and the ideal ‘graduate attributes’ of designers. This clearly has implications for how sustainable design is taught.

This paper explores future scenario planning as a highly appropriate context for the development of this innovation capability. Scenario planning has recently become an important tool for envisioning sustainable futures (Manzini 2003). Offered to students as an intensive workshop that emulates a collaborative problem-solving design exercise, scenario planning provides a novel forum for the generation of, reflection on and debate about possible design solutions or ‘concrete hypotheses’ (Manzini 2002) for more sustainable ways of living, working and playing.

Outlining the strategic value of a range of foresight concepts, methods, technologies and creativity tools, the paper offers explicit, practical examples of how these tools can be effectively integrated into a future scenario planning workshop. In particular, it is the change agency sought by such tools that shares strong synergies with innovation in design. Finally, the paper analyses the problems and opportunities associated with the promise and ambition of this style of education.

INTRODUCTION

Scenario planning has a long history in design as a way of generating visions of the future. The significance of the relation between design and planning on the one hand, and the development of unsustainability on the other, is however, quite recent (Fry 1999).

The context of sustainability is fundamentally at odds with the traditional product focus of industrial design education and practice. In order to plan for more sustainable ways of living, working and playing, designers need to expand the context of their practical decision-making well beyond narrow conceptions of the client, market and product. They need practical experiences of design as a potentially future changing activity. This paper seeks to present this argument in the context of our future scenario planning activity within the Sustainable Design program at the University of Western Sydney.

I. HOW WE HAVE COME TO UNDERSTAND SCENARIO PLANNING: THREE THEORETICAL CONTEXTS

Over the last four years, we have developed a hybrid model of scenario planning for sustainable futures drawing on a range of theoretical sources. Here, we will outline just three of those sources. The first, Strategic Foresight (SF), is invested in developing fast growing and strategically clever future businesses based on trends analysis and creative, lateral thinking. Foresight practitioner and author Dominique Purcell (Marsh et. al. 2002) helped design our early workshops and introduced us to some effective techniques to facilitate future scenario planning. SF seeks to read trends forward or ‘stand in the future’ and ‘backcast’ how to get there from here. It thinks across sectors and skill bases. It is convergent in terms of bringing seemingly disconnected aspects together, but also highly object oriented and outcome driven, so that the individual with foresight is rewarded with the best possible ‘market position’ in the future. Much of the technical design of our intensive workshops we learnt from this approach. The process of gathering data on emerging trends, analysing the potential consequences of those trends using a matrix and finally visualizing possible future worlds based on this analysis, is a process we continue to utilise as part of our hybrid model.

While SF has a conventional approach to sustainability based on the Triple Bottom Line strategy of reporting on environmental, social and economic factors (Elkington 1997), it is driven by economic decision-making and has poor recognition of the impacts of fast, product-based innovation. For the purposes of designing for sustainability, the foresight model is limited by an assumption that growth in technological contexts correlates with a growth in knowledge and future opportunity, unrestricted by how things are in the present (Marsh et. al 2002). This thinking sustains the development approach without questioning resource throughput; it misses the significance of design in facilitating the ability of new ideas to take shape and break
Appendix X Dissemination of findings in peer review conference papers

out of old practices, and the overarching reality of unsustainability that must be designed with. Knowledge must be linked to existing material conditions. For an individual to claim an advanced position, the networks and systems that an individual exists within must also be supported.

A very different approach to scenario planning emerged from the work of Ezio Manzini and Francois Jegou (2000) who conceived scenario planning as a design tool for facilitating the sustainability of human communities. The design-orienting scenario (DOS) expands upon the idea of scenarios as 'visions' or slices of future life and sees them instead as 'concrete hypotheses' that can be compared and judged much as a range of alternative design concepts might be developed in response to a brief. While SF supports design innovation as the proliferation of solutions customised for individual consumers, the DOS is strongly systems-oriented and emphasises the design of feasible ways to share resources and enhance social and environmental well-being.

Manzini and Jegou's scenarios support a view of design where the brief emerges less from a specific client or from a situation in which certain new everyday activities emerge. SF tends to privilege the capacity of technological innovation to drive change. The DOS on the other hand foregrounds the results needed by a community. Desirable practices are imagined and then products or services that would be needed to make that scenario feasible are proposed.

There are three key aspects to this approach that distinguish it from other forms of futures thinking. Firstly, the emphasis is on everyday human practice rather than on macro trends. Secondly, the approach highlights the significant role of design in facilitating change through 'bottom up interventions'. Third and most importantly, is the critical notion of interdependent well-being that can only be achieved by thinking communally.

The third theoretical context informing our model of future scenario planning is Tony Fry's (1999) concept and practice of 'defuturing'. The insight of defuturing is that where we are now is a consequence of design decisions made in the past; the pathways into current epic problems such as climate change were in part 'planned blind' by design. The practice of defuturing entails 'reading' the extent to which any design contributes to or diminishes future sustainability. Students practice defuturing as a way of preparing for the intensive creative activity of future scenario planning. They enter their second workshop having researched the history of particular current problems such as carbon-dependent transportation, and therefore with a good understanding of how the problem came to be and how it is likely to evolve given present indicators. Understanding the historical context as it has shaped both our material environments and our thinking puts the student designer in a far better position to design 'bottom up interventions' and to actively participate in the evolution of sustainability.

II. PAST CONTEXT: HOW DESIGN 'PLANNED' UNSUSTAINABILITY

Since its inception, industrial design has been enamoured with designing the future. The early American industrial designers working in the 1930s who established the profession, presented themselves as leaders and forecasters of style. Future trends research was encouraged in Harold Van Doren's widely read textbook Industrial Design (1940:49) as a means of keeping up with technological trends and a fickle consumer market. Beyond the immediate commercial demands to apply market foresight, industrial designers fashioned themselves as visionary leaders, able to see beyond the present to design future worlds. Norman Bel Geddes most famously presented this persona in Horizons (1935), which contained future narratives of things to come illustrated with fantastic futuristic designs. Bel Geddes, like a number of his contemporaries believed that the rapid changes being witnessed in the modern world were signs that a utopian future was on its way to being realised and that industrial designers had a significant role to play in shaping it.

The most concrete and influential visions of the future were presented in exhibits designed for the 1933 New York World's Fair. Industrial designers were responsible for the most-visited exhibits, including General Motors' Futurama (Bel Geddes), Democracy (Henry Dreyfuss), Consolidated Edison's City of Light (Teague) and the Transport Exhibit in the Chrysler Pavilion (Raymond Loewy). These exhibits were hugely popular and deployed elaborate exhibition techniques to dramatise detailed and compelling visions of the future.

More than five million people saw Bel Geddes' Futurama which took the audience on a 16 minute simulated low plane flight tour of America in the year 1960—a 35,000 square foot model made from one million trees, 50,000 tear-drop shaped vehicles and half a million buildings. The landscape was viewed from the air as carefully planned cities and pastoral areas connected by a superhighway system (Nye 1994:218ff). In its presentation of a utopian future, industrial design positioned itself as a societal guidance system, reflecting and projecting a belief that the world required ordering from an elitist position held by the designer. These visions sought not only to design a future, but to accelerate the path to it. Such faith in planning the future from above resulted in a failure to see that designing only happens from within a system. Rather than speed up the arrival of a utopian future, this form of future planning sped up the rate of change itself and accelerated unsustainable rates of consumption (Fry 1999:121).

These early future scenarios had faith in the expert, visionary leader and exclusively Western perspective. They were presented as complete and detailed but devoid of humanity; people were absent in the visions, reflecting a failure to grasp future social relations (Nye 1994:221). The appeal of constructing idealist utopias devoid of life still informs many contemporary design visions of the future.

At the University of Western Sydney, future scenario planning assumes a participatory, human-based approach, capitalising on human capacity, skills and everyday experience. The focus is on reorienting ordinary unsustainable behaviours. The scenarios are hypotheses of everyday activity rather than top-down, all encompassing
Appendix X Dissemination of finding in peer review conference papers

III. SCENARIO PLANNING WORKSHOP OUTLINE

The majority of our scenario planning activity takes place in two intensive day-long workshops as part of Sustainable Design: Sustainable Futures, a second year core unit within our undergraduate degree. We have found the intensive workshop process to be a highly effective means of encouraging collaborative idea generation and cooperative learning.

Students are split into groups of four with each group selecting a major thematic to study from water, energy, food, transport and consumption. These themes allow for macro research but also micro design proposals for facilitating everyday sustainable practices. Each group selects a theme to explore for their future scenarios based on the year 2020.

The following figure outlines the process of future scenario planning over the semester. The objectives, activities, methods and tools used are explained below with an example.

![Figure 1: Future Scenario Planning over the semester](image)

To understand our current unsustainable, students are asked to ascertain and present the historical bases for current problems within their thematic area. They also reflect on how design is implicated in this unsustainability following Fry’s theory of defuturing.

Contemporary trends research is used to project how trends may impact on the future. This is achieved through identifying current trends from popular and academic sources. A trends table template is then used to compile the data projecting the long term impact of the trends (SF). The purpose of Workshop 1 is to present a cumulative snapshot of possible worlds in 2020. For future mapping we use the Matrix Model (SF) to develop four possible worlds around the themes. Contemporary trends research is used in SF to foresee how today’s trends may influence the future.

Key trends are identified prior to the workshop and separated into certain and uncertain trends (Step 1). The two most crucial uncertain trends are selected (Step 2) and the extreme opposing ends of the continuum are identified (Step 3).

Students are required to justify their decisions by asking five ‘why’ questions and finally creating a sentence describing each of the opposing trends identified (Step 4).

**Step 1: Certain and Uncertain Trends in Housing**

<table>
<thead>
<tr>
<th>Certain</th>
<th>Uncertain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ageing population</td>
<td>Density per hectare</td>
</tr>
<tr>
<td>Higher incomes</td>
<td>Home ownership</td>
</tr>
<tr>
<td>Expensive energy</td>
<td>Mean House size</td>
</tr>
<tr>
<td>Increase in homes/capita</td>
<td>etc</td>
</tr>
<tr>
<td>Increase in population in NSW</td>
<td></td>
</tr>
<tr>
<td>Longer work hours</td>
<td></td>
</tr>
</tbody>
</table>

**Step 2: Selection of Two Crucial Uncertain Trends**

<table>
<thead>
<tr>
<th>Certain</th>
<th>Uncertain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ageing population</td>
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<td></td>
</tr>
<tr>
<td>Longer work hours</td>
<td></td>
</tr>
</tbody>
</table>

**Step 3: Opposing Ends of Selected Trends Identified**

| High Density Housing VS Urban Sprawl         |
|----------------------------------------------|------------------------------------------------|
| Home Ownership VS Renting                    |

**Step 4: Explanatory Sentence**

*High density housing has increased in popularity, with a steady increase of people migrating to the city centres.*

![Figure 2: Future Mapping Steps](image)
Appendix X Dissemination of finding in peer review conference papers

opposing ends to create two axes (Fig. 3). The quadrants are named, and the impact of the relationship between axes is explored (Step 5).

The quadrants are illustrated with a scenario narrative or story board based on what is happening in that quadrant or 'possible world'. At the end of the workshop an exhibition of the group scenarios is held. This motivates students to take ownership of their work.

Step 6. Explore relationships between axes

- Urban Sprawl
- Home ownership
- Renting
- High Density Living

1st order impacts
Home Ownership, urban sprawl and increased house size leads to large mortgages

2nd order impacts
Multiple incomes are required to enter the property market = dual income house

3rd order impacts
Parents become dependent on child care systems, urban sprawl and isolation of community leads to large centres requiring transport to and from child care prior to and after working hours, leading to generations of children growing up with minimal parental guidance.

Fig. 3 Future Mapping using Matrix

The objective of Workshop 2 is to personalise the scenarios and bring to them the experience of the everyday, emphasizing the work of Manzini and Jegou. 'A Day in the Life' scenarios are generated in explicit detail. Here we get students to develop personas in order to visualise a day in their lives in the year 2020. They answer questions such as: how do you work; how do you interact with friends; how do you travel; how do you socialise?

Reflections are made on the scenarios to connect the daily activities to the trends that influence the sustainability of our society. Activities such as driving to work in a company car, using air conditioners, printing paper, and filling up a garbage bin with short term packaging, all relate to our high resource consumption.

Design briefs for sustainability are then developed. The design brief is used for two reasons: A. To bring the abstract concepts discussed so far into a medium that design students are familiar with. Once the design brief is developed, skills that students have gained in studio subjects take over; B. In order for creative concept generation to be successful, a degree of focus is required. Rather than giving students the task of making utopian sustainable worlds, single daily activities are selected and transformed into small manageable design briefs (Fig. 4).

To assist your persona complete the daily activity of picking up the kids from school within the quadrant comprising of Urban Sprawl/Home Ownership, whilst satisfying the design criteria of:

- A. low material intensity (less material removed from nature therefore having a smaller environmental impact);
- B. low energy use in any form - electricity, fuels (solutions must be highly efficient across the life of the product);
- C. high regenerative potential (enhancing and if possible regenerating environmental and social resources);
- D. providing a positive experience in that completing the activities is fulfilling and
- E. reducing car dependency

Fig. 4 Example of Design Brief

Concept generation in response to the design brief is the final activity of Workshop 2. A range of creativity tools are on hand to assist in this process. The facilitator offers these tools to groups as required: when they have exhausted possibilities using one method another may be suggested. Of specific interest is a 'Think Back' exercise where students are asked to think back to a time in history when their current problem was not an issue and ask how did we get by without X; i.e. how did we get by without air-conditioners? The exercise is successful as it forces students to acknowledge that there have been alternative practices in place in the past and that there is an opportunity to draw on and re-invent such practices in the present.

The remainder of the session is devoted to developing the concepts into solutions for 2020. Students use written scenarios to backcast feasible solutions and story boards to present the final 2020 concepts be they product, systems or services.

IV. CONCLUSION

Future scenario planning for sustainable design is an exciting work in progress forging alternative pathways and directions for design thinking and practice. It is not however without its problems and limitations. It is generally very difficult for example, for students to make the leap from object-oriented to systems design. The development of design briefs to respond to particular elements of the scenario is a new activity that will help to create synergies between scenario planning and studio based design projects. It will allow students to design things that do not stand in isolation but rather must be shown to enable the operation of broader systems.
Scenario planning allows us to rehearse feasible sustainable futures and at the same time understand far more comprehensively the unsustainable future that we are currently 'standing in'. It helps us to embrace and harness design's ability to make a difference and foster this aptitude in students.

REFERENCES

Sustainable Everyday Project http://www.sustainable-everyday.net/scenarios/?page_id=26
Conference paper 2: Sustainable literacy for Industrial Designers through Action Research

The following paper was presented at the International Conference on Engineering and Product Design Education in Newcastle in 2007. The paper disseminates in part the selection of Action Research as the methodology for the thesis, and the final variation of the potential DfS vocations in utilising participatory action research for community collaboration for DfS consultants.
Appendix X Dissemination of finding in peer review conference papers

Han Brezet suggests that there are four types of innovation (see figure 1) moving from technical solutions in making products more efficient from less damaging materials i.e. hybrid cars, to socio-technical solutions that address consumption and the social context in which they are used, such as walking school bus, car pooling and public transport [6, 7]. To date most of the improvements in minimizing the ecological impact of products have been within the technical solutions of product redesign where only limited gains can be made.

SUSTAINABILITY LITERACY FOR INDUSTRIAL DESIGNERS THROUGH ACTION RESEARCH

Stephen CLUNE¹,
¹University of Western Sydney

ABSTRACT

By changing behaviours to more sustainable practices it is possible to greatly reduce the environmental impact of the individual. This paper illustrates industrial designers need to understand behavioural change for sustainable design. It proposes action research as suitable tool for designers to engage with behavioural change, and discusses the implications for teaching action research to industrial design students.

1 BEHAVIOURAL CHANGE FOR SUSTAINABLE DESIGN

The origins of Industrial Design are closely linked to the rise of the consumer society, led by the design of the desirable and streamlined products of the 1930s. Increasing consumption through design was an economic strategy successful in leading the USA out of the great depression [1]. While this strategy was fantastic from an economic perspective, the environmental impact of rising consumption is a core issue with regard to ecological unsustainability.

Industrial design education has traditionally focussed on the immediate practical concerns of developing material product solutions that best serve requirements and criteria set by a client. Design innovation within this framework commonly results in shortened product lifecycles, which ultimately support the net escalation of resource consumption and waste. [2]

Design’s role in the net escalation of resource consumption is unacceptable when future sustainability is considered. In order to move towards a long term sustainable society, it is proposed that a reduction of resources in the order of 90-95% is required [3-5]. It is proposed that such reduction will take place by making products from less resource intensive materials (technical solutions) as well as by changing the resource intensive behaviours of our everyday life (social solutions)[5].

Han Brezet suggests that there are four types of innovation (see figure 1) moving from technical solutions in making products more efficient from less damaging materials i.e. hybrid cars, to socio-technical solutions that address consumption and the social context in which they are used, such as walking school bus, car pooling and public transport [6, 7].
Figure 1 suggests a significant passage of time would be a prerequisite for functional and systems innovation. Leapfrogging to functional and systems innovation today however, would be far more desirable.

In order to achieve functional and systems innovation as proposed by Brezet social change is required. The social role for the designer has largely been neglected, ‘there has been little theorizing about a model of product design for social need’ [9]. Margolin suggests the potential of the social designer is similar to the social worker who collaborates to intervene in unacceptable situation. Viewing sustainability in this light is favorable. Consuming excessive resources can be considered unacceptable social behaviour which requires positive intervention by the designer who is responsible for creating products and services that facilitate this consumption.

The behavior of the end user has largely escaped discussion in industrial design literature. Results from research conducted within the University of Western Sydney (UWS) industrial design program showed that industrial design students struggle to conceptualise system-wide solutions that can incorporate technical design and social actions. The inability to design for behavioural change affects the ability of designers to design for the higher targets of resource reduction set by the sustainable literature [3-5]. This suggests a gap exists between the theory of sustainability, and the practical application of theory into design solutions.

The adoption of sustainable designs often depends upon the user making a conscious decision to move towards a particular behaviour. If we acknowledge the dependency on behavioural change for the successes of sustainable designs then it is worthwhile for design to explore effective ways to contribute to positive behavioural change.
Doug McKenzie-Mohr [10] proposes that behavioural change is best addressed at the level of local community. Action research from the social sciences has been successful as a strategy to enable behavioural change at the localised level. Mohr’s “community based social marketing” closely resembles the framework of participatory action research; a situation is analysed and clear prescriptions for change are proposed, implemented and reflected upon with the assistance of those involved. In this way, positive action is taken to alter existing behaviours and the complexity of habits, processes and product environments that sustain them. The localised collaborative approach gels well with the core concept of sustainability in encouraging diverse local solutions. While abstract in the first instance the parallels between action research and the design process are substantial and provide a framework that can address behavioural change.

2 PARTICIPATORY ACTION RESEARCH FOR BEHAVIOURAL CHANGE

Design is an action based discipline priding itself on its creative problem solving ability. Participatory Action Research (PAR) is potentially a sustainable design tool to assist in the move towards a sustainable society. Borrowed from the social sciences action research’s similarities to the industrial design process have already been identified by Swann as illustrated by Figure 2 Action Research v the Design Process.

![Action Research v Design Process](image)

*Figure 2 Action Research Similarities to the design process. Amended from Swann*

Kemmis’ [11] four step model of action research; Plan, Act, Observe, Reflect can easily be overlaid on the generic design process. The initial stages of the design process in identifying problem opportunities, developing the design brief and initial investigation fall within the planning stage. The action stage consists of selecting concepts through to prototyping. Testing and evaluation is largely an observation activity and once the design is manufactured the process is reflected upon in theory and the cycle starts again.

The areas where industrial design practice lags behind PAR is in the collaborative nature of PAR in which reflection plays a key role [12]. It is clear however that collaboration and reflection are key strategies for effective sustainable design.

2.1 Collaboration to Address Behavioral Change

The collaborative nature of action research parallels the ideas of progressive sustainability theorists such as Ezio Manzini [4] and Doug McKenzie-Mohr [10] who
suggest that sustainability can only be achieved by collaboratively engaging with stakeholders at the community level.

The following example illustrates the need for collaboration to address behavioural change. A redesign workshop was held with a group of secondary school students to redesign the school backpack. The empty backpack weighs 3kg with a volume of 40L and an estimated ecological rucksack 22kg (abiotic and biotic). Within the redesign exercise a multitude of solutions to reduce the material intensity of the backpack occurred; including appropriate selection of materials and the immediate re-use of locally available materials. Redesigning the bag to lessen the environmental impact was achievable. However, when looking to dematerialise the bag to reduce resource use by 90-95% it was discovered that teachers may need to change the delivery of homework so the backpack is not required. Parents and the school may have to rethink how the school lunch is delivered. The schoolchildren’s use of the backpack needs to be understood so the function of the backpack may be met in alternative ways. The dematerialisation of the backpack cannot be achieved without collaboration with relevant stakeholders in both the design process and in the implementation of solutions.

Robinson highlighted that as complexity increases in the move beyond the product to functional or systems innovation collaboration is required [13]. The framework of PAR can assist in such collaboration, empowering the participants to share their learning on how change can happen.

2.2 Reflection over Time

Sustainable design cannot be embodied in a one-off solution, it has to succeed and adapt over time with continual reflection in what Manzini describes as ‘social learning’. [14] Sharing the reflections on sustainable design (both successes and failures) is required to build knowledge as we can ‘only become more sustainable, but never become fully sustainable’. [1]

Sustainable design removes the finishing point in the existing ‘make - waste’ cycle. The existing paradigm of manufacturing in which most products are designed to be landfill in the shortest time possible, is no longer acceptable in light of contemporary circumstances. Design issues emerge across the entire life cycle of the product and industrial concepts such as extended producer responsibility (EPR), Extended designer responsibility (EDR) and industrial ecology, reflect the change to a cradle to cradle perspective.

Considering the product (or service) across its entire lifespan and the impact that it may have from cradle to cradle [15] presents new challenges. To engage in the complexity of sustainability, flexibility is required. The management of resources embodied within products over time has to adapt to changing environments as new solutions are found and opportunities are presented.

Sharing of discourse on sustainable design by reflection will assist in the knowledge generation of sustainable design. Stand alone solutions, even system based ones must be tested by collaborative involvement and reflection. John Ehrenfield has been critical of case studies of sustainable design in presenting brilliant concepts in theory that are

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inadequate in real life. Openness and transparency can only assist the learning process for sustainable design [16].

3 EDUCATION FOR PARTICIPATORY ACTION RESEARCH

The assumption that problems are overcome through the delivery of technical product based solutions is the core issue preventing the adoption of PAR within Industrial Design education.

Further concerns relate to the structure of academic institutions where standard assessment techniques leave ‘little time for reflection in a timely fashion’ [17]. Within the design studio, designs are rarely resolved beyond the conceptual stage, nor are they implemented. Therefore design is assessed prematurely and theoretically, which could be contributing to the lack of meaningful reflection within industry.

3.1 Improving Reflection and Collaboration in Industrial Design Students

Within the UWS Industrial Design curriculum, current units of study are being redesigned to encourage reflection and collaboration as valued outcomes and key skills required in designing for system-wide change.

To encourage reflection, submissions from one unit of study are analysed in teams as empirical evidence in the following unit of study, completing the PAR cycle. The key to developing reflective learners is developing a repertoire of reflective questions and providing opportunities to practice them [18]. Exploring the submission of previous units and the underlying assumptions they hold encourages such reflection.

To encourage collaboration the community within the student body is acknowledged. Projects where students have life experience are selected, allowing student to move between the role of participant and designer. Student teams are directed through the PAR cycle to identify and overcome barriers to sustainable modes of behaviour. The creative skills of the Industrial Designers assist greatly in this process.

The future direction for UWS is to expand our relationship with local council and industry partners to trial collaborative projects over time at the level of local community. The published results and reflection from one year would inform practice for the following year, allowing for ongoing projects over time that can increase in complexity.

4 CONCLUSION

It is proposed that Participatory Action Research can be adopted as a tool for enhancing both sustainable design, and sustainable design education. It potentially offers a mature discipline that could be adopted as a sustainable design tool without the need to develop a new suite of methods. Through the use of Participatory Action Research it is envisaged that industrial design students can begin to design for behavioural change leading towards long term sustainable solutions, moving beyond the incremental, product-focussed improvements of what we have today. It is hoped that if successful through education this framework may continue into the workforce.

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The possibilities for design at the community level are viewed as additional entrepreneurial opportunities for industrial design students as opposed to client responsive product design.

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Conference paper 3: How you define is how you design: problematic definition in Design for Sustainability Education

The paper ‘How you define is how you design: problematic definitions in Design for Sustainability Education’ was presented at the changing the change conference in Torino, Italy. The paper disseminates in part the framework behind the literature review, and a brief overview of the results of the evidentiary chapters in relation to A. problem definition and B. the importance of pedagogy to bridge the gap between theory and practice.
How you define is how you design

Problematic definitions in Design for Sustainability Education

Stephen Clune

Abstract

This paper proposes that problematic definitions of sustainability, contribute to problematic Designs for Sustainability (DfS). Understandings of ‘unsustainability’ are embodied in realised design outcomes, or ‘How you Define is How you Design’.

The proposal is explored through results of a three year action research project at the University of Western Sydney. The project aimed at improving the ability of undergraduate design students to Design for Sustainability. This was achieved by theoretical and pedagogical interventions within the sustainable design curricula to A. increase students understanding of unsustainability and B. assist in transforming this understanding into Designs for Sustainability.

Such interventions are required if we wish to influence the practice of our future generation of designers.

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1. Introduction

This paper proposes that problematic definitions of sustainability, contribute to problematic Designs for Sustainability (DfS). Understandings of ‘unsustainability’ are embodied in realised design outcomes, or ‘How you Define is How you Design’.

The proposal draws on results from a three year action research study at the University of Western Sydney where theoretical and pedagogical interventions were implemented in the Sustainable Design curricula. The interventions attempted to A. increase students understanding of unsustainability, and B. transform the understanding of unsustainability into realised conceptual design solutions. This paper explores the process of how progressive DfS theories are transformed into conceptual design solutions in undergraduate industrial design education.

This paper is structured to provide a background to the framework of ‘How you Define is How you Design’ by a brief reading of the history of Ecodesign, illustrating that a poor understanding of unsustainability is embodied in design solutions and strategies. This is followed by a more appropriate definition of unsustainability. The methodology for the three year action research project at the University of Western Sydney is outlined, introducing the sample for the project in students participating in the sustainable design stream of the undergraduate bachelor Design / Industrial Design program. The theoretical and pedagogical interventions made in the sustainable design curricular in 2006 and 2007 are outlined. Finally the impact of these interventions is discussed in relation to students’ improved designs for sustainability, which were achieved through a more appropriate understanding of unsustainability.

2. Background

The historical reading of the progression of Ecodesign to Design for Sustainability also marks a progression in definitions of unsustainability. The framework of ‘How you Define is How you Design’ is used to explore this history of Ecodesign illustrating how definitions of unsustainability and design strategies are closely aligned.

The early focus of EcoDesign framed pollution as the problem, therefore cleaner production was the solution; waste was the problem therefore recycling was the solution; resource exploitation the problem, therefore LCA and design for efficiency (EcoDesign) were deemed solutions. These initial strategies represent a ‘technical’ school of thought behind which are the dominant forms of DfS engaged with to date by industry. The concern is that the dominant forms of DfS practice are based upon a narrow, non-relational and ill-defined notion of unsustainability.

A progression to more refined definitions of unsustainability offering a ‘social’ orientation for designers has been attempted, for example; Product Based Wellbeing was the problem therefore a service society via Product Service Systems is the solution. This marks a progression from the end of pipe solutions (waste and pollutions) to the front of pipe in acknowledging consumption. Schmidt-Bleek’s (1999) MIPS (material Intensity per unit of Service) presents a strategy that defines inefficient material consumption matched with poor service life as the problem, therefore more efficient material consumption and better service life are the solutions (MIPS).

Tischner’s progressive abstraction in defining problems can be applied to unsustainability as the definitions have progressively moved deeper and deeper to what would be the root causes of unsustainability (cited in Lewis and Gertsakis 2001). Moving from treating the symptoms of unsustainability to treating the cause introduces progressive theorists such as Manzini and Shove. Manzini defines unsustainability in social terms through a lack of commons and contemplative time, therefore he posits Design Orientated Scenarios that bring people together and the creation of contemplative time as possible solutions (2003). Finally Shove’s work can be appropriated to define the problem of unsustainability in terms of Consumption, Cleanliness and Convenience in acknowledging inconspicuous consumption and the ontology of design as the
problem, of which to date there has been limited design response in interpreting the complex definition of unsustainability and transforming understanding into DfS outcomes. The hypothesis that a more informed definition of unsustainability will lead to more appropriate DfS is presented within this paper. The above overview of DfS strategies also marks a progression in the understanding of unsustainability.

Unfortunately the problem of poorly defined understanding of unsustainability is not isolated to industrial practice. Ramirez’ (2006, 2007) studies of both Australian and International institutions teaching industrial design highlighted that the type of DfS taught is dominated by a technical approach focusing upon end of pipe strategies such as recycling and disposal. Educators defined ‘sustainability as being identical with ecological design or green design, which focuses mostly on minimization of environmental impacts and usually not covering aspects of promoting equity’ 2007 p3. This is problematic for Industrial Design education and indicates that an intervention is required to shift the understanding of unsustainability to a more holistic approach. Design education in the form outlined above may be contributing to broader problem of inadequately designing for sustainability.

The author’s definition of unsustainability identifies embodied and inconspicuous consumption in our everyday worlds as the major contributor to the ecological crisis.

Drawing on discourse of embodied energy and ecological-rucksacks, embodied consumption shifts the focus to the demand side and refers to the energy, water and natural resources embodied within the products and services used within our everyday practices, a type of consumption which goes largely unnoticed by the consumer and thus leads to a ‘disconnect’ between the results these resources afford and the resources themselves. The concern of embodied consumption is best described by Frascara’s observation of consumerist culture that ‘ready-made products appear like magic’ (1996 p 45). Lenzen illustrates that within Australia 48% of Co2 consumption occurs through goods and services purchased for the house (1998). The end-user only sees the tip of the iceberg in relation to what they actually consume.

Inconspicuous consumption refers to the inconspicuous (unnoticeable, unobtrusive, unostentatious) normality of our consuming (Shove 2003). Our default habitual daily behaviours consume a great amount of resources. Embodied consumption shows us only the tip of the iceberg in what we consume (the embodied consumption is hidden), where by inconspicuous consumption highlights that a large percentage of our consumption goes unnoticed as it is habitual, which suggests that the iceberg may not even be seen. Tonkinwise highlights that it is the ‘throughput’ of materials in the house are the core contributor to an unsustainable rate and scale of resource consumption (2005) and Manzini highlight that it is within the boring and mundane everyday where the drivers of consumption occur (2003).

Elizabeth Shove (2003) is influential in providing insight to inconspicuous consumption of the everyday; Shove presents our unsustainability by asserting that the normality of our everyday life is driven by comfort, cleanliness and convenience. Thermal ‘comfort’ has seen a shift from personal heating which most civilization developed as a means to maintain comfort of the individual through clothing, to space heating in the warming of a larger environment (home, workplace, car and shops) to maintain comfort. ‘Cleanliness’ identifies how shifts in bathing and laundering habits have occurred, for example a major shift in practice has occurred from the weekly shower to the twice daily shower with obvious resource implications in water usage. Finally ‘convenience’ and social efficiency allowed products to be a dominant focus within the house; products designed to create or manage time dominate the aisles of our shopping centres i.e. ‘fridges, freezers, vacuums, microwaves, recorders and packaged food all share the premise of convenience. Shove provides insight into the normality of the everyday practices that have contributed to the unsustainable behaviours of the present. Shove’s perspective on inconspicuous consumption is critical to defining why we are unsustainable. In order to design for sustainability an understanding that acknowledges the drivers behind inconspicuous consumption is required, Tony Fry’s philosophy of Defuturing does just that.
Tony Fry philosophy of Defuturing provides a process for understanding the drivers of unsustainability and strategically targeting interventions that may contribute to sustainability. Fry’s philosophy suggests that our present is a construct of the past, therefore the future will be a construct of the present. Through deconstructing our past and why we are unsustainable, a road map to sustainability can be developed (1999). The philosophy is heavily drawn upon in encouraging students to create a holistic perspective on unsustainability prior to offering DfS solutions.

This paper illustrates how the University of Western Sydney has engaged in the shortcomings outlined above through an Action Research project over three years. The project developed interventions aimed at engaging industrial design students with A. a deep understanding of the drivers of unsustainability to form an appropriate definition and B. to transform the definitions into conceptual design scenarios.

3. Methodology

Action research was used to integrate the interventions through the three year project. Stenhouse (1975), Carr and Kemmis (1983) proposed the ‘teacher as researcher’ as a viable profession to contribute to knowledge, however Kemmis notes that today the ‘teacher as researcher’ has limited application due to national curricula and reduced teacher responsibility (Carr and Kemmis 2005). It is believed that Industrial Design education is still afforded this original position as industrial design is not governed by a national curriculum (like nursing and education) therefore the recommendations made have a direct route to impact within the curriculum of the design disciplines.

The project examined over 500 conceptual DfS scenarios which were the outcomes of student assessment tasks at the end of the compulsory sustainable design stream. The second year industrial design students had completed the formal sustainability stream therefore the results are indicative of their understanding of unsustainability at the particular time, the proposal ‘how you define is how you design’ forms the premise for this assessment. The assessment tasks were ‘conceptual design scenarios’ illustrating sustainable solutions to thematic areas i.e. water, transport and energy. The structure of the unit is modeled on Tony Fry’s Defuturing in that ‘the present is a construct of the past, therefore the future will be a construct of the present’. The unit offers three distinct periods in the past, present and the future. The past is explored by a tutorial exercise where by students identify why we are unsustainable and how design has contributed to this. The framework of Shove’s Comfort, Cleanliness and Convenience (2003) is used to illustrate how inconspicuous consumption is attributable to design. The nucleus of the ‘how you define’ unsustainability is formed through this task. The present is explored through contemporary trends research where current trends are extrapolated for their potential impact on a sustainable future. The future scenarios are constructed in a series of day long intensive workshops utilizing a hybrid model of scenario planning (Lopes, Clune et al. 2007). Finally Designers respond to the scenarios with ‘conceptual design scenarios’ to contribute to a sustainable society.

Using content analysis the ‘conceptual design scenarios’ were examined against categories represented within the progressive DfS theory. The categories for analysis included the sustainable ‘school of thought’ that was represented by the design scenarios, be that ‘technical’, ‘social’ or ‘socio-technical’. Brezet’s (1997) four types of innovations in ‘product improvement’ offering incremental improvements to existing products, ‘product redesigns’ to existing products to offer resource saving, ‘functional innovation’ where by the function of the products is questioned and met in alternative ways and ‘systems innovation’, where systemic changes are offered as the solution. The potential resource reduction was also measured through a quick MIPS (Material Intensity per Service of Use) calculation which located the degree of resource reduction that the design’s offered.

Content analysis was used to internally validate the results across the interventions that were made in the years ending 2005, 2006 and 2007. The interventions were both theoretical and
Appendix X Dissemination of finding in peer review conference papers

pedagogical, and focused on both sides of the framework ‘How you define is how you design’, to better our definition of sustainability ‘how you define’ by increasing students understanding of unsustainability, and second to transform the understanding into realised conceptual design solutions ‘how you design’.

4. 2005 Pilot; troublesome definitions of unsustainability

2005 was a pilot year for the study and highlighted that the students’ conceptual design scenarios struggled with two key elements; first the radical scale of achieving Factor 10 reductions and second, the proposed agency of design to effect change outside of technical product design. The problem lied in defining both ‘unsustainability’ and ‘what Industrial Design is’.

The majority of conceptual design scenarios offered designs with incremental ‘product improvements’. In relation to resource targets established such as factor ten and factor twenty only a fraction more than ten percent of solutions reduce resources greater than factor ten, with over sixty percent of solutions offering only incremental improvements. While resource reduction is not the only criterion, the designs did not engage with the social or social technical school of thought, which the author hypothesizes as contributing to low scale of resource reduction. The understanding of design’s agency to influence behaviours or to operate at a level outside of the product was largely absent. The problem in defining is not only located in defining unsustainability but in defining the scope of industrial design, viewing industrial Design as a purely product orientated occupation. This, it was hypothesized, severely curtailed students’ ability to contextualize design’s agency within society.

The road go-cart (see figure 1.) is a typical example of a student’s response to transport. The solution is purely focused on the car as the problem. The solution that is presented is more fuel efficient and uses less materials, and is well refined with regard to technical detail. However throughout the process the demand side of transport was never questioned. The complex social drivers underlying the need for the car are not acknowledged in how the student has defined the unsustainable problem to respond to.

The intervention planned for the following year focused on two areas; first to increase students understanding of unsustainability with regards to the scale of resource reduction required in relation to the demand-side drivers of unsustainability and design’s agency. And second the process for transforming the understanding of unsustainability into design solutions was developed.

A series of lectures, debates and tutorial discussion were implemented. The lectures quantifying the ‘scale of reduction’ were given explaining the underlying rationale for targets such as factor 20.

Formal debates within class were held, for example ‘is the Tesla Roadster is an effective transport solution for Sydney?’ The opposing sides were briefed with alternative information, one pro evolving car technology one pro public transport, walking and biking. The examples of Curitiba’s public transport system and the grand Lyon Vélib’ bike share were pitted against the electric Tesla. The debate explored the limitation of electric cars to reduce congestion and more widespread issues of city planning, exposing the limitations of the technical solutions and the opportunity represented by public transport, walking and biking to contribute in a greater way to the transport mix. Tutorial discussions on Ezio Manzini’s criterion for the sustainable Everyday projects in light of the student’s project were also conducted. The criteria of ‘low material and energy intensity’ was easily understood, however the criteria to ‘integrate and share’ and ‘bring people closer’ (Manzini, 2002, p.10) appeared to be an abstract criteria for students and a dimension of sustainability that has previously not been considered.

Particular attention was paid to the transformation of nascent understandings of unsustainability into design solutions. While it was identified by the researcher that the student design in 2005 were not representative of sound definitions of unsustainability, it was difficult to locate if the problem was simply a poor understanding of unsustainability, or that the designer’s lacked the skills to transform the broad definition of unsustainability into resolved design solutions To transform the understanding of unsustainability into design solutions, several mechanisms
were put in place which included articulating the polar opposite of sustainability, transforming the understanding into a brief for sustainability and applying creativity tools to the brief to refine DIS.

First the definitions of unsustainability were articulated, templates were developed to articulate why we are unsustainable. For example our transport is unsustainable because of A. dependency on oil, B. dependency on transport including conventional modes of satisfying this dependency At this stage, students were encouraged to address the root cause, to move beyond the obvious issues of cars being the problem to the underlying causes i.e. Urban sprawl and divided work and home locations. The polar opposite of unsustainability is then articulated to formulate criterion for sustainability. The criterion for sustainability is then transferred into a human-centered design brief. Once the design brief is identified the hypothesis is that students are now working with the familiar tools of design, just a slightly altered brief. The abstract notion of sustainability has been transferred into a straightforward design problem. The focus presented from the design brief allows creativity tools to be applied. Creativity tools require a well defined problem to enable them to succeed (Osborne 1963, Shneiderman and Fischer 2005) which the design brief affords. Even if students are adverse to sustainability all that is required is the appropriate application of design skills from this point forward.

To assist your persona complete the daily activity of picking up the kids from school within the quadrant comprising of **Urban Sprawl/Home Ownership**, whilst satisfying the design criteria

- A. low material intensity (less material removed from nature therefore having a smaller environmental impact); B. low energy use in any form - electricity, fuels (solutions must be highly efficient across the life of the product); C. high regenerative potential (enhancing and if possible regenerating environmental and social resources); D. providing a positive experience in that completing the activities is fulfilling and E. reducing car dependency.

A suite of creativity tools are then applied to design briefs in intensive day long workshops. Previously in 2005 the problems lacked focus; while we encouraged students to generate multiple solutions, when it came to the selection of solutions the lack of criteria curtailed students ability to make decisions.

The creativity tools drawn upon by staff included Osborne’s checklist, morphological analysis and think back exercises. Morphological analysis charts are developed with students to expand the number of possible solutions they have to pursue. One creativity tool developed that proved successful is the ‘Think Back’ exercise (Lopes, Clune et al. 2007) which supports Fry’s philosophy of defuturing. Students are asked to ‘Think Back’ to a time in history when society addressed its needs without electricity, air-conditioners; prepared food without fridges or coordinated social events without mobile phones? The exercise is successful as it forces students to acknowledge that there have been alternative practices in place in the past and that there is a great opportunity to draw on and re-invent such practices in the present.

### 5. 2006; Pedagogic interventions

The results of the first intervention saw an improvement in the student’s conceptual design scenarios. The percentage of designs that addressed a higher level of resources reduction greater than factor 10 had increased by 12%, and there were 19% fewer designs that were classified as incremental improvements. The results were also encouraged by designs drawing upon higher types of ‘functional’ and ‘systems’ innovation.

The results indicate that positive ground had been made with regards to students’ understanding of the problem of unsustainability. The solutions had addressed sustainability at a deeper level. Figure 2 ‘A suite of solutions to reduce demand for commuting’ is typical of the design solutions presented in 2006. The solution progressed to the demand-side of transport, attempting to resolve the issue via reducing demand as opposed to making vehicle more efficient. Available technology was drawn upon to create a scenario that would significantly reduce the demand to commute for work and study. The solution is successful when judged against the metrics used in the study. The alternate criteria for sustainability, combined with a well thought
through design brief assisted to create alternate ‘conceptual design scenarios’ which supported the notion that ‘how you define is how you design’.

While progress had been made in student ability to design for deeper levels of sustainability, primarily through the generation of sustainability criteria and design briefs, Industrial design’s contribution to the process appeared to be poorly understood. The concern of the author was that the process developed had facilitated design responses that forced students to design solutions representative of the criteria, which was formed on a slightly more progressive understanding of unsustainability. The learning that occurred through the process was however, shallow. Students completed the process and generated concepts; however they had not located the solutions within the context of everyday life.

The apparent shallow understanding led the author from focusing on what to teach to focusing on how to teach, and the pedagogy used in education for Sustainability was engaged with. Multiple sources converged upon deep learning as the appropriate pedagogic approach to best facilitate Education for Sustainability (Ben 1999, Warburton 2003). The key to deep learning is on moving the delivery of the unit from being teacher-centered to student-centered.

Deep learning is closely aligned to the constructive approach to knowledge, in that the teacher cannot hand out knowledge; knowledge is created through the learner via the transformation of personal experience (Dewey 1963, Kolb 1984). Learning by doing to create understanding is closely associated with deep learning, while surface learning refers to more temporary learning (Williams, 1992, p45 cited in Beatie et al 1997) often associated with rote learning. Deep Learning is therefore assumed to be the appropriate pedagogic approach for DfS where understanding needs to be decisively linked to thinking and the planning and making so integral to design. Wanting students to be engaged, enthusiastic, understanding and appreciative of the subject matter is advocating a deep approach to learning (Lublin 2007). The hypothesis was that by employing the pedagogy of deep learning, greater engagement from the students with the problem of unsustainability would be afforded, which by default would lead to heightened DfS solutions through the framework ‘how you define is how you design’.

Industrial Design is in an advanced position with regards to deep learning as the constructivist approach of ‘learning by doing’ is a staple in design courses, Industrial Design almost teaches Deep Learning by default. Yet a comparison between the strategies for deep learning and the teaching of sustainable design highlighted that the unit could be delivered with a far more student-centered approach.

Engaging in the students’ perspective forms the core of Deep learning. The interventions that were implemented as a result of this engagement centered on removing the ambiguity from the unit structure and assessment tasks, while a student-centered focus was achieved through increased peer review and opportunities for personal reflection.

Previously the structure of the unit had phases of Fry’s defuturing operating concurrently, for example students were answering a tutorial question on the historical reasons to why we are unsustainable (focusing on the past) while at the same time collating contemporary trends research (focusing on the present). There was ambiguity in not having a clear focus to the task at hand from the student’s perspective, which reduced the capacity to fully engage with articulating an understanding of the problem (unsustainability). The unit was therefore divided into three distinct sections to provide a clear structure in the past, present and future. The assessment tasks were rescheduled to support this structure, and also reduce conflict with other units. A side effect of the rescheduled tasks was that the actual time spent designing was reduced; a greater period of time was spent deconstructing the problem so that when students were finally asked to design there was a clearer framework for what was required.

To encourage a student-centered approach peer review of assessment was implemented to enhance group cohesion and further progress an understanding of the objectives of the unit. To encourage personal engagement empirical data collated from previous subjects completed by students in LCA personal journals was used to generate current trend research and engage in the student’s experience. Using past assignments is also viewed to encourage personal reflection
throughout the course and build a holistic view of education. To further encourage student reflection tasks were scheduled to allow for development and reflection. Often reflection is asked for at the end of the session when there is little chance for change. Asking for reflection in action as advocated by Schön (1991) by asking reflective question intersession allows students to modify the conceptual design scenarios prior to submission of the final assessment.

The majority of interventions planned for 2007 were pedagogic and related to encouraging deep learning. The same theoretical content was presented within class as in 2006, with a slightly altered delivery in 2007. However two notable changes occurred in delivery. First between the creation of the design brief and creativity tools being applied, students were asked to provide utopian solutions that fitted the brief perfectly. From the solution students were then asked how the solutions could be implemented, drawing on McKenzie-Mohr’s (2000) community based social marketing, students identified barriers and benefits to the solutions were then transformed into further design briefs that the creativity tools are applied to. This step was missing in the previous cycle resulting in strategies being presented instead of design solutions.

The second was the presentation of the final concept in the form of a storyboard of the ‘conceptual design solution’ context. The process of story boarding assists students to think through how there solution is integrated within society. An example was developed and presented to students from previous year’s work; this also assisted in setting expectations within the unit.

6. 2007; Reconciling Defining and Designing

The results of the pedagogic intervention appeared to significantly alter the results presented within the unit. The results from 2007 saw ‘conceptual design scenarios’ embodying Brezets ‘System Innovation’ increase by 18%, and for the first time saw the majority of solutions embody a ‘social’ school of thought. The higher achieving students reconciled a sound definition of unsustainability (how you define) with designed solutions (how you design). The solutions moved from strategies as the concept, to strategies with concrete technical designs to facilitate the concept. Instead of presenting sharing as the concept, designs to overcome the barriers of sharing were presented. CBSM potential to generate design concepts appeared successful.

The minor change in presenting story board and designing utopian visions also appeared to have a positive impact. The example (figure 3.) presented as a storyboard highlights how the sustainable strategy is proposed (sharing), but relies on technical design in order to bring the strategy to fruition suggesting a normalization of the role of design’s social agency. The poster assisted students to think through the design solution in context.

The process of encouraging students to design utopian visions is one that Andrews (2007) and Fry (1999) argue as dangerous. The utopian visions created by the early industrial designers such as Bel Geddes’ Futurama and Dreyfuss’ Democracity were top down visions void of humanity, they assumed the god-eye perspective of planning from above as expert, visionary leaders, yet they were complete and detailed but devoid of humanity: people were absent in the visions, reflecting a failure to grasp future social relations (Nye 1994).

The dangers were managed by: A. having an excellent understanding of why we are unsustainable through a defuturing exercise B. forecasting a probable scenario narrative (persona based and therefore human centered) on trends research, making the utopian scenario very much a response to the probable future narrative, not a blank canvas and finally C. Checking the vision with regards to barriers, desirability, implications and normalising capacity of the design solutions. The utopian visions encouraged uncompromised scenarios as the starting point, which moved far beyond the incremental improvements seen in 2005 and 2006 and the majority of EcoDesign case studies presented in the design literature. The scenarios were then worked backwards; the barriers to implementation actually created opportunities for design i.e exploring the barriers to communal living highlights points for design intervention.
While the minor pedagogic changes when looked at in isolation appear insignificant and trivial, the impact on education is significant, the results across the three years cycle highlighted that the pedagogy of design education has an equal importance to the theoretical content delivered. This should not be underestimated. The process is testament to how Action Research can be utilised within design education.

7. Conclusion

The combination of interventions lead to conceptual DfS scenarios that better embodied the progressive sustainability theories via a better problem definition of unsustainability. This was evidenced by higher instances of systemic social-technical design solutions presented by students.

If we are to re-orientate towards more sustainable directions, enabling designers the skills to seek and define why we are unsustainable, and transform that knowledge into resolved conceptual designs is critical. If designers cannot adequately visualise an appropriate response to unsustainability within the confines of academia, then there is little hope of implementing solutions with the additional pressures of professional practice. The argument presented in this paper highlights the key role education plays as a bridge between theory and practice, enabled by the teacher as researcher. In conclusion a greater emphasis on the problem definition of unsustainability in context leads to higher designed outcomes.

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Fig. 1: example student conceptual design work 2005. Problem Definition: cars inefficient in fuel consumption and produce emissions. Design Solution: Small efficient car.

Fig. 2: example conceptual student design work 2006. Problem Definition: commuting long distances to place of work and study. Design Solution: a suite of solutions that focus on removing the requirement to commute.
Fig. 3: example student conceptual design work 2007. **Problem Definition:** single car trips on long commutes, inadequate facilities for car pooling system. **Design Solution:** cars retrofitted for sharing and a car pooling service.
The below image is a section of the 2008 Student Feedback on Unit survey that indicates an increase in students’ perceived relevance of the unit SDSF. The relevance increased from 4/5 in 2006 and 2007, to 4.5/5 in 2008. This occurred after students were briefed in the three vocational variations presented in Chapter 9, and asked to illustrate how their conceptual design scenarios would make profitable business ventures for their future careers.

![Figure AXI.1 Ethics approval and conditions](image-url)
Table XII.1 presents the proposed entrepreneurial sub-major for Industrial Design Students at UWS. The table is compiled from the 2007 UWS handbook.

<table>
<thead>
<tr>
<th>Unit</th>
<th>Description</th>
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<tr>
<td>MG102A.1 Management</td>
<td>This is an entry-level management unit that focuses on the development of an understanding of managing in an organisational context. The objectives of the unit are: to acquire knowledge of management processes, to analyse classical and contemporary management theories, and to describe the dynamic nature of managerial practice in changing social and economic environments. This unit will explain how management theory is evolving and owes much to modern and post-modern thinking as well as economic planning principles and the behavioural, social and political sciences. This unit is a foundation unit for students of management and allied degrees and can be taken as an elective by students from other courses wishing to learn more about management policies and practice.</td>
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<tr>
<td>Foundations</td>
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<tr>
<td>200154.1 Entrepreneurial</td>
<td>This unit examines the theory, practice and nature of entrepreneurship, as a virtual but often neglected and misunderstood mode of management. A basic premise underlying this unit is that all business entities require enterprising management to enhance their survival ability. This proposition is relevant to new and older, small and large organisations. Additionally, contemporary management practice requires the modern manager to be creative in a learning context and the ways in which these creative environments are reached through entrepreneurship are explored.</td>
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<td>200609.1</td>
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