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The Education of Undergraduate Product Designers in the Principles and Practice of Sustainable Design

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A thesis submitted in partial fulfilment of the requirements of The Robert Gordon University for the degree of Doctor of Philosophy

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Abstract

There is a growing recognition that product designers have a responsibility to ensure that their designs are intrinsically sustainable and do not add to the growing pressures on the environment. Developing sustainable products requires designers to be aware of the conflicting issues and constraints which need to be taken into account as part of the design process. Finding appropriate ways to provide the essential knowledge to support designers so that they can develop sustainable products has been the focus of the research reported in this thesis.

A set of characteristics which can be used to classify levels of sustainability of products was established which identified "tangible" and "intangible" considerations which would need to be understood and applied by product designers. Having established a framework for understanding and applying sustainable characteristics to new products, an educational strategy was developed and evaluated with groups of product design students in two institutes of higher education in Scotland.

The strategy for providing the design students with the necessary understanding suggests that "tangible" characteristics should be introduced at an earlier stage in the students' education followed by more "intangible" characteristics at a later stage. The literature review explores the definitions between green design, eco design and sustainable design and explores how the concept of sustainable design has been communicated to designers through the design brief and as part of the educational process. The thesis examines pedagogical strategies which have been used in design education to provide students with insights into the issues surrounding sustainability.

The methodology adopted for this research was based on an action research model, which involved the researcher undertaking a series of case studies with groups of design students and using her own design practice to gain insights into the design process. The case studies were used to develop a prototype educational strategy for introducing the characteristics into an undergraduate design curriculum.

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Table of Contents

List of figures and Tables

1.0 Introduction

This chapter introduces the research presented in this thesis. It provides a brief description of the context in which the research is located. The aim of the research, research questions and objectives are stated. A definition of key terms used throughout the thesis is also provided.

1.1 Rationale for the Research

Current patterns of production and consumption were identified as a major contributor to the continuing deterioration of the environment and peoples' quality of life in the 1992 Earth Summit report *Agenda 21* (UNCED, 1993). Subsequently, the modification of patterns of production and consumption is being driven by government legislation and hindered by confusion surrounding the definition of the term 'sustainability'. A commonly used definition is provided by the World Commission on Environment and Development (WCED) conference report *Our Common Future* (Brundtland, 1987) defining 'sustainable development' as:

"...meet[ing] *the needs of the present without compromising the ability of future generations to meet their own needs."* (Brundtland, 1987: 43)

This quote provides an obscure aim that can be applied to all sectors of industry and society. However, it also generates questions, such as what constitutes need? (Ryn & Cowan, 1996). Confusion also occurs when different sectors of industry use the term

'sustainability' to describe similar approaches to reducing and preventing environmental problems. Adding to this confusion are terms such as 'sustainable consumption' or 'sustainable technology'. The mixing together of incommensurate issues referred to in these different terms makes the term 'sustainable' complex and difficult to understand (Goldsmiths, 2000).

Sustainability has become an increasingly prominent issue for those involved in the design and production of everyday objects, such as the vacuum cleaner, mobile phone and packaging in all forms. Objects such as these are major contributors to present and future environmental problems. These everyday objects:

- Add to the problem of waste management;
- Pollute the land, air and water;
- Add to global warming through the use of fossil fuels for energy;
- Add to the division between the rich and poor through ownership and a desire to own; and
- Increase the proliferation of disposable products.

The implementation of legislation and directives[1] forcing producer responsibility throughout the entire lifecycle of a product has made sustainability an important issue for the design profession. Many companies are expressing the need for environmentally literate designers, but are having difficulty recruiting, as traditionally, product designers have not been trained to address sustainability (Tischner & Charter, 2001).

[1] For example the WEEE Directive which forces manufacturers to be responsible for the disposal of electrical and electronic products. For designers this necessitates that end of life strategies such as design for disassembly to be included in the design of the product where appropriate.

The designer's ability to assimilate ideas, values and specifications within a single product provides an opportunity to influence design towards sustainable solutions. Incorporating sustainability into a design solution requires an additional layer of complexity in the design process. Some of this complexity comes about because of the difficulty in identifying the parameters of sustainability for product design, as it is subject to a range of interpretations depending on the context and particular agenda of those using the term.

Complicating designers' adoption of sustainability further are the perceived contradictions faced by designers: conflicts appear to exist between value judgements, societal norms, economic considerations and practical issues such as legislation. Findings from Dewberry's Doctoral Thesis (1996) confirms this by stating that designers are confused by the proliferation of environmental information available, which they find difficult to understand on a day-to-day basis. Information gathered from magazines, academic research, books or websites each may have a different focus, for example manufacturing or commerce.

In order for designers to successfully design a product to meet the needs of a client they must possess a basic understanding of many different areas that contribute to the design of a product (Lofthouse, 2001). A basic understanding of areas such as ergonomics and anthropometrics, materials and manufacturing processes as well as the role of aesthetics are developed as part of a designer's education and training, and refined as they gain experience as a professional. Due to the complexity and evolving nature of sustainability, designers may benefit from developing a basic understanding of the principles of sustainable design prior to embarking on professional practice, as they have with the afore mentioned areas. With an understanding of sustainability and their role in how to achieve it

product designers would have the ability to design sustainable solutions. However, it must be recognised that other factors can hinder or drive the inclusion of sustainable principles in the design of a product, such as the client possessing a major role in determining the nature of the product.

PhD research has been undertaken into the communication of eco-design to design professionals (Sherwin, 2000; Lofthouse, 2001). This research has shown that although product designers are recognised as playing an important role in the design of sustainable solutions, they lack an understanding of the issues. Therefore appropriate support mechanisms and training at a relevant stage in a designers' career must be considered. This research proposes that, by developing an understanding and exploring sustainable product design as part of a designer's education, they can become familiar with the principles and parameters that can be applied in professional practice. To the author's knowledge this specific PhD research has not been previously undertaken in this area.

1.2 Aim of the Research

The aim of the investigation is to determine an effective way of facilitating product design students to design more sustainable products.

1.3 Research Questions

The investigation was carried out from the perspective of a product designer. The inquiry sought answers to the following questions:

- What are the core issues of sustainable development relevant to the field of product design?
- At what phase in the product design process is the integration of sustainable thinking appropriate for the generation of sustainable product solutions?
- How can the characteristics of sustainable product design be communicated to a designer more effectively?
- Is an educational tool an appropriate format for informing product design students of a proposed set of characteristics of sustainable product design?

1.4 Research Objectives

The four objectives of this research were as follows:

1. Utilising the information gained from a contextual review, formulate a set of characteristics of sustainable product design that are practical to product design practice.
2. Investigate design briefs, to establish their possible role as a mechanism for influencing the generation of sustainable product designs.
3. Formulate an educational tool, which clearly and concisely illustrates the characteristics of sustainable product design in conjunction with the design process.
4. Evaluate the appropriateness of the educational tool to product design students in terms of level of understanding of sustainable product design and ability to integrate into design practice, meeting the characteristics defined in the first objective.

1.5 Scope of the Research

The effect of current patterns of production and consumption on the environment, economies and societies identified in *Agenda 21* (UNCED, 1993) combined with an increase in legislation such as the Integrated Product Policy (Charter, Young et. al., 2001) are drivers for this research. Subsequently an increased need for design professionals literate in sustainable issues who possess the ability to generate sustainable product solutions has emerged (Charter & Tischner, 2001). Product designers have a pivotal role to play in the adoption of sustainable patterns of production and consumption as they form the link between 'client', 'product' and the 'user' (Dewberry & Goggin, 1996).

This research does not attempt to address all of the issues identified as 'sustainable development' in the report *Our Common Future* (Brundtland, 1987), although it acknowledges and is informed by them. Rather this research focuses on the reduction and prevention of environmental problems that occurs as a result of everyday objects as created by the product design industry. This includes the re-design of products and new product development (NPD).

The thesis understands sustainability in terms of the triple-bottom line: environmental, economic and social sustainability (Charter & Tischner, 2001). However it also recognises that product design, designers and those who educate them can only influence the adoption of sustainable principles within the confines of their practice. The majority of change is influenced by Governments, managers and public opinion. Therefore, this thesis addresses sustainability within the parameters of product design.

It aims to increase designers' understanding of sustainability, by providing them with information specific to their needs when engaging with the design process. It does not provide checklists describing best practice, as such checklists have already been developed which focus on specific stages of the design process such as end of life strategies (for an example see Clark, 1999). It does provide design students with a basis on which to build their knowledge of sustainable product design, encouraging product design to move beyond recycling and cleaner manufacturing processes to include sustainable forms of consumption, aesthetics, function and interaction.

The study has focused on the early phases of the product design process, specifically problem solving, ideas generation and concept development. It has adopted a lifecycle thinking approach to the integration of sustainability into design practice: all stages of a product's life cycle are considered during ideas generation and concept development. It is believed that by considering all stages and decisions relating to sustainability during the early phases of the design process a more successful sustainable product solution will result (Tischner & Charter, 2001).

The study focuses on the perspectives, working practices and requirements of product design students rather than design professionals. Due to the nature and complexity of sustainable product design, design education provides design students with an opportunity to engage with sustainability without the constraints of business. It is hoped that, by introducing sustainable product design to product design students during their education, awareness and understanding of the issues specific to design will be carried on through to their professional practice.

1.6 Definition of Terms

Throughout the thesis specific terms are used which require definition within the context of the research. The following provides the reader with definitions of key terms.

Educational Tool

The term 'educational tool' is used throughout the thesis. This term refers specifically to a document developed for lecturers or facilitators, setting out an intense workshop exploring sustainable product design. It is also used to describe a set period of time consisting of a series of design-based activities, seminar and design practice.

Sustainability

What is understood by the term 'sustainability' is continuously changing as awareness and understanding of the issues and problems evolve. This thesis understands 'sustainability' as a strategy to alleviate environmental, economic and social problems – the triple bottom line – induced by societies' and industries' actions.

Sustainable Product Design (SPD)

There are several definitions available in the literature describing what is meant by sustainable product design. In *Sustainable Solutions* Charter & Tischner define SPD as,

"...concerned with balancing economic, environmental and social aspects in the creation of products and services." (2001: 122)

Ezio Manzini describes SPD as *"learn*[ing] *to live better, consuming less and regenerating the quality of our living contexts"* (2000: 76).

This thesis agrees with both of the above definitions. Sustainable product design is understood as considering the environmental, economic and social effects of products in the design of such products.

Set of Characteristics of Sustainable Product Design (SPD)

The term 'set of characteristics of SPD' is used extensively throughout the thesis to describe the parameters of sustainable principles product design can address and utilise. The characteristics relate to the various stages involved in the design of a product and what a designer should be considering in order to develop a more sustainable product. These characteristics have not been solely defined by the research described in this thesis, rather they have been collated from recognised authors in the field of sustainable design and product design to provide an overview of what can be considered during the process of designing.

Product Design

Product design is the term used to describe the design and development of industrially-produced products that people come into contact with and use everyday. These products form our material culture, enabling society to function, not only in a practical and utilitarian way, but also in ways that give pleasure and meaning (Heskett, 1980). Product design differs from engineering design in that it is user-centred, whereas engineering design is technology-centred.

Design Process

The product design process refers to a series of stages with specific actions typically used to develop a solution to an identified problem or need. These stages include developing a design brief; problem solving and ideas generation; conceptual design; concept development; and detail design.

Professional Practice

This term is used throughout the thesis to describe the design process carried out by designers in the real-world, within the constraints and motivations placed on them by business.

Design Practice

Design practice is a term used to describe the output produced by a designer engaging with the product design process. It is also used to describe the output produced by the research-designer and product design students who took part in the research and refers to brainstorming, notes and sketches produced.

1.7 Summary of Introduction

The rationale (section 1.1) describes the research focus in context: sustainability has become an increasingly prominent issue for those involved in the design and production of everyday items. It acknowledges previous PhD research findings, which state that designers are confused by the proliferation of environmental information available and that they have difficulty addressing it on a day-to-day basis (Dewberry, 1996). The overall aim of this research is to investigate an effective way of facilitating product design students to design more sustainable products on the premise that by interacting with sustainability at this stage in their design career, they will develop an understanding that equips them to design more sustainable products.

The scope of the research is described as focusing on the integration of sustainability in the early stages of the design process: problem solving and ideas generation. Data for the investigation of the research questions and objectives was gathered from the researcher's own design practice and case studies investigating the implementation of an educational tool.

2.0 Contextual Review

The aim of the Contextual Review is to locate the thesis within the current field of sustainable design. By examining relevant literature and research programmes a gap in current knowledge is identified.

2.1 Overview of the Contextual Review

The contextual review begins with a brief description of the product design process and an overview of the origins of sustainability. It goes on to address the following questions relating to the research objectives:

- Where can designers access information on SPD?
- What tools and models are available to designers and how appropriate are they?
- At what stage in the design process is it appropriate for the designer to include sustainable principles in order for those principles to be evident in the final product?

Figure 1 provides an overview of the areas that were investigated in the Contextual Review. Each topic is represented by a hexagon, a shape that appears both in nature and in man-made products such as the domes of the Eden project in Cornwall (Eden project Ltd, 2004). This shape was chosen as it clearly displays the interconnection between topics. The hexagons are colour coded to cluster topics: cream represents legislation, sustainable development and globalisation; yellow, the origins of sustainable design; green, sustainable design; blue, product design; and turquoise represents sustainable product design (SPD). The key topics are represented in larger text, giving an indication of their relative importance within the contextual review.

Fig. 1 Visual Overview of the Contextual Review

2.2 Product Design

2.2.1 The Diversity of Product Design

Design is a broad field with a variety of disciplines, for example graphic design, interior design, architecture, digital media, product design and engineering. Each design discipline involves a balance between function provided by technology, and art (Cooper & Press, 1995). In product design the balance lies between function provided by engineering, and sensory appeal and human factors, provided by the designer. Each design discipline produces a 'product', an outcome that may be virtual, a physical artefact or an environment.

Products are diverse and ubiquitous. People come into contact with a wide range of designed products providing both function and convenience every day, from an alarm clock and a toothbrush; a milk carton and a kettle; a laptop and a mobile phone; food packaging and the microwave oven; TV and remote control; to the bedside table. These products not only provide a function, they also make up our material culture. *The Meaning of Things* (Csikszentmihalyi & Rochberg-Halton, 1981) describes a study which examines how and why urban Americans relate to the objects they possess. This study provides evidence of the importance of material culture, not only as providing a function but also as expressing individual social values and aspirations. Dant (1999) and Heskett (2002) also illustrate that products fulfil our basic needs as well as being expressions of who we are and what we want to be. Therefore in product design, 'product' refers to objects that people come into contact with everyday. These products perform a function or personify a lifestyle image and in many cases attempt to do both.

The term 'product' can be misleading as it can be used to describe both a service and an object. This is evident in the increase in product-service mix such as MP3 players and *"fusion products"* (Seymour, 2002), for example mobile phones with digital cameras built in. Fletcher & Goggin (2001) express some concern about product-service mix and fusion products, suggesting that their value lies in the service they provide. Subsequently, the service provider, the physical object, loses its value resulting in an increase of the product's proliferation as consumers look to own the newest model. Manzini (2001) agrees and warns of a *"rebound effect – by which actions expected to bring environmentally positive effects, in fact bring insignificant if not actually negative results"* (Manzini, 2001: 77).

2.2.2 Product Design Process

"Design isn't just the object you pluck off the shelf and take to the checkout – it's about trail and error and a series of decisions that starts before you even know your objective. The design process isn't a mysterious activity designers carry out behind a cloak of secrecy, magically emerging with a sparkling new market-beating product or service." (Design Council, 2004)

The 'design process' refers to a series of phases, during which specific actions are carried out. By carrying out these actions, in a predictable order, a solution to an identified problem or need is generated and developed. There are differing versions of the design process documented, each with a slightly different emphasis depending on the design discipline (such as Lawson, 1997; Dewberry, 1996; Baxter, 1995). The British Standards Institute *BS 7000* (1989) for the management of new product development illustrates a model of the ideal phases in a product's lifecycle, from trigger to disposal (Fig. 2). Models

of the design process such as the *BS 7000* model present the process as a linear, systematic set of procedures. In practice however, the process of designing a product is more chaotic and complex, with phases fusing and repeating one another, in relation to the nature of the problem being solved (Kelly & Litman, 2002).

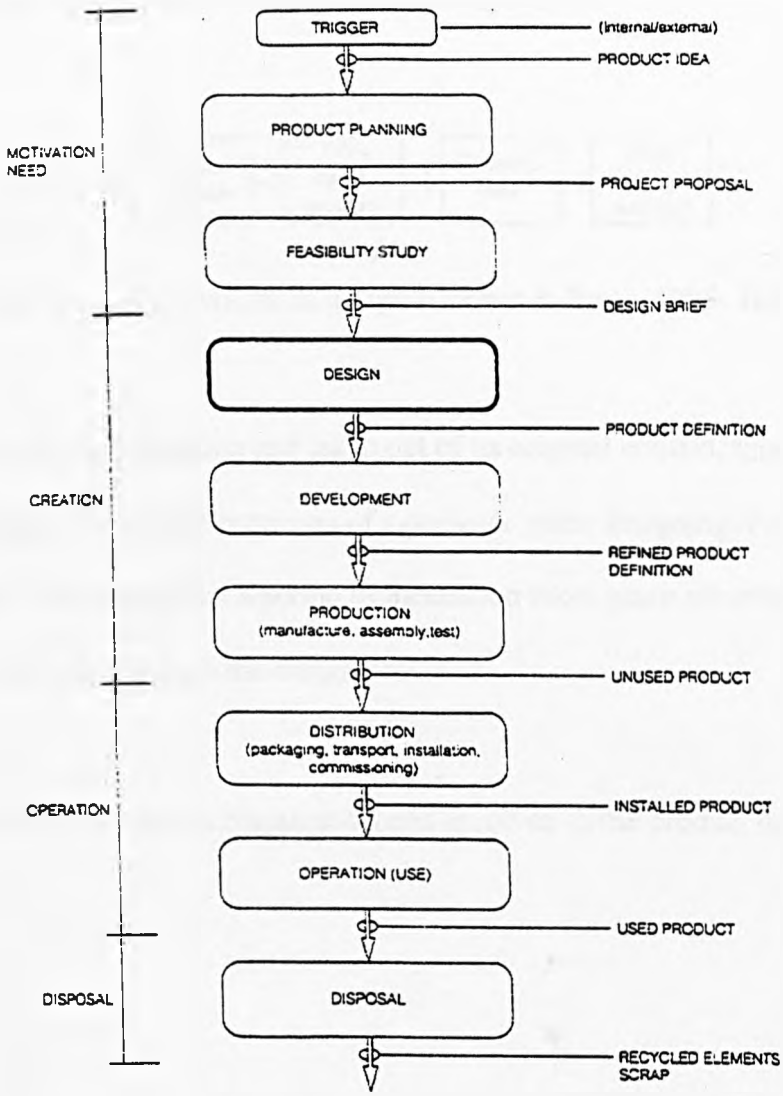


Fig. 2 Product lifecycle as described in BS7000 (BSI, 1989:8)

The process of designing takes place within the mind of the designer (Lawson, 1997) and is externalised in the form of sketches, models and verbal descriptions. Tacit knowledge, observations and research are gathered and considered *"providing designers with a picture, which depicts the inter-relationship(s) between different and often contrasting elements of a problem"* (Valentine & Baxter, 2001: 238). Cooper & Press (1995) provide a model of the internal creative processes involved in designing (Fig. 3).

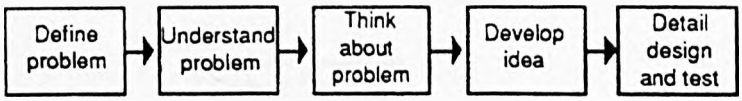


Fig. 3 The internal creative process of design (Cooper & Press, 1995: 36)

Although an over-simplification and taken out of its original context, this map provides some insight into the thought processes of a designer when designing. For example *"think about problem"* illustrates that a period of incubation takes place allowing the designer to think about and work through the design problems.

So what are the phases and subsequent actions involved in the product design process? (see Fig. 4).

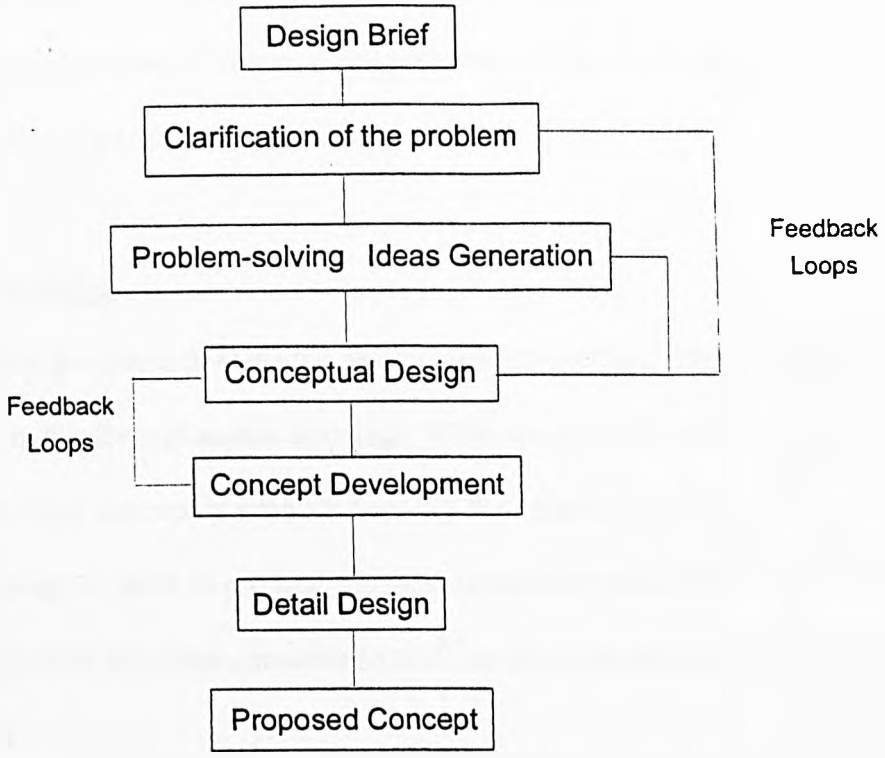


Fig. 4 Illustration of the product design process showing iterative cycles for feedback.

Clarification of the problem

Designing begins with a process of negotiation: clarifying the objectives of the project, outlining targets and identifying design problems – the briefing stage. Briefing the design team can involve a written document, discussions with the client or both.

Research

Once the initial objectives have been defined the design team attempts to understand the nature of the problem the design solution must address through research and observation.

Ideas generation

Utilising tacit knowledge, research and problem solving methods ideas are generated to solve the design problem identified by the client.

Conceptual design

Viable ideas generated to solve the design problem are then conflated into a series of concepts, in the form of sketch drawings. When the number of possible ideas has been exhausted, each concept is evaluated against the original aim of the design to determine which concept is liable to produce the most satisfactory solution. There may be more than one concept that provides a suitable solution to the problem or several concepts that can be combined.

Concept development

The viable concepts are individually developed with the aim of arriving at a range of solutions from which the client can select one concept that meets the client's requirements. If this does not occur the latter stages of the design process are repeated until a suitable solution is generated. At this stage the client or a focus group of potential consumers may be consulted. The information gained from these consultations will inform the design team in terms of further product development.

Detail design

Concentrating on the product solution, this phase in the design process addresses the manufacture and production, material selection and technology required for the product. Material specifications, technical and economic feasibility are re-checked and CAD

documents are drawn up. At this point the manufacturer will take the decision to develop the product or not.

2.2.3 The Role of the Designer

"Design is a value-driven activity. In creating change, designers impose values upon the world – values of their own or those of their client. To be a designer is a cultural option: designers create culture, create experience and meaning for people" (Press & Cooper, 2003: 6)

Product designers rarely work in isolation. The design of a product whether in-house or for a client, involves a multi-disciplinary team made up of for example, marketing, technology and human factors experts in addition to product designers. Freelance product designers also draw upon each other's skills during the generation of ideas or simply to gain knowledge on specific production methods.

In *The Design Experience,* Press & Cooper (2003) discuss the changing role of design and the designer in today's consumer culture. They describe designers as a combination of craftspeople, cultural intermediaries and entrepreneurs, skilled as researchers and life long learners. Designers are the link between companies, products and consumers (Dewberry & Goggin, 1996). It is the designers' ability to assimilate ideas, values and specifications within a single product that provides them with an opportunity to influence design towards sustainable solutions.

Even with the ability and opportunity to include sustainability within the design of a product, it is the client or manager who determines whether these issues are included in the design brief.

Although the client or manager makes the decision as to whether sustainable principles are included in the design of a product, with an understanding of sustainable principles and practice a designer can influence the final outcome so that it is fundamentally more sustainable.

2.3 Consumerism

2.3.1 Material culture, consumption and branding

"Consumption provides meaning, or at least legitimises the lack of meaning, in the secular modern world. Through consuming we meet individual needs, construct our identities and confirm our membership of social groups. Increasingly we define ourselves in terms of our styles of consumption and the values about our lives that they express – our lifestyle – *rather than the job we do. Ours is a culture of acquisition, possession and consumer experience."* (Press & Cooper, 2003: 11)

The above quote illustrates the importance placed on the role of consumption and ownership of products in current society. The variety of products we consume, from which experiences are gained, make up our material culture. Through material culture people identify and personify their social status, identities and desired lifestyles. Unlike previous ages, we surround ourselves with objects rather than people (Baudrillard, 1997).

The personification of a lifestyle image through the consumption of a product is influenced by branding. Through branding companies promise that ownership of their product will provide them with specific experiences and tell others the type of person they are. The projection of a lifestyle in terms of social values and aspirations through the ownership of a product has resulted in companies such as Nike claiming they produce a lifestyle brand which utilises products as a marketing tool for the personification of that brand (Klien, 2000). The desire to own products that project a lifestyle image has always been present, see for example Adrian Forty's (1986) *Objects of Desire*. The difference today is the purchasing power people possess.

2.3.2 Globalisation and sustainable consumption

Utilising the product as a marketing tool for the adoption of a brand, has led to consumers questioning the legitimacy of large corporations in the production of products and the acceptability of globalisation. The anti-globalisation movement was brought to the public's attention by seminal literature such as Naomi Klien's *No Logo* (2000) and the May Day protests reported in the media. Robins & de Leeuw (2001) state that globalisation highlights both the inequalities in consumption between the developing and affluent countries and the development of high-consuming sectors within emerging markets, which the global environment cannot sustain.

In *Expansion or Sustainability: Two Models of Development* (2002) Margolin argues that expansion and sustainability are agendas for social development that are not only conflicting but also on a collision course, evident in the growing gap between the rich and the poor. Discussing each model separately, Margolin concludes that sustainability is the

model that design should incorporate and society should move towards stating that the model of expansion is to blame for societies' adoption of materialism. However these models could, and should, coexist. The problem with adopting a purely sustainable model of development is its inability to accommodate growth, reducing production and trade, which drives countries' economies. Adopting a purely expansionist model of development leads society, in particular people and business, to identify well-being with consuming and owning products: materialism. For these two models to successfully coexist, changes in societies' and companies' attitudes must occur, which can be achieved by increasing companies' awareness of sustainable issues. One such change is the incorporation of sustainability into the design of products and services. This necessitates producers paying more than lip-service as required by government legislation.

Hawken et. al. (1994) discuss the models of expansion and sustainability further in *Natural Capitalism: The next industrial revolution.* They propose that there should be a shift in the economy from an emphasis on human productivity to a radical increase in resource productivity. They state that it is not resources that will limit progress of society as the world's population expands, rather the way in which the resources are used. *Natural Capitalism* suggests that conventional thinking in relation to the sustainability model is flawed in attempting to create a balance between economics, the environment and social behaviour. Rather these three issues, economy, environment and society, are intertwined and interdependent. Hawken's et. al. (1994) propose industry utilises and sees the potential of four kinds of capital: financial, human and manufactured capital which follows conventional thinking, and natural capital *"made up of resources, living systems, and ecosystem services"* (1994: 4).

In 1973 economist Fritz Schumacher predicted in his seminal text *Small is Beautiful* that the pursuit of profit and progress, and the development of globalisation would result in economic inefficiencies, inhumane work practices and environmental damage. Over thirty years later his predictions have proved to be correct, evident in the growing gap between the rich and the poor. To prevent such economic inefficiencies Schumacher suggested community based ownership and regional workplaces which utilise local labour and resources. This proposition is referred to in the field of sustainability as 'localness' and is in direct opposition to globalisation.

Research into sustainable consumption has been carried out by the United Nations Environment Programme (UNEP) Production and Consumption Unit (UNEP, 2002). Focus has been on two areas: the *Advertising and Communication Forum on Sustainability* drawing upon the influence of advertising agencies and the media to promote sustainable consumption; and the youth, recognising that young people have a significant role to play in the changing of patterns of consumption through their purchasing decisions (UNEP, 2002).

Sustainable methods of production and consumption are key issues in moving towards sustainable development. Although product designers do not make the decision as to how and where products are manufactured they do have a role to play, for example, by changing public opinion through advertising and the media and by suggesting alternative consumption methods.

2.4 Environmentally Friendly Design

Literature on the emergence of environmentally friendly concerns has not been extensively reviewed in this section, more in-depth reviews can be found in the PhD theses of Fletcher, 1999; Dewberry, 1996; and Lofthouse, 2001. This review does, however, discuss the origins of environmentally friendly design as this is of main interest to this study.

Modern concerns for the impact of societies' and industries' actions on the global environment emerged during the 1960s, with seminal literature such as *Silent Spring* (Carson, 1965). At this time Vance Packard's *The Waste Makers* (1961) warned that the consumer boom which had been cultivated post World War Two, would lead to a throwaway society. Design professionals were criticised for the types of products and culture they were creating. A new agenda filtered into the design profession, designers were urged to shift their approach from quantification to quality of life (Whiteley, 1993). The International Council for the Society of Industrial Designers (ICSID) conference in 1969 reflected this change in perspective in its theme 'Design, Society and the Future'.

One of the harshest critic of design's approach was Victor Papanek in his seminal book *Design for the Real World* first published in 1972. In the preface to the second edition of this book he states:

"...industrial design has put murder on a mass-production basis. By designing criminally unsafe automobiles that kill or maim ...by creating whole new species of permanent garbage to clutter up the landscape, and by choosing materials and processes that pollute the air we breath, designers have become a dangerous breed." (Papanek, 1984: ix)

Papanek stated that design could be used for a purpose, which would be greater than what he perceived as being the production of convenient lifestyle products aimed at a mass-market. He was harshly critical of built-in obsolescence, resulting in disposable products that incited consumption patterns. He warned that creating such products also creates a society with ethics and values that could be discarded when they are no longer appropriate to a given situation.

The message to designers conveyed in the book '*Design for the Real World*' was: *"design for people's 'needs' rather than their 'wants'"* (Papanek, 1984: 219). The popularity of this message was matched by criticism from those involved in creating and maintaining patterns of consumption, who accused Papanek of possessing a naïve attitude (Whiteley, 1993). In defence of these accusations Papanek stated in the second edition that he did not propose substituting design for consumerism with design that was ethically and morally correct, rather that there was space in the marketplace for both.

"...many design professionals found it difficult to accept my proposal that design for areas previously neglected was one direction for design. *Instead they felt that I proposed* substituting *concern for the vast human needs in the world* for all commercial design, as now practiced. *Nothing could be further from the truth: all I suggest is that we add some intelligently designed goods to a global marketplace now flooded with manufactured 'bads'"* (Papanek, 1984: 69)

2.4.1 Green Design

In 1979 James Lovelock first introduced the Gaia theory in his book *Gaia: A New Look at Life on Earth.* The Gaia theory maintains that the Earth has the capacity to self-regulate, keeping the climate, land and oceans in a stable balance favourable for people and animals. When this self-regulating system is disturbed, by for example pollution, it is no longer able to maintain a balance. This means that the world moves to a new state of equilibrium which may no longer be suitable for the species currently inhabiting the planet. The Gaia theory was criticised because it cannot be tested, it is not possible to prove that an organism can produce or is the result of its environment (DEMI, 2004). Lovelock's warning that the Earth would not be able to maintain a balance was in accord with conclusions from the Club of Rome 1972 report *Limits to Growth* (Meadows et. al., 1972) and was reiterated in their 1992 report *Beyond the Limits* (Meadows et. al., 1992).

Public interest in the protection of the ecosystem peaked during the 1980s. Media images of environmental disasters, such as the meltdown of the Chernobyl power plant and the identification of the depletion of the ozone layer, were catalysts for both public and political attention. Political and economic changes occurred towards the latter part of the 1980s with the implementation of directives such as the Montreal Protocol, banning the use of CFC gases (Burges, 2000).

The 1980s were the *"age of the designer"* (Dewberry, 1996: 18). Lifestyles were bought and visions of well-being were portrayed through the ownership of gadgets. This was the beginning of an age of information technology and mass-communication, notably with the introduction of mobile phones. With the increase in design, production and consumption of

gadgets and convenience goods came concern about their effect on the ecosystem leading to the emergence of 'green design'.

'Green design' became a mantra for the 1980's defined as focusing on a single issue or element of a product's lifespan (Goggin, 1996). This single element is what creates the environmental problem, for example applying green design principles to a product which contains disposable batteries would results in the batteries being substituted for rechargeable batteries.

Green became a lifestyle choice. The green consumer emerged, as people portrayed their concerns for the environment by shopping at The Body Shop and buying products such as Ecover cleaning agents. Individuals began to recognise connections between macro-environmental concerns and micro consumption (Whitely, 1993).

2.4.2 Eco-Design

Environmentally friendly design grew in popularity during the 1990s, driven by Agenda 21 (UNCED, 1993). Agenda 21 instigated the introduction of government legislation such as the 1995 U.K. Environment Act[2].

During this period Victor Papanek published a follow up book to *Design for the Real World* (1984), titled *The Green Imperative* (1995) a more positive book than the former. This book conveys the same message as *Design for the Real World* (1984), using product

[2] This Act required companies to adjust their waste disposal strategies from dumping on landfill sites to recovery, recycle and prevention. This was supported by the Landfill Tax, which places a financial levy on goods and materials entering the waste stream. Also included in the Act was a producer's responsibility obligation section implying that companies are responsible for the environmental impact of a product throughout its lifecycle.

examples and the traditions of specific social groups such as the Inuits and Aborigines to illustrate design for need rather than design for consumer wants.

Dewberry and Goggin (1996: 13) define eco-design as, *"address*[ing] *environmental criteria across the entire product lifecycle to prevent environmental gains in one area being offset by increased impacts elsewhere"*. Central to eco-design is lifecycle thinking. Lifecycle thinking can be defined as connecting the design of a product to the larger system of material extraction, production, transportation, use and disposal, and all associated stakeholders. This requires communication between all stages in the design and development of a product, in particular design needs to analyse and re-evaluate product concepts in light of environmental constraints in production, use and disposal (DEMI, 2004). The need to evaluate products in light of environmental constraints led to the development of a series of evaluation tools such as Life Cycle Analysis (see section 2.6.3), which evaluates the environmental impact of a product identifying and quantifying energy, materials and waste released (Hook, 1996).

As with green design, eco-design does not appear to be radical enough to tackle the environmental and social problems produced by the patterns of production and consumption. In *Design, Environment and Social Quality* (1994) Manzini criticises the redesign of existing products as not being sufficient to influence change. He proposes a more radical model that moves towards sustainable development but does not create a scenario of deprivation. The proposed model is sustainable design. However, the redesigning of existing products should not be dismissed as they can change behaviour and aid consumers in the acceptance of a sustainable society.

2.4.3 Green, Eco and Sustainable Design

As described in the previous sections (2.4.1 and 2.4.2) the terms 'green' and 'eco' have evolved over the years through seminal literature, conferences and research. As our understanding has advanced in industry and academia, these terms have established and developed an understanding in the public realm.

Adding to the complexity already surrounding these issues – green, eco and sustainability – the terms tend to be used interchangeably despite the fact that they are not identical. In product design and development sustainability is regarded as being the same as eco-design (Tischner & Charter, 2001). However, Goggin (1996), Dewberry (1996) and the DEMI project (2004) suggest subtle differences between each of these terms in relation to various levels of commitment. For example,

- Green design: limited to tackling a single issue or element of a product's lifespan.
- Eco-design: focuses on reducing the environmental burden of a product throughout its lifecycle.
- Sustainable design: *"favours the lifecycle,..., but places considerable emphasis on the additional considerations necessary to achieve sustainable development."* (DEMI, 2004).

2.5 Definitions of Sustainable Design

2.5.1 Sustainable Design

Fry (1999) describes the problem of sustainability as:

"...a question that continually changes, but ever remains the same, a question that gets constantly clearer but still stays ill defined" (Fry, 1999: 8)

This quote draws our attention to the point that our understanding and definitions of sustainability are constantly evolving. Fry suggests that by acknowledging the past, design can gain the ability to sustain people and the global environment by understanding people's need for instant gratification, a philosophy he refers to as *"defuturing"*. He also proposes that by stating what is unsustainable a designer is able to decipher what is sustainable. By looking at the past, designers can not only draw out information on how certain materials, manufacturing and energy consumption have damaged the environment but they can also gain some insight into how people have interacted, used, valued and disposed of products, vital information if a designer wishes to successfully develop a sustainable solution.

Even with these insights the question still remains: what is sustainable product design?

The definition of sustainability commonly quoted is provided in *Our Common Future* as,

"...meet[ing] *the needs of the present without compromising the ability of future generations to meet their own needs."* (Brundtland, 1987: 43)

Due to this definition's lack of specificity, other definitions of sustainability have been developed in relation to specific industries. However the underlying aim described is still appropriate.

The difficulty in defining sustainability in relation to design was discussed by a variety of delegates involved in the design, production and consumption of products at the *Is Sustainability Sustainable?* Conference at the Design Museum, London (Goldsmiths College, 2000). Through group sessions, delegates with backgrounds in design, engineering, education and marketing, discussed the appropriateness of the term 'sustainable design'; the potential of substituting this term for another more specific to design; and the key areas a responsible designer needs to address in order to achieve sustainable solutions. Delegates agreed that 'sustainability' was a confusing term due to it being used by various sectors of industry to describe similar approaches to the reduction and prevention of environmental damage. Yet being a generic term it allows the various sectors of industry to communicate therefore a term specific for design may not be advantageous. In relation to the question: what actions should a responsible designer take, it was acknowledged that there is a need to reduce and when possible prevent possible damage to the ecosystem caused by the production, consumption, use and disposal of products.

Phillips' design strategy group define sustainable design as a systems-thinking approach in a *"...solutions-oriented design process aimed to stimulate technological change and social innovation in the current system of production and consumption, in order to decrease the use of environmental resources and enhance people's quality of life"(Rocchi, 2001)*

What is understood is that sustainable design cannot be clearly or concisely described in a single sentence definition. Rather, sustainable design has to be defined in layers illustrating relationships, actions and individuals i.e. client, designer, management, consumer. Leading thinkers in the field of sustainable design, Ursula Tischner, founder of Econcept an eco-design consultancy, and Martin Charter, a professor in SPD and co-ordinator of the Centre of Sustainable Design, provide a visual overview of environmentally friendly design in relation to sustainable development in *Sustainable Solutions* (2001). Illustrated through the use of layers (Fig. 5), the visual begins with product design in the centre, moving outwards to eco-design and then sustainable design. This visual also illustrates the relationship between consumption and production in sustainable design.

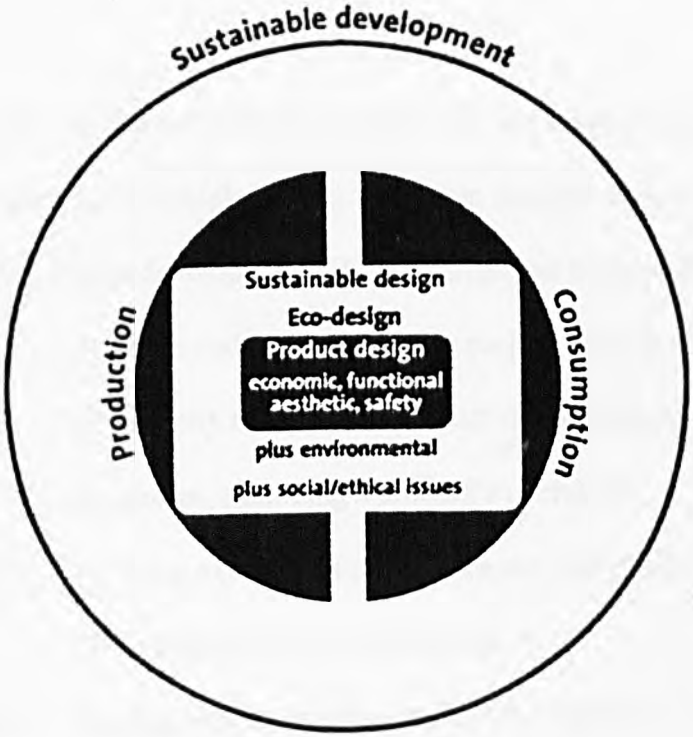


Fig. 5 The relationship between eco-design, SPD and sustainable development (Tishcner, 2001: 120).

Tischner & Charter (2001) define sustainability as meeting the triple-bottom line, put simply this refers to:

- Environmental: reduction and prevention of damage
- Economic: profit and turnover
- Social: peoples needs and desires

2.5.2 Models and Approaches

Models of sustainable design have been established that provide an overview of sustainable design and/or categorise levels of sustainability that may be achieved by designers. They suggest approaches to developing an understanding of sustainable design by dividing sustainability into varying levels and presenting this information visually accompanied by text explanations.

Charter & Chick's (1997) model describes a four-step approach to sustainable design: repair, refine, redesign and rethink (Fig. 6). Each step requires creativity and innovation during product design and development. The four steps can be described as:

- Repair: Consider end of life strategies such as providing the user with the opportunity to repair the product through the inclusion of familiar fastenings, extending a product's useful life.
- Refine: Refining existing practice, processes and products through the implementation of eco-efficiency.
- Redesign: Redesigning an existing product to incorporate environmental factors.
- Rethink: This final step requires a fundamental shift in thinking in order to move towards new ways of achieving peoples' needs. This may involve strategies such as replacing products with services and

considering alternative forms of consumption (Charter & Chick, 1997).

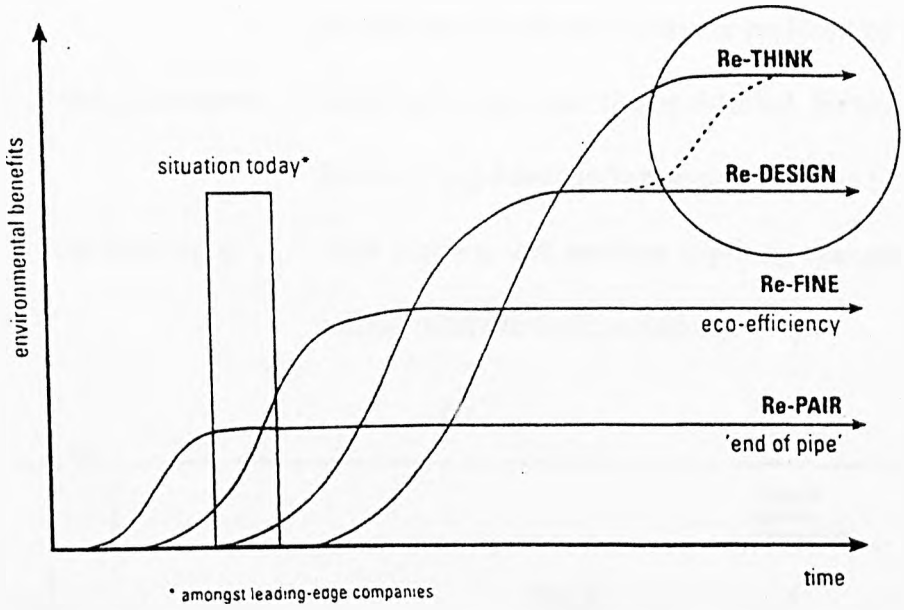


Fig. 6 Four-step model (Charter & Chick, 1997: 5).

'Repair' and 'refine' describe the current stage in industry as representing an incremental shift in thinking largely resulting from government legislation. 'Redesign' describes the current stage of leading-edge companies such as Phillips and Sony who are aware of sustainable design and aim to incorporate sustainable issues into existing designs. 'Rethink', however, represents a significant leap in thinking, Charter and Chick (1997) propose the implementation of a systemic infrastructure to enable the cyclical flow of energy and resources within product systems to achieve 'rethink'.

Brezet (1997) (Fig. 7) proposes a similar model for 'eco-design innovation', directly related to product design. However, his model illustrates that moving from level one to four requires eco-efficiency, takes more time and involves more complex input (Lofthouse, 2001). The four steps Brezet (1997) proposes are:

- Product Improvement: Improving an existing product in terms of pollution prevention and environmental care.
- Product Re-design: The product concept stays the same, but parts of the product are developed further or replaced by others.
- Function Innovation: Altering the way function is fulfilled, for example moving from a paper-based information exchange to email.
- System Innovation: New products and services requiring changes in relation to infrastructure and organisations.

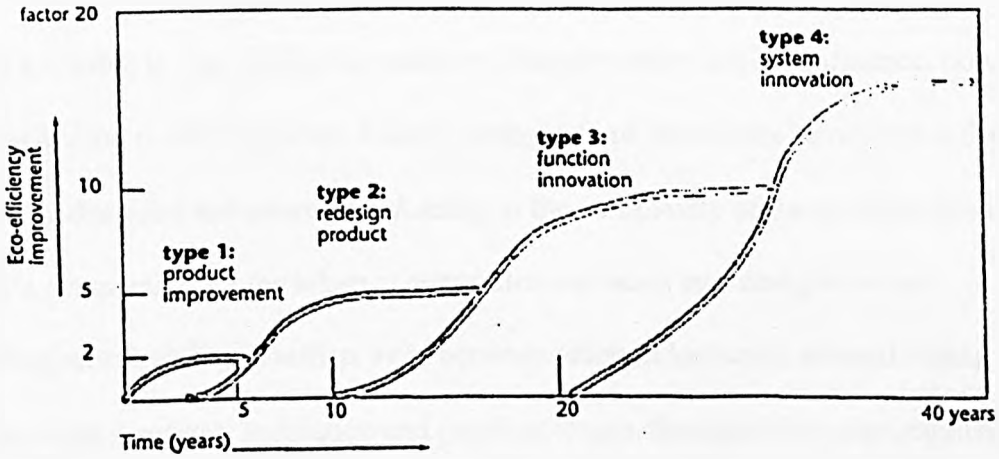


Fig. 7 Four-steps of eco-design innovation (Brezet, 1997: 22).

Both the models described provide the designer with the opportunity to locate existing products or concepts within the field of sustainable design. However these are theoretical models describing sustainable design in terms of a hierarchy. A designer would require further information to address sustainable issues.

These theoretical models are valuable in terms of breaking down stages in sustainable design. They could also be used as evaluation tools after the design process. However, they don't encourage sustainable thinking and require significant explanation.

2.5.3 Accessible Information for Designers

Sustainable Product Design (SPD) is complex in nature: it is a multi-faceted collection of problems that are amorphous, where the information is confusing, where there are conflicting values and where the ramifications for the whole system are unclear. This complexity is characterised by the difficulty of accessing information specific to the product design process. If designers wished to incorporate sustainable values into their design solutions they would be required to be familiar with a substantial body of literature, a time consuming and demanding task, which design professionals working to a client deadline are liable to find difficult to achieve. Designers have limited influence, however their contribution is still important. Client, managers and consumers have more influence over what is designed and consumed. Adding to the complexity of the problem from the designer's perspective are the inherent contradictions faced by a designer when considering sustainability, conflicts exist between value judgements, societal norms, economic considerations, legislation and practical issues. Sustainability also requires a designer to consider design problems in context rather than in isolation.

Until recently accessing information on the context and contribution design can make in relation to sustainability has been difficult. The Internet has been a useful tool providing designers with quick access to information.

In 1995 the *Centre for Sustainable Design (CfSD)* was established within the Faculty of Design at the Surrey Institute of Art and Design (www.cfsd.org.uk). It aims to facilitate discussions and research on sustainable design through training, conferences, publications and a website. Since 1995 it has become a key contributor to the field bringing together

designers, marketing specialists, manufacturers, managers and academics. Publications include literature such as *Sustainable Solutions* (Charter & Tischner, 2001), the *Journal of Sustainable Product Design* as well as conference proceedings. Although accessible to designers, these publications are aimed at academics in terms of the issues discussed. The *CfSD* has been active in promoting sustainability as an important issue for business, producers and designers.

In 2001 the *Design for Environment Multimedia Implementation (DEMI)* project launched a web-based resource providing those involved in the design and production of products with information on sustainable design issues. This easy to access tool provides users with as much or as little information as required and is aimed at all design disciplines. This website is of use to designers at varying stages of their career and education.

The UK's Design Council 2004 agenda aimed to support design professionals and design education in areas prominent to design such as sustainability (Relph-Knight, 2004). This is partly achieved by the inclusion of an overview of sustainable design on the Design Council website (www.design-council.org.uk). This particular approach is accessible to designers, both students and professionals, as the Design Council website is well known in the field in the U.K.

Other literature aimed at designers is emerging, aiming to raise product designers' awareness of their role in the field of SPD. Including the *o2* website (www.o2.org), which lists an international network of designers engaging with and well versed in sustainable design. As yet there is still little guidance and information on the application of SPD (Tischner & Charter, 2001).

2.5.4 Academic Versus Industrial Definitions

In *Environmentally Conscious Design* (1997) Argument et. al. note differing interpretations of the definition of eco-design by academics and industry. They state that industry is:

"...more focused on today and immediate problems (end of life, limited resources and energy consumption) ...Academics, on the other hand [are] *more concerned with moving towards sustainability (eco-lifestyles, global warming, ozone depletion and sustainable development)..."* (Argument et. al., 1997: 79)

Due to the constraints placed on industry and design professionals in terms of cost, marketing and production, industry currently understands sustainable product solutions to be meeting *"repair"*, *"refine"* and those on the cutting edge *"redesign"* as defined by Charter and Chick (1997: 5). Academics, on the other hand have fewer constraints placed on them and are able to consider sustainability in terms of *"redesign"* and *"rethink"*.

Within academia there are different foci. Research has been carried out into pragmatic areas of the design process such as production and end of life strategies, for example active disassembly (Chiodo et. al., 1998), as well as less pragmatic areas such as the adoption of environmental thinking by design consultancies (Dewberry, 1996). Despite the agreed importance of the designer's role in creating sustainable solutions (Fletcher, 1999; Dewberry, 1996) only a few studies have focused on the communication and integration of sustainability into the product design process, such as Sherwin (2000) and Lofthouse (2001), both collaborating with Electrolux product designers.

Designers are key players in the integration of sustainability into products. However, they have a limited awareness and knowledge of environmental issues, *"...because of the lack of integration of eco-design modules into design college or university curricula. This means that materials reduction, recycling or energy-efficiency opportunities are unlikely to be considered unless they are in 'the brief'."* (Charter & Tischner, 2001: 17)

The above quote illustrates designers require access to guidance on what sustainability is and how to integrate it into design practice at an early stage in their careers. Sherwin (2000) and Lofthouse (2001) have both considered the communication of SPD to design professionals, yet research has not been carried out into the value of communicating and integrating SPD as part of a product design student's education.

2.6 *Criteria and Tools for SPD*

2.6.1 Criteria for SPD

There have been numerous examples of criteria for sustainability for various design disciplines (such as James, 1997; Fuad-Luke, 2002). The following section of the contextual review describes several sets of criteria available for designers.

Criteria for sustainable design range in their focus from criteria for specific areas in the design process, for example recycling or materials selection, as well as criteria that attempt to encompass all possible areas of sustainable design. As our understanding of sustainability is continuously evolving, so too are the criteria which designers consult.

An initial set of criteria for sustainable design was proposed by Papanek (1984) in his seminal book *Design for the Real World*. Papanek (1984) proposed six directions that design could follow in order to address ethical, moral and ecological issues. He prescribed designing for the individual rather than the mass, addressing real rather than ideal needs and behaviour. The six directions he proposed were:

- *"Design for the third world"*: developing basic tools that would allow people from developing countries to be self-sufficient rather than designing for what we in the developed countries believe they need – with our cultural needs and desires attached.
- *"Design of teaching training devices for...the handicapped and the disabled"*: generating design for prosthetics, wheelchairs, hearing aids that are user-centred, flexible and affordable for those using the product.

- *"Design for medicine, surgery, dentistry and hospital equipment"*: designing products that not only meet the needs of the patient but also those caring for them, functionally and aesthetically.
- *"Design for experimental research"*: design equipment that is cost effective and accurate for carrying out research.
- *"Systems design for sustaining human life under marginal conditions"*: moving away from additional extra features and existing products towards innovation that will enhance peoples' lives.

The directions Papanek (1984) describes are slightly outdated. The design discipline has moved on from designing for individual needs and is focusing more on inclusive design. The field of SPD has gone beyond some of the assumptions Papanek makes in his directions specifically in terms of the third world: that western designers make assumptions as to the needs of those in the developing nations.

Papanek's (1984) six directions for design can be perceived as a starting point for the development of criteria for sustainable design. Subsequently sustainable design disciplines have developed, for example Ryn & Cowan (1996) propose five principles of eco-design in their book *Ecological Design*. These principles, aimed primarily at architecture, suggest working with communities, considering the space and environment in which a product is to be situated and a *"partnership with nature"* (1996: 104).

In *The Next Industrial Revolution* (2001) McDonough and Braungart criticise society's approach to the adoption of sustainability, claiming that the infrastructure of current industry practice is outdated. They dismiss people's well-intended attempts to adopt

sustainability such as the buying and wearing of clothing made from recycled plastic bottles. They state:

"Blindly adopting superficial 'environmental' approaches without fully understanding their effect can be no better than doing nothing." (2001: 143)

However, the adoption of *"superficial 'environmental' approaches"* does serve a purpose, by encouraging people to be pro-active. By making incremental changes society will be able to make significant shifts towards a sustainable society as a result of individual choice rather than as a reaction to a disastrous event or being imposed by governments (Manzini, 2001).

McDonough and Braungart (2001) argue that the current approach, labelled 'eco-efficiency', is a valuable tool but only as a prelude to *"eco-effectiveness"*. They suggest three principles of eco-effectiveness:

- Waste equals food: products should be made of materials that return to the environment as a nutrient or materials that can be continuously and effectively recycled.
- Respect diversity: *"...respect, maximise and even enrich cultural and material uniqueness of a place"* (2001: 348). Flexible design that allows for changes in peoples' needs.
- Use current solar income: simply use solar energy whenever possible.

The aforementioned criteria or principles are aimed at sustainable design and are also applicable to the design of sustainable products. Datschefski (2001) provides a

comprehensive set of criteria specifically for product design in his book *The Total Beauty of Sustainable Products* (2001) and through his website www.biothinking.com. He describes SPD in five principles:

- Cyclic: *"...use materials in cycles and instead of emitting waste and poisons, only emit materials that can be 'food' for something else"*
- Solar: *"Products in manufacture and use consume only renewable energy that is cyclic and safe"*
- Safe: *"All releases to air, water, land or space are food for other systems"*
- Efficient: *"Products in manufacture and use require ninety percent less energy, materials and water than equivalent products did in 1990"*
- Social: *"Product manufacture and use support basic human rights and natural justice"* (Datschefski, 2001)

Datschefski goes into further detail for each of the five principles above, providing product examples as well as explanations. For example in relation to 'Cyclic' he discusses recycling, reuse, remanufacture and biodegradable materials. The information provided by *The Total Beauty of Sustainable Products* and the biothinking website is valuable to both product design students and design professionals in terms of ease of access in a language product designers understand, with examples of how they have been applied.

Stuart Walker (1998) provides a set of qualitative criteria for SPD developed from an exploration of abstract and theoretical ideas through design practice based on the notion of local production. He advises designers to appropriately combine the use of non-specific, mass-produced components that can be recovered and reused with locally produced parts. He draws attention to surface deterioration which can cause a sense of dissatisfaction

making the product prematurely *"aesthetically obsolete"* regardless of performance; and illustrates that a lack of understanding of one's material culture not only hinders product repair and maintenance but also creates a distance, or lack of association with objects. These criteria draw attention to the importance of the relationship between the individual with their material culture and the importance of aesthetics.

Another set of sustainable principles for all design disciplines is provided by the *DEMI* project (2004). The six *Design for the Environment Implementation (DEMI)* principles for design for sustainability are a coherent introduction to the field:

- Efficiency: Doing more with less. Focusing on minimising the impact of resource use throughout a product's lifecycle.
- Sufficiency: Exploring how people's 'needs' can be met by other means and encouraging people to consume in an appropriate, rather than compulsive manner.
- Scale: Considering the size and consequences of human activities.
- Systems: Drawing attention to the dependency of interconnected elements, both material and immaterial, nature and society, required for the system to function correctly.
- Equity: Introducing some of the key issues involved in moving towards a more just and sustainable future.
- Appropriateness: Making the right choice in terms of meeting real needs and being sensitive to cultural identity. (DEMI, 2004)

As with the five principles described by Daschefski (2004) the *DEMI* principles are explained further, for example 'efficiency' refers to disassembly, substitution, lifecycle

thinking, achieving efficiency, dematerialisation, recycling, etc. From a designer's perspective, a criticism of the *DEMI* principles could be that they consider the bigger picture, such as equity and scale which should be considered at a managerial level rather than by the designer aiming to solve a design problem.

As can be seen from the principles reviewed, many describe similar objectives such as using materials that return to the ecosystem and lifecycle thinking, indicating that there is some consensus as to what SPD issues are. The authors who provide the various sets of criteria are from differing backgrounds, illustrating the multi-disciplinary nature of sustainable design. As previously stated the field of sustainable design is continuously evolving, new thinking is emerging and designers themselves are beginning to tackle sustainability practically. However none of the criteria reviewed are described in conjunction with, or in relation to, the various stages of the product design process.

2.6.2 Sustainable Products

"Sustainability *is becoming a new point of entry into the market for companies and for brands that wish to remain competitive in the coming years."* (Rocchi, 2001: 171)

The above quote illustrates that some companies are beginning to see the inclusion of sustainability in their products opening up potentially new markets. Large corporations such as Sony, Phillips, Nike have been developing sustainable product concepts illustrating ongoing research carried out within these companies. For example Phillips have been involved in an EC funded project titled *"LiMe"* (Fig. 8), a community based product in the form of a café table that provides users with community information such as the leasing of

gardening tools or available babysitters. The aim of the product is to bring communities together creating self-sufficiency through the use of technology (Philips, 2004).

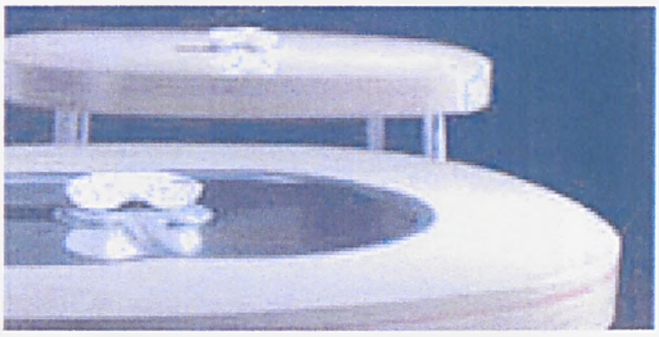


Fig. 8 LiMe (Living Memory) café table by Philips (2004).

Companies such as Freeplay produce products that are sustainable such as the wind-up radio. Originally invented by Trevor Bayless for the transmission of health information to people in Africa, the clockwork mechanism replaces the need to use batteries as an energy source. Freeplay has continued this by educating individuals on the maintenance of these radios.

Droog Design are also associated with sustainable design in the design of such products as the tulip bulb packaging made from dried cow-dung by Andreas Moller (Fig. 9). However Droog Design state in *Less and More: Droog Design in Context* that their approach to sustainable design is more of an *"artistic commitment, products that appeal to the imagination, design that reflect*[s] *our culture"* (Ramakers, 2002: 9).

Fig. 9 Tulip bulb packaging (Ramakers, 2002: 11)

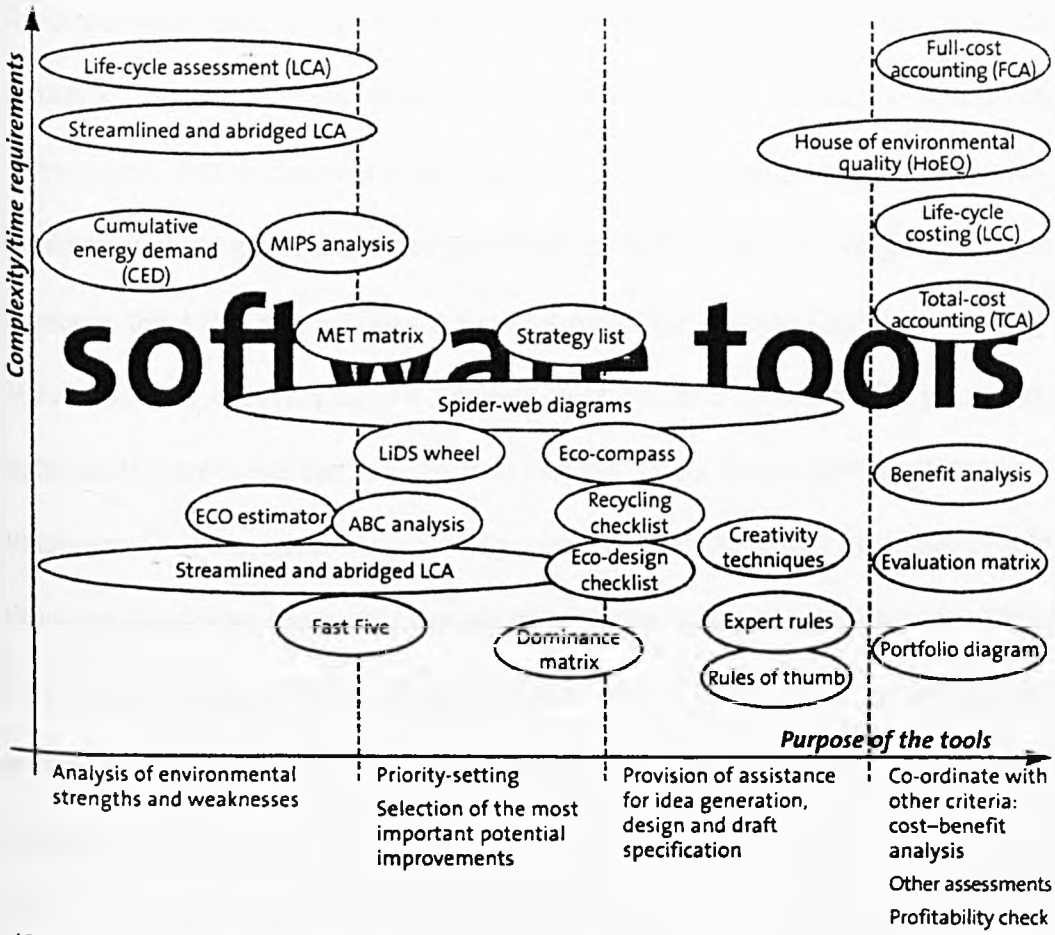
Design competitions raise the profile of sustainable design such as the UK competition Design Sense. Entries have included the Climatex Lifestyle Upholstery Fabric or the C1 motorcycle from BMW (Design Museum, 2000).

The inclusion of sustainable thinking by designers is beginning to happen in everyday products, meeting government legislation and more experimentally through concepts such as those produced by large corporations such as Phillips and design groups such as Droog Design.

2.6.3 Tools for the inclusion of SPD

There are a variety of tools available to measure the adoption of sustainability and provide information on their current effect on the global environment. For example, ecological footprint analysis (Wackernagel & Rees, 1996) can be utilised to identify how much an individual, population or nation requires in terms of carrying capacity, to sustain its current lifestyle.

There are a variety of tools available to aid the adoption of eco-design throughout the designing, development and production stages of a product's lifecycle. There are fewer tools available for the inclusion of sustainable thinking in the design process. Tools available to designers are represented in Fig. 10.



ABC classification system (A = serious problems, action required; B = no direct action required but should be monitored; C = not a problem)
LiDS Life-cycle Design Strategy
MET Material, Energy, Toxic emissions
MIPS material input per service unit

Fig. 10 Tools for the inclusion of sustainable and eco-design (Tischner, 2001: 269).

"Any one approach to sustainable product design will be incomplete" (Walker, 1998: 41). Many of the approaches represented in Figure 10 do not take into account user-centred issues that are inherent to SPD, they have been developed for specific stages in the design process. This section of the contextual review considers the appropriateness of a selection of eco-design tools that have been developed to aid those involved in the design of a product.

Checklists have been developed to be consulted in parallel to design practice. These identify strengths and weaknesses of an existing product to establish potential areas for development, and to ensure that nothing is forgotten during designing. Examples of checklists include general eco-design checklists such as the eco-design checklist by Econcept, the ABC Analysis or the Eco-Estimator by Philips (Tischner et. al., 2000). The *Sustainability Cycle* (James, 1997) can be classified as a checklist. The principles of sustainability are presented in a circle at varying levels, colour coding determines the sustainability of a product concept. Other checklists include lists for material selection providing the design team with a range of eco-materials to choose from or alternatively a list of hazardous materials to avoid. These include checklists for recycling and disassembly such as the Directive on Waste from Electrical and Electronic Equipment (WEEE) checklist.

Expert rules and rules of thumb are similar to checklists in terms of the timescale required when using them. Both sets of rules are based on widely accepted experience involving the evaluation of environmental strengths and weaknesses, for example long life products e.g. coffee machines, videos, TVs, will create a greater environmental impact during use compared to other phases in their product lifecycle (Tischner, et. al., 2000).

The appropriateness of checklists is questionable. Checklists have to be consulted as often as possible as each decision is made which may hinder the creative process. However it is recognised that some checklists can save time, such as lists of appropriate materials, as these can be easily consulted when required. Checklists, expert rules and rules of thumb require the design or design team to be familiar with eco-design or SPD for issues to be

considered during the early stages of the design process, otherwise they become an evaluation tool.

Life Cycle Assessment (LCA) is a well known tool for the analysis of the environmental impact of a product. There are a number of examples of software databases that allow designers and manufacturers to input data and get an analysis of the proposed product, material or manufacturing process in terms of level of environmental impact throughout a product's entire lifecycle (Hook, 1996). This type of analysis can be carried out when redesigning or new product development (NPD). When re-designing an existing product LCA can be carried out to evaluate, identify and prioritise areas in the design that may be harmful to the environment. Armed with this information designers can concentrate on the identified problems and develop an environmentally friendly equivalent or in the case of NPD, LCA can be carried out to a certain extent during the finalisation of a proposed concept prior to production. LCA cannot be carried out as the initial stages of the development of a NPD. Through LCA companies can build up a database of information specific to their products, however it may be difficult to measure some aspects of a product's lifecycle such as the interaction with the user and the final impact that the materials may have on the environment.

The results from LCA can be used to identify the competing demands on a product with the competing ecological requirements, through the use of a Dominance Matrix as described in *How to do Ecodesign?: A guide for environmentally and economically sound design* by Tischner et. al. (2000). The matrix compares the demands of the product against ecological requirements, identifying areas that the design team should focus on. However

this form of assessment and ranking is subjective as it relies on the expertise and judgement of the person doing the assessing (Tischner, et. al., 2000).

Regardless of the tool applied to either professional practice or by a design student, the designer still requires an understanding of the issues involved in SPD. The point in a designer's career in which they develop an understanding may be as part of their design education, as a design student, or prior to a project in professional practice.

2.6.4 Gaining an understanding of SPD

As described in the previous section a designer can gain an understanding of SPD by exploring the literature and websites available. Ideally the designer would gain an awareness of the principles of SPD as part of their design education. In professional practice however, it would be much simpler for the designer to access information on SPD from one source. There have been several initiatives to increase design professionals' understanding of SPD, such as the range of training and conferences offered by the Centre for Sustainable Design, and training aimed at product marketing through *The Living Product* project (Kajzer, 2002).

The Promise approach developed by Deft University (Brezet & van Hemel, 1997) aims to educate professional designers and engineers in eco-design through training encompassed in a manual that can be consulted when required. This approach includes the use of spider-web diagrams: a product is evaluated against a list of criteria such as materials, energy consumption, production, use and disposal; the level at which they achieve sustainability is visually represented on the diagram (Fig. 11).

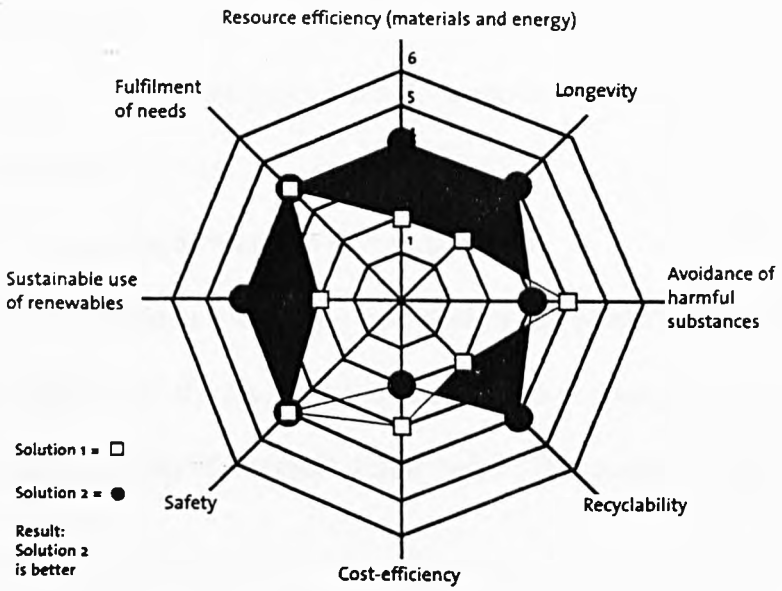


Fig. 11 Spider web diagram (Tischner, 2001: 280)

The EcoReDesign programme carried out by RMIT University in Australia in collaboration with seven companies developed a comprehensive information kit for those involved in product design. The information kit consisted of a video and a detailed 'how to' manual explaining and discussing case studies based on the products, people and companies involved in the programme. The researchers involved in the programme worked closely with the product designers in the companies providing workshops, LCA, eco-design brief development, concept design and an open forum to ask any questions regarding the inclusion of eco-design, resulting in a variety of successful eco-design products such as the Dishlex Global dishwasher (Gertsakis, 2001).

A similar approach to the EcoReDesign programme for gathering information on what professional product designers specifically need in order to develop sustainable products was also adopted by Sherwin (2000) for his doctoral research, in collaboration with Electrolux in the UK. The Awareness project aimed to inform industrial designers at Electrolux of eco-design at the early stages of the design process. The project centred

around the design of an 'eco-design kitchen of the future' (Thompson & Sherwin, 2001). The Electrolux industrial designers were informed on eco-design during a two day workshop involving:

- An introduction to what eco-design involves;
- An examination of eco-design case studies and product examples;
- Identification of the project's time constraints and target audience; and
- The development of a project design brief. (Thompson & Sherwin, 2001).

Following the two day workshop the industrial designers were aided by a facilitator who summarised eco-design into a form manageable for ideas generation, answered questions and reviewed concepts they produced. The result of the project was a series of sustainable product concepts, which were showcased as inspiration to others in the company and shown at the annual corporate exhibition. Sherwin's (2000) approach to the education of design professionals illustrated the importance of facilitation and inspiration.

In her PhD research Lofthouse (2001) also worked with the industrial designers at Electrolux. Her study investigated the specific needs of designers requiring an effective tool that will inform them of eco-design. Through a survey and one-to-one interviews Lofthouse (2001) established a framework for an eco-design tool: information, inspiration and guidance. This research verified Dewberry's (1996) and Sherwin's (2000) conclusions: that designers required information that they could consult on a day-to-day basis but inspiration in the form of case studies and product examples is as important. Lofthouse (2001) subsequently developed an eco-design tool titled *Information/Inspiration.*

In March 2004 Manzini conducted a workshop titled *Enabling Solutions* (2003), the aim of the workshop was to *"conceive new service ideas based on the observation of promising cases of social innovations. In particular, the focus is on cases of 'enabling initiatives', and on the concept development of an advanced enabling solution."* (Manzini, 2003: 1). The premise behind the workshop was that there is potential for design to enable the adoption of a sustainable society by developing and exploring further current sustainable ways of living, which people are beginning to adopt. Manzini proposed that enabling solutions can be organised into three categories:

- User-oriented solutions: enabling the end user to obtain his/her own results.
- Community oriented solutions: enabling a community building process.
- Micro-enterprise-oriented solutions: enabling development through entrepreneurial-ship and creating innovative forms of micro-enterprises.

The workshop involved lectures, discussion, individual research identifying potential enabling scenarios, and then utilising those scenarios to design sustainable solutions. All of which were represented in a poster, a storyboard illustrating the interaction between the solution user and the solution itself and a system-map illustrating the variety of stakeholders, their links and the flow of materials, energy, information and money. The resulting outcome of the workshop was an exhibition of the solutions and a website titled 'Sustainable Everyday: Scenarios of Urban Life' (www.triennale.it/triennale/sito_html/quotidiano/eng/home_.html).

The development of these training tools for professional product designers could be adapted to educate product design students in the latter stages of their design courses. Inquiries such as the EcoReDesign project undertaken by RMIT University of Australia

provide an insight into the information a professional designer requires in order for the development of a sustainable product solution. This inquiry identifies the information a design student requires before embarking on a professional career.

2.7 *An appropriate phase in the design process for sustainability*

2.7.1 The role of the design process as a possible mechanism for change

"If environmental aspects are taken into account during the earliest phases of product development, then it is more likely that reduced environmental impacts can be integrated into the final product." (Tischner, 2001: 264)

The design brief is the first point of contact for a designer/design team with a design problem. The design brief is a set of instructions identified by the client or, at a managerial level, outlining the design requirements (for further explanation see section 2.2.2).

A number of authors have considered the integration of environmental considerations, either eco-design or SPD, into the design brief (Sherwin & Bhamra, 2001; Dewberry, 1996). These authors agree that decisions regarding the environmental impact of a product are made prior to production and cannot be altered beyond this point (Design Council, 1998).

Although designers are aware of the importance of SPD and their role in its inclusion they are unable to influence the development of the design brief, *"such significant design decisions are often made elsewhere at a more senior level, in marketing or by the client"*

(Sherwin & Bhamra, 2001: 7). Dewberry comes to the same conclusion in her review of consultancy practice:

"...surprisingly, a large proportion of the designers interviewed indicated that for many of the design projects they were undertak[ing], *the design brief is basically decided before it is even handed to them. One might presume that the design decision process is taking place at a management level within the company or client."* (1996: 151)

The contextual review has not found evidence to suggest that the inclusion of SPD requirements into a design brief would hinder the design of a sustainable solution. It is presumed due to the role of the design brief that inclusion of SPD would focus a design team's attention on these issues. The literature has shown that the decision to include SPD requirements in the design brief has to be made pro-actively by the client or at a managerial level. Evidence from the previous sections also suggests that currently design professionals require additional support in tackling SPD if it is included in the design brief in order to understand the issues, problems and opportunities.

2.7.2 An appropriate phase in the design process

Current thinking within the field of SPD identifies the early phases of the design process during ideas generation and concept development to be the most appropriate for the development of sustainable solutions that move beyond *"repair"* and *"refine"* towards *"redesign"* and *"rethink"* (Charter & Chick, 1997). The tools and training opportunities described in the previous sections (2.6.3 and 2.6.4) require design professionals to spend some time gaining an awareness and understanding of the opportunities and issues involved. Obviously this requires design professionals to be involved in training, albeit for

a limited amount of time. However 'time is money' and professional designers may not have the time available to gain the comprehensive understanding required for the inclusion of sustainable thinking as an intrinsic part of the design process.

Perhaps an opportunity lies as part of design education, where for example design students learn about issues such as human factors. During design education design students can gain an understanding of the proposed set of characteristics of SPD and explore its integration into design practice without the constraints placed on them by professional practice. As discussed in section 2.5.4 there is a difference in terms of definition addressed by industry and academia: academia is not restricted by cost, timescales, clients or legislation and has the opportunity to explore the integration of all three aspects of the triple-bottom-line. Therefore the inclusion of SPD as part of a product design course curriculum would result in design professionals literate in a basic understanding of SPD that can be built upon as new thinking emerges. The education of undergraduate product design students in the principles and practice of SPD has, to the author's knowledge, not yet been explored through doctoral research.

2.8 Design Pedagogy

"It is essential for those engaged [in sustainable design] to share the expertise they have if further generations of designers are not to emerge from universities with no more knowledge of good practice in sustainable design than their predecessors" (Bhamra, et. al., 2002: 133)

2.8.1 Teaching Strategies

There are a variety of teaching and learning strategies available to tertiary level education ranging from the conventional lecture style to learning from doing. The field of art and design adopts a variety of teaching and learning strategies depending on the objectives and desired outcome of the curriculum. For example in product design, the design process is taught through practical independent or group learning, and other areas such as cultural and contextual studies may be learnt through both practical exercise as well as seminars or lectures. Teaching and learning strategies can be divided into three categories:

- Mass Instruction: e.g. lecturers and taught lessons. The student is dependent on what they learn from the teacher,
- Individualised Learning: e.g. directed problem-based learning. Students are largely responsible for their own learning at their own pace and depth.
- Group Learning: e.g. seminars. Students are largely responsible for their own learning but also dependent on one another's preparation and interaction (The Robert Gordon University, 2002).

Cooper & Press (1995) describe the education of design students as adopting a *"learning by doing method"* (1995: 21). They state that design education draws upon various sources

for inspiration as well as tacit knowledge to solve design problems presented to them as integrated design projects. They identify three areas informing a design project: contextual understanding, design knowledge and design skills (Fig. 12). Therefore there is an opportunity to increase a design student's awareness of SPD through design methods and practice.

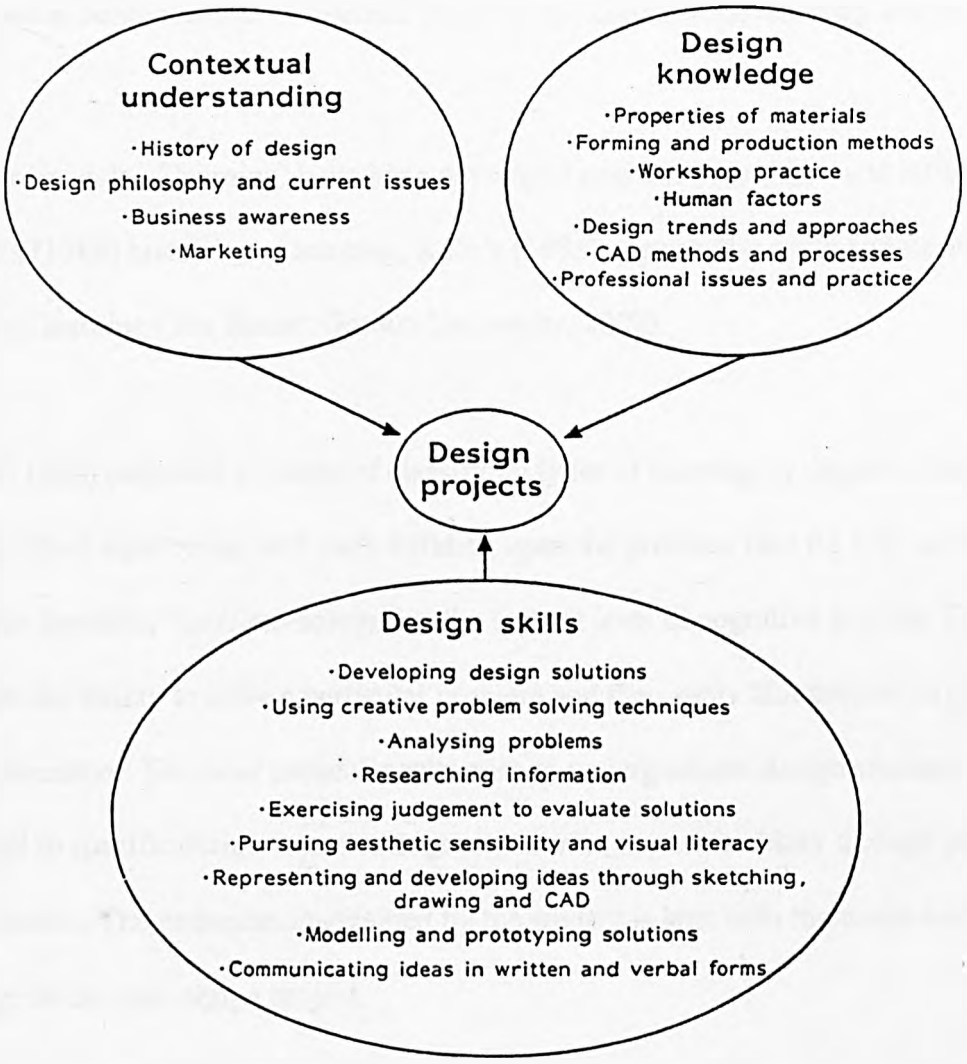


Fig. 12 Map of design education (Cooper & Press, 1995: 22)

2.8.2 Learning Methods

It is important to consider the most applicable manner for undergraduate design students to learn about sustainability. In her doctoral thesis Gray (1988) asserts that the intentions of teaching, the role of the lecturer and the learning methods all need to considered. In the field of pedagogy there are four different psychological approaches to learning, these are described as behaviourism, humanistic psychology, cognitive psychology and intelligence.

Various 'models of learning' have been developed over the years, the most influential are Gagne's (1988) hierarchy of learning, Kolb's (1985) experiential cycle and Race's ripple model of learning (The Robert Gordon University, 2002).

Gagne (1988) proposed a system of classifying types of learning by degree of complexity. He identified eight types, with each building upon the previous (see fig 13). As can be seen from the hierarchy 'problem-solving' is the highest level of cognitive process. This requires the ability to solve a particular problem and then apply that process to problems of a similar nature. This is of particular relevance to undergraduate design students who are exposed to specific design issues such as ergonomics or sustainability through practical experiments. The understanding gained by the student is kept with them and carried through to the next design project.

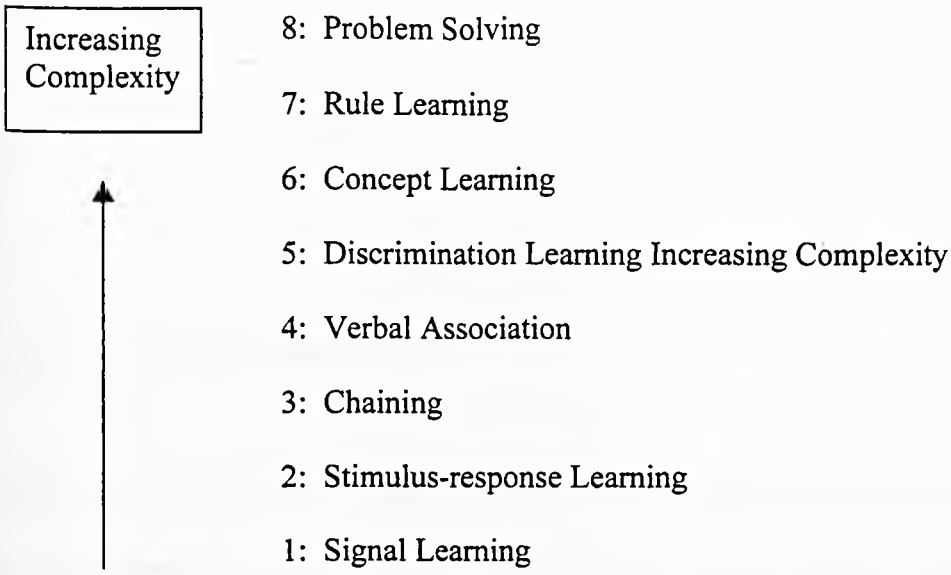


Fig. 13 Gagne's Hierarchy of Learning (1988)

Research has shown that individuals learn more effectively if they are active in the learning process rather than be passive receivers of instructions (The Robert Gordon University, 2002). In design education "*experiential learning*" is widely utilised. Kolb (1984) proposes a cyclical experiential learning model (see fig 14), each stage representing a vital part in an individual's learning. Kolb believed that the learner should be involved in the planning of a learning experience (stage one), for example through discussions with the facilitator or simply writing a to do list. He also maintained that the learner should become actively involved in the learning process, for example learning by doing or formulating questions, this is the second stage in the cycle. The third stage requires the learner to reflect on what they have learnt, why and how. The fourth stage of the cycle aims to link the actual learning experience to the original objectives and methodology illustrating what the learner has gained from the experience.

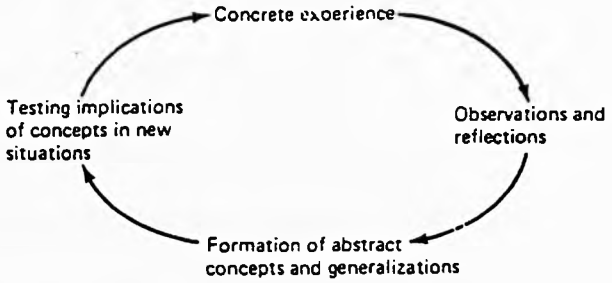


Fig. 14 Kolb's cycle of experiential learning (1984)

Like Kolb, Race proposed a model of learning that is based on experiential learning – learning by doing. Race also believed the learner required reflection and feedback, however he identified an important element of the learning process, the internal motivation the makes a person want to learn. The four basic characteristics Race proposed for successful learning are:

- Wanting: personal motivation
- Doing: practice, trial and error
- Feedback: seeing results and other people's opinions
- Digesting: making sense of what was learnt.

2.8.3 Emergence of specialised sustainable design courses

There is an increasing emergence of product design courses specialising in sustainable or eco-design at both undergraduate and postgraduate level. Undergraduate courses such as the BA Honours Product Design Sustainable Futures, offered by Surrey Institute of Art and Design, covers product design methods through integrated projects, business and marketing, human factors, materials and manufacturing, and sustainability. Their website states *"...first and foremost you are a product designer. But in addition to mastering the usual product design skills, you will have the added knowledge of how to include*

sustainability criteria in your designs" (Surrey Institute of Art & Design, 2004). Such courses encourage sustainable thinking as an intrinsic part of the design process and are perhaps the most appropriate way of educating emerging designers in order for product design to embrace SPD as they have done with ergonomics and anthropometrics. However, presently they only attract individuals who already acknowledge the importance of sustainable design. The student needs to be motivated towards gaining an understanding of sustainability as indicated by Race's model.

A strategy for the inclusion of eco-design into an industrial design course that is not focused on the education of sustainable principles at Loughborough University is described in *Ecodesign Education Strategies* (Bhamra, et. al., 2002). The inclusion of eco-design was not integrated into the course in a holistic sense as in the Product Design Sustainable Futures course described above, but as a module over two semesters. The course material in semester one involved student-led seminars gaining an understanding of the field through literature such as the *Journal of Sustainable Product Design* and *Sustainable Solutions* (Charter & Tischner, 2001). Semester two involved the redesign of products employing strategies from *Ecodesign: a promising approach to sustainable design and production* (Brezet & van Hemel, 1997) (see section 2.6.3). Redesigning in semester two took the form of three phases:

- Analysis of a product and its use
- Identifying the eco-design opportunities
- Eco-redesigning

The members of staff involved in this program illustrated the value of student-led seminars in the assimilation of background information prior to designing. Although there are many

drivers for the inclusion of SPD into design education the lack of appropriate resources for its inclusion in the undergraduate curriculum and lack of staff expertise on the subject are both potential barriers to its introduction. The strategy employed at Loughborough University was to employ researchers with expertise on the subject to lead seminars and facilitate designing.

Jakobsen & Wigum (2001) in Sustainable Services and Systems: 3s and the Impact on Ecodesign Education, describe the introduction of eco-design problems to differing levels of product design students' education at The Norwegian University of Science and Technology (NTNU). Similar to the previous course described, the product design course at NTNU relied on expertise from research staff. The study identified that the development of sustainable services and systems rather than products required a different mindset from the students, however through the use of design scenarios complex concepts were communicated.

2.9 Summary and Conclusions

The contextual review has provided a background context on environmentally friendly design, differentiating green, eco and sustainable design. It has described the diversity of product design, the design process and the role of the designer. The relationship between consumption and material culture has been acknowledged. Globalisation and sustainable consumption in relation to product design has been addressed.

The review of the literature has identified that an understanding and definitions of SPD are continuously evolving as new thinking emerges and designers begin to address SPD in their design practice. Theoretical approaches have been established such as Charter & Chick's (1997) four-steps: repair, refine, redesign and rethink. A general consensus has been agreed in the literature as to a definition of SPD: involving economic, environmental and ethical considerations throughout a product's lifecycle.

Criteria for sustainable design have been developed, as have training, conferences and tools for design professionals (e.g. Papanek, 1984; Datschefski, 2001; Walker, 1998). The tools reviewed require a designer to possess a basis of understanding on sustainable issues related to design in order to successfully apply those tools to the various stages of the design process. Tools reviewed ranged from tools that provided an analysis for environmental improvements; priority setting; and providing assistance when generating ideas. Design professional's training has been investigated identifying the use of 'how to' manuals, workshops and the Internet. The Internet has been a valuable tool for the dissemination of information on sustainable design. Accessible information is provided on the Centre for Sustainable Design, DEMI and the Design Council websites.

The Contextual Review has considered the design brief representing an early stage in the design process to influence change. It acknowledges that clients and management need to be pro-active if sustainable issues are to be included in the design brief. If SPD issues are included in the design brief, the designer/design team still require an understanding of SPD and how to integrate it into design practice. Design professionals require some time away from day-to-day work to gain an understanding of SPD. This may be difficult as they may not have the time to gain a comprehensive understanding in order to move beyond repair and refine towards redesign and rethink.

There is a lack of research into the potential of the inclusion of SPD as part of design education. Bhamra et. al. (2002) describes one course's approach for the inclusion of SPD as part of the curriculum in terms of two modules over two semesters involving student-led seminars and redesigning an existing product. Lofthouse (2001) proposes a framework for tools providing information on SPD to include information, inspiration and guidance.

In conclusion the contextual review has demonstrated that the inclusion of SPD is required as part of design education. Learning and understanding about SPD as part of design education may lead to the development of design professionals being practically literate in the subject.

3.0 Methodology

This chapter outlines the research methodology adopted by this study. The methodological strategy is presented and the methods used to gather information are described. Trustworthiness of the data collection methods is addressed in terms of validity, bias, reliability and generalisability. The chapter concludes with a summary of the research design.

3.1 Overview of the Methodology

In relation to science and art, research in the field of design, particularly product design, is relatively novel (Pedgely, 1999; Lofthouse, 2001). Design is both interdisciplinary and multi-disciplinary in nature, therefore an appropriate methodology cannot be found by adopting only scientific, social science or artistic methodologies. The research methodologies of science, social science and art can act as points of reference for design research (Press, 1995). Where appropriate, design should draw upon these methodologies as well as utilising its own distinct intellectual culture in order to demonstrate standards of rigour (Cross, 1999). Acknowledging the latter, this study has adopted a multi-method approach to gathering information relevant to the research objectives (see section 1.4) drawing upon a social science methodology utilising suitable design methods.

The aim of the investigation is to determine an effective way of facilitating product design students to design more sustainable products. The proposed set of characteristics of SPD are central to a prototype educational tool which takes the form of an intense workshop. Interaction with the SPD workshop allows students to explore the set of characteristics as part of an interactive seminar and through their own design practice. The methodology

applied can be described as action case studies: action research in the form of case studies. Three stages were involved in the collection of relevant information:

1. **The formulation of a set of characteristics of SPD**: The characteristics were initially formulated from the Contextual Review. Two case studies investigated a designer negotiating the integration of the set of characteristics of SPD in the early stages of the design process. The findings from these case studies informed the reframing of the initial set of characteristics of SPD from a rules based checklist to a heuristic set of advisory statements. These advisory statements are central to explaining SPD principles as part of the prototype educational tool.
2. **Investigating the appropriateness of the prototype educational tool:** The effectiveness of the prototype educational tool in raising awareness of the issues to be considered by designers and providing guidance on the integration of the set of characteristics of SPD into design practice was investigated in three case studies. The prototype educational tool, in the form of a SPD workshop, was utilised by groups of design students at varying levels of their education. Observations on interaction with the prototype educational tool were recorded in field note journals and students' concepts, developed as part of the workshop. These concepts were then evaluated against the set of characteristics of SPD. Information gained from each case study informed the development of the prototype educational tool for the next case study in accordance with a model of action research (Robson, 2002).
3. **Additional data gathered for analysis**: Analysis of the data gathered taken the form of multiple perspectives. Additional information was gathered for analysis: a case study revisiting a group of students one year after they had took part in the prototype educational tool was compared to a group of students that had not; a

semi-structured interview on the prototype educational tool with members of academic staff; and feedback from a group of individuals who took part in the workshop as part of a design competition (for further detail see Analysis Chapter 7.0).

Due to the nature of the research objectives, qualitative methods for data collection were applied to an empirical research design. This allowed the collection of information unattainable if quantitative methods had been utilised. Quantitative methods were considered: surveys were initially considered as a method for collecting information on the level of understanding of SPD a design student possessed prior to and on completion of the workshop. This method was not used because the researcher was concerned that it may influence the participating design students by providing them with prompts. The problems incurred when collecting data using surveys in terms of leading is discussed by Payne & Payne (2004) as a potential bias to the research.

The three case studies involving the implementation of the prototype educational tool with product design students took place in two Scottish Universities: Gray's Art School, part of The Robert Gordon University, Aberdeen, involving BSc Hons Design for Industry and BSc Hons Engineering Design students; and the School of Design and Media at Napier University, Edinburgh, involving BDes Hons Consumer Product Design students. The product design students who took part ranged from second to fourth year[3], all possessing an understanding of the design process.

[3] This inquiry specifically refers to the Scottish system of Higher Education. This differs from the English system in that there are four years in a degree carried out in Scotland, rather than three. However, the prototype educational tool is applicable to product design courses in English Higher Education institutes if applied to second and third year.

3.2 Methodology

3.2.1 Case Study

The research methodology is exploratory in nature: it aims to investigate an effective way of facilitating product design students to design more sustainable products, applying the proposed set of characteristics of SPD as part of the prototype educational tool. A multiple-design was used as opposed to a single case study design. A definition of a case study was provided by Yin (2003) as:

"...an empirical inquiry that:

- *Investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident."* (Yin, 2003: 13)

Case study methodology was applied to the first two stages of the study:

- Two case studies investigated the integration of the set of characteristics of SPD into the product design process using the researcher's design practice. Methods for data collection included sketches, sketch models and a *"design diary"* (Pedgely, 1999).
- Three case studies evaluated the effectiveness of the prototype educational tool which allowed students to explore the set of characteristics of SPD as part of a workshop. Methods for data collection included participant-observation recorded in field note journals, mind maps produced by the students prior to, and on completion of the prototype educational tool and students' concepts with verbal descriptions recorded on video and evaluated against the set of characteristics of SPD.

A further case study was carried out as part of the analysis of the research. This case study revisited the first group of students who interact with the prototype educational tool and compared them to a group of students who had not been exposed to the prototype educational tool. Both groups of students were involved in a two week project to design a sustainable form of water container whose contents could be consumed while on the move. The presentation of their concepts was recorded and evaluated against the characteristics of SPD.

3.2.2 Action Research

In conjunction with a multiple-case design, a model of action research was employed as defined by Robson (2002). Action research premise is to identify and understand a problem, introduce a solution to improve the situation and to monitor the effectiveness of the change introduced: improvement and involvement are central to this methodology which has been used extensively by pedagogical research. This is of particular relevance due to the nature of evaluating the effectiveness of the prototype educational tool.

In the case studies investigating the effectiveness of the prototype tool (see sections 6.2, 6.4, 6.5), improvement and involvement were achieved by participant-observation recorded in field note journals (see appendix 10.3). The field note journals contained observational, theoretical and methodological notes (Newberry, 2001). The observational notes described observations made by the researcher participating as facilitator of the SPD workshop. The theoretical notes attempted to derive meaning from the observational notes suggesting improvements and changes for the next case study. The methodological notes

reflect on the delivery and layout of the prototype educational tool. These field notes were used to improve the prototype educational tool and inform the development of the set of characteristics of SPD prior to the next case study.

Swann (2002) describes action research as a practical research methodology that identifies a situation in a real-life context that needs to change. Participatory activities are used, collaborating with those experiencing a situation that requires change, followed by a cyclic process of planning, acting, observing and reflecting. He argues that action research provides a ready-made systematic framework for research that can be easily adopted and understood by designers due to its similarities with the design process. He outlines the design process and research process as the following:

- Design process:

  "problem/research – analysis – synthesis – evaluation" (Swann, 2002: 55)

- Action research process:

  "plan – act – observe – reflect" (Swann, 2002: 56)

It is essentially the practical, problem-solving nature of action research that attracts designers to this methodology. Archer (1995) agrees with Swann (2002) defining action research, in which the researchers' own design practice is a principle method of enquiry, as a *"systematic enquiry conducted through the medium of practical action, calculated to devise or test new, or newly imported information, forms or procedures and to develop communicable knowledge ...*[to] *produce insights which might otherwise never be obtained..."* (1995). Similar to the design process, a problem or situation is identified, investigated and improved upon, leading to an improvement in practice (Yen et. al., 2002). In the case of this study, the lack of understanding of sustainability specific to product

design in both professional practice and design education was the problem. This study aimed to discover if improvements might occur with the implementation of the prototype educational tool. The prototype educational tool itself was improved upon from observations made when it was applied in real-life contexts.

3.2.3 Action Case Studies

The research methodology applied is a combination of action research and case studies, 'action case studies' is the term used to describe a hybrid approach applied to this inquiry. It illustrates that the researcher requires the opportunity to observe and understand an intervention in design practice and then inform the intervention from observations made to improve a given situation. Yen et. al. (2002) describes action case studies as,

"...a hybrid of understanding of theory and its change to practice, designed to balance the trade-offs between being either a researcher capable of making interpretations of theory to design and a research/practitioner involved in creating change in design practice." (Yen et. al. 2002: 4)

Yen et. al. (2002) goes on to state that the application of this research methodology results in a goal-oriented case study involving problem solving that attempts to learn general lessons from specific cases through the multiple-case design. This approach was adopted by the multiple-case design inquiring into the appropriateness of the prototype educational tool in communicating the proposed set of characteristics of SPD.

3.2.4 Multiple Perspectives

Triangulation involves the use of multiple sources to enhance the rigour and validity of research (Robson, 2002). Cohen & Manion (1994) define triangulation as:

"*...techniques in the social sciences* [that] *attempt to map out, or explain more fully, the richness and complexity of human behaviour by studying it from more than one standpoint...*" (1994: 233)

Robson (2002) identifies four types of triangulation:

- Data triangulation: the use of more than one method for gathering information;
- Observer triangulation: using more than one observer in the study;
- Methodological triangulation: combining quantitative and qualitative methods;
- Theory triangulation: using multiple theories or perspectives.

This study has adapted data triangulation to analyse multiple perspectives, described as viewpoints. Six viewpoints involving differing methods have been employed: design practice; mind maps produced by students; transcriptions from student presentations of concepts and the concepts themselves; a comparison of a group of students which interacted with the prototype educational tool with a group that did not; interviews with members of staff who provided their opinion on the effectiveness of the prototype educational tool; and feedback from individuals involved in a product design competition. The conclusions and findings are described fully in the Analysis Chapter (7.0).

3.3 *Trustworthiness of the Research*

3.4.1 Validity

Validity of the methods used in the collection of data to address the research questions was achieved through the use of multiple sources of evidence. A multi-method approach was adopted during the action case studies, gathering data from different sources to provide as complete a picture as possible. This approach resulted in a variety of viewpoints that could be triangulated when analysing the data. However, the data gathered is limited to the context and individuals involved. For example, the case studies investigating the integration of the proposed set of characteristics of SPD involved the researcher's design practice. There are limitations to this approach in terms of generalisability and objectivity: it is only one designers' process documented; and objectivity in terms of the researcher carrying out the designing and then analysing the data gathered. It would have been inappropriate for this study to involve peer designers, due to time constraints. Involving the researcher as the designer has allowed information and insight to be gathered on the thought processes involved in the negotiation of the integration of the proposed set of characteristics of SPD. These limitations also apply to the evaluation of the effectiveness of the prototype educational tool. It is, however a prototype, stating this allows the researcher to acknowledge the limitations of the study and state that further research needs to be carried out involving another facilitator.

3.4.2 Bias

The researcher acknowledges that there are several areas of potential bias threatening the validity of the research presented in the thesis. This section will identify these areas of potential bias and describe how the researcher limited their affect on the conclusions of the investigation.

Potential bias lies in the role of the researcher. She took on several positions, researcher, designer, workshop facilitator, developed the prototype educational tool from her findings and analysed the data gathered. In relation to her role as a researcher-designer, it was felt that this was justified due to the focus of this part of the investigation. Gathering data on the negotiation process when integrating the set of characteristics of SPD into the design practice, which intrinsically occurs in the mind of the designer would be extremely difficult if carried out by a peer designer. Allowing a peer designer to become familiar with the set of characteristics of SPD at this juncture would have been time consuming.

In relation to the evaluation of the effectiveness of the prototype educational tool the researcher developed the tool, facilitated it in terms of implementation and evaluated its effectiveness. It is acknowledged that this approach may be prone to bias, perhaps inward looking. A model of action research was applied with this in mind as this methodology maintains that *"...practitioners are more likely to make better decisions and engage in more effective practices if they are active participants in educational research"* (Robson, 2002: 216).

A further potential bias in the development of the prototype educational tool described in case studies two, four and five is the use of 'reflection-in-action' (Schon, 1991) which

resulted in a change in variables. Because of the restricted time frame of the project and the availability of the student participants, it was inevitable that some of the variables would change. Any changes made were as a direct result of situations which arose while running the workshop.

Finally another potential source of bias which could affect the validity of the investigation was *"respondent bias"* (Lincoln & Guba, 1985). This may have occurred during the case studies investigating the effectiveness of the prototype educational tool, in the form of students participating in the SPD workshop attempting to provide the researcher with the answers they believed the researcher is looking for. This potential bias is particularly difficult to address in this setting. It was addressed through the use of mind maps, rather than surveys, to illustrate and record the students' understanding of SPD prior to, and on completion of the prototype educational tool.

3.4.3 Reliability

Reliability of the findings was assured through a clear trail of evidence of the various forms of data i.e. the reflective and field note journals (see 10.1, 10.3.3, 10.5.3, 10.7.3), video recordings of case studies and design sketches (10.3.2, 10.5.2, 10.7.2). This trail of evidence is in two forms, in the thesis, as a description in the Case Studies, chapter 6.0 and the Appendices (10.0) and the accompanying journals, sketchbooks and video footage. The researcher acknowledges that the investigation is qualitative in nature and the data gathered subjective. However precautions were taken such as the evaluation of student concepts produced as part of the SPD workshop in relation to the proposed set of characteristics of SPD. (See section Case Studies Chapter 6.0 and appendix 10.3)

3.4.4 Generalisability

Payne & Payne (2004) state that the findings resulting from case studies can be problematic in terms of generalisation as they are based on the behaviour of an identified group of individuals. They state that in qualitative inquires, the generalisation is less important as understanding grows *"inductively"* (Payne & Payne, 2004: 34) out of studies.

However, this research aims to investigate an effective way of facilitating product design students to design more sustainable products. The prototype educational tool was applied to three different groups of product design students at varying levels of design education. Case study two involved 2nd year students from BSc Hons Design for Industry and BSc Hons Engineering Design from the Robert Gordon University; case study four involved 3rd and 4th year students from BSc Hons Design for Industry also at the Robert Gordon University; and case study five involved 2nd year students from BDes Hons Consumer Product Design from Napier University. In order for this investigation to be generalisable further research must be carried out involving another SPD workshop facilitator. This further inquiry will add strength to the validity of the research.

3.4 Description of the Methods

3.4.1 Methods used for Immersion

Methods used to gather data during the formulation and development of the proposed set of characteristics of SPD included:

Contextual Review

Through the contextual review the researcher collected and conflated criteria proposed by recognised authors in the field. These criteria formed the initial set of characteristics of SPD. Seven areas were selected for the contextual review, and have been grouped thematically in the following way:

- Product design
- Consumerism
- Environmentally friendly design
- Definitions of sustainable design
- Criteria and tools for SPD
- An appropriate phase in the design process for sustainability
- Design pedagogy

The material was taken from a number of sources:

- Robert Gordon University and Aberdeen University library catalogues
- The British Library catalogue
- Online databases such as Design and Applied Arts Index and the Index to Thesis

- Conferences and websites such as the Centre for Sustainable Design
- Search engines such as Google.

Critical assessment of existing sustainable products

Utilising a method adapted from design practice, products currently available on the marketplace claiming to be examples of sustainable design were critically assessed utilising the criteria established by recognised authors, developing a typology of effective and ineffective use of aesthetics, interaction and instruction. Products were discovered during the contextual review, these were then critically assessed utilising the initial set of characteristics of SPD as described in Chapter 4.0. Observations were made and recorded on these products in a reflective journal (10.1).

Methods used to gather data on case studies one and three, investigating the researcher negotiating the proposed set of characteristics of SPD into design practice:

Problem solving, ideas generation and concept development

Using a variety of techniques the designer can generate solutions to problems identified by the design brief. In case studies one (10.2) and three (10.4), the researcher used brainstorming and a morphological matrix to generate ideas addressing specific problems identified in the design brief. These were then conflated to generate a series of concepts.

Methods used for gathering data on the effectiveness of the prototype educational tool when applied to groups of product design students, case studies two, four and five, included:

Flowcharts

Flowcharts were used throughout the development and application of the prototype educational tool (see reflective journals in appendix 10.1 and Chapter 5.0). These charts allowed the researcher to map out the sessions involving the students and improve upon previous sessions by displaying all activities involved in the prototype educational tool.

Mind Maps

Mind maps were produced by the design students interacting with the prototype educational tool prior to, and on completion of, the sessions. These mind maps illustrated to the researcher the initial level of understanding of SPD the students possessed. A comparison of the initial mind map to the mind map produced on completion was conducted visually illustrating any refocusing or increase in understanding. (see Appendix 10.6 and Chapter 6.0)

Semi-structured Interviews

Semi-structured interviews were carried out in relation to the mind maps produced by the students in case study four. The students were asked to explain the meaning of keywords written in their mind maps (These are detailed in Appendix 10.6). This data informed the researcher as to whether her understanding of the keywords in the mind maps differed from the students' intended meaning, as mind maps may be seen as a subjective form of data collection. A semi-structured interview was also carried out with the lecturing staff who were involved in facilitating the SPD workshop (An account of the interview is in Appendix 10.9). This interview focused on their opinion in relation to the effectiveness of the SPD workshop.

Participant-observation

Participant-observation was utilised to inform the development of the prototype educational tool (see chapter 6.0 sections 10.3, 10.5 and 10.7). When facilitating the application of the prototype educational tool to design students, the researcher observed the students' interaction with the tool. Due to the unpredictable nature of involving people, 'reflection-in-action' (Schon, 1991) was utilised to adjust the prototype educational tool as it was implemented.

3.4.2 Methods used for displaying

Methods used for displaying the development of the set of characteristics of SPD include:

Reflective Journals

In the form of sketchbooks, this was a device used throughout the study to record the researcher's emerging thoughts, allowing the researcher to reflect on the research process, note and explore ideas visually. (See Appendix 10.1 for an example)

Concept Maps

Visualisation was used to explore and formulate the set of characteristics of SPD. Concept and mind maps were used by the researcher to explore areas of the research and formulate thinking. These were recorded in the reflective journals (10.1).

Methods used for displaying the researcher's design practice in case studies one and three include:

Sketch sheets and models

Sketch drawings and cardboard models were used to record the design process. (See Appendix 10.2 and 10.4 as well as Chapter 6.0 sections 6.1 and 6.3)

Design Diary

The *"Design Diary"* (Pedgley, 1999) is similar to the reflective journal. In the first case study, notes and reflections were recorded after each period of designing. In the third case study, an entry was made once design practice had concluded. This provided information on the researcher-designer's negotiation with the proposed set of characteristics of SPD in her design practice, informing the development of the set of characteristics of SPD. (See Appendix 10.2 and 10.4)

Methods used for displaying data gathered from the implementation of the prototype educational tool included:

Tables displaying information

Tables were used to display information from the mind maps produced by the design students prior to and on completion of the prototype educational tool, and to display important quotes from the transcripts which were identified through coding. (See Appendix 10.0)

Field note journals

Participant observation was recorded in field note journals. Field notes were recorded in mind maps during the implementation of the SPD workshop and then events were written up after each session. The field note journal contained information on observations,

theoretical notes identifying improvements and changes and methodological notes reflecting on how the prototype educational tool was conducted (Newberry, 2001). (See Appendix 10.3.3, 10.5.3, 10.7.3)

3.4.3 Methods used for analysis

Methods used for analysis of the design practice exploring the integration of the proposed set of characteristics of SPD included:

Visual Analysis

Mapping the design process and colour coding stages provided an analysis of the researcher's design practice. Understanding how a designer negotiated the inclusion of the proposed set of characteristics of SPD into the design process informed the formulation of the set of characteristics of SPD. (See Appendix 10.2)

Methods used for the analysis of the effectiveness of the prototype educational tool included:

Transcription and Coding of Students' Sustainable Concepts

Student presentations of sustainable concepts produced as part of the prototype educational tool were transcribed and then analysed against the set of characteristics of SPD, providing data on students' understanding and ability to address sustainability in their design practice. Evaluation was carried out in two stages. The evaluation criteria were taken directly from the set of characteristics of SPD, as described in chapter 4.0. Firstly, the oral presentation provided by the students was transcribed and coded (see Appendix 10.3 for

transcription codes). Further assessment looked at the concepts produced by the students in the form of sketches were also evaluated against the set of characteristics of SPD as well as determining the feasibility of the concept (Appendix 10.3.2, 10.5.2 & 10.7.2). As part of the SPD workshop student groups attempted to produce sustainable solutions to design problems, these concepts were critically assessed against the set of characteristics of SPD.

Colour Coding

Colour coding was used in the analysis of the mind maps produced by the design students. Each characteristic was represented by a colour,

- Red represented 'end of life strategies'
- Orange represented 'doing more with less'
- Blue represented 'real behaviour'
- Yellow represented 'aesthetics'
- Green represented 'sustainable consumption'

The visual difference in colour provided the researcher with an overview of the proposed set of characteristics of SPD recalled individually by the students.

3.5 *Summary of the Research Design*

The methodological approach adopted by the research can be described as an empirical multiple-case design utilising a model of action research. A qualitative multi-method approach to gathering data relevant to the research objectives has been applied. The methods used are described in terms of immersion, data display and analysis. Methods included the researcher's design practice, participant observation recorded in field note journals, transcription of student concepts and presentations. Multiple perspectives have been applied to the analysis of the data collected.

4.0 A Set of Characteristics of Sustainable Product Design

The following chapter describes the formulation of a set of characteristics of SPD, which are central to the prototype education tool in explaining sustainable product design principles to undergraduate product designers. It begins by describing the initial formulation of a set of sustainable product design principles and discusses an appropriate format. It concludes by describing the set of characteristics of SPD utilised in the research described in this thesis.

4.1 Initial Formulation of a Set of Characteristics of SPD

The initial set of principles of sustainability were derived from a literature review. This review provided the researcher with a range of definitions from recognised authors such as those suggested by Walker (1998), Fuad-Luke (2002), Papanek (1984) and Datschefski (2002) (see section 2.6.1 for a review of their principles). The principles these authors propose vary in range and breadth, for example Papanek (1984) discusses the ethical responsibility of product designers whereas Datschefski's (2002) principles are engineering design focused.

To provide an overview of the principles of SPD proposed by a range of authors a table was developed displaying sustainable principles. The table (Table 1) was divided into six sections: efficiency; food for other systems; energy; safety; social issues; and design issues. The table comprised of a set of sustainable statements accompanied by product examples. This table was useful in terms of conflating and representing all the information gathered from the literature review. However, a limitation of this table was that it is a list

of principles outwith a context, with no indication or guidance as to how to understand or how they could be integrated into design practice.

Table 1. Table of sustainable statements

Characteristics of SPD		Product Example
Efficiency	Resources and energy in the manufacture, embodiment, use and disposal of a product should be 90% less harmful than equivalent products in 1990 (Datschefski, 2001).	Quattro multifunction power tool by Black & Decker. No-Shank minimalist toothbrush. Tripp Trapp growing chair.
	Aim to *"do more with less"* (DEMI, 2001).	
	Efficiency demands *"resourcefulness"*, *"restraints"*, (Walker, 1998) and inventiveness[4].	
	Dematerialise by integrating services into existing products or apply oriented services.	
	Opportunities include miniaturisation, utility and multi-functional products.	
Food for other systems	Products should be either capable of being recycled in a closed loop or be made from biodegradable materials (Datschefski, 2001).	Duracell 'blister-free' blister pack for AA batteries. Recycline toothbrush. Patagonia fleece (made from 90% post consumer recycled polyester). Tear-strip envelopes (which can be resealed and reused). Cornstarch pen.
	Design for recycling involves four principles: design for disassembly (Chiodo, Billett & Harrison,1998); labeling materials; use fewer different types of materials; and only apply surface graphics, finishes, colours and adhesives that will not contaminate materials (Datschefski, 2001). Using recycled rather than virgin materials where appropriate.	
	Provide the opportunity to reuse components by integrating non-specific mass-produced components with locally produced components.	
	Allow for repair, remanufacture and upgrading by considering the types of fastenings and adhesives applied.	
Energy	Consider the type of energy a product requires during use, where it is mainly consumed.	Taxi bike. Sekio thermic watch (muscle power). Cooksack portable solar oven.
	Utilise renewable energy, for example solar (photovoltaic solar cells), muscle power or energy from mains supplies generated by wind, wave or biomass.	
	Avoid batteries as they cannot be safely recycled and are toxic at the end of their useful life.	

[4] The design process provides opportunities to test every element of a product's impact before it is manufactured, ensuring efficient and safe use of resources and energy. Regardless of the support tools available to assist the designer in decision-making, the ethical and moral basis on which all design decisions must be built has to come from designers (Denison & Yu Ren, 2001).

Table 1 (Continued)

Safety	Consider what will happen to the product at the end of its useful life, because *"if there is no plan or system for product take back and full reuse and cyclicity then every product sold represents a toxic release"* (Datschefski, 2001)	DesignTex upholstery fabric made by Rohner Textile.
Societal issues	Encourages sustainable patterns of consumption by making alternatives seductive and pleasurable, offering experiences and material products that perform well and are affordable by the general public.	*Fairtrade Foundation* Products such as Auro paints and the Wilkhahn staff room. 'LiMe' by Phillips Design
	Products and services should be designed to encourage 'sustainable consumption' by offering the consumer a sustainable solution that meets their needs and performs well.	
Design issues	Designers must remember that people's ingenuity allows them to supersede the intended use of almost anything. Products and services should be designed with real, rather than ideal, behaviour patterns in mind.	'Nebula' by Phillips Design
	Familiar fastenings and the opportunity to customise add a sense of rapport and value to a product perhaps extending its life[5].	
	Product aesthetics – form, graphics, colour, finish – can encourage interaction with a product in a sustainable manner.	
	Utilise new technology that contributes to, rather than threatens, sustainability[6].	

Products themselves can provide a designer with vital information on the successful or unsuccessful integration of sustainability. Products embody a wealth of knowledge such as how one design team addressed a specific issue or how a user interacts with the product. A group of products claiming to be examples of sustainable design were evaluated with the premise of developing a typology of effective and ineffective use of aesthetics and product scripts informing the principles of SPD. These products were critically assessed against a

[5] A lack of familiarisation and sense of rapport with objects that make up one's material surroundings results in products only being valued for their functional convenience. Consequently, when they fail to perform their intended task they are discarded and replaced rather than maintained, repaired or upgraded (Walker, 1998).
[6] For example technology can provide the opportunity to reduce materials use and the possibilities of substituting products for services and experiences (Tischner & Charter, 2001).

set of criteria formulated from the principles of recognised authors. A typology of this nature, which is not based on function, would:

- provide the research with information on the aesthetic, effective and ineffective use of visual traits of sustainable products,
- reveal the relationship between visual information and user actions,
- illustrate to designers in the language and terms of design how sustainable problems can be solved.

This method of evaluating is commonly used by design, specifically during the research phase of the design process. Walker (2005) discussed a similar assessment process in *Unmasking the Object – a critique and reframing of product design for sustainability* at the European Academy of Design's 6th International Conference. Walker illustrated that contemporary mass-produced objects are intrinsically physical manifestations of an un-sustainable way of creating products (2005). He explored the relationship between the problems associated with product design and sustainability to create an *"aesthetic typology"* of un-sustainable products.

For the purpose of this inquiry a selection of products that claim to be examples of sustainable design by authors, designers or producers was gathered in a reflective journal. As much information as possible was gathered on the products, for example a company's green policy, materials or manufacturing processes used. This information was obtained via design and company literature as well as company websites. The products were evaluated against the following criteria:

- Aesthetics
- Instructions for the user

This exploratory method can only make general observations due to the subjective, intuitive and normative nature of the products and practice of product design (Walker, 2005). Observations illustrated the complexity of achieving sustainable product solutions demonstrating that one product cannot embody all of the principles of sustainability. Rather, appropriate principles are addressed which are determined by the nature of the design problem, user and product function. In terms of aesthetics many of the products can be described as 'form following function'.

4.2 *A Matrix of SPD*

As a conscious effort to move away from the checklist based criteria of sustainable design the researcher explored several formats to display the information gathered from the critical assessment of products and the literature review. As a progression from the table of sustainable principles (see Table 1) the researcher explored the potential of a matrix of SPD.

The proposed matrix of SPD was in the form of a set of generic questions that may be used by the designer to identify any possible sustainable design problems. The identification of such sustainable problems may occur while the designer is exploring design problems stated in the design brief, or once the product has been designed. An index of sustainability would accompany the matrix allowing the designer to visually plot sustainable design solutions.

Although an appropriate approach to an aspect of sustainable product design, the matrix deviated from the requirements of the research objectives. As the aim of the research was

to investigate an effective way of facilitating product design students to design more sustainable products, a focus on developing a format that explains the identified principles of sustainability was required. This led to the development of a set of characteristics of SPD.

A rules based set of characteristics of SPD were developed through the case studies (see sections 6.1 and 6.3), the result of which was the following set of characteristics of SPD which were used in the SPD Workshops.

4.3 A Set of Characteristics of SPD

The proposed set of characteristics of SPD are divided into five taxonomies, these are as follows:

- The product is designed with an end of life strategy
- The product is designed to do more with less
- Product scripts address real behaviour, satisfy real needs and encourage users to be proactive
- The product displays appropriate aesthetics
- The design of a product influences individuals to adapt sustainable and sufficient patterns of consumption.

4.3.1 End of Life Strategy

There are lots of reasons as to why people throw away products e.g. no way of repairing the product, transient fashion or advances in technology. Most products end up on landfill

sites which is detrimental to the environment in terms of land, air and water pollution and to our health. If there is no plan or system for a product once its useful life has expired then it represents a toxic release. The characteristics are:

End of life strategy: a designer should determine what happens to a product after its useful life has expired and provide the user with clear instructions on how to dispose of the product. There are a variety of options for disposal, the majority of which require some form of disassembly.

Disassembly: design a product that can be simply, quickly and safely taken apart – disassembled – making component and material segregation possible. A product can be disassembled by minimising the number of different types of material; clearly labelling materials for segregation; making components modular, separating parts by function; avoiding adhesives which contaminate materials; applying snap fastenings that are easily located; and using fastenings that can be taken apart with standard tools (Datschefski, 2002; Chiodo et. al., 1998).

Recycling: design a product that can be disassembled for recycling. Clearly label materials; minimise the use of different types of materials; and avoid finishes, graphics or adhesives that may contaminate materials. When possible use recycled materials. Recycling means continuously reusing materials without deterioration so materials can be returned back to the eco-system (Datschefski, 2002).

Reuse: design a product that can be disassembled, allowing components to be reused in similar or different applications. In terms of electrical and electronic products, components

such as liquid chrystal displays (LCDs) can be refurbished and reused in the same or similar products, for examples see Walker (2005). Design can also reuse materials such as the Remarkable Pencil, each pencil is made from one vending cup (Remarkable Pencils, 2005).

Repair and remanufacture: Applying familiar fastenings to products allowing them to be repaired or upgraded with new technology. By repairing or upgrading technology in products we extend a product's useful life. Upgrade is not an unfamiliar concept, upgrading computers by adding additional memory is a familiar practice.

Extending a product's useful life: Design products to be durable, with familiar fastenings to allow for repairs, upgrading or customisation (Walker, 1998: Hinte, 1997). Use components that will not break easily or within a set time frame. Design the product to function well.

Throw away product: when designing products to be thrown away consider the types of materials and components used, will they degrade over a short period of time, are they hazardous or toxic.

4.3.2 Doing More with Less

This characteristic maintains that the design of a product should aim to achieve the same, or more, from less materials and energy consumption: a concept called eco-efficiency.

Efficiency is a key area for improvement, efficient products reduce the depletion of available resources, both natural and man-made and decrease the impact of human actions

on the environment. It is a key area of business as it results in cost savings and is often required by government legislation such as the WEEE directive.

Efficiency: Design products to do more with less (DEMI, 2001). Aim to minimise a product's impact on the environment by reducing materials, energy and water consumption in manufacture and use. Aim to reduce materials, energy and water consumption by 90% less than 1990 product equivalent (Datschefski, 2002). To achieve this designers must consider efficiency throughout the lifecycle of a product. A large majority of energy is consumed during the use of a product, consider how many products are used everyday that require batteries, or energy derived from fossil fuels to function. Consider alternatives to these forms of energy, such as renewable energy.

Renewable energy: Design products that are self-sufficient. Utilise renewable energy for example solar, wind, hydro and muscle power.

Renewable materials: consider the types of material properties the design of a product needs, many of these can be filled by renewable materials, for example consider using bio-plastics which degrade without harming the ecosystem (Thompson, 2001). Labelling of materials is important so people are informed if plastics can simply be thrown away, will biodegrade, or if they have to go through specific treatments to be disposed off.

Design can reduce the impact of a product further in terms of achieving more with less by utilising local materials and labour for products that are sold within a specific region.

Local materials and production: Design products that can be manufactured and repaired locally, by utilising locally available materials and production (Walker, 1998). Locally produced products have many benefits, they create local employment, and reduce the environmental impact of product as materials and components don't have to be transported over long distances. If products are produced locally then they can be repaired and upgraded locally, extending a product's useful life. Using local materials and productions can give a product a look that is unique to the region as well as meet the specific needs of those purchasing the product.

One way of achieving more with less is by substituting products for services. There are various types of services, sharing or leasing products, as well as substituting material products for immaterial products. For example there are various websites that allow you to lease DIY or gardening products over a period of time. This is cheaper for the consumer than purchasing the product, as they only pay for the time they use the product and a small fee for insurance. The manufacturer owns the product and is responsible for repairs and maintenance.

Dematerialisation and services: When appropriate dematerialise products, substitute material products for immaterial products or services (Charter, 2001). However, there is some concern when dematerialising products that by disassociating a product from its service may result in little value being placed on the product resulting in it being easily disposed off (Fletcher & Goggin, 2001).

Modular/Multi-functional: When appropriate design products that perform more than one function (DEMI, 2001: Datschefski, 2002). This reduces the environmental impact that several specialised products may produce by reducing the amount of materials consumed per product. Examples of multi-functional products are mobile phones with built-in camera and the Black & Decker Quattro tool which has one power source and a variety of interchangeable heads. The problem with multi-functional products are that they may not deliver the variety and quality a specialised product will.

Miniaturisation: Reduce the size of a product by utilising new technology, this will reduce the amount of materials consumed per product. Like the previous options the problem with miniaturisation is people don't associate value with small products and this can lead to proliferation, which increases the environmental impact of such products.

Technology is important to sustainability, when used appropriately technology can create more sustainable products.

4.3.3 Real Needs and Pro-activity

These characteristics are:

Product Scripts: A product script is a term used to describe a plan of action the designer intends the user to follow in order to make a product perform its function (Jelsma & Knot, 2001). By considering the actions a user has to perform for a product to function a designer can encourage users to be pro-active. Actions can be encouraged in one direction and restricted in another using shape, colour, texture and instructions. For example by making

it difficult to locate and open a battery compartment the user will be encouraged to use the solar power option.

Appropriateness: design a product to meet the needs of the user (DEMI, 2004). Consider the scenario the product will be used in, who will use it and how will they interact with the product as well as its purpose. Address real behaviour rather than ideal (Thompson & Sherwin, 2001), understood through observation. Appropriateness also requires designers to be culturally aware, be sensitive to cultural identity by carefully considering the impact of name, shape, function and colour.

Inclusivity: design products which address the needs of the widest possible audience, irrespective of age or ability. Customisation may be a possible way of achieving inclusive design.

4.3.4 Aesthetics

The way a product looks can encourage us to spend more or simply buy it. It's the first thing we notice when we come upon it in a shop. If something catches your eye in a shop you think *"I like it, I want it. Now what is it?"* (Seymour, 2002). A product's look sparks curiosity and interest so we as consumers will go and investigate further.

The look of the products we individually prefer portrays to others the lifestyle and image that we want to possess. Aesthetics are also used by companies as a commodity, a way of selling more or slightly different products. We as consumers throw away products because they are no longer new, they are old fashioned due to transient nature of fashion. But this

continuous turnover of products is not necessarily a bad thing, as it creates employment. By preventing product turnover, without finding a substitution, we as designers will not only put ourselves out of work, but also many others and unemployment is un-sustainable[7].

Aesthetics influence consumers' decisions. Make sustainable products aesthetics appropriate, spark curiosity and interest so people will investigate further. A product's aesthetic is derived from the system of manufacturing used to produce it. Interwoven with this is the designer's aesthetic, specifying shape and surface characteristics, which are closely related to fashion.

"A product may initially produce a positive aesthetic experience – outwardly it may be judged both beautiful and tasteful. However, knowledge of the environmental degradation, social inequity and exploitation which may have gone into the production of the product may well change this experience. We may see the object in a new light – the object stays the same but our knowledge alters our experience of it." (Walker, 1998).

We should not be attempting to find a 'sustainable aesthetic' rather we should be embodying sustainable principles into the entire lifecycle of a product and meet the needs of the user. Designing in this way, new types of products will emerge whose aesthetics go deeper than shape and surface (Walker, 1998).

[7] This relates to the nature of capitalism. It may be argued that capitalism is fundamentally unsustainable and alternative societal models, for example those based on co-operatives exchanging goods and services such as in the Findhorn Community, represents a more sustainable model.

A stereotypical aesthetic of sustainable products can be described as 'sandals and brown paper bags'. It represents popular ideas of sustainable products being earthy and natural. But this image also portrays sustainable products to be inferior and backward, which will not encourage consumers to purchase such products. Products influenced by nature need not be inferior if we think in terms of biomimicry (Benyus, 1997).

Biomimicry: imitate or take inspiration from nature to solve problems in a sustainable manner.

Product aesthetics can determine how long a person will keep it. A damaged or old fashioned aesthetic can result in a person simply throwing a product away. One way of preventing this is through durability. Considering how the aesthetics of a product will age during use. Selecting durable materials or finishes will reduce surface deterioration allowing the user to create a rapport with the product.

Allowing a product to age gracefully (Hinte, 1997) can be achieved by using aesthetics that can take scratches or other forms of surface deterioration. This will extend a product's life by creating a rapport with the product.

Fashion is naturally thought to be against the principles of sustainability. Sustainable products' aesthetics could be classical or anti-fashion – by avoiding temporary fashion trends. Temporary fashion trends could be used to aid the transition towards acceptance of sustainable products (Walker, 2001), if the product is designed appropriately, e.g. by designing a product that can be disposed of within a short time frame as long as it is disposed of in a sustainable manner.

Customisation: design products that are modular or can be customised. A customised product will meet the needs of a user in terms of both function and aesthetics.

4.3.5 Sustainable Patterns of Consumption

This characteristic refers to the way people buy things, not the consumption of energy. These characteristics are:

Alternative forms of consumption: This characteristic maintains that alternative forms of the act of consumption and the types of products we consume need to be developed. Encouraging consumers to adopt purchasing behaviour that serves their needs without having detrimental consequences on the ecosystem (DEMI, 2001). But this does not require creating a scenario of deprivation (Manzini, 2001) rather reducing conspicuous, impulsive consumption for sufficient consumption – enough to meet our needs (DEMI, 2001).

To achieve this we must ask: what are people trying to achieve by consuming and owning this product? Can these needs be achieved in alternative ways? This involves moving away from people perceiving status and well-being as the amount of products that they own, to finding a way of meeting needs.

Affordability: design products that are affordable for all sectors of society, making sustainability achievable for all. In order to reduce the detrimental impact of human actions on the environment everyone needs to be able to afford sustainable products, don't make sustainability a lifestyle that is only in a price range the affluent can afford (Manzini,

2001). This may involve persuading people that slightly more expensive purchases that last longer are of more benefit to them. For example some may not buy energy saving light bulbs because they are expensive, but if we consider the bigger picture an energy saving light bulb would save money as they have a longer life span.

Temporary ownership: Needs do not have to be achieved through product ownership, temporary ownerships of products or virtual rather than material products can provide the same service or function. Consider alternative product forms such as virtual products or services which meet the needs of users without physically embodying a product.

4.4 *Division of the Set of Characteristics of SPD*

The set of characteristics of SPD proposed by this study have been divided into five taxonomies (see section 4.3). Each taxonomy aims to provide the undergraduate product designer with a clear understanding of all of the areas of sustainable development that are relevant to the field of product design. Lofthouse's (2001) doctoral research suggests that *"nuggets of information"* are required in order for designers, undergraduate or professionals to digest information on SPD.

The set of characteristics of SPD are also referred to as tangible and intangible characteristics throughout the thesis. 'End of life strategies' and 'doing more with less' are described as tangible. These characteristics have pre-determined options such as recycling or using kinetic energy. The intangible characteristics, 'aesthetics', 'needs and pro-activity' and 'sustainable consumption' require the designer's tacit knowledge and skill to identify potential problems and develop innovative design solutions.

4.5 Summary

The initial set of principles of sustainability for product designers was derived from recognised authors such as principles suggested by Walker (1998), Papanek (1984) and Datschefski (2002). These formed a table of sustainable product design principles informed also by the evaluation of products claiming to be examples of sustainable design.

This table was developed into a set of characteristics of SPD, nuggets of information divided into five taxonomies:

- The product is designed with an end of life strategy
- The product is design to do more with less
- Product scripts address real behaviour, satisfy real needs and encourage users to be proactive
- The product displays appropriate aesthetics
- The design of a product influence individuals to adapt sustainable and sufficient patterns of consumption.

5.0 Prototype Educational Tool

5.1 Design Pedagogy Applied to the Prototype Educational Tool

For an overview of design pedagogy see Contextual Review section 2.8.

The proposed prototype educational tool was considered to be the most appropriate method of providing undergraduate product design students with an understanding of sustainable product design principles. Gray (1988) asserts that the intentions of teaching, the role of the lecturer and the teaching and learning methods all need to be considered when developing an educational tool. A model of experiential learning described by Kolb (1984) was used in the development of this prototype education tool (see Fig. 14)

The proposed prototype educational tool applies a constructivist approach to learning, requiring the participants to develop and negotiate the generation of concepts. The application of problem-based learning provides a catalyst for generating new knowledge of how sustainable concepts can be incorporated into the design process. Critical thinking through interaction and reflection is beneficial for design students as it allows them to interpret the set of characteristics of SPD, developing knowledge that can be transferred to a variety of design problems.

5.2 Formulisation of a Prototype Educational Tool

The prototype educational tool was formulated on the premise that through interaction, design students can gain an understanding of the sustainable development issues relevant

to the field of product design. The proposed set of characteristics of SPD, described in the previous chapter, form the basis of the prototype educational tool. The activities and tasks that form the prototype educational tool introduce and allow the participants to explore and develop an understanding of the set of characteristics of SPD. It not only aims to provide design students with an understanding of the proposed set of characteristics of SPD but also the opportunity and guidance to integrate these issues into their design practice. The following objectives relate to the prototype educational tool:

- To formulate a prototype educational tool which addresses aspects of sustainability specific to the field of product design;
- To formulate a prototype educational tool which provides assistance with the transferral of knowledge into design practice;
- To deliver the prototype educational tool in a format appropriate for design students, which encourages understanding through interaction.

The prototype educational tool provides a framework for a workshop. In this context the term workshop is used to describe an intense period of study focused on generating an understanding of the set of characteristics of SPD, utilising design methods and practice.

The prototype educational tool is broken into three stages. Stage one introduces the design students to SPD through identification of their current level of understanding and the students' development of this understanding using problem solving methods. Stage two introduces the set of characteristics of SPD in the form of an interactive seminar employing key phases and product examples. Finally, stage three mediates the assimilation of the knowledge gained and applies it to design practice.

The SPD workshop consists of a series of activities undertaken by small groups of design students instructed and aided by a workshop facilitator. The activities were adapted for design practice as familiarity with the activity allows the design students to concentrate on the task in hand, rather than the context. The activities involved in the workshop are described as follows:

Stage One

- Individually, the design students create a mind map describing what they understand by the term SPD. This is a timed activity that introduces the students to the problem and provides data on the level of understanding the design students already possess prior to an explanation of the set of characteristics of SPD.
- In small, pre-designated groups, the design students generate as many as possible characteristics a sustainable product could possess, using brainstorming. They suggest possible ways a designer can design an environmentally friendly product.
- Evaluating the results from the brainstorming session, the students select and develop a set of sustainable design criteria that can be used to critically evaluate the sustainability of a variety of products.

Stage Two

- Using the sustainable criteria for the evaluation of products created by the students, each group is provided with three pre-selected products to evaluate and determine the most and least sustainable. The pre-selected products possess both sustainable and unsustainable aspects encouraging debate among the student groups. Examples

of products could include a Nike running shoe, chopsticks, a bottle of water, a wind-up radio, a plastic bag and a single use coffee filter.

- In the form of a seminar, the workshop facilitator explains to the students the set of characteristics of SPD, using keywords, product examples and questions. It is at this juncture clarification is gained by the students of the actions and considerations to be taken in design practice, in order to achieve a sustainable product design solution. Student preconceptions and misunderstandings are addressed.
- With an understanding of the set of characteristics of SPD, in their designated groups the students re-evaluate the three pre-selected products and decide which is the most and least sustainable.

Stage three

- Concentrating on the least sustainable product, the students identify and list problems with the product under the headings of interaction, function and sustainability.
- Using the list of problems identified from the least sustainable product, the student groups brainstormed possible design solutions.
- The student groups collectively re-designed the least sustainable product to be sustainable. A sustainable concept is produced and presented describing the problems addressed and reasons are provided as to why this concept is more sustainable than the original.
- Individually the students create another mind map describing what they now understand by the term SPD. This is also a timed activity (see Fig 15).

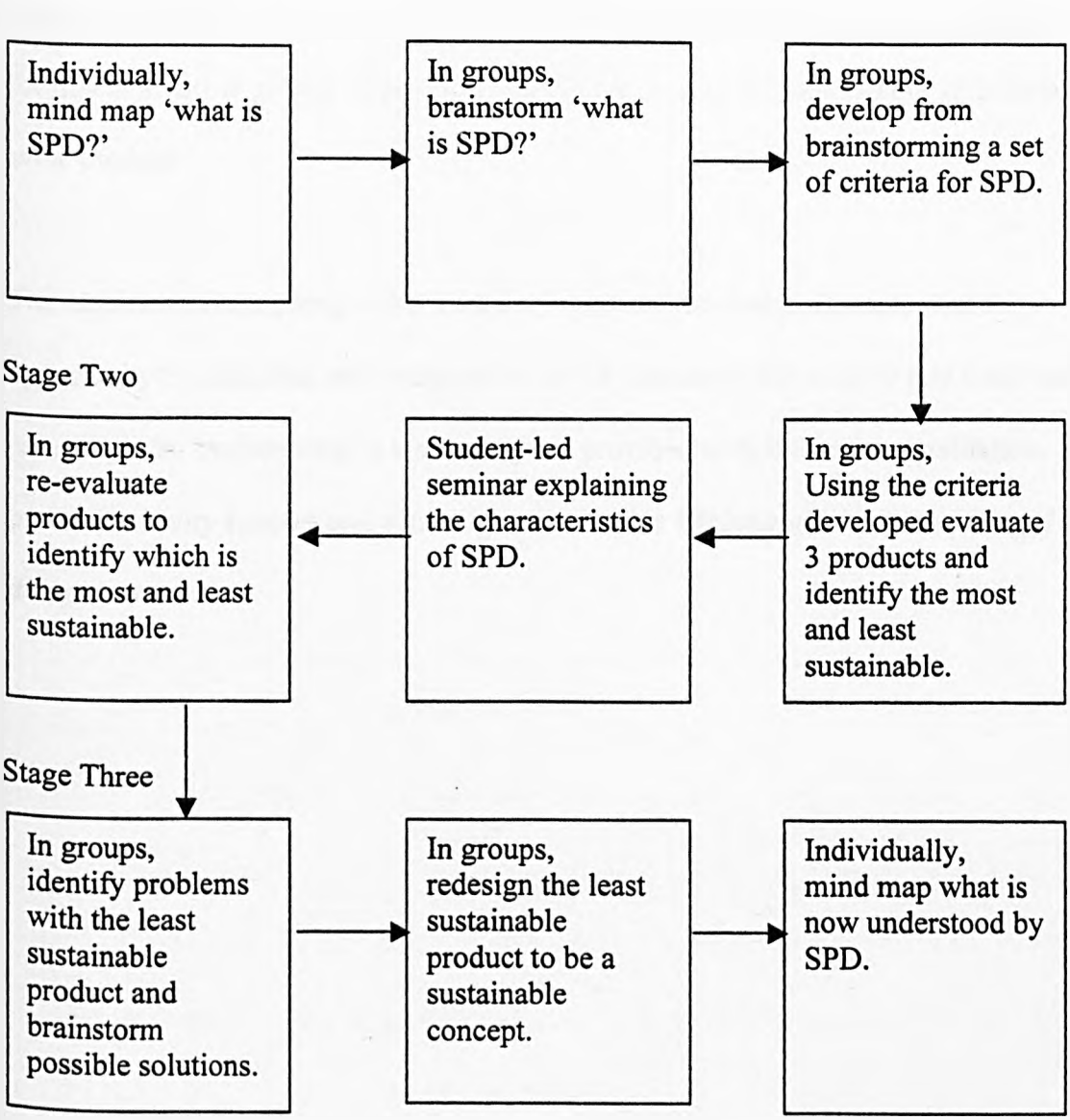


Fig. 15 Flowchart of the three stages involved in the prototype educational tool.

A variety of products could have been selected for student evaluation, the first task in stage two. A range of products were selected on the basis that each product challenged the undergraduate student to explore a different sustainable problem, e.g. the bottle of water questions material selection and need, and the Nike running shoe requires the student to consider branding as well as the inherent problems with materials. In relation to the aim of

the task, to encourage the students to consider un-sustainability and sustainability in relation to a physical product, the products selected are not the only products appropriate for this task. Other groups of products could have been used, for example variations of the same product.

The inclusion of designing in the workshop provides the design students with an opportunity to assimilate and integrate the set of characteristics of SPD into their design practice, in an environment in which they are provided with immediate facilitation. This practical activity focuses and encourages sustainable thinking as an intrinsic part of the design process.

5.3 Summary

The prototype educational tool adopted a model of experiential learning as described by Kolb (1984). A constructivist approach was applied requiring the participants, undergraduate product design students, to develop and negotiate the set of characteristics of SPD, as described in chapter 4.0, through design-based activities.

Three stages of the prototype educational tool are described: stage one introduces the undergraduate students to the problem, what is sustainable product design?; stage two allows them to explore the set of characteristics of SPD through design-based activities and an interactive seminar; and stage three explores the set of characteristics of SPD through design practice.

The proposed prototype educational tool evolved as it was implemented in case studies two, four and five, see Case Studies chapter 6.0 for a description and rationale which explains the iterative development of the prototype educational tool. (See appendix 10.10 for the prototype educational tool facilitation notes).

6.0 Case Studies

This chapter describes the five case studies carried out to investigate the research questions and objectives. It begins by describing the formulation of a set of characteristics of SPD through case studies one and three. Case studies two, four and five describe the implementation of an educational tool based on the set of characteristics of SPD. Each case study describes the rationale and objectives it is addressing, it describes the results, analysis and concludes with a summary of the findings.

6.1 Case Study One: Design Practice Exploring the Characteristics of SPD

6.1.1 Rationale for the Case Study

As a conscious effort to move away from checklist based criteria for SPD, which require the completion of the design concept before evaluation in terms of the level of sustainability which occurs, the characteristics were explored through the researcher's own design practice.

The aim of this case study was:

To investigate the set of characteristics of SPD further as a model appropriate for integration into design practice.

At this juncture, the characteristics of SPD were in the form of a table of sustainable statements accompanied by product examples (see Table 1). The aim of the case study was

two-fold: to gain first hand knowledge of how a designer interacts and negotiates the integration of the sustainable statements into design practice; and secondly, engaging with the characteristics in their current format, a table of sustainable statements, to inform their development.

The researcher acknowledges the limitations of this case study. Firstly, the generation of a sustainable product solution will derive from the researcher-designer's understanding of the characteristics. However, the integration of a subject area into the design process is intuitive requiring the designer's tacit knowledge. In order to gather this information the researcher must carry out the design practice. The researcher did consider involving peer product designers in the case study, however it was felt that the involvement of others would be time consuming as they would have to be informed of the characteristics, which were at that point still in development. Gathering data on other product designers' thought processes was considered to be beyond the scope of this research project. The researcher-designer is not attempting to produce a complete sustainable product solution but rather investigate the thinking process involved when integrating sustainability into design practice. Secondly, the process of designing a product in real life involves a design team with experts in areas specified by the design brief. The aim of the researcher is to provide the product designer with an understanding of SPD. As the researcher-designer focused on the early stages of the design process this was not an issue.

The case study was recorded and documented in a design diary. Entries were made after each design session. It was also documented in the researcher-designer's sketch sheets. It took place over a period of seven weeks, which coincided with other research.

6.1.2 Results of the Case Study

A relatively straightforward design problem was specified by the researcher-designer and written as a design brief (see Appendix 10.2). The brief was to design a containment unit that allows individuals to eat light meals while on the move. Prior to designing, the researcher-designer carried out a small observational study, recording the behavioural patterns of people eating on the move. Observations, along with sketches of current products available, were recorded in the design diary.

How to integrate the characteristics of SPD into designing was carefully considered. The form of a table of sustainable statements did not seem appropriate to the researcher-designer (see Table 1). The designer had some difficulty interpreting the statements into the design process, which were out of context. As a result, the researcher began to explore the sustainable statements both visually as well as linguistically. The results of this were three visual maps of a set of characteristics, each exploring the characteristics' connections, language and division between the tangible and intangible (see Fig 16, 17, 18).

Fig 16. Characteristics a product should possess to be sustainable.

Fig 17. Advisory statements for product designers wishing to develop sustainable solutions.

Fig 18. The characteristics of SPD represented as keywords.

In parallel to reframing the sustainable statements, the researcher-designer began to focus on problem solving. Problems specified by the design brief were listed, as were a set of sustainable problems identified by the researcher-designer in relation to the design brief. Problem solving was employed in two steps: step one identified problems with existing products on the market and various solutions were generated through brainstorming; step two involved the generation of possible solutions to the sustainable problems. A mind map was produced conflating both brainstorming sessions, the results were then developed into a series of initial concepts (Fig 19).

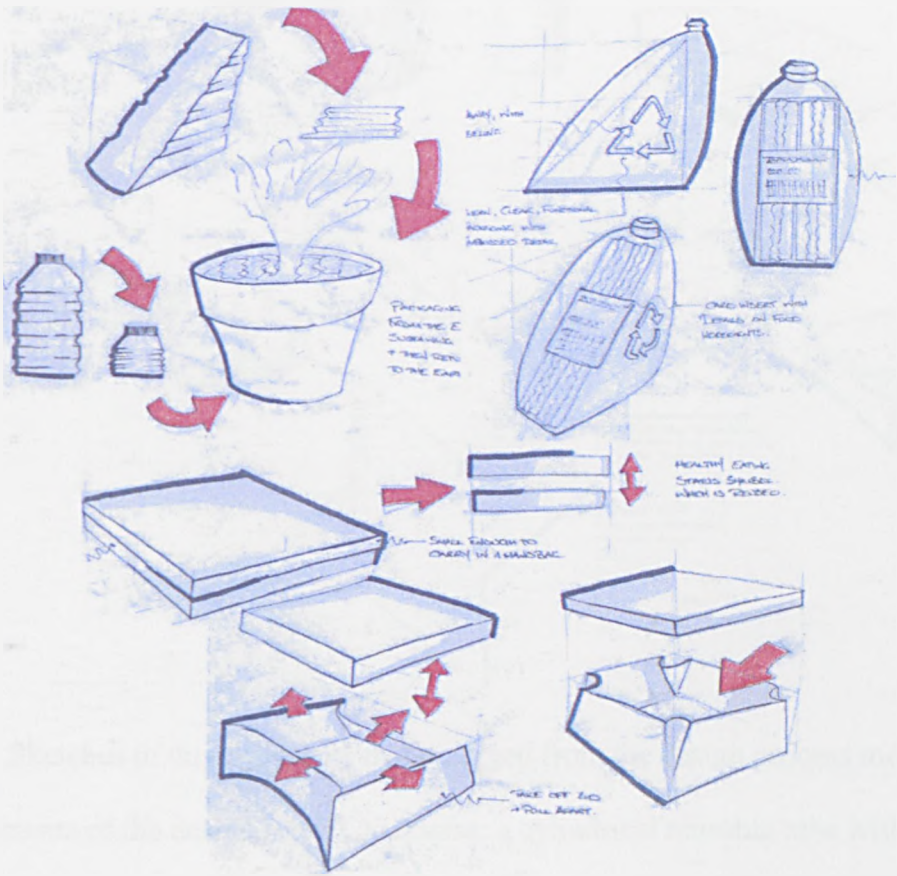


Fig 19. An example of a sketch sheet produced as part of case study one. These sketches illustrate the outcome of the two step brainstorming process in the form of initial concepts addressing the design problem – containment and eating of light meals while on the move. See Appendix 10.2 for case study output.

The initial concepts were compared to the design brief and the characteristics of SPD to make a decision as to which concepts should be developed further. Three concepts emerged, the strongest meeting all the criteria specified by the design brief. These were developed further (Fig 20).

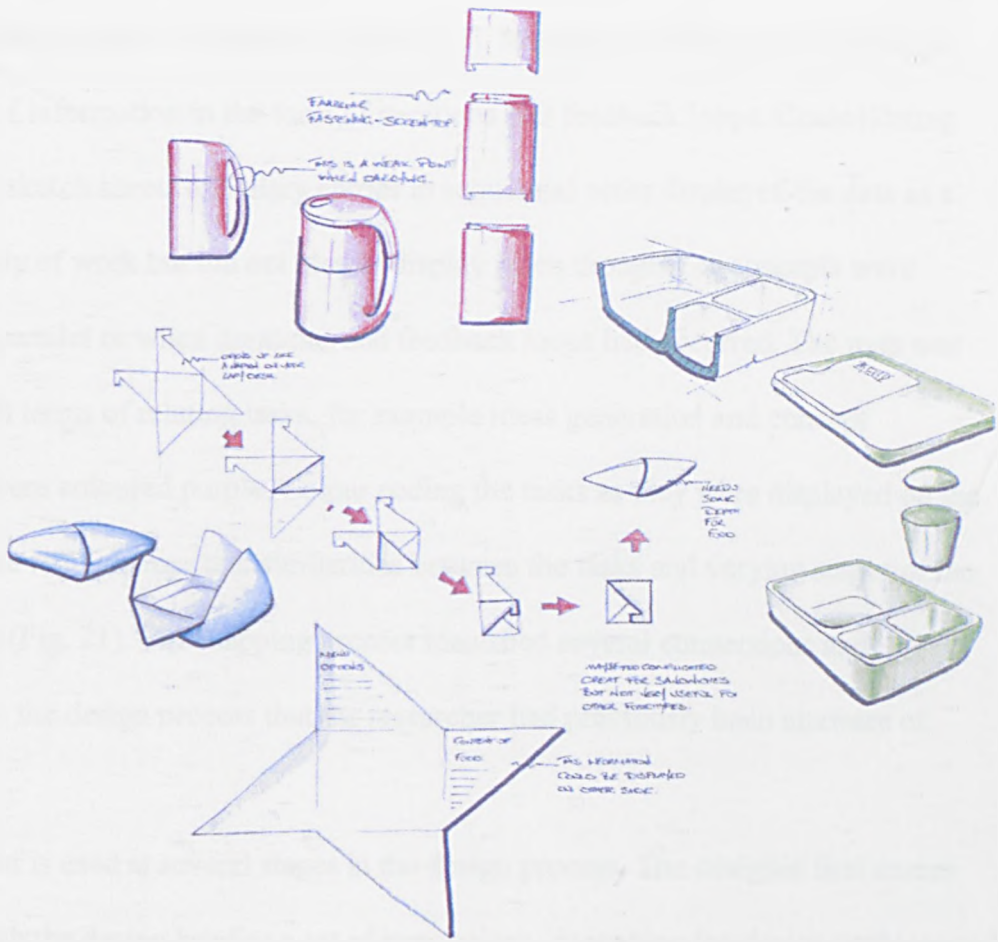


Fig 20. Sketches of three concepts that emerged from the design process meeting the requirements of the design brief. Clockwise: a cylindrical reusable tube with familiar screw on fastening; a lunch box with menu which is completed by consumer and returned to lunch provider with the next days choice; and packaging which wraps around food reducing adhesives etc.

6.1.3 Analysis of the Case Study

Analysis began by collecting all the data from the design diary, concept and mind maps, sketch sheets and displaying them in sequential order. Displaying the design process in this way allowed the researcher to consider all the data in context (see Appendix 10.2).

The data was reduced by mapping the design process from beginning to end as described by the design diary, maps and sketches (see Fig 21). Mapping the design process added another layer of information in the form of iterations and feedback loops. Consolidating and laying out sketch sheets and diary entries in sequential order displayed the data as a continuous body of work but did not clearly display when thoughts or concepts were considered in parallel or when iterations and feedback loops had occurred. The map was colour coded in terms of relating tasks, for example ideas generation and concept development were coloured purple. Colour coding the tasks as they were displayed on the map showed the relationships and similarities between the tasks and varying stages of the design process (Fig. 21). The mapping process identified several connections and relationships in the design process that the researcher had previously been unaware of.

The design brief is used at several stages in the design process. The designer first comes into contact with the design brief as a set of instructions, describing the design problem and the context in which it occurs; the brief is later consulted in the design process to evaluate generated initial concepts, allowing the designer to make informed decisions as to which ideas to develop further. It is applied again as an evaluation tool, after the development of concepts to again determine which concept is the possible solution to the identified problems. Therefore, it can be conceived that if the characteristics were included in the

design brief, concepts would be generated and evaluated in relation to both their function and sustainability.

A key phase in the case study occurred during the problem solving phase in the design process. Entries in the design diary clearly show the researcher-designer negotiating the integration of the set of characteristics of SPD into her practice:

"...Intuitively I feel there is a way to brainstorm using the core characteristics, it just may involve a variety of approaches..." (Appendix 10.2)

There are two distinct problems for the researcher-designer at this point, the format of the characteristics to allow easy integration and how to integrate them into the design process. From the map (Fig 21) it can be seen that a reframing of the characteristics took place at this point, three alternative sets of characteristics were formulated. The first set framed the characteristics as 'what a designer should consider when developing sustainable product solutions' (Fig 16) and the second set as 'advisory statements' (Fig 17). This reframing from a rules based set to a heuristic set of characteristics represents a shift in the researcher's thinking. Neither set of characteristics were used in the design practice, in fact the researcher-designer condensed the characteristics into a set of key words and phrases (Fig 18) retaining their definitions in her mind.

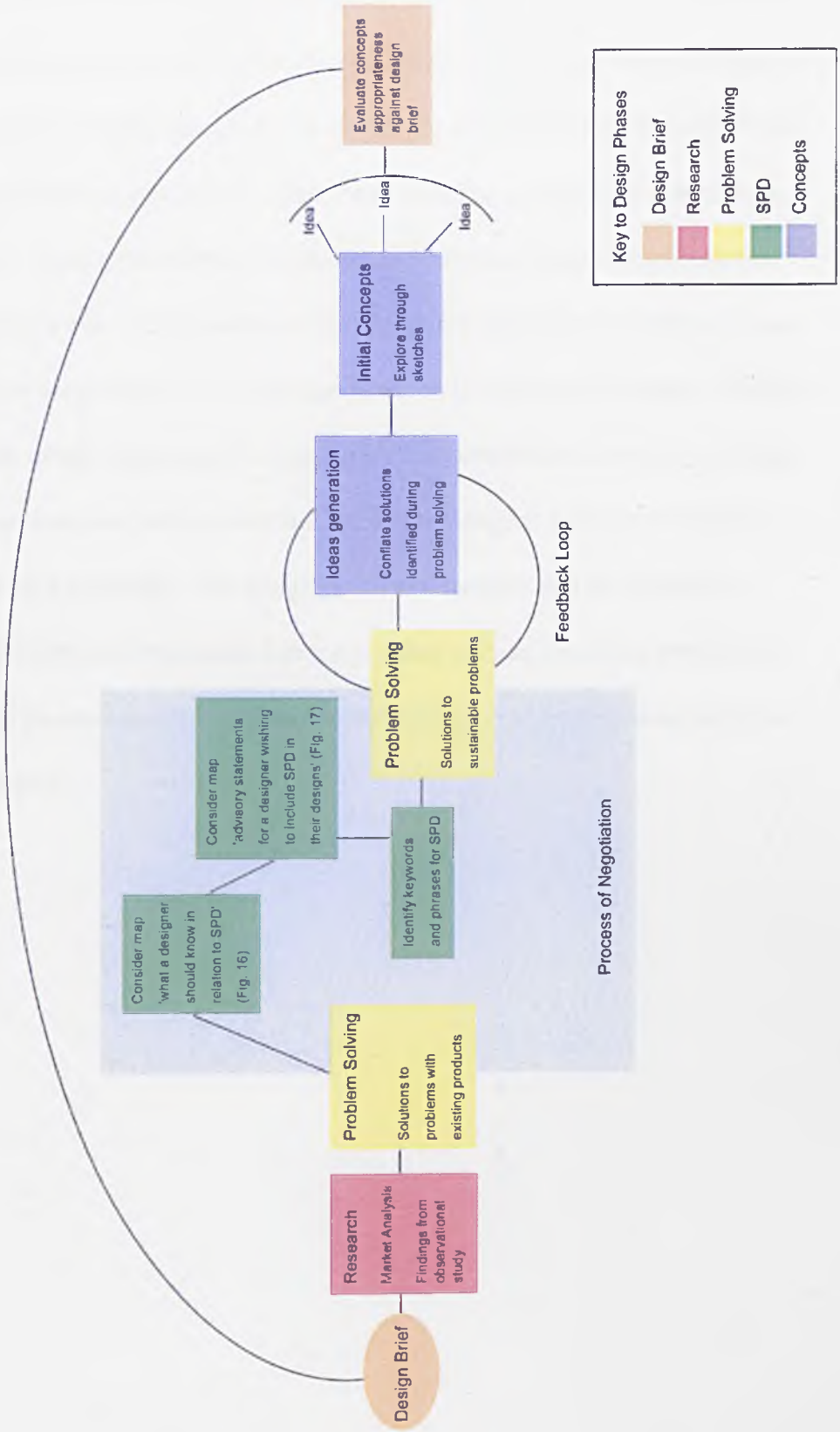


Fig 21. Map of the design process illustrating feedback loops.

Ideas generation and concept development illustrated a division between the tangible and intangible characteristics. As the process of designing unfolded, it became clear that the tangible characteristics constrained the generation of ideas, due to pre-determined options. An example of tangible characteristics with pre-determined options would be end of life strategies: options include recycle, reuse, repair, re-manufacture, disposal and extending a product's useful life. These pre-determined options make these characteristics easier to address, arguably this is due to their nature or the designer's familiarity with them. These tangible options have been addressed in previous research (Lofthouse & Bhamra, 2000) as areas for concern for design engineers. The intangible characteristics do not hinder ideas generation, however these are perhaps less familiar to the designer and how to address them presents more of a challenge. The design practice illustrates that the intangible characteristics of SPD should be addressed at the problem solving and ideas generation phases of the design process and the tangible characteristics be addressed as concepts are explored and developed.

6.1.4 Summary

Exploring this set of characteristics of SPD through the researcher's own design practice had an affect on their formulation. It became clear that the researcher-designer required both a concise set of keywords as well as an expanded set of statements explaining the keywords. Without an understanding of sustainability provided by the expanded statements, a designer would not be able to integrate them into the design process. The language of the keywords and statements was explored and a set of advisory statements divided into tangible and intangible characteristics emerged. The advisory statements required further expansion.

The case study also confirmed the researcher's original proposition that the design brief could play a role in the inclusion of sustainability into the design of products, as it is used as both a set of instructions and criteria for evaluating the appropriateness of the proposed design solution.

6.2 *Case Study Two: Implementation of Educational Tool Workshop One*

6.2.1 Rationale for the Case Study

The case study addressed the following research objective:

To evaluate the appropriateness of the proposed prototype educational tool for teaching product design students in terms of level of understanding of SPD and their ability to integrate SPD into design practice.

The aim of the case study was to investigate whether the prototype educational tool in the form of an intensive workshop, can focus design students' understanding of SPD and aid them in the integration of sustainability into their design practice.

The case study took place over four half day sessions involving students from second year BSc Hons Design for Industry and BSc Engineering Design at Gray's School of Art , The Robert Gordon University. The workshop was conducted in the design students' studio.

6.2.2 Results of the Case Study

The product design students were divided into five groups, with both Design for Industry and Engineering Design students in each group. Advice was taken on how to arrange the groups from the course leader and a lecturer. Both members of academic staff were present at different sessions throughout the workshop, the researcher adopted the role of workshop facilitator.

The first session involved the students completing four tasks. Individually, students were required to mind map, 'what they understood by the term sustainable product design'. As a group the students had to:

- Generate using brainstorming what they understood by the term sustainable product design.
- From the results of the brainstorming session develop a set of sustainable criteria for the evaluation of a product. In addition, they generated a list of keywords.
- Using the sustainable criteria they developed, evaluate a group of pre-selected products to determine the least and most sustainable products.

The students encountered no difficulties carrying out the above tasks. One group took a different approach to the brainstorming task, instead of asking what they understood by sustainable design they asked what is not sustainable and related this question to products. Their ideas were then developed into sustainable criteria. This group was particularly successful at this task, generating a substantial amount of ideas and many of the characteristics of SPD. The group appeared to progress further than others in gaining an understanding of SPD.

The second session of the workshop began with a seminar headed by the researcher-facilitator explaining the proposed set of characteristics of SPD to the whole group. The characteristics were described in six distinct areas relating to a product's lifecycle: need and conception; manufacture; packaging and distribution; consumption; use; and end of life strategy. A grid was placed on a whiteboard with the latter as headings. As the researcher-facilitator described the characteristics, product examples and keywords were placed on the grid providing the students with a visual overview of the topic. Although the researcher-facilitator attempted to involve the students in discussion through questioning, interaction was not forthcoming.

After the characteristics of SPD were described the students were required to complete three tasks in their original groups:

- Referring to the characteristics of SPD, re-evaluate the three pre-selected products and decide the most and least sustainable product.
- Concentrating on the least sustainable product, identify and list its design problems.
- Brainstorm solutions to the least sustainable product's design problems which had been identified.

Debate occurred within the groups when deciding upon the most and least sustainable products after re-evaluation, many found that the answer was not straightforward. In some instances the groups did not select the product the researcher-facilitator had identified as the least sustainable product prior to the workshop commencing. It is believed that some student groups were influenced by the product itself, selecting the product they wanted to redesign.

The third session of the workshop required the students to individually redesign their group's least sustainable product (Fig. 22). This session did not go as expected, many of the students decided to leave once instructions were given. In hindsight, the researcher believes this was due to the students no longer working as part of a group, the group dynamic had been broken. To remedy the situation in the final session of the workshop, the students again worked in their original groups to redesign the least sustainable products. The students were much more productive. At the end of the session the student groups presented their sustainable concepts.

Fig 22. Group of students redesigning a mobile phone as part of the workshop.

A final mind map was produced individually by the students at the end of the last session. All materials relating to the characteristics were removed and the students were allocated the same time to produce the mind map as before.

6.2.3 Analysis of the Case Study

In case study two several methods of data collection were applied: the researcher kept a field note journal documenting her perceptions and any changes made during the course of the workshop; two mind maps produced by the students prior to and on completion of the workshop; and students' sustainable concept sketches accompanied by video recorded presentations explaining the redesigns. Each piece of data provided an insight into the appropriateness of the proposed educational tool in terms of changes in understanding and ability to integrate sustainability into design practice (see Analysis Chapter).

Field note journal entries were made up of observational, theoretical and methodological notes as described by Newberry (2001). Several changes required were made clear by the field notes. Firstly instruction sheets explaining the tasks were required, as once these were provided the students had significantly fewer questions about the task in hand. Secondly, a reframing of the original question presented to the student groups for brainstorming from 'what is sustainable?' to 'what is not sustainable?' accompanied by some product examples. Thirdly, the framing and delivery of the proposed set of characteristics of SPD required addressing. In terms of framing, the researcher-facilitator felt there was some confusion when discussing, for example, end of life strategies as part of need and conception, packaging and end of a product's life, the characteristics need to be made clearer. Also the involvement of the students in debate and discussion needed to be increased.

The mind maps produced individually by the students were colour coded in relation to the set of characteristics of SPD:

- Designing a product to have an end of life strategy (red);
- Designing a product to do more with less (orange);
- Designing a product to address real behaviour in terms of product scripts (blue);
- Designing a product to be aesthetically pleasing and seductive (yellow);
- Designing a product that considers sustainable patterns of consumption (green).

(see Appendix 10.3)

A comparison of the first maps produced by the students prior to the workshop showed that all of the students had some awareness of sustainability and sustainable development. Words such as recycling, global warming etc. appeared on the mind maps. These mind maps were mainly colour coded red and orange representing end of life strategies and doing more with less (see Fig 23). In comparison, the second mind map produced on completion of the workshop illustrated that a refocusing of what the student understood by SPD had taken place as blue, yellow and green as well as red and orange being represented (Fig 24).

It may be argued that the students were merely surface learning, regurgitating what they had been instructed; the researcher acknowledges this may be the case. Using a questionnaire to evaluate the students' understanding was considered but the researcher felt that this would be less effective on this occasion than using mind maps, which would be less prone to potential bias. With the mind maps the students were not led but simply asked a question which they answered in their own words and addressed what they could recall.

Fig 23. An example of a mind map produced by a student prior to the workshop.

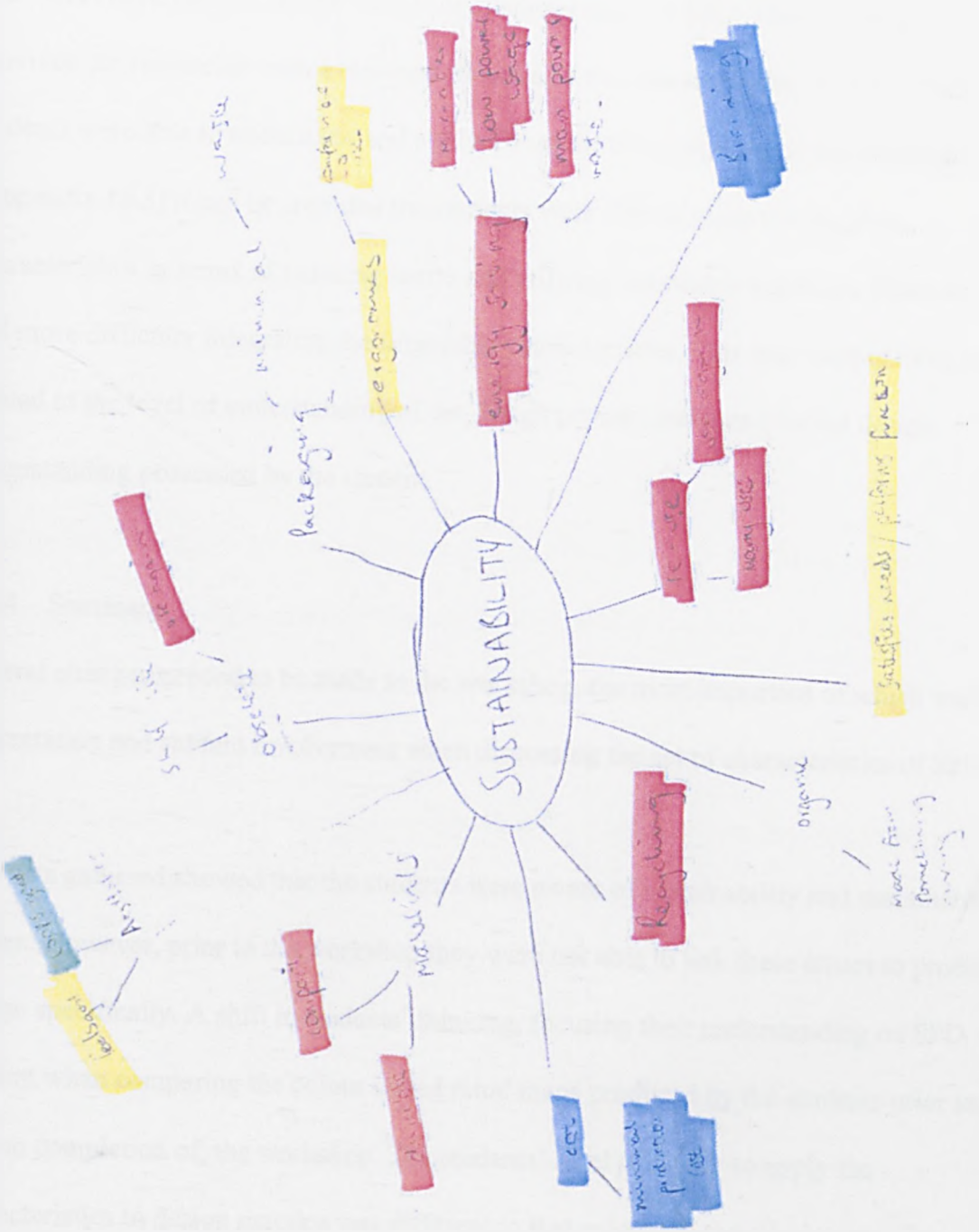


Fig 24. An example of a mind map produced by the same student on completion of the workshop.

The researcher evaluated the student group's sustainable concepts in the form of sketches and verbal descriptions, against the set of characteristics of SPD. These presentations provided the researcher with a clearer indication of the characteristics of SPD which the students were able to understand and apply. From the transcriptions of the presentations (Appendix 10.3) it can be seen that the students were able to grasp the tangible characteristics in terms of reducing waste and utilising renewable materials. However, they had more difficulty integrating the intangible characteristics. This may simply have been related to the level of understanding of the design process and user-centred design understanding possessed by the student.

6.2.4 Summary

Several changes needed to be made to the workshop, the most important of which was the presentation and student involvement when discussing the set of characteristics of SPD.

The data gathered showed that the students were aware of sustainability and sustainable design. However, prior to the workshop they were not able to link these issues to product design specifically. A shift in students' thinking, focusing their understanding on SPD, was evident when comparing the colour coded mind maps produced by the students prior to, and on completion of, the workshop. The students' level of ability to apply the characteristics to design practice was different to that evident in the mind maps. The sustainable product concepts produced by the students sufficiently addressed end of life strategies and doing more with less. However the more intangible, user centred characteristics were not evident to the same extent in the concepts.

6.3 Case Study Three: Design Practice Exploring the Core Characteristics of SPD

6.3.1 Rationale for the Case Study

This case study addressed the following research objective:

To investigate the proposed set of characteristics of SPD further as a model appropriate for integration into design practice.

This case study was carried out following the findings of case study two, which implemented the characteristics as part of a proposed educational tool for product design students. Findings from the data gathered, in particular the results of the analysis of the sustainable concepts and student presentations, indicated a possible problem with students' understanding of the intangible characteristics, for example, the characteristics addressing user interaction, aesthetics and consumption as these characteristics were not evident to the students. Therefore, the researcher investigated the intangible characteristics through her practice, aiming to integrate the information obtained from this case study and reformulate the characteristics prior to the second workshop.

The case study took place over a concentrated period of time, lasting only five hours. An extended timescale was not required as the researcher only sought to focus on the problem solving and ideas generation phases of the design process. As with the previous case study involving the researcher's own design practice, the limitations of the study are acknowledged. In this case the researcher acknowledges that problem solving and ideas generation are not ideally conducted in isolation, rather three or more designers with knowledge in the specific areas are required. However, as with case study one, providing designers with an understanding of the characteristics to the same level as the researcher

would have been time consuming. As there was a short period between the first and second workshop this would not have been possible. The researcher attempted to identify ways in which the characteristics could be reframed making it easier for the students to understand and integrate the intangible characteristics into their design practice.

The case study was recorded and documented on sketch sheets produced by the researcher-designer. A design diary entry was made on completion of the session, which took place over a five hour period, recording initial thoughts.

6.3.2 Results of the Case Study

As with case study one, a relatively straightforward design problem was identified for the purpose of the study. A design brief written for the Royal Society of Arts (RSA) student design awards was adopted. This brief required the redesigning of the packaging for a bar of soap to appeal to a family market and compete against the variety of liquid soaps currently available on the market (see Appendix 10.4).

Drawing upon information gained from case study two, the proposed characteristics of SPD were reframed prior to the study from characteristics explained in relation to a product's lifecycle to five distinct characteristics, as follows:

- End of life strategies;
- Doing more with less;
- Considering a product's script, encouraging pro-activity in the user, and addressing real behaviour;
- Appropriate sustainable aesthetics; and
- Alternative forms of consumption.

Within each characteristic are a further set of keywords, for example within end of life strategies lies throw away products and biodegradable materials, recycle, reuse, re-manufacture, design for disassembly and extending a product's useful life, such as ageing gracefully (see Chapter 4 for description of these terms).

As previously, the researcher-designer identified problems with current products and identified sustainable problems from the design brief. A two-step brainstorming process took place: firstly brainstorming the problems with current products; and secondly alongside the solutions from the first step, brainstorming the sustainable problems concentrating on the intangible characteristics. The results of the brainstorming generated a series of ideas, which could be developed further into design concepts (Fig 25).

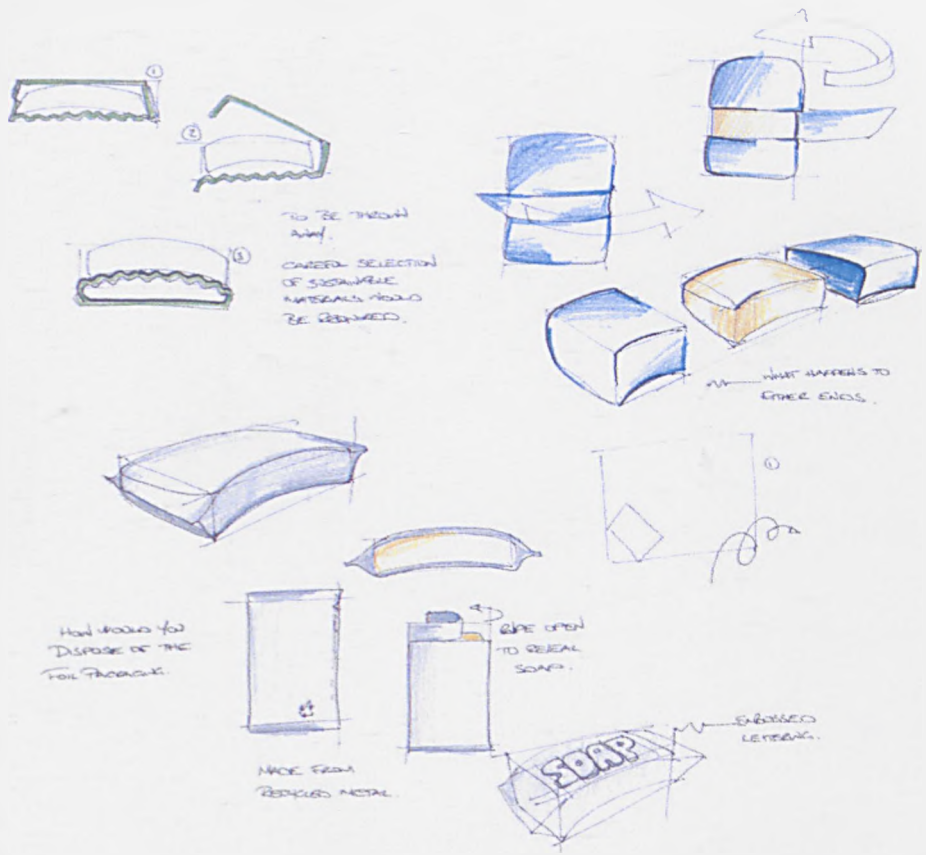


Fig. 25 Sketches of concepts. For a full set of sketches see Appendix 10.4

6.3.3 Analysis of the Case Study

As with case study one, a map of the design process was produced for analysis (Fig 26). This map was colour coded and feedback and iterative loops were identified in the process. This map confirms the findings from case study one, showing the importance of the design brief in the design process and highlighting the negotiation process the researcher-designer engaged with as part of the design process. It also shows how the researcher considered the characteristics of SPD alongside the design process in order to reframe them to be practical for the designer.

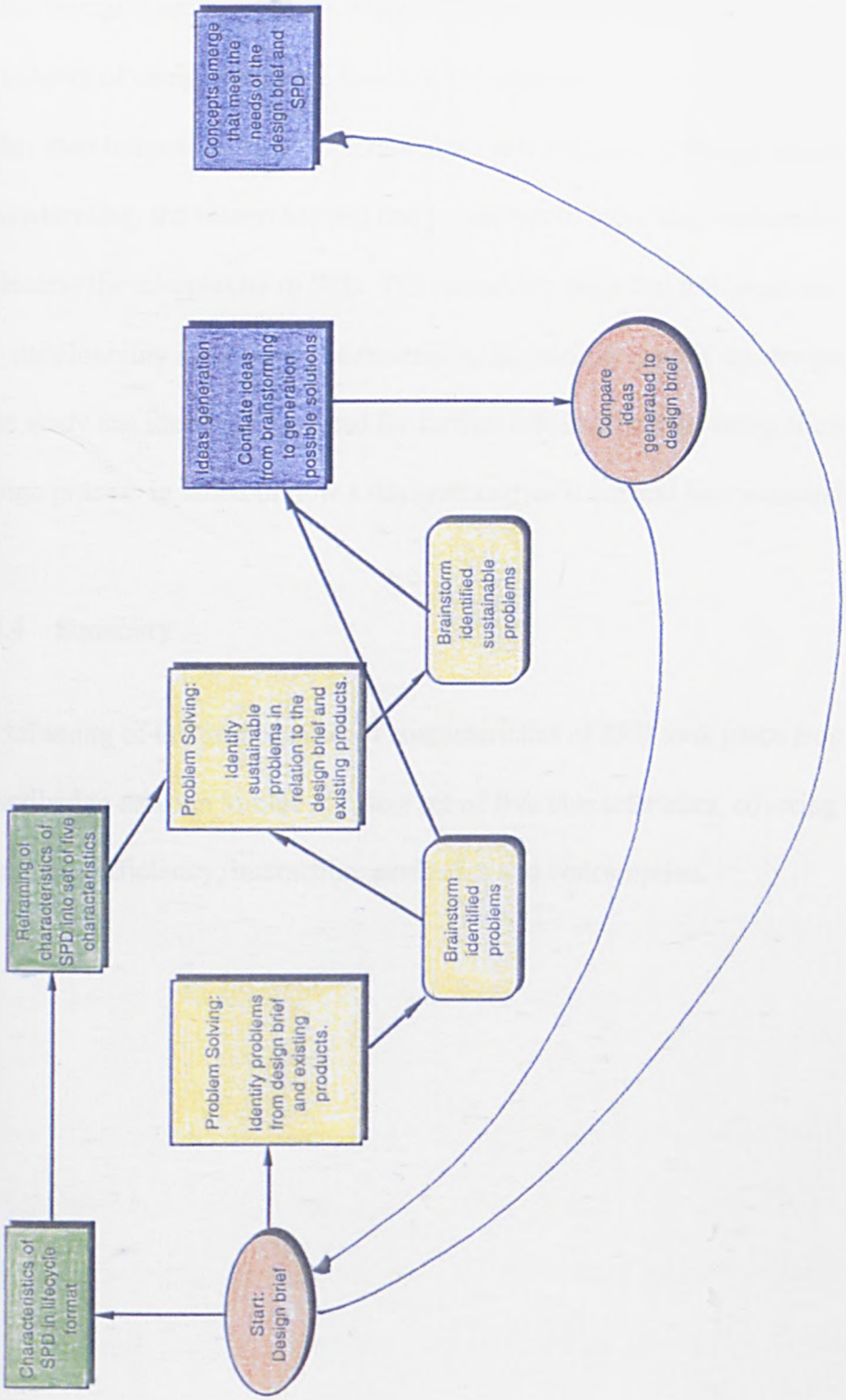


Fig 26. Visual map of design process providing insight into the integration of SPD into the researcher's design practice.

Initial thoughts recorded in the design diary drew the researcher's attention to the possibility of using alternative forms of ideas generation such as morphological matrix rather than brainstorming to generate ideas and solutions to design problems. Using brainstorming, the researcher still had to attempt to solve the problem in two steps, perhaps reflecting the complexity of SPD. The researcher feels that this must be overcome in order for sustainability issues to be considered as an intrinsic part of the design process. This case study has identified the need for further research into the integration of SPD to the design process in terms of how a designer carries it out and how successful they are.

6.3.4 Summary

A reframing of the proposed set of characteristics of SPD took place from characteristics described in relation to lifecycle, to a set of five characteristics, covering end of life strategies, efficiency, interaction, aesthetics and consumption.

6.4 Case Study Four: Implementation of Educational Tool Workshop Two

6.4.1 Rationale for the Case Study

This case study aimed to address the following research objective:

To evaluate the appropriateness of the proposed prototype educational tool to inform product design students in terms of their level of understanding of SPD and ability to integrate SPD into their design practice.

The aim of the case study, as in case study two, was to investigate the prototype educational tool in the form of an intensive workshop focusing design students' understanding of SPD and aiding them in the integration of sustainability into their design practice. This case study also aimed to investigate the appropriateness of changes made to the educational tool from the findings of case study two.

Due to the findings from case study two, the workshop was carried out over two consecutive days, providing the participants with an intense period of study and allowing them to interact with the workshop without distractions from other course work. The workshop took place in the students' design studio, as previously. Twenty-five third year BSc Hons Design for Industry students were to be involved, this number changed as not all of the students attended the workshop – some arriving late or leaving early.

The same methods of data collection were employed as in case study two: the researcher kept a field note journal documenting her perceptions and any changes made during the

course of the workshop; two mind maps were produced by the students prior to and on completion of the workshop; and students' sustainable concept sketches accompanied by video recorded presentation explaining the redesigns were evaluated.

6.4.2 Results of the Case Study

The educational tool implemented in case study four followed a similar format to the original educational tool. Some changes were made as a result of the findings of case study two, these will be described in the following section.

The product design students were divided into groups prior to the workshop, on the advice of the course leader. Unfortunately, these groups had to be changed on the morning of the workshop as not all of the students were present. The groups were reduced from seven to four groups, made up of third year and two fourth year students.

As before, the workshop began with the students individually generating a mind map describing what they understand by the term SPD, which was followed by brainstorming in their designated groups. Unlike the first workshop, the students were asked to brainstorm what is un-sustainable, beginning with un-sustainable products and identifying why these products had un-sustainable attributes. Changing the problem 'what is SPD' into a problem the students are more familiar and comfortable with appeared to help them to address the issues.

On completion of brainstorming un-sustainable product design, the student groups were asked to develop their ideas of what un-sustainable product design is into a set of evaluation criteria for un-sustainability (Fig 27). Three out of the four groups had difficulty with this task. It was at this point that the students were beginning to think about what SPD means to them as product designers. Keywords, such as recycling and reuse, appeared as did consumer psychology and fashion, the latter keywords were not evident at this stage in workshop one.

Fig 27. Group of students formulating a set of evaluation criteria for un-sustainability, from the previous brainstorming activity.

The groups were then asked to evaluate three pre-determined products to establish which is un-sustainable. Again the groups took the initiative and evaluated the products in terms of which was least and most sustainable. Images of the products were placed on a simple index of sustainability, with the most sustainable at the top and least at the bottom of the scale, providing the students with a visual representation of their choices. A form was provided for the student groups requiring them to list their evaluation criteria and the

results of the product evaluation. From this form, it was observed that the students filtered the list of criteria they had on the wall made up of post-it notes, into a list of keywords written on the form.

Changes were made to the explanation of the proposed set of characteristics of SPD. Following case study three the characteristics were re-framed into a set of five under which specific areas for consideration were described. To increase the interaction of the students in the seminar each student was provided with a sheet of paper on which was written a keyword and its definition. When the keyword was mentioned the student read out its definition. The researcher-facilitator also arranged the room differently to workshop one, everyone sat around in a circle creating a feeling of openness and equality making the students more at ease when they wanted to contribute to the discussion. These changes affected the seminar, the students were more alert, they questioned and provided product examples more readily.

On completion of the seminar the students were asked to place the sheets of paper with keywords and descriptions under the appropriate characteristic heading. This caused much debate amongst the students. The aim of this was to encourage the students to consider the connections between characteristics.

The students also debated in their groups the most and least sustainable products when they re-evaluated the pre-selected products. Again their choices were visually represented on the index of sustainability.

The second day of the workshop involved the student groups redesigning the product they had identified as the least sustainable product. The sustainable concepts were far more developed than those generated by students in workshop one. This may be because this group of students were further ahead in the course. The students seemed to easily adopt the principles of end of life strategies and doing more with less but had more difficulty addressing product scripts, aesthetics and sustainable consumption. When encouraged to consider the latter characteristics, the student groups began to explore and address the concepts.

The students completed the workshop by individually generating a mind map of what they understood by SPD and presenting their sustainable concepts in groups.

6.4.3 Analysis of the Case Study

Several changes were made to the layout of workshop two informed by the first workshop. An index of sustainability on which images of products that had been evaluated by the students according to their judgements in terms of the products' level of sustainability was introduced. Although this clearly and visually displayed choices it did not appear to aid the students' understanding of the issues, therefore it was removed from the workshop layout. The discussion on the characteristics of SPD was more successful, increasing students' participation in the discussion as well as holding their attention.

The mind maps produced by the students were colour coded as in case study two (see Appendix 10.6 for an example). Those produced prior to the workshop showed an understanding of sustainability. Unlike the first maps produced for case study two, the first

maps produced in this case study focused on design issues. Although terms such as 'long-lasting' and 'environmentally friendly' were included in these maps so were terms such as 'consumption', 'cost' and 'maintenance'. Therefore, it could be suggested that the students involved in this workshop developed an increased understanding of sustainability in relation to design in comparison with those in the previous workshop. This understanding was built upon, as demonstrated in the mind maps produced on completion of the workshop when coded.

However, the students' understanding and ability to address both the tangible and intangible characteristics may have been due to their level of understanding of the design process. Issues such as user needs and consumer psychology are introduced at this level of their education and perhaps it is this prior knowledge that helped them to consider the intangible characteristics.

The students appeared to understand not only the tangible issues but also the intangible issues, evident in the presentations of their concepts. This group of students were able to go beyond end of life strategies and doing more with less to address issues such as branding and the whole product system. For example, group one re-designed the packaging for bottled water. The concept produced not only addressed issues such as size and mass of waste by applying biodegradable-plastics, but instead of using a plastic or paper insert all branding details were included in the design of the bottle:

"...the actual sphere is an impressionable shape because its full of fluid, ...it actually creates its own base ...the actual sphere is a biodegradable product with a rubber sort of squeeze cap and so the water is released...the point of sale for a start would encourage

the fact that it is biodegradable so you wouldn't get it mixed up with recycling products..."

(See Appendix 10.7)

6.4.4 Summary

Two tasks involved in the workshop appeared to be redundant, specifically the index of sustainability and requiring the students to evaluate and re-evaluate the same products.

The data gathered from the mind maps showed that this group of students possessed some prior knowledge of SPD. However, a refocusing still occurred evident in the comparison between the first and second mind maps. These students were also able to address both the tangible and intangible issues evident by its inclusion in their sustainable concepts. The researcher believes this is because of the students' level of education, as in stage three the students are already addressing issues such as branding and consumer psychology.

6.5 Case Study Five: Implementation of Educational Tool Workshop Three

6.5.1 Rationale for the Case Study

This case study addressed the following research objective:

To evaluate the appropriateness of the proposed protoype educational tool to product design students in terms of level of understanding of SPD and ability to integrate into design practice.

As with case studies two and four, the aim of this case study was to investigate the appropriateness of the prototype educational tool in the form of an intensive workshop focusing design students' understanding of SPD and aiding them in the integration of sustainability into design practice. The study also aimed to investigate the appropriateness of changes made to the prototype educational tool from the findings of case study four.

This case study also investigates the appropriateness of the prototype educational tool when applied to a different product design course. The study took place over one day at Napier University, School of Design and Media Arts with second year students from BDes Hons Consumer Product Design. As with case studies two and four, the workshop was carried out in the students' design studio, utilising the same methods of data collection: a field notes journal, mind maps and students' concepts and presentations.

6.5.2 Results of the Case Study

Informed by the previous case studies the following format for the workshop was developed:

Stage One

- Students individually mind map what they understand by the term sustainable product design - a timed exercise lasting fifteen minutes.
- In pre-designated groups, the students brainstormed what is not sustainable. Beginning by identifying products that are not sustainable and noting why, for example a mobile phone - because the battery can't easily be disposed off and therefore can result in a toxic release.
- Brief plenary session drawing upon the concepts the students have identified as being un-sustainable, turning these around to be sustainable.

Stage Two

- Discussion on the proposed set of characteristics of SPD. Each student is given at least one keyword and description to add to the discussion. When their keyword arises they read out the description resulting in everyone taking part and increasing student contribution to the discussion.
- The students are then asked to put the keywords under the appropriate heading. Where the keywords are placed is briefly discussed.
- In groups, the students evaluate three pre-selected products to identify which is the most and least sustainable and the reasons for their choice.

Stage Three

- In groups, the students identify the problems with the least sustainable product.
- The least sustainable product is re-designed to become a sustainable concept, which is presented to the rest of the participants.
- Individually, the students mind map what they now understand by the term sustainable product design. Again a timed exercise lasting fifteen minutes. (For facilitator's notes see Appendix 10.7)

The groups of students that took part in the final workshop appeared to cope with the activities they were asked to participate in. Although perhaps unsure of this method of exploring a subject, they created mind maps, brainstormed and participated in the discussion readily.

During the evaluation of the pre-selected products, the groups focused on the negative aspects of the product. The researcher-facilitator had not noticed this in previous workshops. Group three stated that two of their products were sustainable as they represented different aspects of sustainability.

As with the first workshop, the students appeared to struggle when redesigning the product they had identified as the least sustainable (Fig. 28). They lacked confidence in their decision making process, which was added to by students joining the workshop who had not been involved in the session prior to designing. The students appeared to have problems addressing the intangible issues as in workshop one, but were able to address the tangible issues such as biodegradable materials and recycling (see Appendix 10.7).

Fig 28. Students from Napier University involved in the workshop, redesigning an existing product to be sustainable.

6.5.3 Analysis of the Case Study

Time scale was a factor that had to be taken into consideration for this workshop, especially as students did not all attend punctually. Students who joined the workshop, particularly in this case study, had a disruptive effect and influenced the students who had attended the workshop from the beginning. For example, two students joined group three as they began to redesign the product they identified as being least sustainable. The researcher observed how these students influenced the group's decisions and presentation of their sustainable concept. These students affected the group dynamics in terms of focus and concentration on the tasks at hand.

The students' bias towards understanding of the tangible characteristics is evident in the colour coded mind maps produced individually by the students. As with the previous workshops, the mind maps produced prior to beginning the workshop show an awareness of the global issues involved in sustainability in the use of words such as 'eco-friendly' or 'recycle' and 'planned obsolescence'. The mind maps produced on completion of the workshop demonstrated some refocusing although the majority of maps are dominated by

red and orange, 'end of life strategies' and 'doing more with less' characteristics (see Appendix 10.7). This obvious lack of understanding of the intangible issues was again evident in the sustainable concepts and presentations.

From the transcripts of the sustainable concepts and student presentations, it is evident that this group of students did not fully understanding the issues being discussed and were unable to integrate sustainability into their designs as the students in workshop one were. The facilitator and lecturers present at the presentations asked several questions in order to draw out why the students believed their products to be more sustainable than the originals. One reason as to why this occurred may be the time scale of the workshop, the previous two workshops were carried out over a period of two days: four half day sessions in workshop one and two consecutive days in workshop two. Due to the shorter time scale the students may have been overloaded with information, which they found difficult to integrate into the design process.

6.5.4 Summary

Students did not appear to have any difficulty completing the tasks throughout the workshop. However, they appeared to have problems with the integration of SPD into their design practice. This may be as a result of the limited time scale available as the prototype educational tool was carried out over one day, or due to the level the students were at in their education.

6.6 Conclusion

Through the use of empirical research used in these case studies, a set of characteristics of SPD has been developed utilising the researcher's own design practice. The use of the researcher's design practice provided some insight into how, and at what stage in the design process, a designer may integrate sustainability. This insight informed the development of the proposed set of characteristics of SPD into a set of 'advisory statements', keywords with expanded descriptions further divided into tangible and intangible characteristics.

Investigating the prototype educational tool through a series of three workshops led to the development of a workshop that employs design methods and practice transferring theory into practice. The level of the students' education and training appeared to effect their appreciation of, and ability to integrate, SPD into their design practice.

7.0 Analysis

The following chapter analyses the data gathered in relation to the research questions. The framework of analysis is described and a visual representation is provided for the reader. Six viewpoints are described in the analysis from which conclusions are drawn.

7.1 Description of the framework of analysis

The framework for the analysis of the data gathered has been developed in conjunction with the case study approach described in the methodology chapter (section 3.0). Due to the qualitative nature of the data gathered, which has immersed the researcher in the problems identified by the research questions, creative analytical methods have been employed. The creative analytical methods that have been developed do not attempt to isolate specific data but to interpret the outcomes of the data holistically.

The framework of analysis is based on the Miles & Huberman's (1994) model of analysis involving data reduction, data display and conclusion drawing. The framework applies a conflation of multiple perspectives of data gathered, some of which have been collected from the case studies described in the previous chapter and some which have been collected specifically for the analysis. The data takes the form of a series of viewpoints, all of which address different aspects of the original research questions. Viewpoint one verifies the formulation of the set of characteristics of SPD drawing upon the literature review, product evaluation and the findings from the researcher's own design practice. Viewpoints two to six analyse the effectiveness of the prototype educational tool: looking at the students' mind maps, concepts and presentations which are described case by case in

the Case Studies Chapter (6.0). Viewpoints four to six gathered data specifically for analysis, this involved: reflection on the students' understanding a year later, comparing students who took part in the workshop to students who did not; a dialogue with members of academic staff who took part in the workshops; and finally the opinions of individuals who took part in a condensed version of the workshop as a master-class for Channel 4's Ideas Factory competition. Following the model of analysis utilised by Bunnell (1998), the Miles & Huberman (1994) model has been adapted and can be described in three stages (see Methodology chapter 3.0):

Stage One: Immersion in the data gathered in terms of the various viewpoints.

Stage Two: mapping, categorising and coding using both colour and text to display the data.

Stage Three: Conclusion drawing – reflecting upon all viewpoints to draw conclusions in relation to the original research questions.

The visual overview of the framework illustrates the three stages of the analysis. Beginning at the outside moving towards the central circle, the outskirts illustrate the six viewpoints addressed in the analysis coming together immersing the researcher in the data. The next circle shows the move from immersion to reduction in the form of visual maps, coding in colour and text and categorising the data gathered from the various viewpoints. From the data reduction and data display patterns conclusions are drawn represented by the inner circle (see Fig. 29).

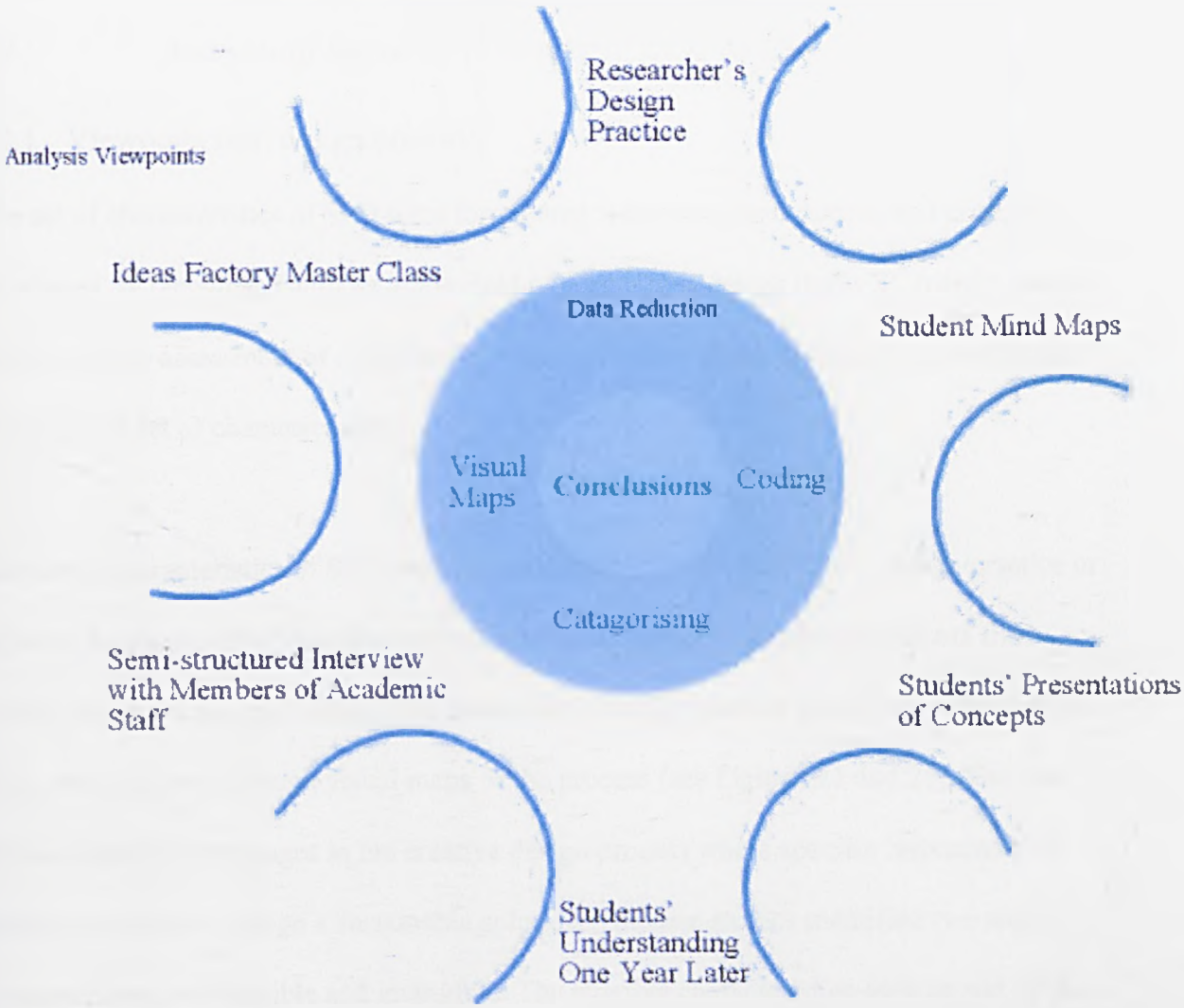


Fig 29. Visual overview of framework of analysis

7.2 *Analysis of the set of characteristics of SPD*

7.2.1 Viewpoint one: design practice

The set of characteristics of SPD were formulated from recommendations and criteria developed by recognised authors in the field of sustainable design (table 3). Insight gained from a critical assessment of sustainable product solutions also informed the development of the initial set of characteristics.

The set of characteristics of SPD were reframed through the researcher's design practice in order to develop a set of characteristics that meet the needs of the design process and reflect the way a designer thinks. The researcher's design practice (see Appendices 10.2 & 10.4) was analysed through visual maps of the process (see Figures 21 and 26). The case studies identified the stages in the creative design process where specific information is required in order to design a sustainable solution. The case studies identified two sets of characteristics, the tangible and intangible. The tangible characteristics such as end of life strategies have predetermined options available to the designer. The intangible characteristics such as product scripts and aesthetics do not have predetermined options. The design practice showed that by addressing these characteristics first and the tangible as part of concept development, sustainable product solutions can result at an early stage in the design process. A 'process of negotiation' was identified in this study visually represented in Figure 21, where in parallel to brainstorming identified problems with the design problem as described in the design brief, the researcher-designer had to consider how to integrate the set of characteristics of SPD into the design solution. The result of this negotiation process identified that the set of characteristics of SPD needed to be in the form of short headings or keywords with expanded explanations. The researcher's

understanding of what was required for design practice changed from a rules based set to a heuristic set which were more conducive to the product design process.

These case studies also concluded that the design brief has an important role in the design process as a set of instructions and a set of evaluation criteria, therefore inclusion of SPD in the design brief could result in sustainable solutions. However, analysis of the case study showed that if the researcher had no prior understanding of SPD before the design process had begun they would have difficulty addressing both the intangible and tangible issues. Therefore, designers need to possess an understanding of SPD prior to the beginning of the design process.

Conclusions from case study three questioned the use of brainstorming as a way of including SPD into the design process, suggesting that alternative forms of problem-solving and ideas generation may be more helpful.

The set of characteristics of SPD developed through the design practice case studies formed the central part of the SPD workshop described as a prototype educational tool. As described in section 6.1, the set of characteristics were explained through an interactive seminar utilising student participation followed by the students applying the set of characteristics of SPD in their design practice.

7.3 *Analysis of the Educational Tool*

7.3.1 Viewpoint two: Students' Mind Maps

Participants in the prototype educational tool workshops, case studies two, four and five, were asked to individually produce a mind map of what they understood by the term 'sustainable product design'. The mind maps were produced prior to and on completion of the workshop before the students presented their sustainable concepts. Instructions as to how to mind map, along with a visual example, were provided before the design students produced their first mind map. Each mind mapping session was a timed activity lasting fifteen minutes. Although the mind maps were intended to be produced individually they were not produced in isolation from other participants therefore participants did confer, regardless of the researcher's attempts to prevent this.

The aim of the mind maps was to provide a visual indication of possible shifts in the participants' thought processes, focus and understanding of SPD. This was to be achieved through comparing the first map (see fig. 23) to the second map (see fig. 24) produced on completion of the workshop. By also comparing the final mind map with the set of characteristics of SPD the researcher was able to decipher which characteristics are readily understood.

The researcher is aware of the limitations of this form of evaluation. Problems occur when analysing the mind maps as the subjective interpretations of words and phrases used by the students may present a differing meaning to the student and the researcher. The extent to which this occurs was briefly investigated through a series of follow-up informal interviews with students who took part in workshop two, case study four (see Appendix

10.5). These students were asked to describe their first mind map by further explaining their perceived meaning of keywords in the first level of the map; secondly, they were asked to describe their second mind map again focusing on the meaning of keywords; and finally they were asked to describe the difference between the first and second map (see transcription in Appendix 10.6). When asked to describe the meaning of the words these students had used in their mind maps they provided simple explanations suggesting the researcher's interpretation was reliable.

Initial findings from the mind maps produced prior to taking part in the workshop showed that the design students were familiar with the term sustainability evident in the inclusion of terms such as 'environmentally friendly' and 'green'. These initial maps also demonstrated an awareness of some of the issues relating to sustainable development such as 'global warming', 'pollution' and 'ozone depletion'.

The case studies informed the development of the set of characteristics of SPD. Presentation and content were improved as the researcher gained experience and data from the case studies. The set of characteristics of SPD as described and presented in case study five were used as criteria for the evaluation of the mind maps (see chapter 4.0 for a description of the set of characteristics of SPD). The students did not write down the exact words used by the researcher in the set of characteristics of SPD, therefore an interpretation had to be made by the researcher: for example words such as 'bio-degradable' and 'lifespan' were colour coded as an end of life strategy. In some cases the researcher looked at the second branch of the mind map for clarification, for example

'materials', 'substitutes', 'local' refers to substituting with local material[8]. This is a limitation of the analysis.

A comparison between the first and final mind maps shows that a definite refocusing of the students' understanding had taken place, visually represented in the introduction in some cases by yellow, blue and green representing aesthetics, product scripts and consumption patterns respectively.

Mind maps produced for case studies two and five, workshops one and three, involving second year students visually show less of an understanding of the intangible characteristics in comparison to workshop two involving third year students. However, there is an increase in the number of red and orange, end of life strategies and doing more with less, on the second map compared to the first map, as well as keywords that were not present in the first map such as 'efficiency' in second year student maps. This finding is perhaps linked to the stage these students are in their education as they are not yet familiar with issues such as user-centred design and consumption as students in year three.

The researcher is aware that the content of the second mind map is, to an extent, a reiteration of the set of characteristics the researcher introduced the students to during the workshops. The mind maps are, however a representation of what the students have retained and understood. The findings from the mind maps show that a shift in understanding has taken place due to participation in the workshop. This is also evident in the student presentations of their sustainable redesigns. In order to investigate whether the students have truly understood, retained and adopted the set of characteristics of SPD the

[8] This refers to the students interpretation of 'localisation' as described on their mind map. See Chapter 4.0 The set of characteristics of SPD for the definition of localisation described to the students

same groups of students would have to be revisited in future years. Revisiting a group of students who took part in workshop one is described in viewpoint four.

It should also be noted that there are more 'end of life strategies' and 'doing more with less' characteristics so the colours representing these characteristics were dominant. It is the introduction and inclusion of yellow, green and blue representing other characteristics that is significant to the research findings. As the introduction of such characteristics suggests, these design students are beginning to consider sustainability as an intrinsic part of design practice through consideration of the entire lifecycle of the product they are designing.

7.3.2 Viewpoint three: Students' Concepts and Presentations

A significant part of the prototype educational tool involved the design students exploring the set of characteristics of SPD through their own design practice: transferring theory into design practice. As part of each workshop the students were asked to evaluate three pre-selected products to determine which was the least sustainable. Concentrating on the product they felt was the least sustainable, the student groups attempted to re-design the product with the aim of designing a sustainable concept that provided the user with the same function as the original product. For example when redesigning a single use coffee filter the students had to generate a concept that provided the user with a single cup of filtered coffee in a sustainable manner. Observations made by the researcher recorded in field note journals of the evaluation of the products and selection for re-design were that some groups were inclined to select the product which they felt was more fun to re-design, such as in case study two when one group had to select between a plastic bag and a mobile phone, the mobile phone was selected.

On completion of the SPD Workshops the students presented their sustainable concepts in the form of a ten minute oral description illustrated by their concepts. These presentations were recorded on video and transcribed. The oral descriptions the students provided were analysed to provide evidence of the students' understanding of the set of characteristics of SPD which had previously been explained to them, and as a means of evaluating the concepts they presented.

The transcriptions were coded in relation to the research objective:

To evaluate the effectiveness of the prototype educational tool for product design students in terms of level of understanding of sustainable product design and ability to integrate into design practice, meeting the set of characteristics in the first objective.

The coding system developed (Table 2) provides evidence of the students' level of understanding of SPD through the identification of sustainable problems with the original product and subsequent solutions. The resulting sustainable concepts described by each student group provided evidence of the level of the set of characteristics the students were able to assimilate into design practice. These were broken into the identification of tangible characteristics and intangible characteristics. Identification of student groups criticising their sustainable concept solutions and rationalising their decisions also provided evidence of their level of understanding and ability to consider sustainable issues in design practice.

Explanation of Code	Code
Identification of sustainable problems with original product: Pragmatic	pra-prob
Qualitative	qua-prob
Solutions to identified problems: Pragmatic	pra-sol
Qualitative	qua-sol
Identified un-sustainable features of redesign	uns
Rationalisation of un-sustainable features	rat

Table 2. Coding system for transcripts of student concepts produced during workshops.

The transcriptions of the three case studies showed a difference in the level of understanding of the set of characteristics of SPD. Coded transcripts from case studies two and five highlight that the student groups identified mainly tangible problems with the product they were re-designing. The student groups in case two were more prolific with their identification of the tangible problems with the current product than the students in case five, who went straight to explaining the solutions to the problems. All participants in the case studies were asked to firstly identify the problems and secondly to provide possible sustainable solutions.

Case studies two and five mainly provided tangible solutions to their identified problems, for example group one in case two described the following solution to the single use coffee filter:

"And you could have a biodegradable packaging so you've virtually got no waste whatsoever at the end of the whole process. You've got coffee, you've got a snack, you've got no waste because you are not chucking anything in the bin." (Appendix 10.5)

Three characteristics, in particular, reoccurred in both cases two and five, student groups were mainly concerned with reducing waste - the most popular solution being a biodegradable plastic, specifying parts that can be recycled and adding an additional function to a product. To a lesser extent than the students taking part in case four, students in two and five were able to rationalise their decisions. For example, group eight of case two rationalised their decision to design a toothbrush without a handle:

"...the amount of material that the bristles actually use, even although it would be thrown away it could be made out of biodegradable material, or if you can't get suitable material that is biodegradable the amount of material that's used is so little compared to a toothbrush today." (Appendix 10.5)

The students in case five required more prompting for rationalising their design decisions, rationalisation came when they were prompted by the researcher-facilitator or a member of academic staff. (see Appendix 10.7).

Although the purpose of the workshop was specifically to design sustainable product solutions, some students in case studies two and five treated sustainability as an add-on, re-designing the product in relation to users and manufacturing or technology and then adding

on sustainable characteristics as a secondary consideration rather than integrating it at the start.

As mentioned previously, the coded and clustered transcriptions from case four, involving third and two fourth year students from BSc Hons Design for Industry provided evidence of an understanding of SPD at both the tangible and intangible characteristics level. The students were able to identify the sustainable problems with the product in relation to how a user interacts with it. For example, group one were re-designing the packaging for a water bottle:

"...we opted for the bottle as being the most un-sustainable as people don't give any value to this actual bottle after they've drunk the contents. So, they just basically throw it away and even if it is, it is recyclable and it is crushable for sort of waste storage, but you've maybe done it once but you never do it again, you just throw away the bottle..." (Appendix 10.5)

The students in case four were also able to describe both tangible and intangible solutions to the product they were re-designing:

"... biodegradable embossed on it so that you know that it is biodegradable...And that would be the only actual sort of labelling on the product ..." (Appendix 10.5)

They were also able to identify unsustainable features of their redesigns and possessed the ability to rationalise their decisions. For example, the group re-designing the water bottle

packaging stated in response to the facilitator's questions on what is not sustainable about their concept:

"Possibly the nozzle,, because it's got to be made of a different form/sort of plastic. But in saying that, it's a smaller piece of plastic.. So the nozzle can be recyclable but it's so much more smaller than this whole bottle here so,, it's just like that size there – points to lid of original bottle - *as opposed to the whole bottle. So, is a sustainable feature. It's far more sort of, well it's far better than current bottles."* (Appendix 10.5)

The sustainable concepts produced by the students in the form of sketch drawings were critically assessed utilising the set of characteristics of SPD as evaluation criteria. As described earlier in this section, the sketch drawings were used by the students as a tool to visually illustrate what they were describing orally. In terms of the concepts produced, the majority of concepts could be classified as blue sky ideas. All of the concepts included some of the set of characteristics of SPD with varying levels achieved. These varying levels provide further evidence that different levels of education were able to achieve different levels of sustainability.

In conclusion, the evidence provided by the transcriptions of the student presentations showed that the student groups were able to integrate sustainable characteristics into their design practice at varying levels. The students' level of understanding of SPD gained from the prototype educational tool, is inherently linked to the level they were able to integrate the set of characteristics into their design practice. The transcripts showed that there was little difference in terms of level of understanding and ability to integrate SPD into designing between the second year BSc Hons Design for Industry and BEng Hons

Engineering Design students from Gray's Art School and the second year BDes Hons Consumer Product Design students from Napier University. Both courses at this stage were able to understand and address the tangible characteristics but there was little evidence of them addressing the intangible characteristics, therefore it may be concluded that they did not understand these. However the third year BSc Hons Design for Industry students developed an understanding of both the tangible and intangible characteristics evident in the identification of both sets of problems and subsequent solutions. The third year students were also able to identify un-sustainable aspects of their re-designs and rationalise their decisions. These results may be due to the level the students were at in the product design courses. Level of education is an important consideration in relation to the effectiveness of the prototype educational tool. Students are introduced to different aspects of the design process at each stage in their education. It was perhaps a struggle for second year students to tackle and understand characteristics simply because they hadn't encountered these issues at this stage of their education.

7.3.3 Viewpoint four: Analysis of Students' Work One Year Later

Viewpoint four revisited the product design students who had taken part in case study two, the first workshop, to gain an insight into their level of understanding of SPD and ability to integrate SPD into the design process one year later. This group of students, now in their third year, were involved in the Royal Society of Arts (RSA) student competition. A group of seven students selected a project titled 'A drop in the ocean', the brief to design a sustainable alternative to current water bottles. The project took place over a period of two to three weeks concluding with a presentation of their final concepts. The researcher did not take part in any aspect of this project and did not provide the students with any assistance.

A group of eight second year BSc Hons Design for Industry students were also involved in this project. It was felt that by comparing the third year students, who had taken part in the workshop, to the second year students who had not participated, analysis of the comparison would provide the researcher with an insight as to the effectiveness of the SPD workshop in relation to the long-term integration of SPD. Both the second and third year projects concluded with a formal presentation of their final concepts. These presentations were video recorded and coded as previously, the results of which were then compared as were the concepts themselves (see Appendix 10.8).

A wide variety of concepts were proposed as a solution to the design problem set out by the RSA brief, to design a sustainable alternative to current bottles containing water that can be used while on the move. Both groups of students, second and third years, interpreted 'on the move' differently, ranging from going about day-to-day tasks to specific sports such as mountain climbing and triathlons (see appendix 10.8). Comparing the two groups, it is evident in the content of the transcripts that the third year students had a clearer understanding of the issues involved in SPD and possible opportunities for design solutions. It was also evident that this group of students possessed a clearer understanding of what the design brief required, this may be due to their stage in design education. The third year students were able to rationalise their decisions with regards to sustainability, for example one proposed concept was a flat-pack paper cup:

"...I was thinking about making it plastic and so you could have it in your pursel the whole time, but then you've still got the plastic in the end and would you want to reuse it? And

you wouldn't put it in your purse straight away because it would be wet. So it was like a little bit of paper that you can dispose of." (Appendix 10.8)

In terms of coding, both groups mainly described solutions to tangible problems such as product life extension through reuse, recycling and biodegradable materials. The second years paid particular attention to the materials used whereas some designs by the third years considered customisation and product life extension by requiring consumers to invest in a product and specifics such as removing labels. Some third year design concepts also questioned the behaviour of the user in order to address real rather than ideal behaviour. One design put forward by a second year student also did this, however the student had taken part in the workshop the previous year as a Engineering Design student and therefore it can be assumed that the student was aware of the set of characteristics of SPD. Another student from second year did not address sustainability in his design although he was aware that it was a requirement of the design brief as he described the brief at the beginning of the presentation as *"...it's a sustainable design for a water container"*. The second year students addressed sustainability as a secondary consideration and described how they had addressed it later in their presentations as part of material selection. However, the third year students addressed sustainability as an integral part of the product they were designing, describing how they had addressed issues early on in their presentations.

It is clear that the third year students did have a clearer understanding of sustainability, although they still had some difficulty with its complexity when integrating it into design practice. One student in second year, however, proposed a concept that was sustainable throughout its entire lifecycle and encouraged an awareness of local environmental issues.

The proposed design was a biodegradable water bottle which included plant seeds. Once the user had drunk the water, the bottle was turned upside down and planted into the ground, within a few months the bottle had degraded and a plant was in its place. The bottle would have a shelf life of one month and encourage local environmental knowledge on seasonal and local plants. From both groups this concept was the only concept that considered sustainability throughout the lifecycle of the product as well as how people would interact with it.

Although minimal, the transcripts and accompanied concepts provide evidence that the third years were more aware of SPD and how it integrated into the design process. There may be two reasons for this finding, which are intrinsically linked. This provides some evidence in favour of the effectiveness of the prototype educational tool although it may be attributed to the level of education the student has attained e.g. the students have encountered intangible aspects of product design and are more skilful at designing to a brief. (see appendix 10.8).

7.3.4 Viewpoint five: Semi-structured Interview with Academic Staff

It was felt that the opinions of the members of academic staff of the prototype educational tool would be valuable for its analysis. The academic staff, a course leader and a lecturer who both took part in case study two, workshop one, were invited to informally discuss their opinion of the SPD workshop as a prototype educational tool. During this discussion the researcher wished to address the following areas:

- The effectiveness of the prototype educational tool in terms of raising the students' awareness of SPD.

- The stage in design education when the SPD workshop should be conducted.
- Their opinion on the difference between the third and second year students' understanding in terms of intangible and tangible characteristics.

At the outset of the discussion the lecturer provided an example of the value of the prototype educational tool in raising the students' awareness of SPD:

"... I just thinking about the problem we had with one of the fourth years about this time last year, who was looking into this and who didn't turn up to the workshop, and it just seemed that everyone else appeared to have more of a grasp of what sustainability is. Obviously there was value in the workshop." (see Appendix 10.9)

The lecturer also stated that the students who had attended the workshop had taken away with them the concept of including sustainability in terms of lifecycle thinking. Both the course leader and the lecturer agreed that the students who had attended the workshop were more skilful in their inclusion of SPD in their designs for the RSA project 'a drop in the ocean', compared with the second year student who had not attended the workshop but had developed designs for the same project. Their opinions are in agreement with the findings of viewpoint four. In relation to how the second year students cope with the project the course leader remarked:

"...when you have been working with them on the project like this year, the second year - the water bottle, you can see it's been too difficult for them. They can't deal with it and you just have to let them go because they don't know what to do, it's too difficult, they would

have to do your whole workshop again for them to try which is quite interesting because they just can't."

A difference between the maturity of the students, understanding of the design process and ability to integrate contemporary issues such as SPD into the design process between second, third and fourth year students was identified during the discussion. These factors had a direct affect on the workshop in terms of what the students achieved from the workshop. The course leader stated that second year students are:

"... coming up with stuff, you know they're keen, you know most of them are willing to learn I think. In third year, suddenly the penny drops and they become a bit more understanding or sophisticated."

It was suggested by the course leader that a two stage approach would be of benefit to the students in terms of their level of understanding, conducting the workshop when the students are in second year and then a follow up workshop in third year. However the course leader felt that second year was the appropriate year to introduce the topic due to the objectives of the year: students are introduced to aspects of design integrated into design projects, therefore in second year they have the opportunity to explore SPD as an individual design project.

Both the course leader and the lecturer discussed the prototype educational tool in terms of learning for both the students and themselves, mentioning the importance of understanding and experiencing learning for themselves and feeding this back to the students.

When asked what changes they would make to improve the SPD workshop, it was suggested that extending the workshop to allow the students to undertake research in order to find examples of sustainable design, or reading to be conducted out with the time allocated to the SPD workshop would be of benefit to the students' understanding. However it was also noted that the students in second and third year possessed a limited ability to critique literature, for example, rather than investigating a concept suggested by a website or book, the students have a tendency to adopt it uncritically.

In terms of the activities and layout of the prototype educational tool both the course leader and lecturer thought the three stages of the SPD workshop were valuable, in providing the students with a starting point.

"They started understanding how to put it all this together and looking into this in their fourth year and they understand it."

They addressed group dynamics as an important aspect of the SPD workshop, stating that through groups the students can gain an understanding through their peers. However if groups are dispersed and students are asked to work individually, problems occur due to lack of confidence. They put forward this as a possible reason why there were problems with student participation in workshop one.

7.3.5 Viewpoint six: Channel 4's Ideas Factory

Channel 4's Ideas Factory is an initiative to promote careers in the creative industries. In the form of a competition, individuals are given the opportunity to work with those already working and researching in this field. Throughout the UK, different cities ran competitions

focusing on different creative disciplines - in Aberdeen the focus was product design. People were asked to submit product ideas which were reviewed in terms of potential marketability by Gray's Art School staff. A select few went through to the second round which involved a weekend of master-classes.

The researcher was approached by Lighthouse-Graphics, organisers of the event in Aberdeen, interested in the SPD workshop as a master-class because it addressed an important issue for product design. A condensed version of the SPD workshop lasting two hours was carried out with the competition entrants, made up of individuals who had no prior experience of product design. The workshop involved:

- Brainstorming what is 'not sustainable product design';
- Discussion on the set of characteristics of SPD; and
- Redesigning an existing product to be more sustainable.

A survey was developed by the researcher to receive feedback from the group involved (Appendix 10.10). The participants were asked five questions, the answers to be provided on a scale of one to five (one being the highest or most enjoyable and five being the least). The majority of the participants enjoyed the master-class, when asked ten individuals out of fourteen rated their enjoyment of the master-class as two or above. When asked about the appropriateness of the master-class to the product they were designing as part of the competition, again the majority said it was appropriate for their designing, eleven individuals ranked the appropriateness two and above. The majority of the participants, twelve out of fourteen, stated that the master-class had developed their understanding of SPD. When asked to rate the usefulness of redesigning a product in developing their

understanding of SPD four participants stated it was not useful, ranking three and below. Finally, when asked to rate the usefulness of the discussion of the set of characteristics of SPD nine participants stated this discussion was useful, giving it a ranking of two and above, and five ranked it as three and below.

When asked for any comments three statements were made:

"Useful session in that it was a whole new topic to me which was interesting/thought provoking although not entirely relevant to my product"

"Like the brainstorming"

"Thank you, enjoyed the exercise made me think in a different way."

7.4 Comparison to DEMI

As seen in the contextual review (2.6.3) there are a variety of tools available to designers to aid the integration of SPD at the various stages of the product design process. The *Design for the Environment Multimedia Implementation* (DEMI) project is one of the more successful tools for designers in the form of a website, formulated by researchers at Goldsmith's College. As a result of the upcoming government initiatives, the aim of the DEMI project was to *"raise awareness, assess environmental requirements and communicate a core sustainability learning agenda (to staff and students) across the design sector."* (Goldsmith's, 2000).

The resulting website provides information on the origins of sustainability; introducing and explaining sustainable development; DEMI principles for sustainable design accompanied by a gallery of sustainable designs and specific information on materials. The website allows all aspects of sustainability to be easily accessed: although it is presented visually, the pages are easily downloaded and the navigation is simple, as well as all the information provided being in clear and concise language suitable for designers.

The DEMI website does not provide any guidance as to how to utilise their principles. Also, no distinction is made between principles that a company needs to address and those that should be considered by the designer. For example, the principles state the importance of scale in terms of the mass of products produced, due to the amount of the products the company may need to consider putting in place an infrastructure for disposal. At the designer level the impact of materials must be considered.

The information provided by the website is presented in such a way that design students and professionals have the opportunity to dip in and out of the subject allowing them to explore specific aspects of the topic as well as the entire subject. However, being able to dip in and out does not encourage the designer to gain a comprehensive understanding of all the opportunities and problems that need to be addressed when considering sustainability in product design.

Although there are obvious benefits of the DEMI website, this thesis proposes that by providing design students with a basis of information as well as the opportunity to interact with the topic aided by a facilitator familiar with sustainability issues, this would be a more appropriate manner for design students to learn and understand sustainability.

7.5 Comparison to Information/Inspiration

Information/Inspiration was a tool developed by Lofthouse (2001) to communicate eco-design to industrial designers, in particular industrial designers at Electrolux. Lofthouse's PhD research investigated, by surveying industrial designers, to ascertain what they required in an eco-design tool. Lofthouse found that the professional designers required that three areas should be covered by the tool: *"guidance", "education"* and *"information"* (Lofthouse 2001:64). The resulting information was embodied in the *Information/Inspiration* tool.

The tool is in the form of a Microsoft Frontpage 2000 document using HTML pages working on different levels. Information is presented on dark blue pages and inspiration on light blue pages, these are linked through hyperlinks moving from keywords and 'nuggets

of information' to specific details and guidance. As with the DEMI website, design teams can dip in and out of the HTML pages or go through the entire document, it does not require any verbal explanation.

As with the DEMI website, this tool provides those with experience and tacit knowledge in addressing complex topics in the design of products with a tool that provides instant information. It was built on the premise that industrial designers have had little guidance on eco-design during their design education and that they do not have enough time as professionals to attend specific training.

There are some similar features applied in both the DEMI website and Information/Inspiration tools that have been utilised in the educational tool presented in this thesis, for example information is presented in different levels: keywords, 'nuggets of information' and expanded explanations. Sustainability is presented in terms of information and product examples, linking theory with examples of practice. However unlike the DEMI website and Lofthouse's Information/Inspiration tool, the educational tool shares expertise and facilitates an understanding of SPD by applying design methods and practice.

7.6 Summary

Viewpoint one: Investigating the set of characteristics of SPD through personal studies identified a division in the characteristics between the tangible and intangible. These case studies informed the formulation of the set of characteristics of SPD which formed the basis of the prototype educational tool.

Viewpoint two: Colour coding of the mind maps produced by the design students prior to, and on completion of, the SPD workshop illustrated a refocusing of their understanding of SPD. Mind maps produced in case studies two and five involving second year design students show an understanding of the tangible characteristics, whereas the mind maps produced in case study four, involving third year design students, show an understanding of both the tangible and some intangible characteristics.

Viewpoint three: Coding of student groups' presentations of sustainable concepts designed as part of the workshop, as well as critical evaluation of the concepts themselves, provided further evidence for the link between understanding the tangible and intangible characteristics and the stage of the students' design education. Case studies two and five involving second year students mainly addressed tangible characteristics in their designs, in particular focusing on material selection, recycling and adding an additional function to a product to extend its life. Some groups within these case studies treated SPD as a secondary consideration, redesigning the product in relation to users then adding sustainability rather than integrating it from the beginning. Student groups in case study four, third year students, addressed both tangible and intangible characteristics at the early stages of the design process. These students were also able to rationalise and identify unsustainable features of their sustainable concepts.

Viewpoint four: Comparison between two groups of design students both addressing the same design problem, one group who had taken part in the SPD workshop the previous year and one who had not, illustrated a difference in terms of understanding and ability to integrate SPD into design practice. The group who had taken part in the SPD workshop considered SPD from the outset of the design project, whereas the other group of students did not and mainly addressed the sustainability through re-use or biodegradable materials. Therefore, the students who had taken part in the SPD workshop possessed a clearer understanding of SPD.

Viewpoint five: Discussion with members of academic staff from a participating design course illustrated the value of the SPD workshop from their point of view. Examples were provided and comparisons made between students who did and did not attend the SPD workshop. The maturity and ability of the students were also put forward as a possible explanation of the difference in understanding of SPD between second and third year students. It was stated that second year was the most appropriate stage to introduce SPD. It was also suggested a follow up workshop conducted in third year would be of benefit.

Viewpoint six: Competition entrants from Channel 4's Ideas Factory found a condensed version of the SPD workshop enjoyable and appropriate, however these individuals did not understand the link between their competition concepts and the responsibility of designers to consider SPD.

8.0 Discussion and Conclusions

This chapter discusses the findings described in the previous chapters in direct relation to the objectives set out at the beginning of the thesis. It discusses key issues that have arisen as a result of the research findings. It acknowledges the constraints and strengths of the study and states the original contribution to knowledge made by this thesis to the field of sustainable design. The chapter concludes by describing future avenues for further research that have emerged as a result of this thesis.

8.1 Aim and Objectives Achieved

The aim of the investigation is to determine an effective way of facilitating product design students to design more sustainable products.

Objective 1: Utilising information gained from the critical Contextual Review to formulate a set of characteristics of sustainable product design that are practical to product design practice.

Within its parameters, the Contextual Review provided insight into the origins, current thinking and future direction of sustainable design. Various attempts to set out criteria for eco-design and sustainable design were identified, as were models for the inclusion of sustainability into design. It was discovered that many of these models and tools were aimed at design engineers, not at product designers. Research has been carried out into possible ways of communicating and informing professional designers of issues of sustainable product design (Lofthouse, 2001; Dewberry, 1996). The Contextual Review

revealed the importance of the role of design education in communicating and informing undergraduate designers of sustainable product design, building a basis as part of their design education. This basis can be added to as new thinking emerges and can then be carried onto professional practice resulting in a generation of design professionals literate in sustainable design.

A set of characteristics of SPD was formulated grounded in the criteria previously developed by recognised authors in the field of sustainable design. A variety of sources was utilised including judgement criteria for a UK based sustainable design competition, criteria developed from research and principles derived from a critical assessment of products that claim to be sustainable. Conflating the various set of criteria available in the literature along with current thinking, the researcher formulated a set of characteristics of SPD that addressed all aspects of a product's lifecycle from the perspective of the needs and perceptions of a product designer.

The formulation of the set of characteristics of SPD has been an ongoing and iterative process, which will continue as new thinking emerges and moves the field's understanding of the issues forward. The set of characteristics of SPD aimed to provide a product designer with a framework of understanding in terms of the problems and the opportunities of sustainability. This framework can then be built upon as advances in the field occur.

Critical assessment of products that claim to be examples of sustainable design was also carried out for objective one, with the intention of utilising the knowledge gained from products themselves as examples of how a designer has negotiated the integration of sustainability into design practice. This exploratory method illustrated the complexity of

achieving SPD solutions, demonstrating that one product cannot embody or address all the issues with which sustainability is concerned. It also provided insight into the effective and ineffective use of aesthetics and product scripts.

Two case studies were carried out with the aim of reframing the initial set of characteristics of SPD in the form of a list of statements on sustainability into a form appropriate for product designers to integrate into their design practice. Through the contextual review it came to light that a checklist set of criteria did not aid the integration of sustainability into product design due to the dynamic and iterative nature of the product design process, which draws upon the designer's tacit knowledge and experience. As a conscious effort to move away from a checklist of sustainable criteria which hinders the creative design process, the researcher explored the characteristics in their initial form through her design practice. This method provided the researcher with data on the interactions between the characteristics, the designer and the design process. It identified phases in the design process where specific information was required in order to progress. Parallel to the researcher's design practice and as a result of this the characteristics were reframed visually and explored in terms of language from a rules based set to a heuristic set of advisory statements. These advisory statements were developed into a set of keywords for brainstorming.

Case study one illustrated that the designer requires an understanding of sustainability and the keywords in order to integrate them into design practice, prior to engaging with the design problem. It also showed that different information was required at various phases in the design process, for example the distinction between tangible and intangible characteristics. Case study three explored the intangible characteristics further in relation to

problem solving and ideas generation techniques. These case studies identified key phases in the design process where specific information is required, analysis took the form of a visual mapping of the entire design process consisting of design diaries and sketches.

The reframing of the characteristics was also informed by how they were communicated through case studies two, four and five investigating the effectiveness of a prototype educational tool with design students. Each case study provided information on how they were presented in terms of categories that can be easily understood as well as mode of delivery.

Objective 2: To investigate design briefs, to establish their possible role as a mechanism for influencing the generation of sustainable product designs.

The potential of design briefs as a possible mechanism for change influencing product design towards sustainability was investigated through the Contextual Review. Previous research has been undertaken into the potential of the design brief (Dewberry, 1996; Sherwin, 2000). The literature highlighted that although there is an opportunity to influence design through the design brief, designers themselves require an understanding of sustainability in terms of how to address the issues. Sherwin (2000) whose research focused on the behaviour and needs of a group of industrial designers from Electrolux, identified the need for facilitation at two different levels: initially in the form of a workshop during which the content of the design brief was discussed; and an expert for the industrial designers to approach for specific information regarding sustainability.

The potential role of the design brief as a mechanism for influencing sustainable design was highlighted in case studies one and three. Through analysis of the researcher's design practice it was discovered that the design brief has more than one role in the design process. The design brief is a document from which a client specifies their needs to the design team, but it is also used as an evaluation tool throughout the design process to ensure that the design team is addressing all the problems identified in the brief. Therefore if sustainability requirements were included in the design brief, the outcome of the design process would be evaluated in terms of these requirements.

The conclusions from the contextual review were that the context of the design brief is decided by the client or at a managerial level and the designer may have little or no influence. If sustainable problems were included in the design brief, however, due to the nature and content of the document the product designer would require prior understanding of sustainable issues, possible problems and opportunities before the design process begins for a sustainable solution to result. With prior knowledge of the issues, whether specified by the brief or not, the product designer would possess an understanding that can become an intrinsic part of the design process. Therefore education and training is a priority.

As the literature review identified the design brief as too late a phase in the design process to integrate SPD, the research was refocused to investigate an effective way of facilitating product design students to design more sustainable products. The research focused on the education of undergraduate product designers, rather than the postgraduate training of professional product designers, as it was felt that during formal education students have an opportunity to fully explore SPD without the time and cost constraints that occur in a business setting. Also as discussed in the Contextual Review there is a difference in

understanding of sustainability in academia and industry. Academia has the privilege and time to explore new thinking in the field, whereas industry must focus on legislation that will directly affect business.

Objective 3: To formulate an educational tool, which clearly and concisely illustrates the characteristics of sustainable product design set out according to the design process.

The format of the prototype educational tool was based on the researcher's previous experience delivering material to students on the subject of sustainability and her own experience of integrating sustainable issues into product design. It was recognised that for the product design students to engage with the topic the mechanisms for delivery needed to be as interactive as possible, therefore a workshop approach to delivery was chosen.

The prototype educational tool is grounded in Kolb's description of experiential learning based on Lewinian's cycle (Kolb, 1984). In conjunction with the model of experiential learning (see Fig. 21) the prototype educational tool acknowledges the experiences of the participating design students by asking them to identify what they understand by SPD using design methods, then reflecting and discussing what the researcher-facilitator puts forward as the set of characteristics of SPD, linking it to the present through product examples. An understanding of the set of characteristics of SPD is developed and then explored through the students' design practice. By developing an understanding interactively that is connected to past experience and assumptions, reflecting, discussing and exploring concepts in practice, the design student develops an understanding of the set of characteristics of SPD that can be applied to design practice, moving towards the development of sustainable thinking as an intrinsic part of the design process.

The prototype educational tool applied a constructivist approach to learning, requiring the participants to develop and negotiate the generation of concepts. The application of problem-based learning provided a catalyst for generating new knowledge of how sustainable issues can be incorporated in the design process. Critical thinking through interaction and reflection was beneficial for design students as it allowed them to interpret the set of characteristics of SPD, developing knowledge that can be transferred to a variety of design problems.

The prototype educational tool took the form of a workshop, providing a seminar and opportunity to redesign a product. Three stages were involved in the SPD workshop: stage one explored what the students already understood by SPD through mind mapping and brainstorming; stage two involved a seminar on the set of characteristics of SPD; and in stage three the students evaluated products for sustainability and redesigned a product to be more sustainable than the original. Stage one provided the research with information on the present level of understanding of SPD the students possessed and engaged the students with the problem. In stage two, the seminar describing the set of characteristics of SPD, students were encouraged to participate by asking questions based on a discussion surrounding examples of products. Stage three presented the students with several problems, mainly how is SPD applied in practice? Using their new knowledge, the students evaluated a group of products and then redesigned a product.

The SPD workshop was applied to three sets of product design students and three case studies. Field notes were taken on the observations of how the students interacted with the workshop, as well as delivery and content of the workshop. This data informed the

development of the next workshop. Subsequent to the three case studies a further workshop involving competition winners from Channel 4's Ideas Factory was carried out as part of a series of master classes.

The prototype educational tool applied in the case studies clearly and concisely illustrated the set of characteristics of SPD through a seminar, which provided information on the specific characteristics of sustainability for product design as well as product examples. During case studies four and five, a card system was applied to the seminar resulting in an interactive explanation of the set of characteristics of SPD. Evaluating products and redesigning them illustrated the set of characteristics of SPD to the students through practice and engagement.

Objective 4: To evaluate the appropriateness of the educational tool to product design students in terms of level of understanding of sustainable product design and ability to integrate into design practice, meeting the characteristics in the first aim.

Analysis of the appropriateness of the prototype educational tool was carried out in relation to the level of understanding of SPD product design students have gained and their ability to transfer that knowledge from theory into design practice, generating sustainable product designs. The framework of analysis is based on Miles and Huberman's (1994) model of analysis: data reduction, data display and conclusion drawing. Six viewpoints each analysing and drawing conclusions from different aspects of the data were used.

Viewpoints one to three utilised the data gathered from the case studies. Viewpoint one drew conclusions from the researcher's own design practice which provided an insight, in

terms of a designer's thought processes, into how the set of characteristics of SPD could be integrated into design practice. This viewpoint also aided the formulation of the set of characteristics of SPD from the perspective of a product designer's needs. Viewpoint two compared the mind maps produced by the participating students prior to and on completion of the prototype educational tool. The mind maps were colour coded in relation to the final set of characteristics of SPD, providing insight into the students' level of understanding prior to and post interaction with the prototype educational tool. Viewpoint three analysed the concepts the students produced as part of the prototype educational tool. Analysis utilised the sketches produced by each group and transcriptions of the presentations of these concepts, these were coded and paraphrased to provide an insight into the level of SPD the students were able to integrate into their design practice.

Viewpoints four, five and six were conducted primarily for the analysis of the prototype educational tool as described in the research objective. Viewpoint four revisited a group of students, which were involved in a sustainable design project one year after they had taken part in the workshop. Recordings of the students' presentations were made, accompanied by presentation boards, these presentations were transcribed, coded and paraphrased as in viewpoint three. A comparison was made with the transcriptions from this group of students and a group of students doing the same project on the same course but who had not taken part in the workshops. Viewpoint five provided an insight into the effectiveness of the prototype educational tool from the perspective of members of academic staff involved in the product design course through an informal interview. Finally, viewpoint six involved the opinions of individuals from Channel 4's Ideas Factory who had no formal training in product design. Multiple perspectives provided the evidence on which to base the conclusions of the thesis.

8.2 Key Issues arising

8.2.1 Conclusions from the research

The research investigated the potential of the design brief as a possible mechanism for change influencing the inclusion of SPD in the design process. Case studies one and three identified through design practice the differing roles a design brief has in the design process, from a set of instructions beginning the design process and at several stages through designing as a set of evaluation criteria, ensuring that the designer is meeting the needs of the client and the user. However research carried out by Dewberry (1996) identified that the designer has little opportunity for influence over the content of the design brief, it is determined at a managerial or client level. For the inclusion of SPD in the design brief to occur, managers or clients must request it. Analysis of case studies one and three identified a second potential barrier to the integration of SPD into the design process. This was the understanding and awareness of the designer or the design team of the issues and opportunities involved. In order for a successful sustainable solution to result, the designer must be aware of SPD and understand the importance of the inclusion of sustainability at the earliest stage in the design process. The most effective way of gaining an understanding of SPD is through training and education. These findings resulted in the development of a prototype educational tool aimed at design students.

A set of characteristics of SPD was developed through the collation and conflation of recognised authors' criteria of sustainable design, current thinking in the field and from an analysis of products which claim to be examples of sustainable design. These characteristics were investigated through the researcher's own design practice providing the research with data on how a designer might negotiate the integration of SPD into the

early stages of the design process. The result of this investigation confirmed that the designer must possess a basic understanding of the set of characteristics of SPD prior to beginning the design process. The negotiation process between the researcher-designer and the characteristics of SPD in terms of how and when to integrate them into the design process illustrated a division in the characteristics in terms of limiting creativity.

The prototype educational tool was based on the resulting set of characteristics of SPD in the form of an intensive workshop using design methods and practice. A constructivist approach to problem-based learning was applied. Action research informed the development of the prototype educational tool from case study to case study, during each case study reflection-in-action was utilised to adapt to any given situation that arose due to interacting with design students. Evidence of problem-based learning as a suitable form of learning can be found in the transcripts of the student groups' presentations of sustainable concepts. Reflection occurred in the form of the students rationalising their design decisions.

Case studies two, four and five illustrated, through analysis of mind maps, transcripts and student concepts, that the students had gained an understanding of SPD due to their interaction with the prototype educational tool. The mind maps produced individually by the design students showed a refocusing from initial preconceptions to an understanding of sustainability in relation to product design, to varying degrees. Transcripts explaining the students' concepts produced as groups showed the students' understanding of the issues involved and ability to transfer that knowledge into practice, which was facilitated as part of the workshop. A difference in level of understanding of SPD can be identified from the transcripts. Second year students from both Gray's Art School and Napier University were

able to address and integrate the tangible characteristics in their designs. Although some intangible characteristics were included in the mind maps they produced on completion of the workshop, students at this level in their education were not able to integrate them into their designs effectively. Third year students were able to address both the tangible and intangible characteristics in their designs.

A comparison between a small group of students a year after they had participated in the workshop, with a similar size group of students who had not participated in the workshop was made. This study provided insight into the effectiveness of the prototype educational tool. Evidence from the analysis shows that those students who had participated in the SPD workshop the previous year did have a clearer understanding and were able to address SPD more successfully in their designs than the students who had not participated in the workshop. However, this study made the researcher aware that other drivers and barriers were involved in the educational process such as the focus and interest of the student in the subject, their maturity and their level of education. These conclusions were confirmed by members of academic staff, as part of a series of informal interviews.

In conclusion the research carried out in this thesis proposes several recommendations:

- In order for product designers to be able to address sustainability, influencing a change in current patterns of consumption, they must be literate in sustainable product design. The literature identifies the most appropriate time for a product designer to fully explore the emerging field is as part of their education.
- Design practice illustrated that tangible and intangible characteristics can be integrated into the design process at different phases of the design process.

- The proposed problem-based prototype educational tool is effective in increasing students' understanding and aiding the integration of SPD into design practice. However discussion with academic staff identified possible changes to the prototype educational tool: student involvement could be increased by requiring students to investigate product examples and undertaking some research in the area perhaps through required reading.
- By applying the prototype educational tool to groups of second and third year students a two stage strategy was identified for the application of the prototype educational tool: introducing the tangible characteristics in second year and a follow up workshop exploring the intangible characteristics in third year, catering for the students' ability to understand concepts.

8.2.2 Design methods for research

This research adopted a multi-method approach to gathering information drawing upon social science methods. Two types of methods were used, those traditionally linked to research, transcriptions and coding, and design methods adapted for the purpose of the investigation. Visual methods of analysis were also used.

A number of design methods were adapted and used for the purpose of gathering data specific to the research objectives. The researcher's own design practice was used as it was deemed the most appropriate method for gathering information on a designer's negotiation of the integration of the set of characteristics of SPD into the design process. These case studies influenced the formulation and format of the characteristics providing possible guidance in how SPD could be integrated into the design process as well as how to inform design students about the set of characteristics. Only through sketches and design diaries

could this information be gathered and displayed. Analysis of these case studies took the form of visually mapping the design process the researcher carried out, this provided insight into how and when specific issues relating to SPD should be considered. Evaluation of products also informed the set of characteristics of SPD in terms of content. By evaluating the products the researcher was able to gain some insight into an *"aesthetic typology"* (Walker, 2005) and the use of product scripts.

In terms of visual methods of analysis, colour coding and concept mapping were used to display data from which conclusions have been drawn. Without these methods of both analysis and data collection the research could not have been gathered in relation to the requirements of the research objectives.

8.2.3 Educational tools versus toolkit

As can be seen from the Contextual Review there are numerous tools and models available for all forms of design and engineering at differing stages in the design process for the integration of sustainability into design practice. There are also a variety of methods for the evaluation of a product in relation to achieving sustainability once it has reached its final concept stage or has been produced. Walker (1998) states that any one method is not adequate to influence the integration of sustainability into product design. Alternatively a variety of methods for different stages could be used. For example a toolkit could provide a designer with an awareness and understanding of how to integrate sustainability into design practice through the prototype educational tool.

There are advantages and disadvantages to both options. For the toolkit there are two distinct barriers to its success in aiding the integration of SPD into design practice. Firstly,

a toolkit is made up of various tools and models to be used and consulted at different stages in the design process, these may vary depending on the product that is being designed, ranging from rules of thumb to checklists for end of life strategies. A designer must possess an awareness of these tools and the context in which they are proposed, so that there will be a basic understanding of sustainability to ensure their appropriate and successful use. The current approach within professional practice as well as that adopted by design students, is what might be considered to be a bolt-on approach to sustainability in which sustainable issues are considered later in the design process as part of material selection and concept detailing, rather than at an early stage where a sustainable solution is more likely to result. This bolt-on approach not only affects how students, designers and manufacturers treat sustainability, it also affects the way consumers and users perceive it. This has a detrimental affect on the adoption of a sustainable consumer society as described by Manzini (1994). Secondly, toolkits act against the process of designing, in the sense that designers or design teams are required to consult these tools, with the potential of interrupting the process of designing. The design process is not linear although specific stages can be identified, it is much more chaotic relying on the creativity of the design team, which may involve the iteration of phases. Design education does not teach and new designers do not learn about the design process, contemporary or cultural issues, production and communication through a series of checklists, therefore this approach may not be familiar to the designer. Projects are set and students learn through problem-based learning and design practice. The outcomes of projects are assessed in direct relation to assessment criteria derived from learning outcomes. As part of the informal interview with members of staff the researcher learned that assessment for product design courses focuses on the thinking process a student has gone through in relation to the project's objectives.

Learning and understanding SPD as part of undergraduate designer's education also has advantages and disadvantages. It can only be proposed that by learning about sustainability as part of a design student's education they will be able to carry that understanding and awareness into their professional practice. As this research only focused on a relatively short time frame it is impossible to provide data in agreement or disagreement, a more longitudinal study would be required. An advantage as well as a disadvantage of understanding SPD through an educational tool involves the relationship and reality of the design project. As previously stated, design students learn about specific design issues such as sustainability through integrated projects, or workshops such as the one proposed in this research. An advantage of learning as part of design education is the freedom of exploring emerging thinking and concepts within a safe environment that is not limited by business issues such as cost and client needs. The difference between an academic definition of SPD and a professional practice definition is discussed in the Contextual Review (section 2.5.4). Exploring new thinking can help the field progress in terms of new designers' understanding of what they can achieve, pushing the boundaries of product concepts. As there is a difference in definition of SPD between education and professional practice, there is also a difference in what can be achieved and concepts produced in education may not be suitable for business.

Another advantage of educational tools is that students gain an understanding of SPD, which can aid them in the use of toolkits. Unlike educational tools, toolkits rely upon either an in-house or external expert to update them, which can be time consuming. In education there is a synergy between teaching and research.

It is for the above reasons the researcher believes that an educational tool is more appropriate for gaining awareness and understanding of SPD aimed at design students. Although some toolkits, for example providing specific information on materials or recycling procedures are valuable as a first encounter with the topic, they are inadequate as a total solution to ensuring sustainable product design solutions.

8.2.4 Professional versus Educational Context

The thesis describes a set of characteristics of SPD that have been divided into two subjects, tangible and intangible (see section 4.4). Separating the set of characteristics of SPD into these two headings was a direct result of the design practice case studies, as well as the researcher attempting to explain the set of characteristics of SPD to undergraduate product designers as part of the prototype educational tool. The researcher became aware of the division of the proposed set of characteristics as part of Case Study One (see section 6.1).

The researcher acknowledges that within a professional context the tangible sustainable problems would not be separated from the intangible. However within an educational setting, tangible and intangible aspects of product design are often separated in an undergraduate curriculum. For example, BSc Design for Industry students at Gray's School of Art become aware of material selection and manufacturing processes in the first two years of their design course, topics such as consumer psychology are taught as the students become more familiar with the design process. By dividing the proposed set of characteristics of SPD into tangible and intangible, the research is presenting the undergraduate product designers with two levels of information, which as is apparent from

the research described in this thesis, is best delivered at different stages in the design course.

8.3 Constraints and Strengths of the research

The researcher acknowledges the constraints and strengths of this research as:

Constraints

- The research was carried out in two Scottish Universities, involving second to fourth year students. Due to this it was not possible to ensure that both situations were identical. Variations between courses and institutions exist.
- The research gathered on the effectiveness of the prototype educational tool had the potential of being biased as the researcher was forced to adopt several roles: developer, facilitator and evaluator of the prototype educational tool. In order for the research to be more widely applicable further research involving another workshop facilitator would be beneficial. This was beyond the scope of this particular project.
- As the research primarily focused on the effectiveness of the prototype educational tool for product design students, interaction with students was carried out. Whilst this interaction was taking place, events occurred that were outwith the researcher's control in terms of the focus of the design students on particular tasks and the timetabling of students' time. Such events were acknowledged and recorded in the field-note journals. The ability of design students to understand the concepts being explained by the facilitator, as well as the student's focus and awareness of the design process was dependent on the individual.
- The timescale of the study is a possible limitation. A longer study would have investigated further the influence of the educational tool on the understanding developed by design students and emerging product designers.
- Due to the number of participants involved in the study the findings can only provide an insight into the effectiveness of the prototype educational tool.

- The researcher is aware that in an educational setting, student repetition of what has been taught is likely, unfortunately this cannot be prevented. The study attempted to address this through viewpoint four.
- Some of the visual, qualitative methods adopted by the researcher inevitably require a subjective judgement to be made to some extent, for example the mind maps produced prior to and on completion of the prototype educational tool. The mind maps are subjective because they are personal to the individual who produced them, therefore it was difficult for the researcher to interpret and analyse these mind maps.

Strengths

- The research was carried out by a product designer with undergraduate product designers. The researcher's understanding and awareness of the product design process allowed specific data to be gathered, for example the negotiation process involved when integrating the set of characteristics of SPD into the product design process.
- The research took place within two Scottish Universities, across years second to fourth. Involving different years and courses increased the generalisability of the research.
- The research utilised action research methods within empirical research. The adoption of action research in case studies utilising *"reflection-in-action"* (Schon, 1991) aided the formulation of the prototype educational tool specific to the needs of product design students. This approach reflected and allowed for emerging thinking in the field of sustainable product design.

- Visual information was used to collect data and analysis results allowing the researchers to discover elements of student thinking that would not have emerged if influenced by more traditional means of data collection, such as surveys. The study was carried out from a variety of viewpoints. Multiple perspectives provided the research with a comprehensive view of the study.

8.4 Original Contribution to Knowledge

The original contribution to knowledge is evident in four areas of this research:

- The formulation of a comprehensive and concise set of characteristics of SPD developed for and from the perspective of a product designer. The characteristics of SPD provide product designers with a basis of understanding of a critical issue, which can be built upon as further research and thinking emerges. The set of characteristics of SPD proposed in this thesis have been developed not only from a review of the literature, but also from an analysis of products which have been marketed as sustainable product designs. The set of characteristics of SPD have been developed through design practice: through integration into the product design process and as a result of interaction with undergraduate product designers as part of the development of the prototype educational tool described in this thesis. Three different levels of information on SPD have been derived from the set of characteristics: keywords, examples of information and expanded explanations.
- The identification of the process of negotiation a product designer goes through while integrating the set of characteristics of SPD into the early stages of the design process represents an original contribution to knowledge. Figure 21provides insight into the creative thought process of a designer with prior knowledge of SPD, which is required if a sustainable product design solution is to result. This process of negotiation has not been visually displayed in other research and provides a unique insight into the process of designing sustainable products.
- The development of a critical framework of analysis of the product design practice, by visually displaying information gathered in the form of diary entries, sketches and concept maps. The combination of this novel form of evidence provides an original contribution to knowledge. Future studies dealing with creative personal interactions

within an educational context would be able to adopt a similar methodological approach in order to gain insights into the situation being investigated.

- The formulation of a prototype educational tool that describes a set of characteristics of SPD in the form of a workshop aimed at undergraduate product designers, utilising design practice, interactive seminars and existing products. Although problem-based learning is frequently adopted in design education, an example of an educational tool specific to conveying the concept of sustainable product design has not been previously developed.

8.5 Recommendations for Future Work

The following describes potential areas for future work.

In order to make the research presented in this thesis more widely applicable, further iterations of the workshop design implemented by a range of alternative facilitators would be required.. Further evaluation of the prototype educational tool would help to establish whether it is the facilitator's knowledge of the field of SPD or the prototype educational tool which is primarily responsible for increasing undergraduates' awareness of the characteristics which represent a sustainable product design solution.

The prototype educational tool in the form of a facilitated workshop as described in this thesis provides participants with a basis of SPD, breaking down the subject into manageable topics and subtopics which need to be considered and addressed by product designers in the early stages of the design process. As the field of SPD evolves and new information comes forth, the set of characteristics of SPD will require updating to keep the workshop current. The case studies presented informed the researcher of the need for a further level of information in terms of specific information on sustainable materials, manufacturing processes, components and the sourcing of these. This may be presented to product designers in the form of a second workshop or online resource, which can be easily accessed and updated as new materials and manufacturing processes are developed. This information was not included in the workshop presented in this thesis as it was felt that a basic understanding of the issues involved should be understood to avoid the assumption that by only including sustainable materials or manufacturing processes, a sustainable product solution will result.

A longitudinal study investigating the affect of the educational tool on product design students throughout their education and into professional practice is an area for further research. The information gained from a longer study could inform the education of design students further, potentially resulting in sustainable product designers.

Further research into the design of sustainable product solutions as described in the personal studies carried out by the researcher would provide an in-depth understanding of how product designers interact with sustainable principles during the various stages of the design process. This information would be of value for the future development of educational tools which have the purpose of developing knowledge of SPD, in both the education and professional design contexts. The result of this would be guidance for product designers on how to integrate SPD.

Further research into an assessment process of the educational tool presented in this thesis is required to move the work beyond a one-off workshop to become part of a product design course curriculum, which would lead to the integration of SPD as an intrinsic part of the design process. As a sustainability facilitator has been incorporated into professional practice in some large corporations, the opportunities for such a role within universities should be investigated.

Future research may look at design practice as an appropriate method for data collection as well as the procedures adopted for analysis of the data gathered. Research into the field of sustainable design has focused on gathering information utilising a multi-method approach adapted from other research disciplines. There is a growing interest by design professionals in the area of design research identifying and informing the solutions of design problems,

such as the use and adaptation of methods derived from ethnographic research for the purpose of gaining insights into the ways in which individuals use and interact with products (Ward, 2002).

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10.0 Appendix

10.1 Reflective Journal

10.1.1 Extracts from reflective journals

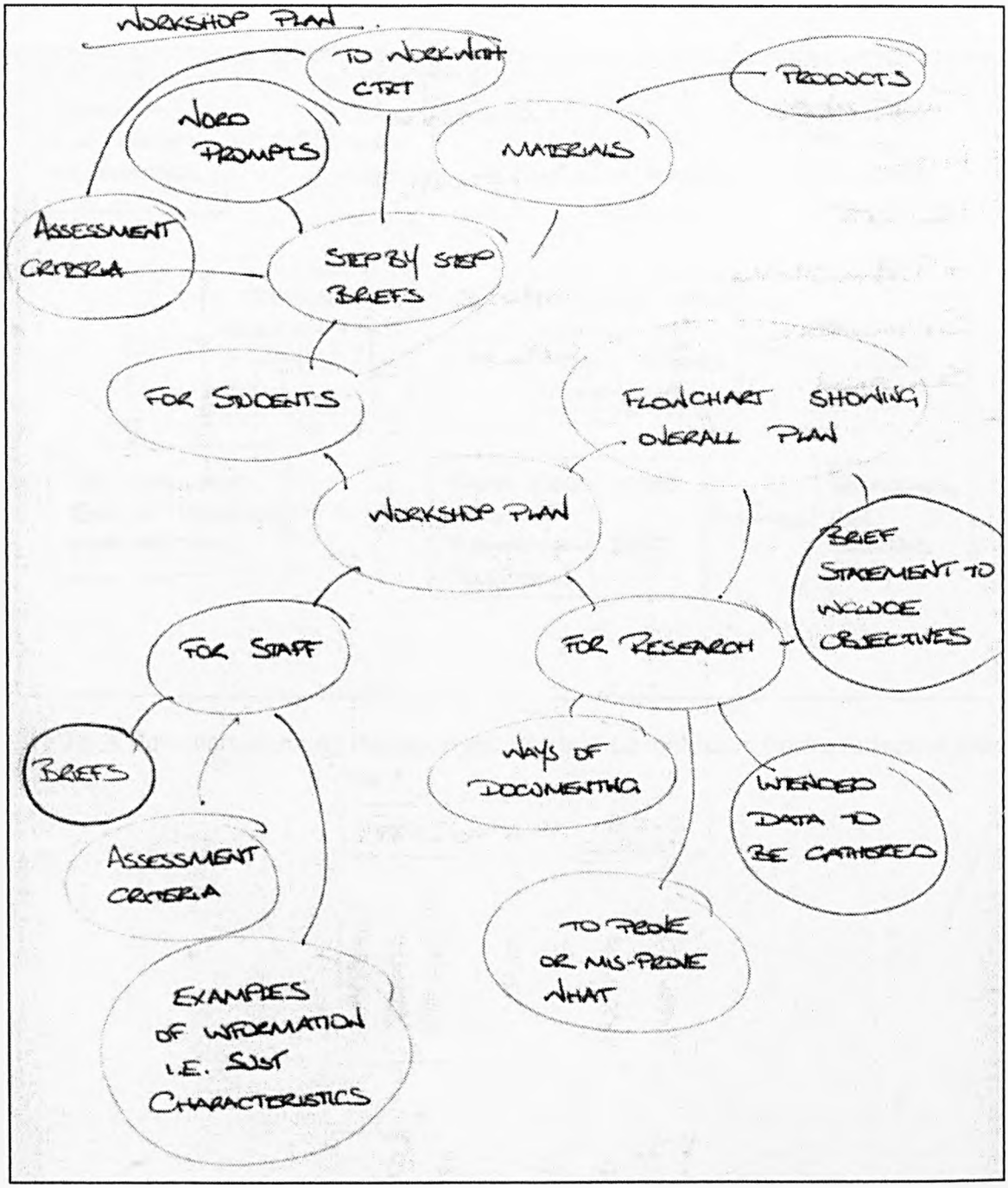


Fig 30. An extract from a reflective journal planning the prototype educational tool.

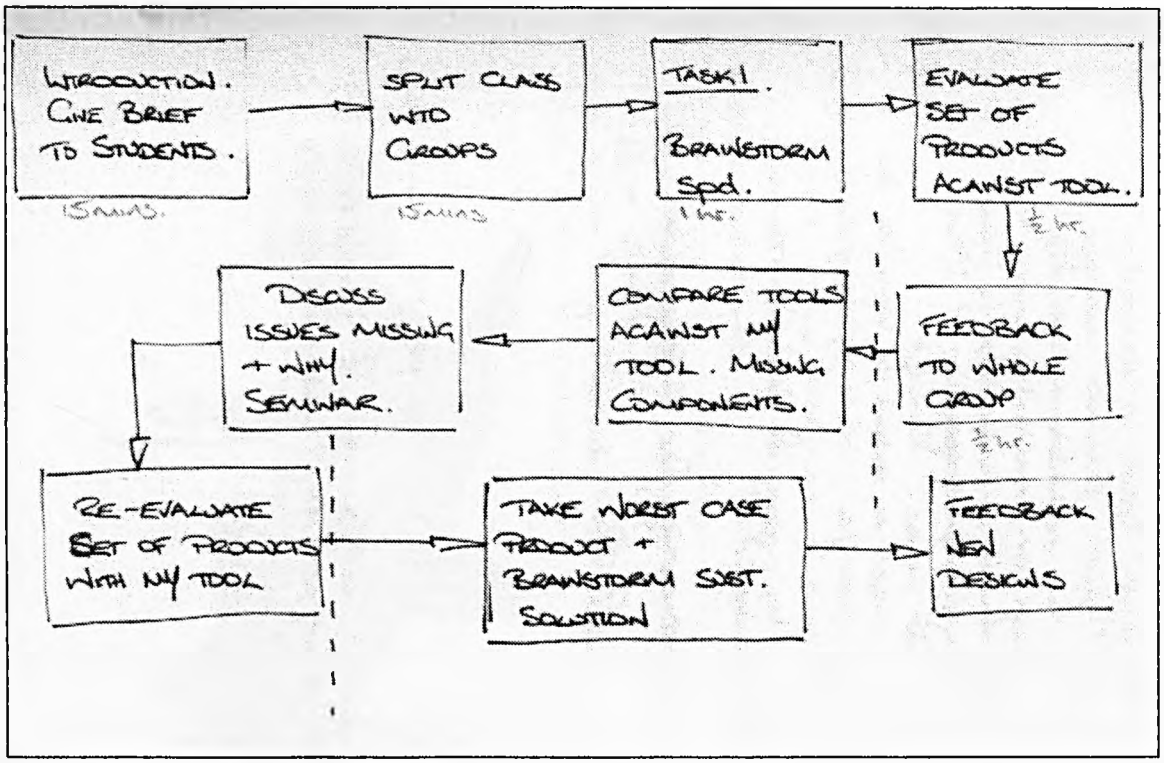


Fig 31. A flowchart planning the prototype educational tool taken from a reflective journal.

10.1.2 Critical assessment of sustainable products

Fig 32. Example of a sustainable product

Product identified by Dastschefski (2001) in 'The Total Beauty of Sustainable Products' as a sustainable product. After evaluation the researcher identified the following characteristics:

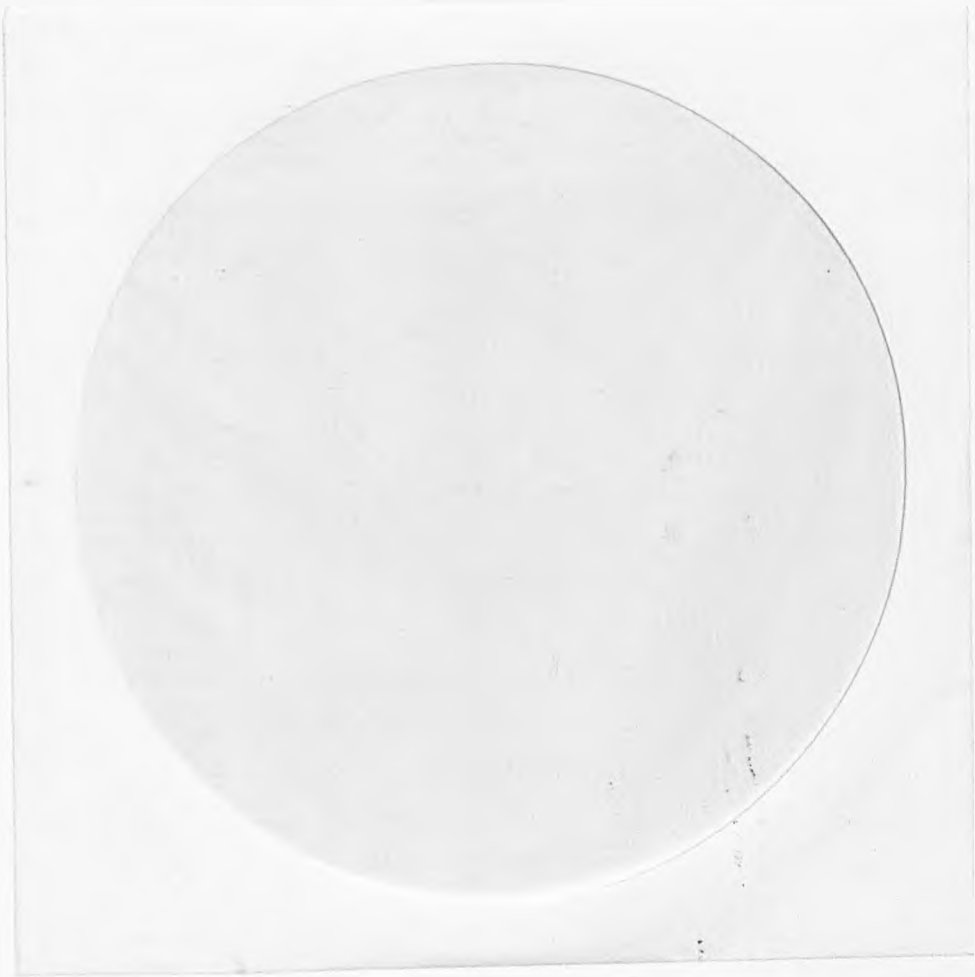
- Long life product: the product grows with the individual from a high chair as shown to a seat for an adult.
- Durable materials that can either display wear and tear or be easily repaired rather than replacing.
- Made from material that is eventually biodegradable without polluting the environment (depending on the paint and varnish used on the product). Material also sourced from a sustainable forest.

10.2 Case Study One: Design Practice Exploring the Set of Characteristics of SPD

Appendix is available on CD ROM

To access: Launch Internet Explorer. Go to File/Open File. Navigate to CD called Appendix and select.

For Appendix 10.2 Case Study One open folder titled App10.2, open file home 1.htm. For Appendix 10.4 open folder titled App10.4, open file home2.htm. Once desired appendix is open, navigate the case study using the scroll bar, to see larger images double click on image thumbnail.



10.2 Case Study 1: Design Practice Exploring the Set of Characteristics of SPD

Note: Figures in this appendix are numbered separately to those in the rest of the thesis.

Wednesday 17th April 2002

Ph.D. research objective:

To investigate the core characteristics of sustainable product design further as a model which can be used to support sustainable product design.

I intend to investigate the core characteristics of SPD further as a model to support sustainable product design through my own design practice, the concept mapping and current literature. In terms of my own design practice, several choices should be made about the form the investigation will take. For example, which is more appropriate: to design with the core characteristics of SPD alongside or to incorporate them into the initial phases of the design process? Should the investigation involve the development of a completely new product or the redesign of an existing product? Should the brief incorporate sustainable goals or requirements? Should the product be generated from an existing identified problem, or should a new problem be identified?

The aim of this notebook is to describe in chronological order my design practice. This will subsequently inform the development of the core characteristics of SPD as they are considered throughout the design process. This notebook – design diary – alongside any sketches or working models is to be used to progress the core characteristics of SPD towards an educational tool. No information has been gathered about how to complete and maintain a design diary; it is based on a reflective journal. Some entries will come straight from or are expanded on from my reflective journal.

Thursday 18th April 2002

As a starting point I have decided to utilise existing identified problems and design scenarios. An example of an identified problem is 'designing a way to make a drink' rather than 'designing a coffee machine'. The later specified the solution which limits creative thinking whereas the former describes a problem. Utilising existing problem provides me with the opportunity to 'redesign' and 'rethink' (Charter & Tischner, 2001)

using the core characteristics. A small notebook has been kept for a few weeks in anticipation of my design practice, a problem should be chosen from here. This approach will probably result in redesigning an existing product.

Using 'design scenarios' allows a variety of different products to be designed under a singular theme. For example, the Eco-Lux research programme (Sherwin & Thompson, 2001) used 'The Sustainable Kitchen of the Future' as a scenario to generate a series of sustainable product solutions including a smart sink, data-wall, cooker, chest freezer, light-plant, passive coolers and portion projector. Philips design have also used scenarios in the development of 'LiMe' and 'Nebula'.

There are a variety of design scenarios I could choose from, for example: the home; entertainment; eating, cooking and buying; leisure; clothing; transport; work. Each of these include everyday activities presenting problems for both the user and sustainability. These scenarios were also discussed at the CFSD 6th conference. I chose mobility as a design element, e.g. entertainment on the move. There are a substantial number of products on the current market which offer the consumer increased mobility, e.g. laptops, PDA's, Walkman's, mobile phones. Lifestyles are becoming characterised by speed and flexibility (Manzini, 2001). These types of products are fashionable and present problems to sustainability, such as proliferation.

I am aware that this approach may not generate the information I require and it may be seen as a biased approach. But hopefully it will generate the information required to inform the development of an appropriate educational tool. I am aware of other approaches by other researchers, for example Stuart Walker devised a set of sustainable characteristics and explored them by designing a product to embody specific characteristics. Until I attempt to address the core characteristics, I won't know if this approach is appropriate or not. I anticipate that the process of designing and how the core characteristics are incorporated will present information for the educational tool.

The design process begins with visualising the design scenario. Below is a copy of an A2 colour image board. Its use is to set the scene, providing me with visual references of ways of being mobile. This will aid me when trying to identify problems or the generation of concepts.

Figure 1. Image board with various food, drink, eating and drinking, and branded utensils.

Friday 19th April 2002

I've been continuously thinking about how to get started. What to design? What problem to address? I have identified, through my own experience, a problem which has the possibility of being an appropriate starting point. Eating on the move. This came about while out shopping one Saturday; I was carrying two or three bags, while also trying to eat a sandwich from Boots and juggling a bottle of water. Eating patterns have generally changed, and I - as do many others - often find myself eating on the run, especially at lunchtime.

This (and packaging design in particular) would be a practical starting point because:

- It contains no electronic or electrical components;
- It involves products we come into contact with everyday. Products we use and abuse;
- It is inherently unsustainable and therefore would be able to demonstrate several of the core characteristics;

- Perhaps less importantly, I've addressed packaging design in my undergraduate work.

Core characteristics it could demonstrate include:

- Doing more with less;
- Food for other systems;
- Misuse of resources;
- End of life strategies;
- Real behaviour and consumer pro-activity;
- Sustainable consumption;
- Waste minimisation…

I need to begin with some background research: market, competition, a clearer identification of the problem through observation. A design brief and design scenario, as well as image boards need to be developed.

Monday 22nd April

Went into town at lunchtime to observe people eating lunch. It was not a particularly nice day so many people seemed to be carrying food to work, etc. I went into shops like Marks and Spencers, Boots, Bakers Oven, O'Briens and Starbucks to see what types of lunches where on offer. (I did not take photos as companies tend to frown upon it).

A variety of different foods and packaging were on offer. O'Briens make sandwiches, wraps, rolls on request wrapping them up in laminated paper using an O'Brien sticker to secure and placing the sandwich and drink (of choice) into a brown paper bag.

Starbucks have ready-made sandwiches in triangular packaging or rolls in clear, sealed bags with paper inserts containing nutritional information. This is all put in a Starbucks brown paper bag with handles. And your coffee is handed to you separately in a paper laminated cup with plastic lid and cardboard sleeve to protect your hands.

Bakers Oven offers similar lunches and similar packaging. Hot foods are contained with a couple of paper bags. Marks and Spencer offer a wide variety of food options and packaging. Sandwiches are packaged. Subs, bagels, round rolls and long rolls are all packed in clear plastic bags displayed on protective trays. Pasta, salads, fruit and sushi are all contained in trays which are either rectangular or eclipse shape. Food is carried out of the shop in a Marks and Spencer's plastic bag.

Boots also offer a variety of foods although packaging is less varied. Sandwiches come in different sized and coloured plastic triangular boxes, like those in other shops. Nutritional details are in the plastic or as stickers on the plastic. Although it contains a recycle symbol the plastic type is not labelled. Wraps and rolls are in plastic bags with card inserts containing nutritional information. Pasta is provided in trays. Boots offer a £2.50 meal deal where you can purchase a specified sandwich, wrap, roll or pasta, a bottle of water or fizzy drink, and a kit kat or bag of crisps. This is all contained in a paper bag (same as Starbucks with a different graphic design). The bag doesn't hold the food very well.

There are obviously other options for lunch, such as fast-food takeaways or your own packed lunch.

Tuesday 23rd April 2002

Collected market research from keynote reports *Snack Foods 2000* and *Fast Food and Home Delivery Outlets 2001* and *Mintel Intelligence reports*.

Thursday 2nd May 2002

More market research on lunchtime eating patterns. Collated information into a word doc.

Marketing Information – project 1

- Only 8% of those sampled by Mintel regularly skip lunch. The consumers who regularly skip lunch primarily live in the South and are in the 20-24 age group. This reinforces the image of the more time-pressured, always-in-a-rush lifestyle of those living in the South, although interestingly Londoners do not fit into this profile. (Mintel, Lunchtime Eating Habits, Leisure Intelligence, August 2001).

- Busier lifestyles, the rise in women in employment and more dual income families with children mean that there is less time to cook, and more emphasis being placed on quick-meal solutions (Keynote Ltd, Market Plus Report, Fast Food and Home Delivery Outlets, (17th ed.) 2001).

- Snacking and grazing: busy lifestyles, the decline of traditional meal-times and the switch to lighter lunches are all factors encouraging outlets to concentrate on snacks as well as full meals such as chicken dips or pizza slices. Sandwich chains and the newer outlets, such as coffee chops have benefited from this trend (Keynote Ltd, Market Plus Report, Fast Food and Home Delivery Outlets, (17th ed.) 2001).

- Lunch breaks average at 36 minutes (Mintel, Lunchtime Eating Habits, Leisure Intelligence, August 2001).

- Most consumers opt for a snack at lunchtime and a full cooked meal in the evening (Mintel, Lunchtime Eating Habits, Leisure Intelligence, August 2001).

- The most popular venue for lunch is at home. Packed lunches and food made at home are the preferred lunchtime fare overall, the next favoured being food bought from sandwich shops. Packed lunches allow for consumption at your desk without having to take time out. They are also cheaper than buying ready-prepared food (Mintel, Lunchtime Eating Habits, Leisure Intelligence, August 2001).

- Eating at their desk at work is consumer's second preferred venue, highlighting the time pressure that most working consumers are under. Convenience is key (Mintel, Lunchtime Eating Habits, Leisure Intelligence, August 2001).

- A large proportion of consumers (33%) will tend to eat the same type of food for lunch and 23% will buy it from the same place each day. For some consumers, lack of available outlets to purchase lunch will necessitate repetition, however, it is a human trait to stay with what we know and are happy with (Mintel, Lunchtime Eating Habits, Leisure Intelligence, August 2001).

- The average expenditure on lunch is £1.98 per day, and more than £5.00 per five-day working weeks. Cost is not the most important factor when selecting lunch. Taste, health and convenience are more important criteria; however, consumers are still looking for value for money and product quality (Mintel, Lunchtime Eating Habits, Leisure Intelligence, August 2001).

- In terms of outlets to purchase lunchtime food to eat elsewhere, sandwich shops come out on top, followed by supermarkets. The extensive ranges that supermarkets now carry, positioned conveniently at the front of the store, make them a good value source for lunch (Mintel, Lunchtime Eating Habits, Leisure Intelligence, August 2001).

- Sandwiches are a good option for food to be eaten on the move. The majority of workers who eat sandwiches still make their own before going to work. (Keynote Ltd, Market Plus Report, Fast Food and Home Delivery Outlets, (17th ed.) 2001).

- The largest sector of the fast-food market is sandwiches (Keynote Ltd, Market Plus Report, Fast Food and Home Delivery Outlets, (17th ed.) 2001).

- The ubiquitous fast-food and takeaway outlet is now an important food source for almost three-quarters of the adult population, whether they are visiting an outlet with their children, eating a takeaway to save time, combining it with a leisure trip or using these facilities whilst travelling. The spread of 'kiosk' and 'express' style outlets has encouraged more eating on the move, as busy working, travelling or shopping consumers demand quicker, more convenient foods (Keynote Ltd, Market Plus Report, Fast Food and Home Delivery Outlets, (17th ed.) 2001).

- Be it low calorie, low-fat, organic or vegetarian, most lunchtime food providers have a healthier option range. As expected, women are more interested in healthy food than men and ABC1s are most likely to look for and eat healthier products. One surprising finding is that the older age group (45+), look for healthy options and check calorie intake much more than the younger age groups (Mintel, Lunchtime Eating Habits, Leisure Intelligence, August 2001). There is a growing concern about healthy eating and obesity, especially amongst children (Keynote Ltd, Market Plus Report, Fast Food and Home Delivery Outlets, (17th ed.) 2001).

- Increasing trends towards informal meal occasions, eating on the move and short lunch breaks will result in a greater demand for fast service snack meals and meal substitutes. Takeaway and delivery options are also likely to enjoy and increased level of demand. Delivery of prepared lunch foods direct to the workplace will also impact on the home-made lunch sector (Mintel, Lunchtime Eating Habits, Leisure Intelligence, August 2001). Stores are expanding and ordering via the internet is growing in popularity (Keynote Ltd, Market Plus Report, Fast Food and Home Delivery Outlets, (17th ed.) 2001).

- There are more single-person households. In 2000 a TGI survey discovered 91.7% of 15-24 year olds use takeaway outlets. The outlets are generally targeted at this age group. Fast-foods are primarily aimed at this age group. 92.2% of 25-34 year olds. 88% of 35-44 year olds and 80.2% of 45-54 year olds use these outlets. These figures only significantly decrease over the age of 55 (Keynote Ltd, Market Plus Report, Fast Food and Home Delivery Outlets, (17th ed.) 2001).

- 78.1% of the skilled working class (skilled manual workers) use takeaway outlets. Followed by 77.9% of the lower middle class (supervisory, admin or professional) and 75.3% of upper middle class (higher managerial, admin or professional) use the outlets. 74.3% of working class (semi-unskilled workers) and only 54.8% of those at the lowest levels of subsistence (state pensioners or widows) use takeaway outlets (Keynote Ltd, Market Plus Report, Fast Food and Home Delivery Outlets, (17th ed.) 2001).

- The food industry is one of the largest customers for packaging and the fast-food sector is one of the most innovative in the use of packaging in order to differentiate between brands (Keynote Ltd, Market Plus Report, Fast Food and Home Delivery Outlets, (17th ed.) 2001).

- The global fast-food companies are increasingly using large packaging suppliers to provide packaging solutions in various national markets. Consumers' expectations of fast-food packaging are being raised (Keynote Ltd, Market Plus Report, Fast Food and Home Delivery Outlets, (17th ed.) 2001).

- Paper packaging still accounts for the largest share of the fast-food packaging – at around 40% of all packaging supplies – while plastics packaging has a 35% share. Glass packaging accounts for most of the remaining share. Plastics is increasing its share of the industry's packaging requirements, as flexible plastic packaging takes share from traditional folding carton board (Keynote Ltd, Market Plus Report, Fast Food and Home Delivery Outlets, (17th ed.) 2001).

Thursday 9th May 2002

The design brief:

The aim of the project is to design a system for containing, protecting and portioning lunchtime foods which allow for product differentiation, branding and information on the nature and content of the food. The system can be used while on the move, at a work desk or on a more social occasion.

Design Problem Scenario: Context

Eating habits have changed. They have moved from the social occasion at each meal-time, in which individuals sit down around a table and enjoy eating with no distractions such as work or TV, to snacking and grazing while moving from one task to next. Busier lifestyles and the rise in dual-income families with less time to cook have necessitated quick-meal solutions. The rise in convenience foods has led to a rise in food packaging accumulating in individuals rubbish bins, on the streets and eventually in landfill sites.

Food packaging serves many purposes. It hygienically contains the food, provides information about its contents, and is used to differentiate and brand products. Mintel Intelligence (2001) survey into Lunchtime Eating Habits observed that consumers tend to eat the same type of food for lunch, bought from the same outlet each day. In a competitive marketplace, packaging can catch a consumer's attention and entice them into purchase.

This design project has investigated lunchtime eating habits. Initial investigations have discovered that packed lunches are the preferred lunchtime meal. Their popularity, as described in Mintel Intelligence Lunchtime Eating Habits (2001), is because they are an inexpensive option that provides the individual with all the foods they prefer, and which can be consumed at an individual's desk without having to take time out from work. Sandwiches are the next preferred option, which can also be eaten at an individual's desk while working and are a healthier option to other fast foods.

The project's target market is wide-ranging as everyone eats lunch. According to a 2000 TGI survey described in the Market Plus Report (2001), from the ages of 15-24, 25-34, 35-44 the percentage of those using takeaway food outlets range from 91.7%, 92.2%, 88% respectively. These figures only begin to decrease from the age of 45 and over. There is no significant differentiation between the sexes, although women do tend to eat healthier options and men prefer larger portions, sometimes opting for a full meal at lunchtime. From this evidence it can be seen that the target market from the project lives within the 15-34 year-old range with no gender preference.

The average time of a lunchtime break is 36 minutes and the average expenditure is £1.98 per day (Mintel Intelligence, 2001). Cost and value for money are not the only important factor when selecting lunch. Taste, health and convenience are also important criteria for those sampled by Mintel Intelligence (2001). In terms of takeaway outlets, sandwich shops are preferred followed by supermarkets.

Low calorie, low-fat, organic or vegetarian, most food providers offer a range of healthier options. These have increased in popularity due to health scares, such as GM foods and BSE.

The food packaging industry is one of the largest customers for packaging and one of the most innovative in the use of packaging, to differentiate between brands. Global fast-food companies are increasingly using large packaging suppliers to provide packaging solutions in various national markets. Paper packaging still accounts for the largest share of the fast-food packaging – at around 40% of all packaging supplies – while plastics packaging has a 35% share. Glass packaging accounts for most of the remaining share. Plastics is increasing its share of the industry's packaging requirements, as flexible plastic packaging takes share from traditional folding carton boards.

Problems identified:

- Juggling drink and food while in transit.
- Disposal of containment system.
- Spilling on work documents.
- Allow and encourages social eating.
- Customisation of lunch options.
- Tamper proofing, protection.
- Safe transportation.
- East of access to food.

Friday 10th May 2002

Brainstorming!

	Juggling food and drink while in transit	Disposal	Customisation of lunch options	Tamper proofing	Safe transportation	Social eating	Spilling
Sustainable consumption							
Real behaviour							
Energy efficient							
Do more with less							
Recycle							
Reuse							
Remanufacture							
Repair							
End of life strategy							

This is my first attempt at brainstorming using the core characteristics. There are a few problems. Firstly, I'm not happy/satisfied that these are the core characteristics. Secondly, perhaps the process needs to be done

in more than one stage. In fact, I'm sure more than one stage is required. Initially I thought I could idea-generate solutions for the product requirements and then brainstorm the core characteristics with the type of product in mind, but the problem with this is that the measurable characteristics (recycle, reuse, etc.) may develop the same answers for each project. Moreover, 'real behaviour' and 'sustainable consumption' become very difficult to deal with, because they are abstract.

A lot of rethinking needs done here. Intuitively I feel there is a way to brainstorm using the core characteristics, but it just may involve a variety of approaches.

Monday 13th May 2002

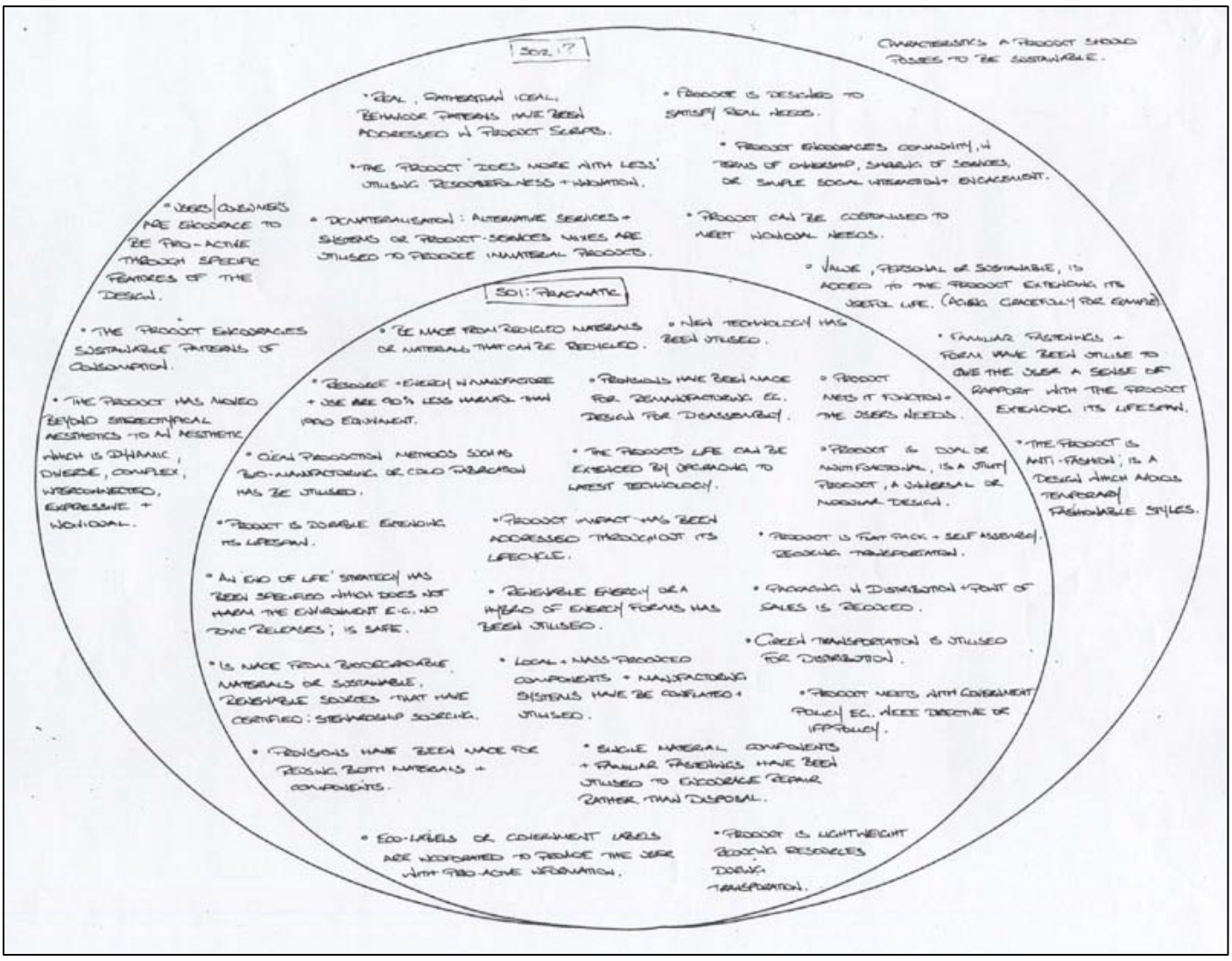


Figure 2. Map of characteristics a product should possess to be sustainable.

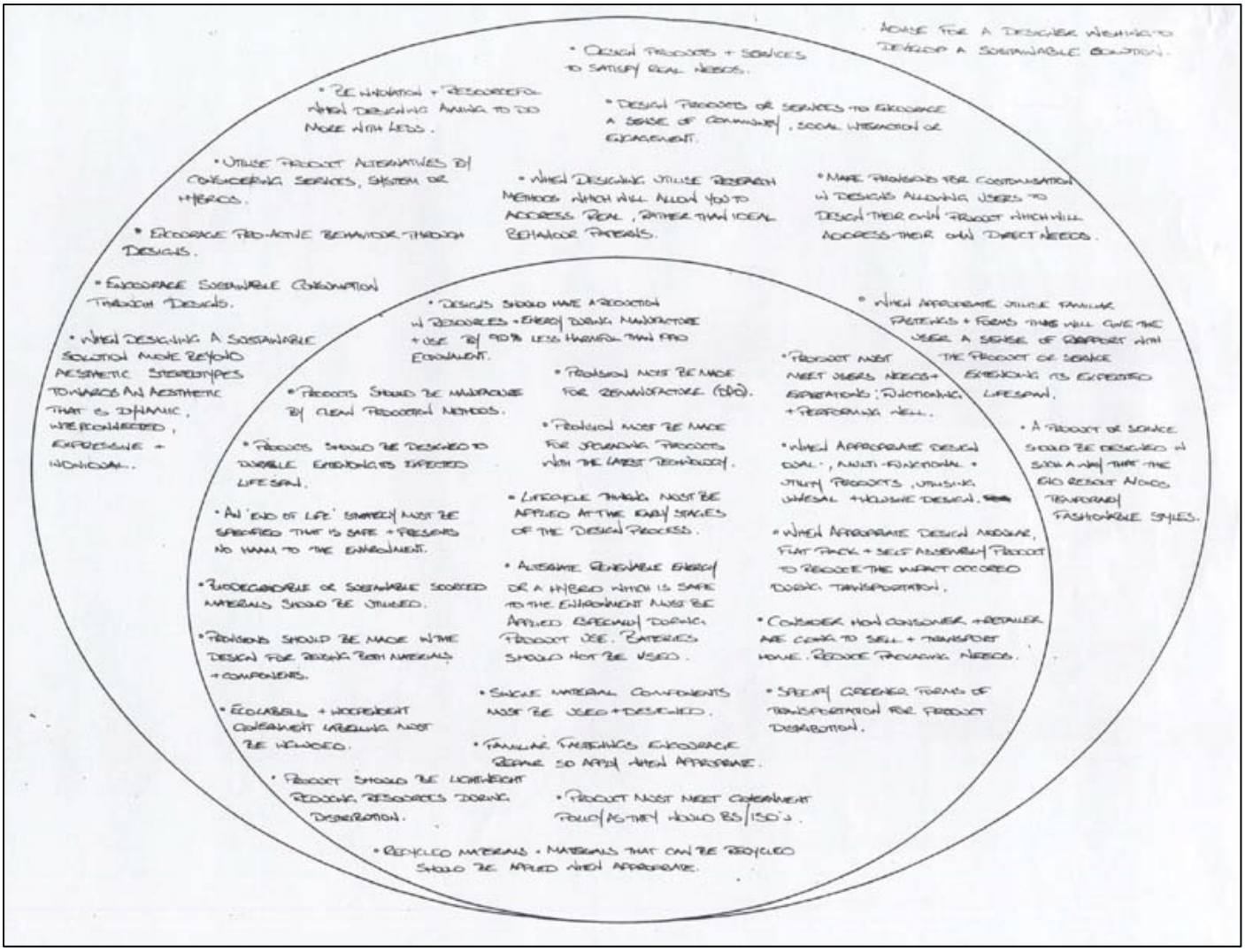


Figure 3. Map of advisory statements.

Tuesday 14th May 2002

Map of key terms.

Over the page is a condensed version of the previous set of core characteristics of SPD stating things to address and consider. I brought them down to one word or key phrases, so they could be used in brainstorming. Already I can see that the majority of the characteristics on the first level – the pragmatic characteristics – would be difficult to brainstorm with. Although some of the characteristics offer more than one option - for example, end of life strategies - others are restrictive to innovation, such as utilising recycled materials (which depends on the design specification). However, the characteristics on the second level, the intangible, provide more opportunity to be innovative. I don't think brainstorming the first level would achieve the results I want; these should perhaps be addressed further into the design process, once concepts have been explored and developed.

Wednesday 15th May 2002

Brainstorming with post-it notes went well yesterday. Spent part of today recording, collating and connecting ideas into concept maps (over the page). Some of the ideas I generated (the brainstorming sessions only involved myself, not an ideal situation) in each one-hour session were obvious, a few were more unique. I am not sure if this idea generation method is the right one and I can still see flaws in the core characteristics. Part of the problem is the need for a two-step approach. I am aware the first brainstorming session influenced the second – the sustainability influence – but this may simply be appropriate for a sustainable project.

The outcome of the brainstorming sessions probably could benefit from further idea-generation techniques, such as naïve user for real behaviour patterns or bi-association. For the purpose of this first project, I will develop the concepts to a final concept stage.

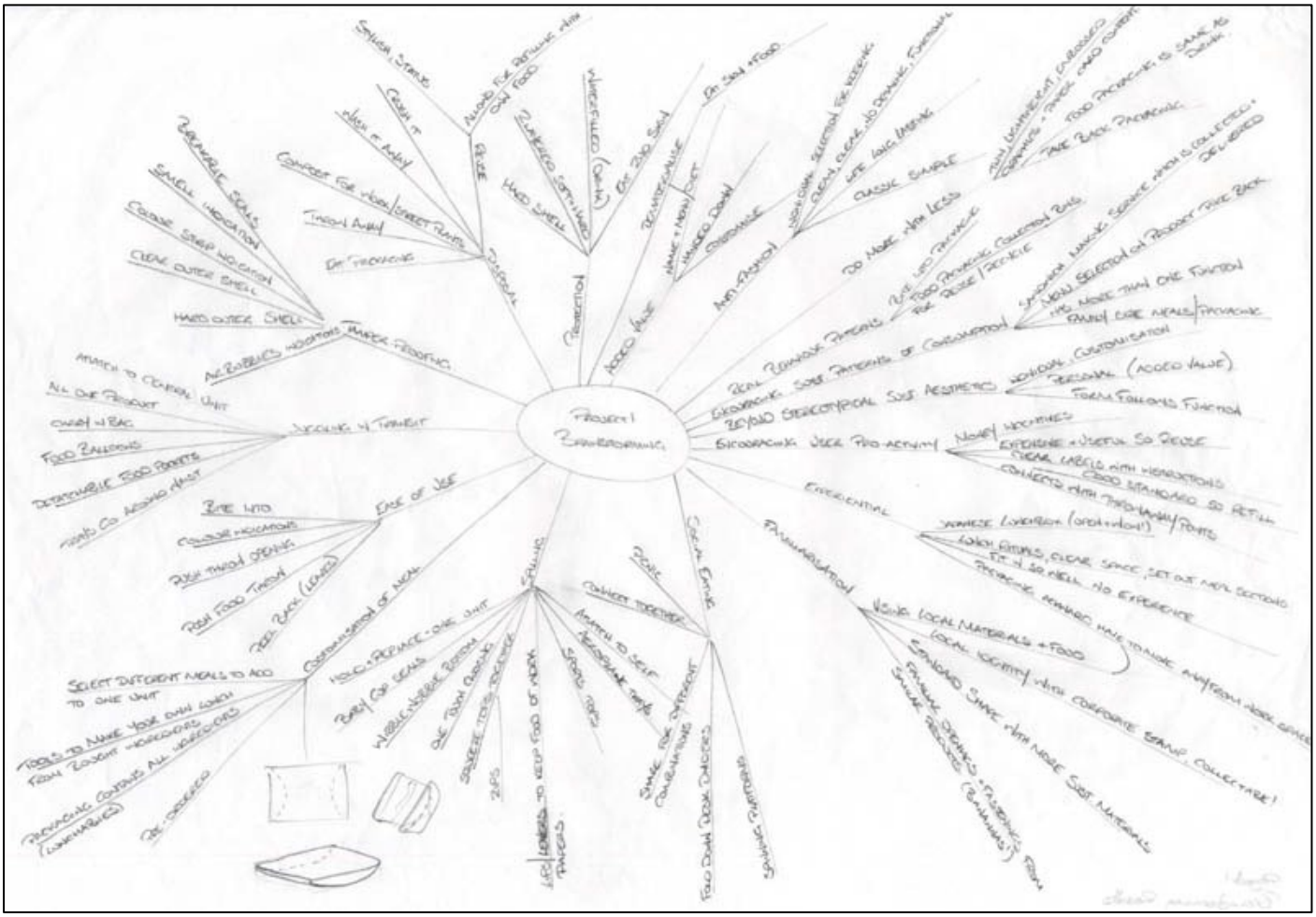


Figure 4. Map of brainstorming.

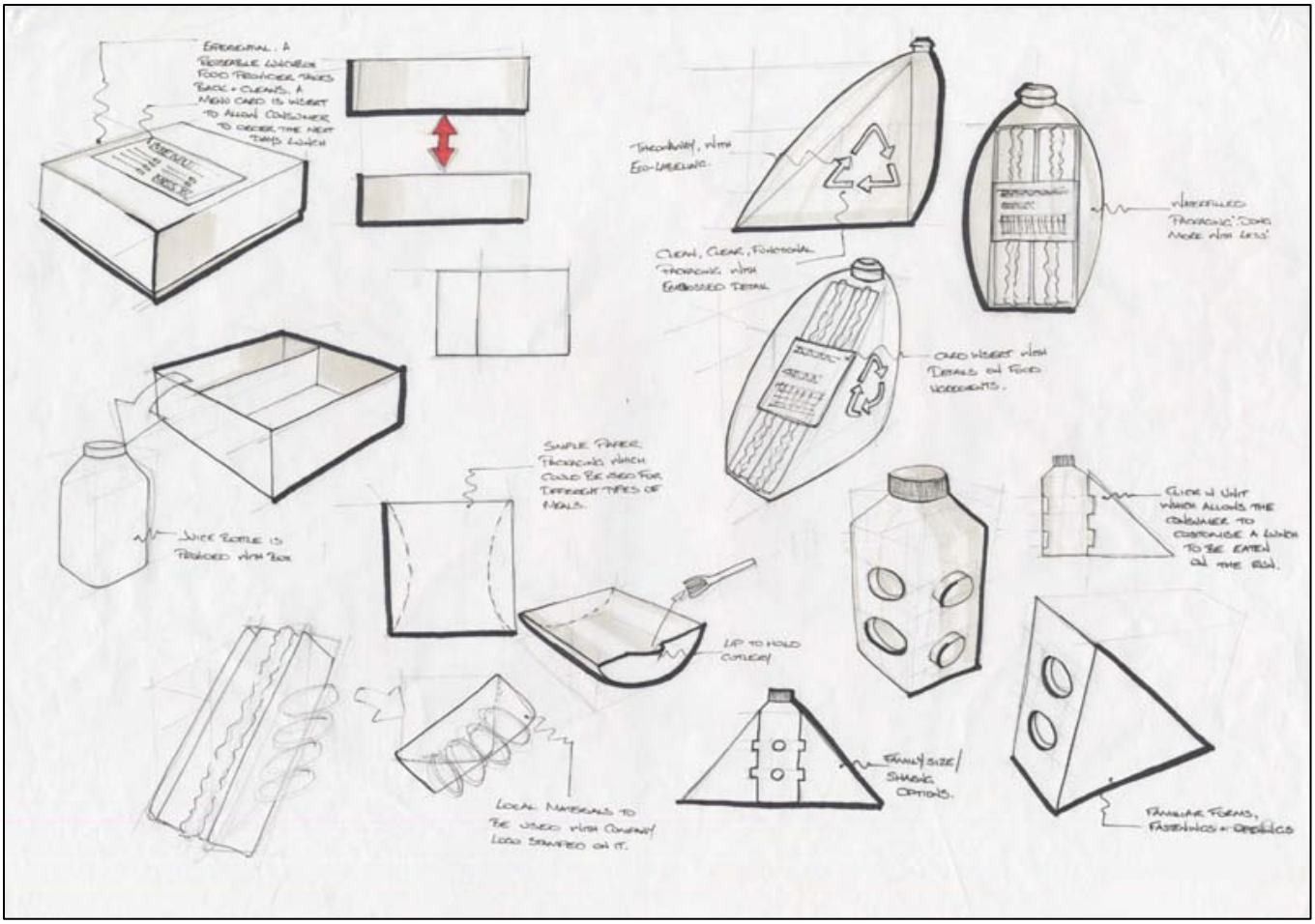


Figure 5. Initial concepts one to four.

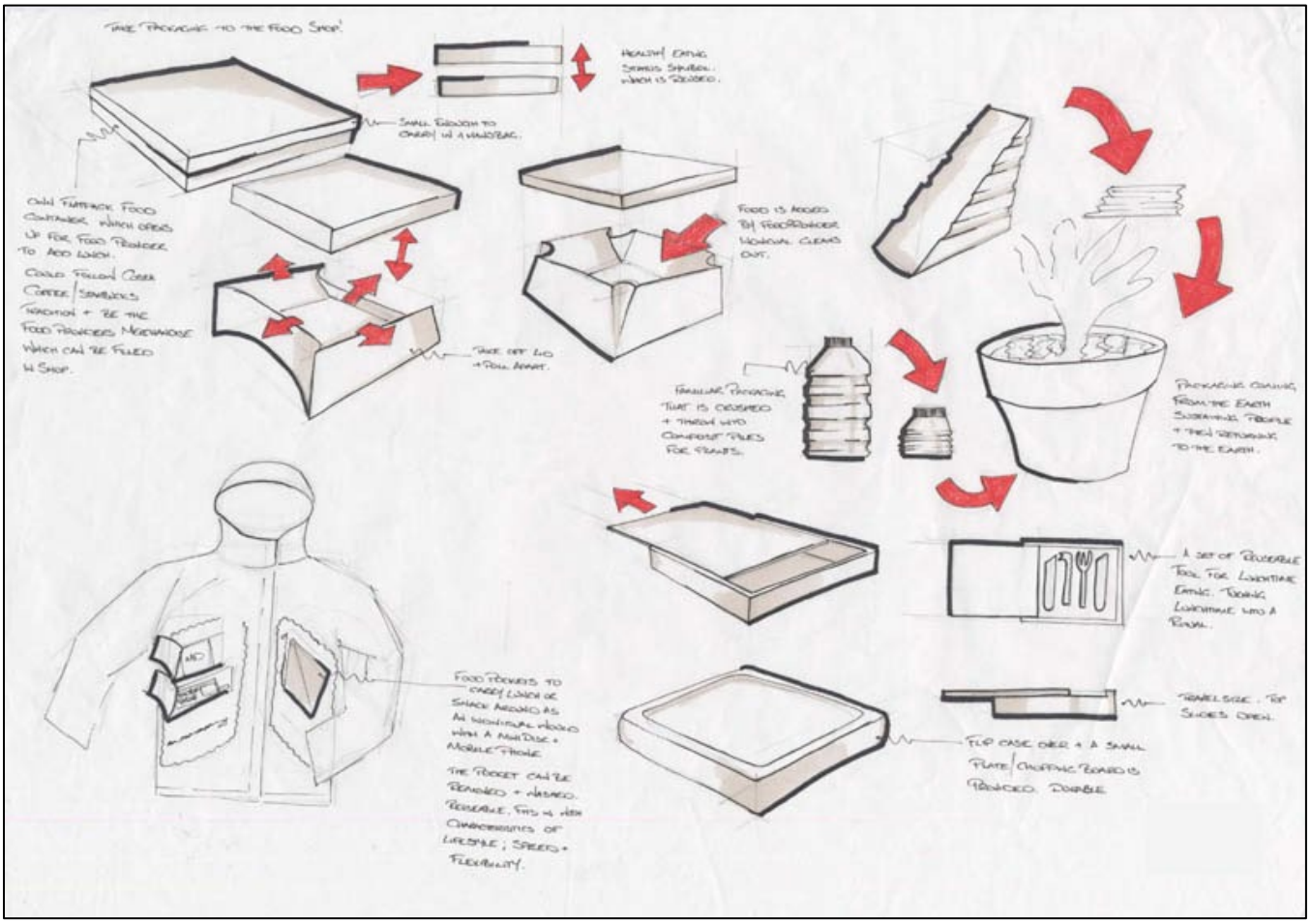


Figure 6. Initial concepts five to eight.

Monday 20th May 2002

Analysis of initial concepts against the original design brief to decide which ones to develop further. The original brief states:

The aim of the project is to design a system for containing, protecting and portioning lunchtime foods which allows for product differentiation, branding and information on the nature and content of the food. The system can be used while on the move, at a work desk or a more social occasion.

The majority of this information is in my own head, not written down in the brief. Some of it is instinctive; from my own experience, perceived and observed from consumers. The criteria which the initial concepts will be analysed against are listed below. They are not in a hierarchical order:

- Contains portioned lunchtime foods;
- Protects lunchtime foods;
- Is tamper-proof;
- Allows for ease of access to lunchtime foods;
- Provides information on the nature and content of the lunchtime food;
- Provides an opportunity for product differentiation and branding;
- Is non-spill;
- Allows for ease of use while in transit;
- Allows for ease of use while at work desk;
- Has an end-of-life strategy;
- Encourages social eating;
- Encourages sustainable patterns of consumption;
- Design does more with less;

- The design encourages sustainable behaviour patterns;

- The design provides the user with an experience as well as a product;

- The design is sustainable.

Criteria for analysis	1	2	3	4	5	6	7	8
Contained portioned lunchtime foods	X	X	X	X	X	X		
Protects food	X	X		X	X	X		
Is tamper-proof		X		X		X		
Ease of access to food	X		X	X	X	X	X	
Provides info. on nature and content of food	X	X						
Opportunity for product differentiation and branding	X	X		X	X		X	
Is non-spill		X						
Ease of use while in transit		X	X	X			X	
Ease of use at work desk	X				X			
End-of-life-strategy	X				X	X	X	
Encourages social eating	X			X				
Is sustainable: Encourages sustainable patterns of consumption	X				X		X	X
Does more with less	X	X	X		X		X	
Experiential	X				X			X
Encourages sustainable behaviour patterns	X	X			X	X	X	X

Concept 1

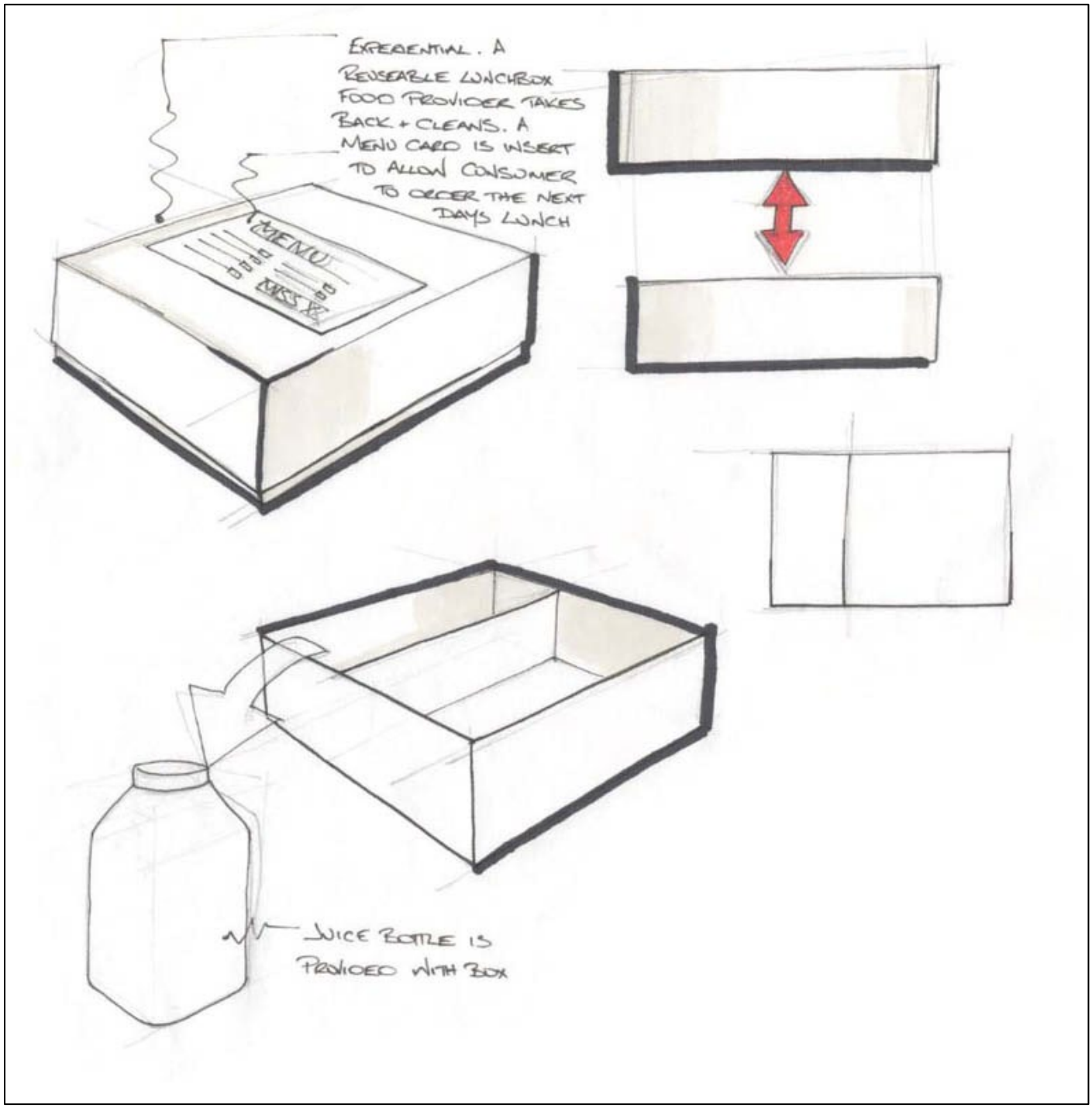


Figure 7. Concept 1: Reusable lunchbox.

Develop this concept further. Be aware it is not: tamper-proof, non-spill, ease of use in transit and whether its sustainable (maybe an idea - in fact I should explore combining concept 5 with this one).

Concept 2

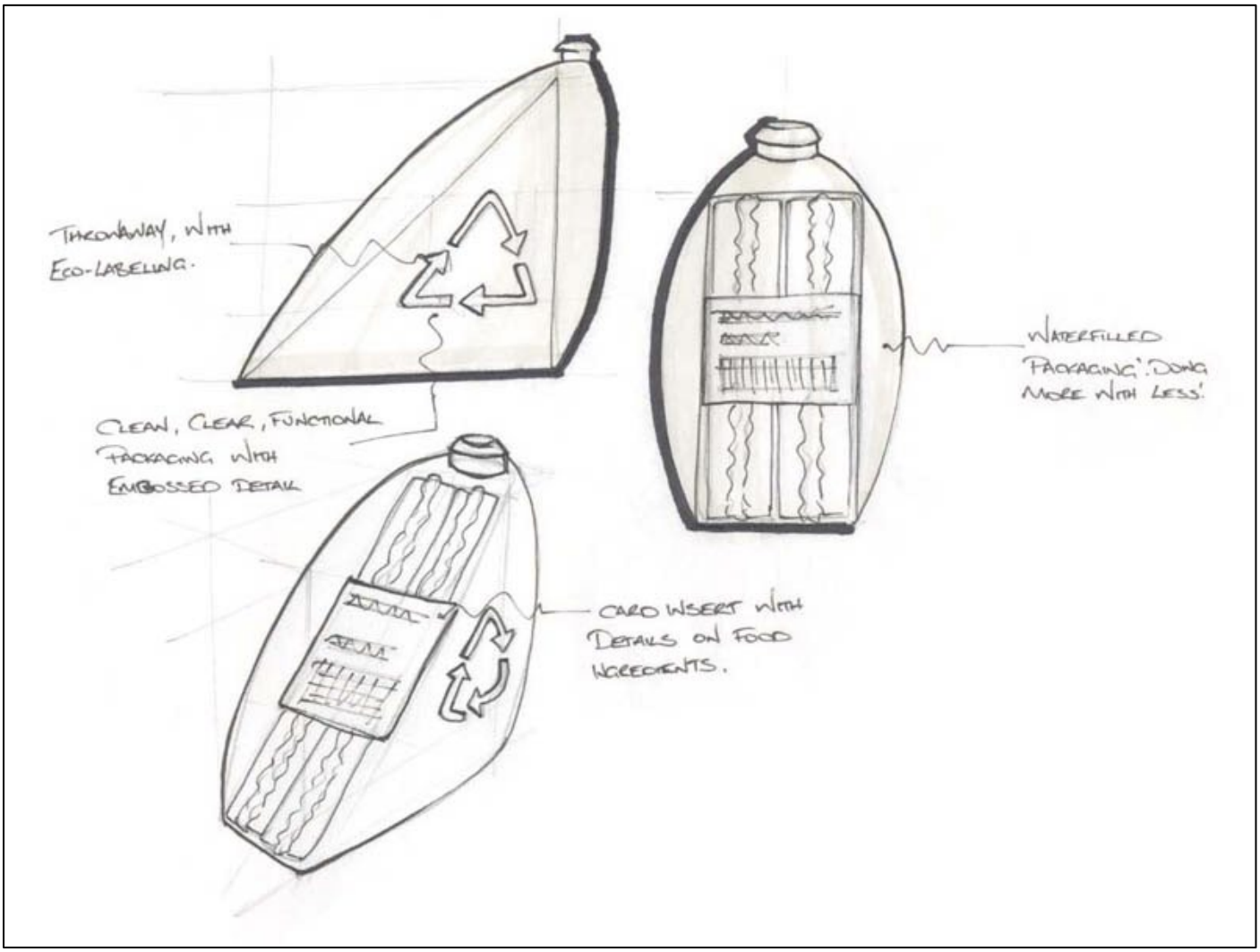


Figure 8. Concept 2: Sandwich container embedded in water bottle.

Develop this concept further, but be aware it is not: ease of use at work, end-of-life strategy, encourages social eating, sustainable patterns of consumption, experiential. Need to develop other food options.

Concept 3

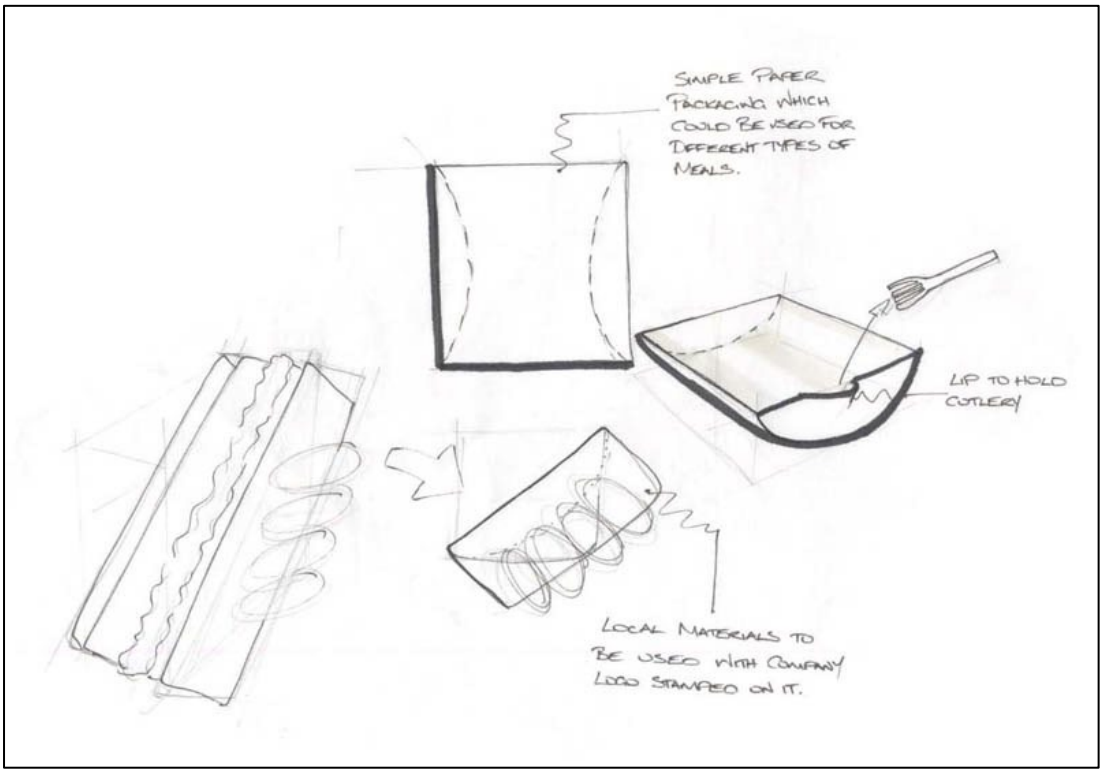


Figure 9. Concept 3: Curved tray.

Don't develop further.

Concept 4

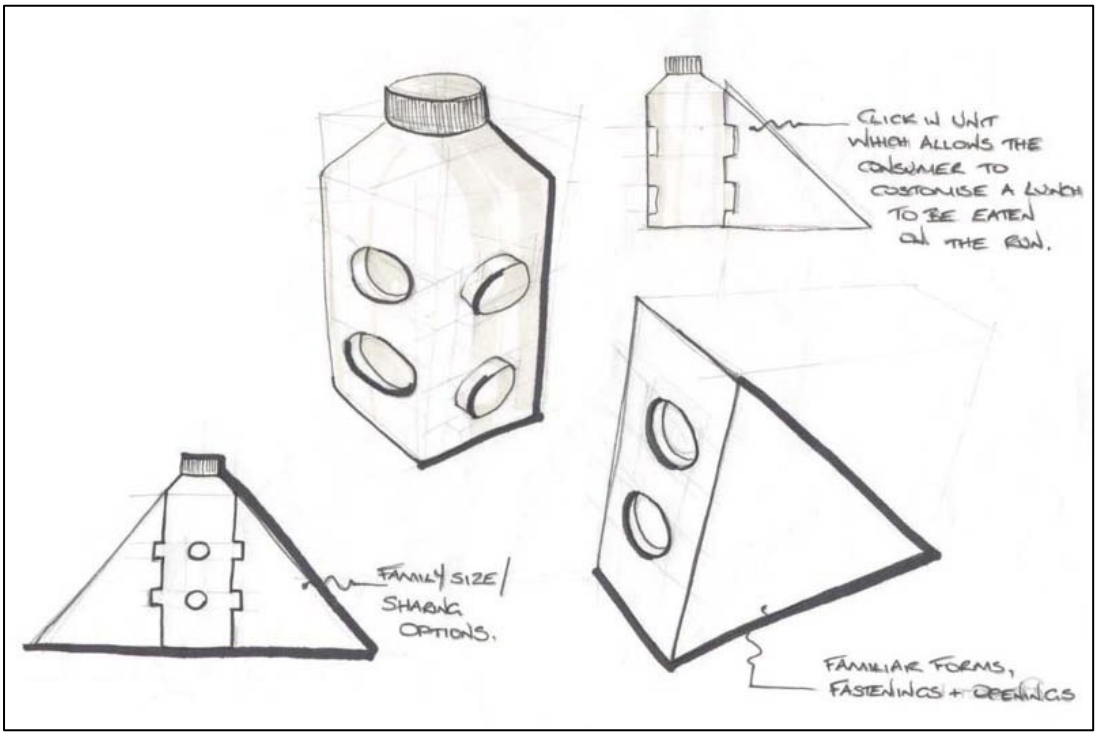


Figure 10. Concept 4: Connectable bottle and food packaging.

Develop this concept further, explore combining it with concept 2.

Concept 5

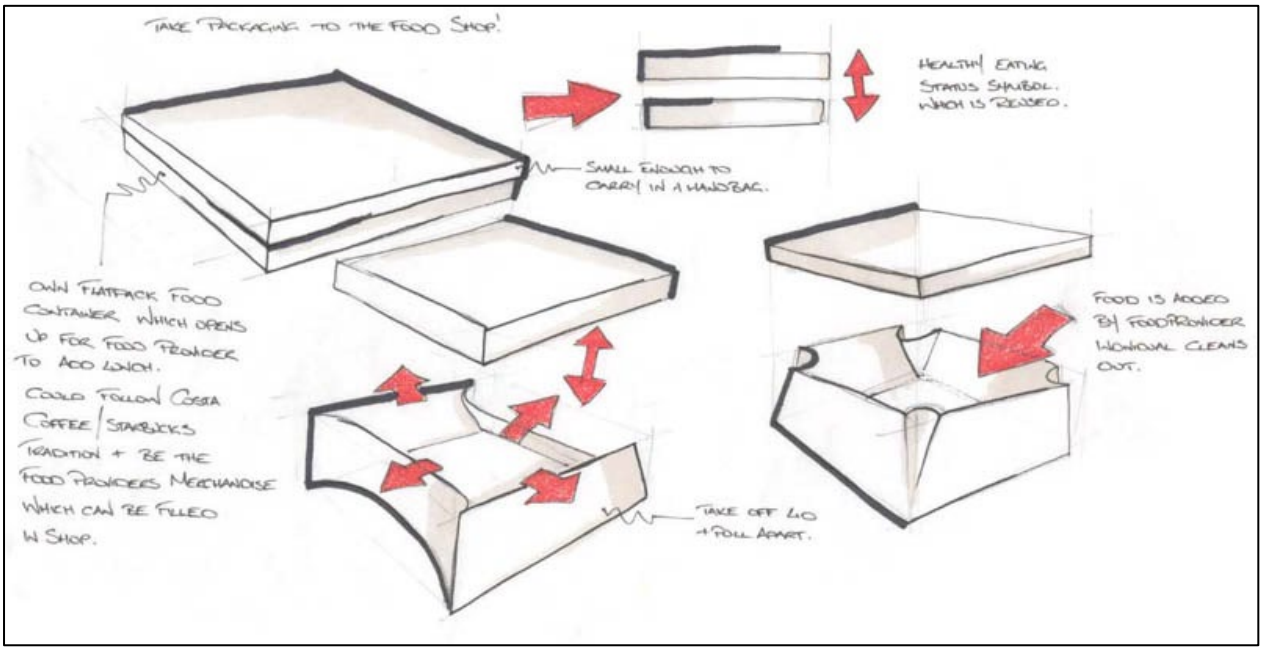


Figure 11. Concept 5: Flat-pack tray.

Don't develop further.

Concept 6

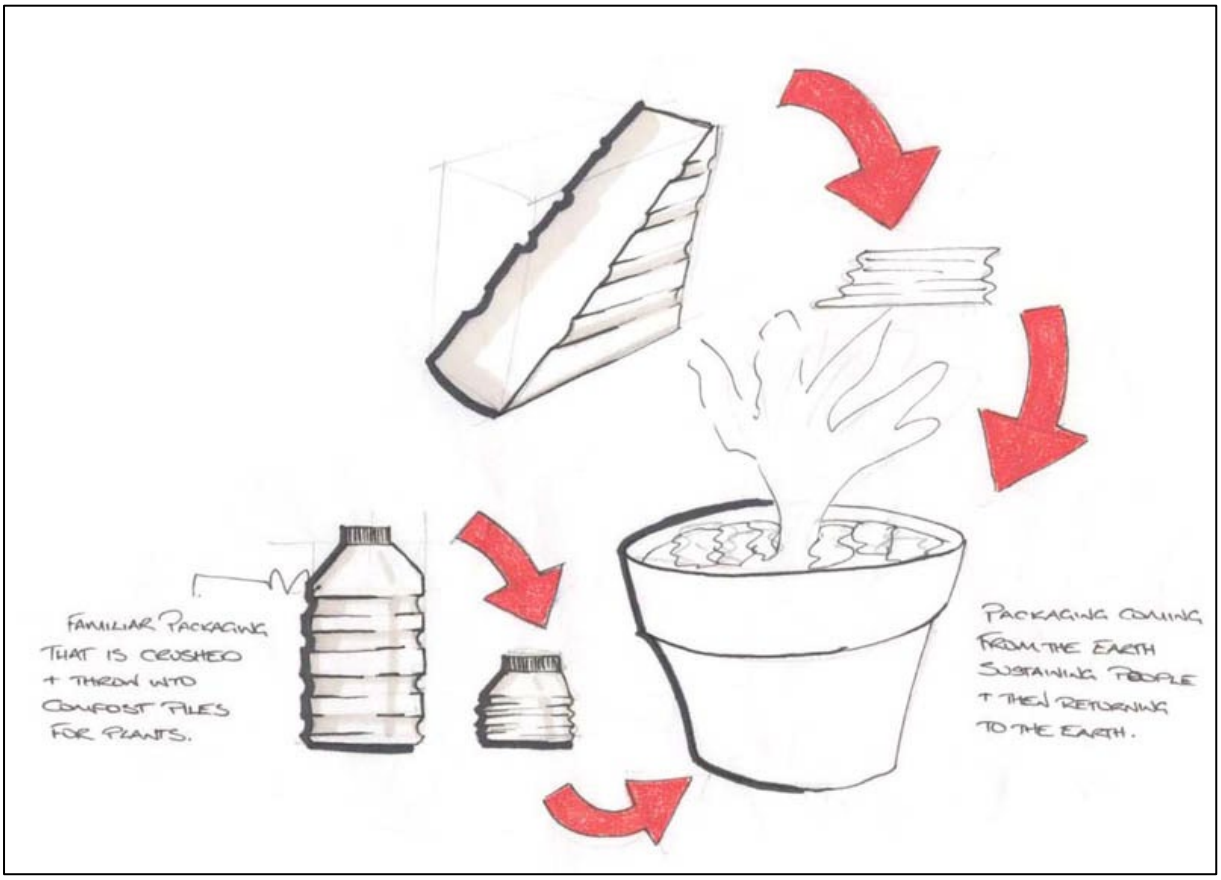


Figure 12. Concept 6: Compostable packaging.

Don't develop further.

Concept 7

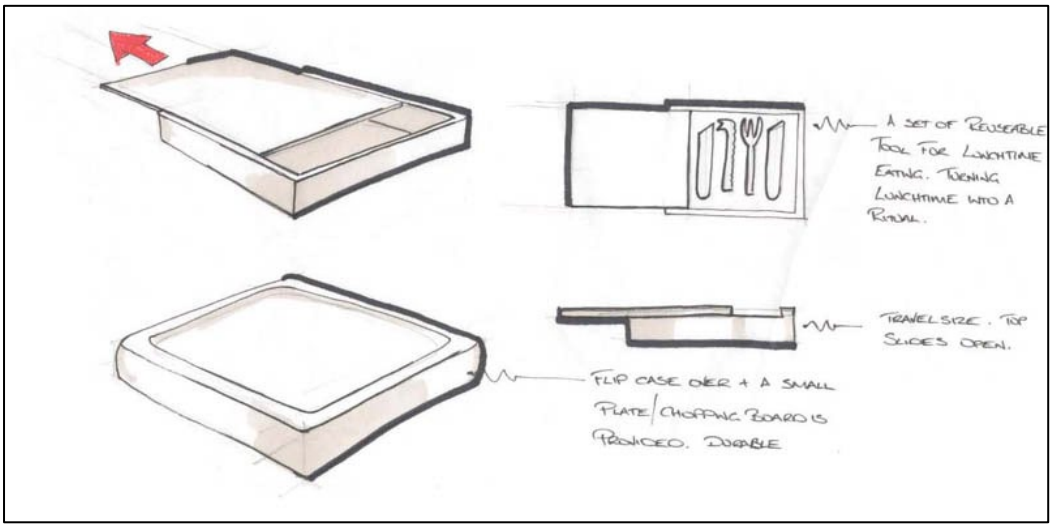


Figure 13. Concept 7: Lunchbox with sliding lid.

Although this concept score is quite high, I will not develop it further because it mainly deals with homemade food. Ordering a sandwich and putting it in your pocket may not be desirable or hygienic. Also only caters for sandwiches.

Concept 8

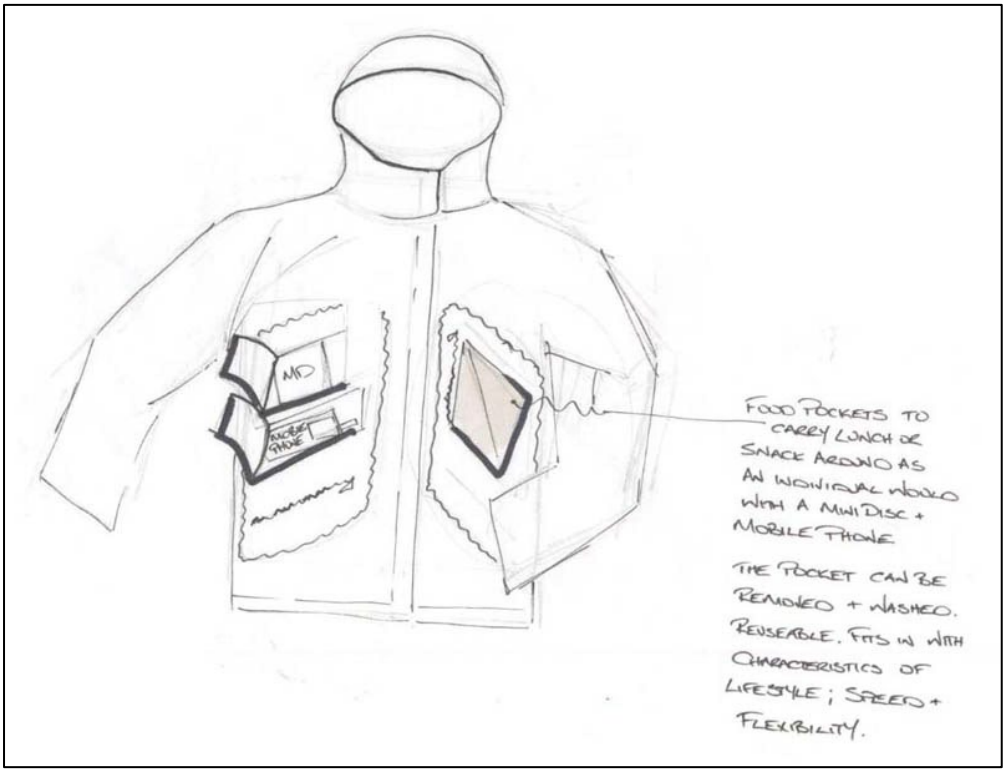


Figure 14. Concept 8: Removable pockets for carrying food on an item of clothing.

Don't develop further.

See sketchpad for initial concepts development.

Thursday 30th May 2002

Spent the past days designing. I have taken the initial concepts and explored/developed them.

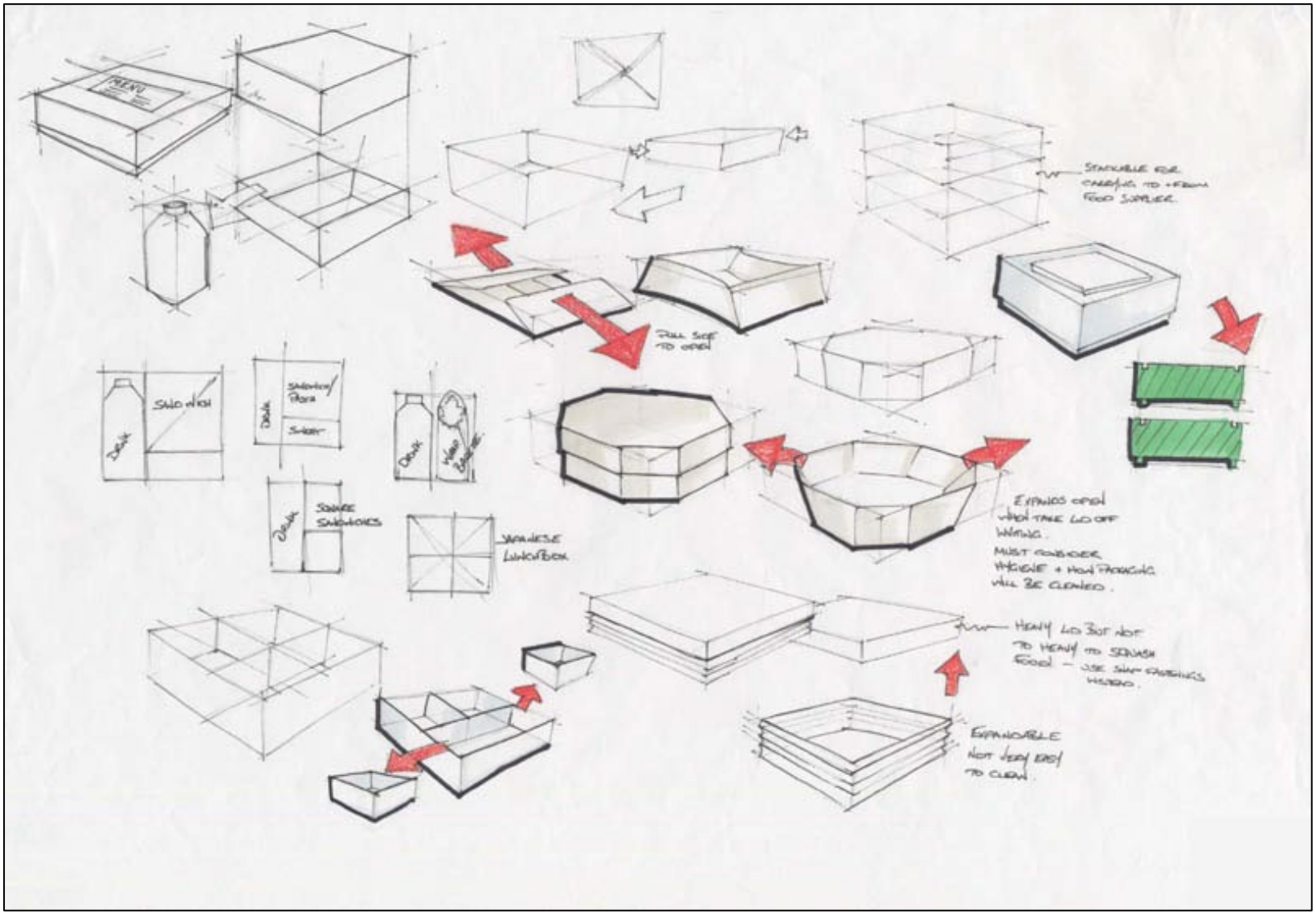


Figure 1. Design 1: Flat-pack and reusable lunchbox.

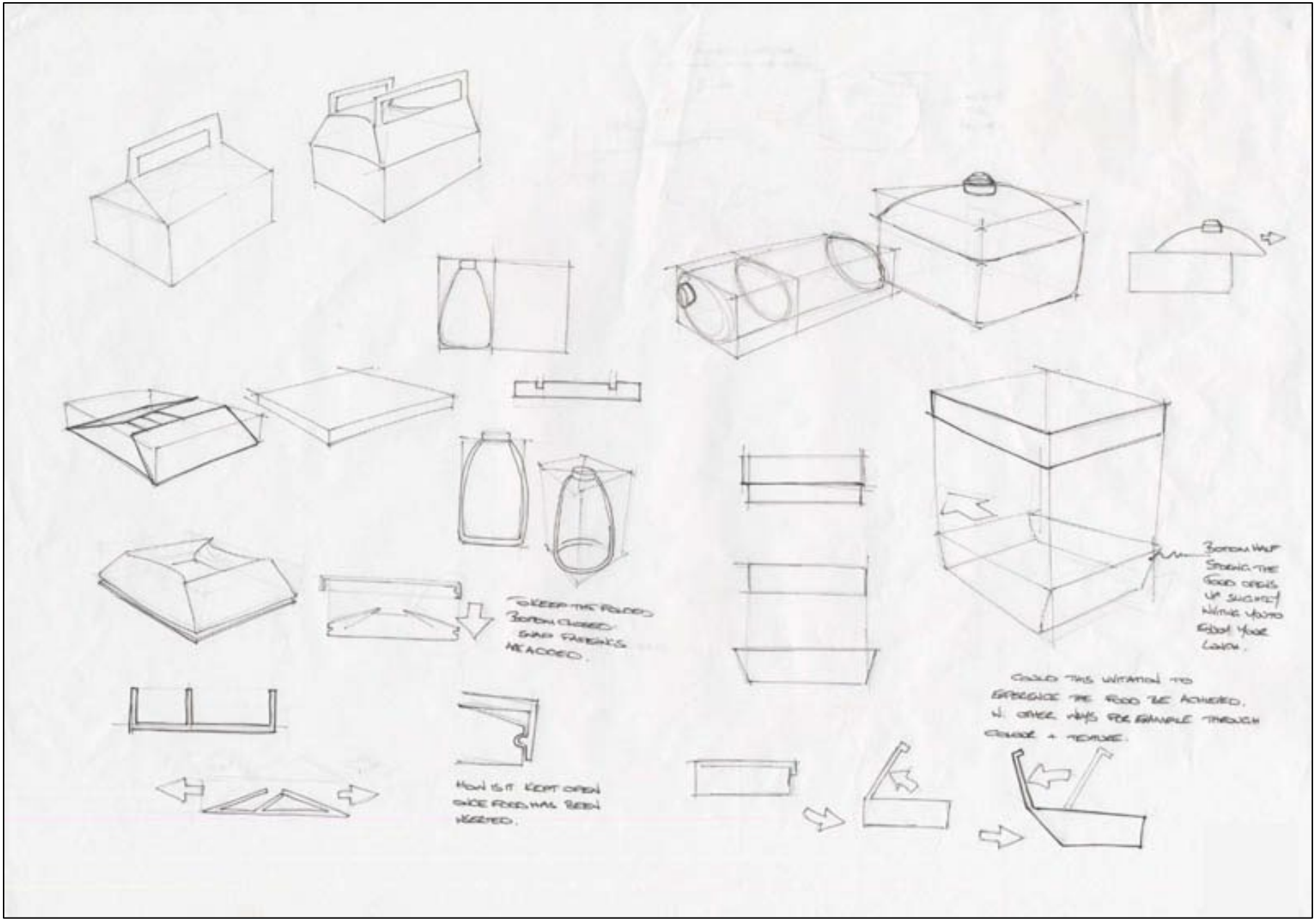


Figure 2. Design 2: Flat-pack and reusable lunchbox.

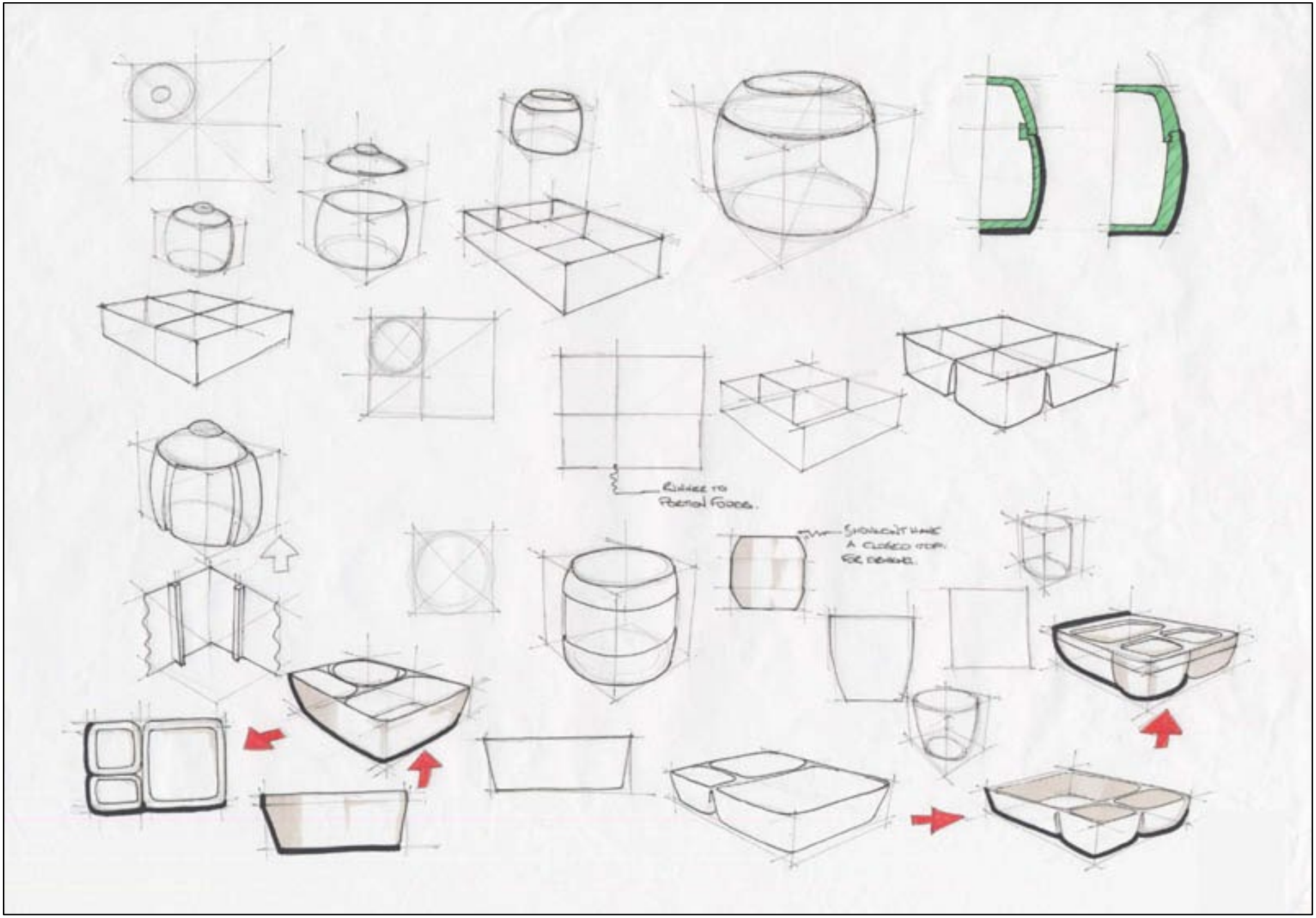


Figure 3. Design 3: Lunchbox jar/tray.

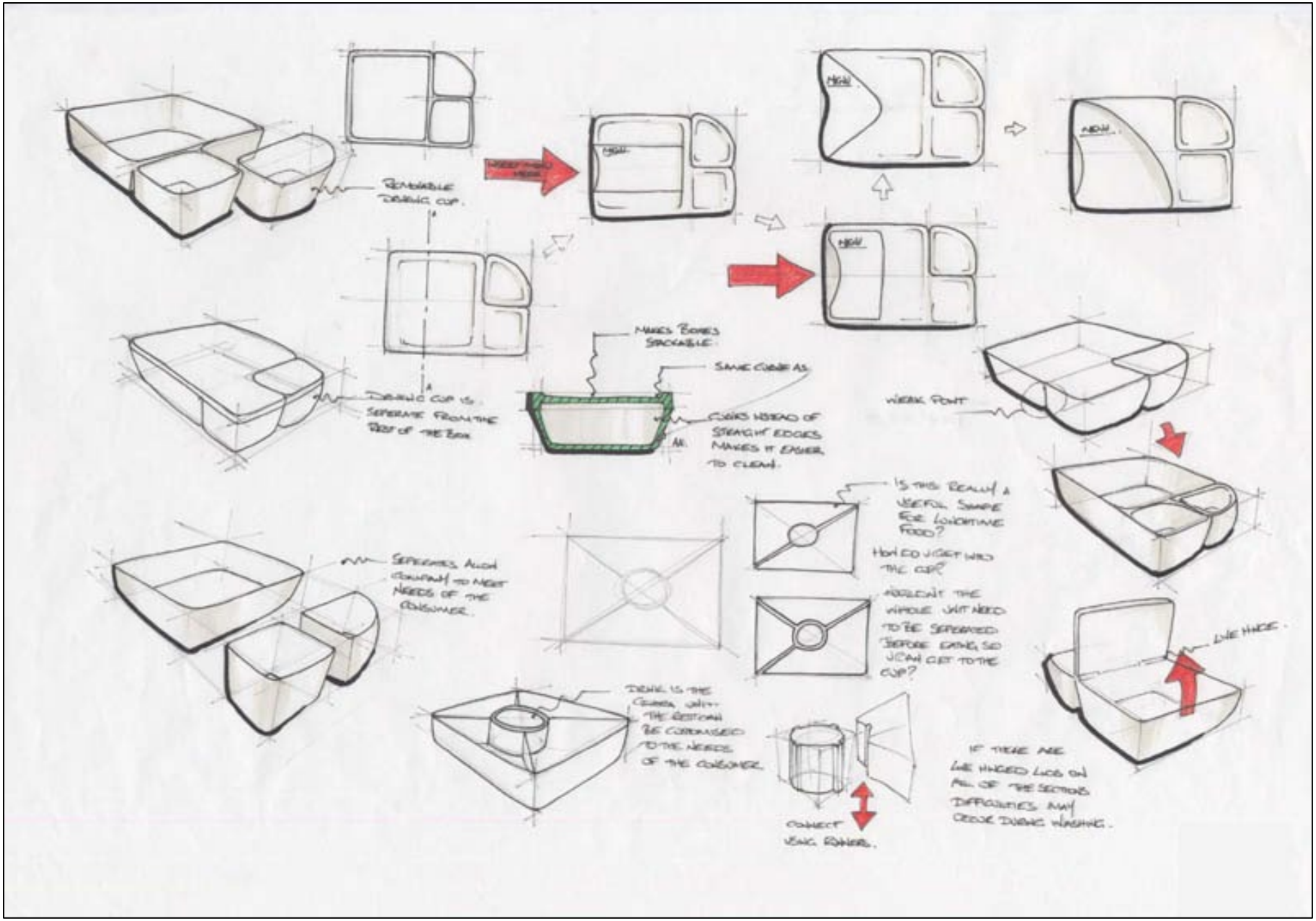


Figure 4. Design 4: Lunchbox tray.

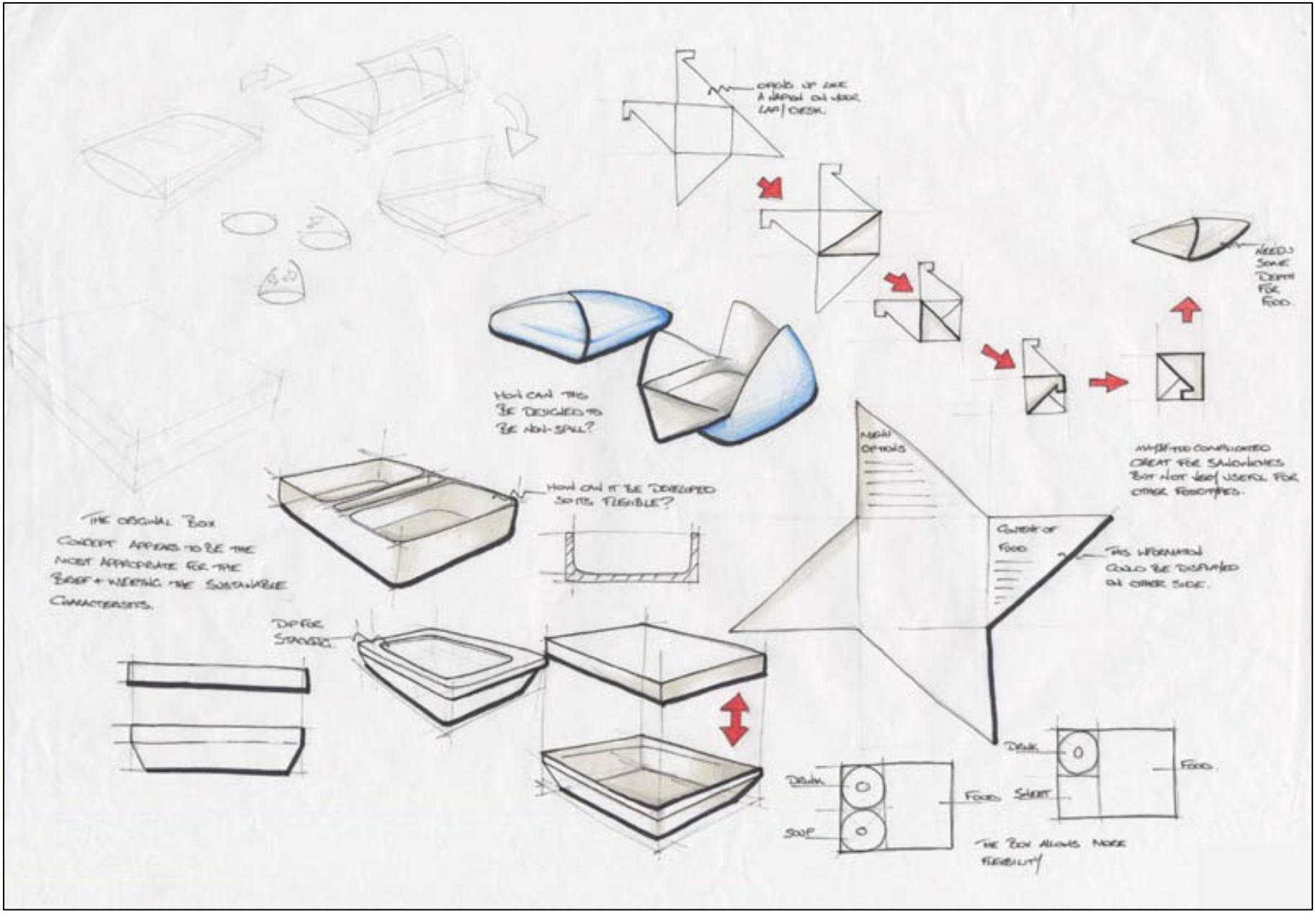


Figure 5. Design 5: Lunchbox package/tray.

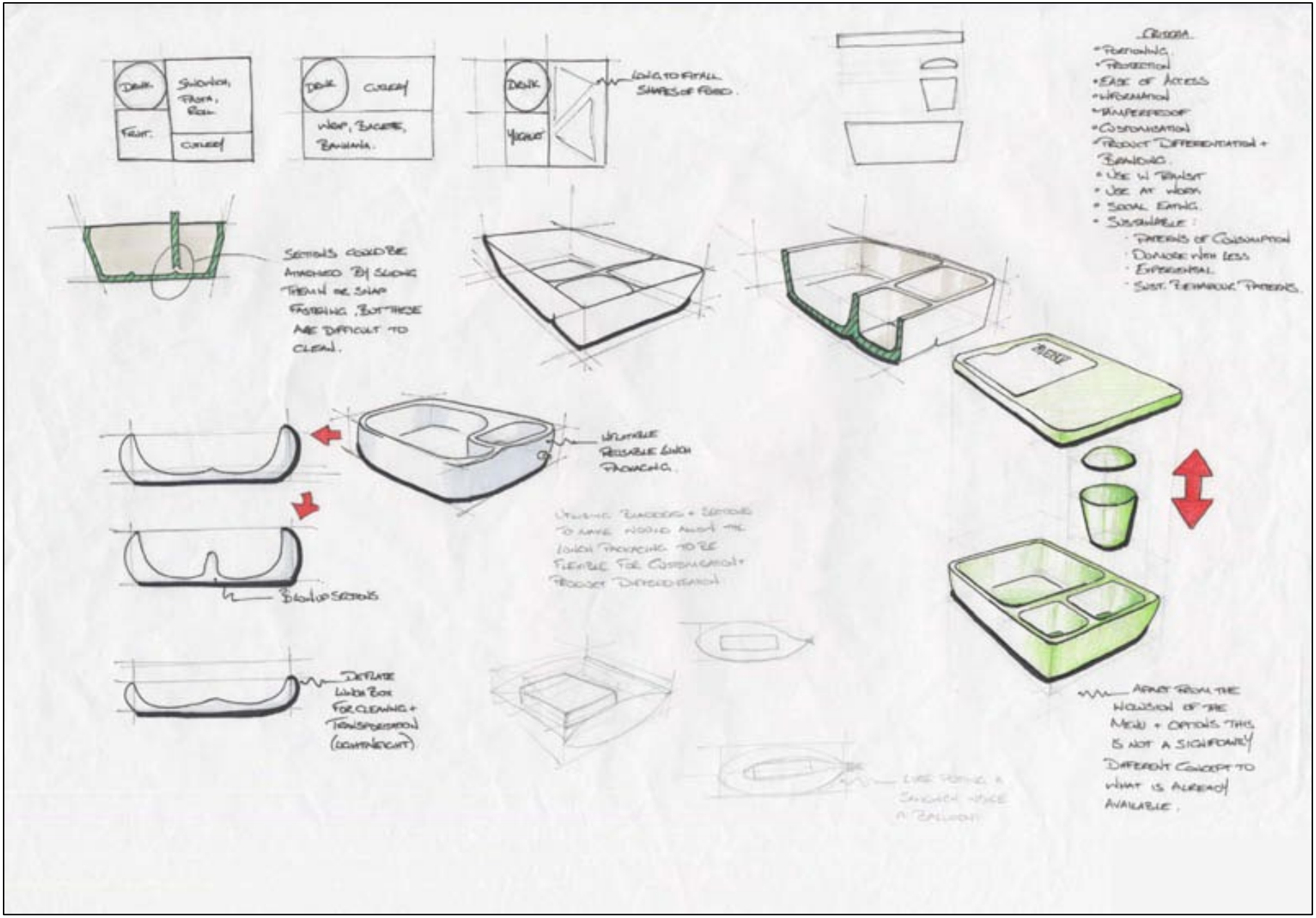


Figure 6. Design 6: Lunchbox tray.

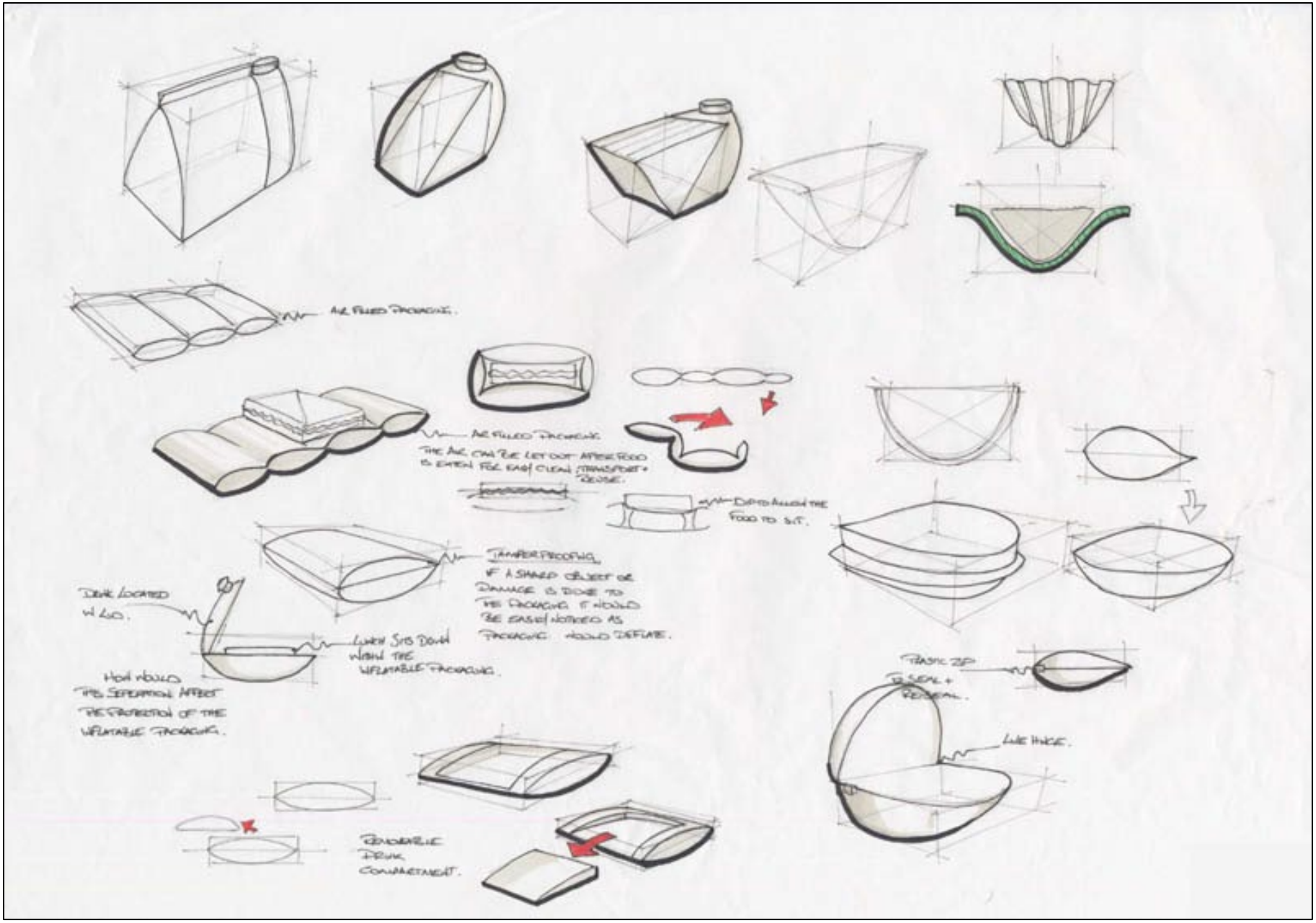


Figure 7. Design 7: Food container embedded into drink container.

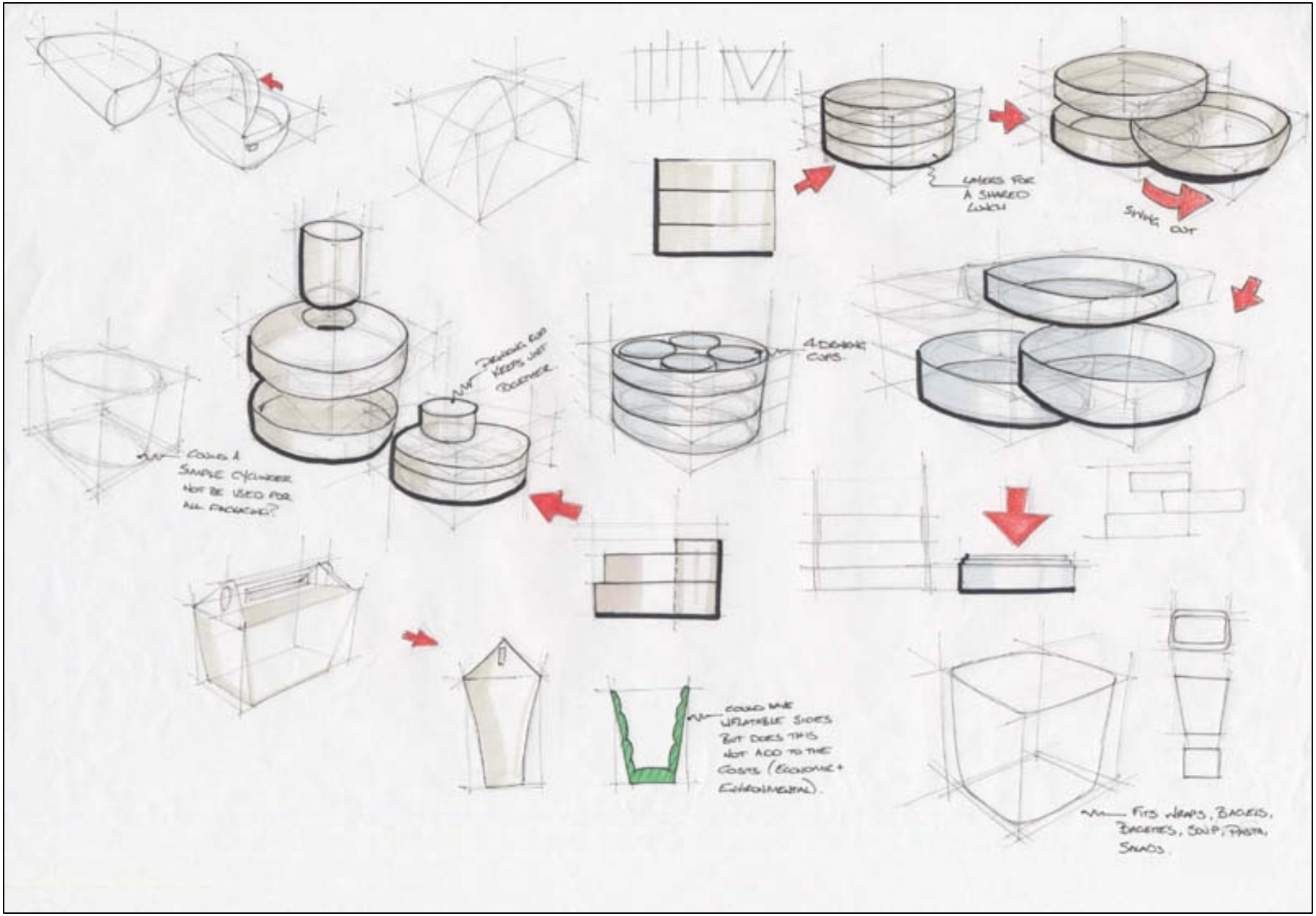


Figure 8. Design 8: Stackable lunchbox.

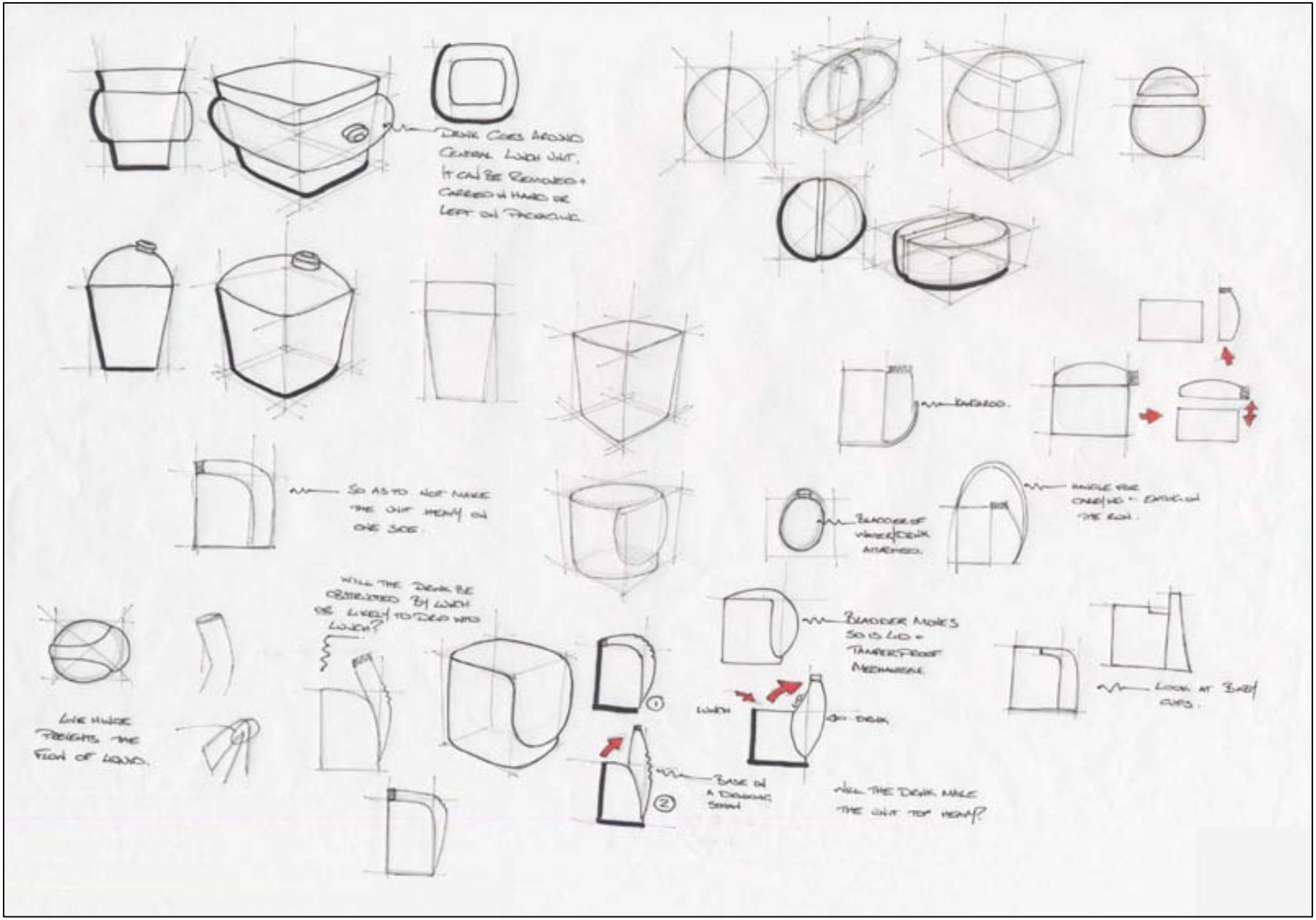


Figure 9. Design 9: Connectable bottle and food packaging.

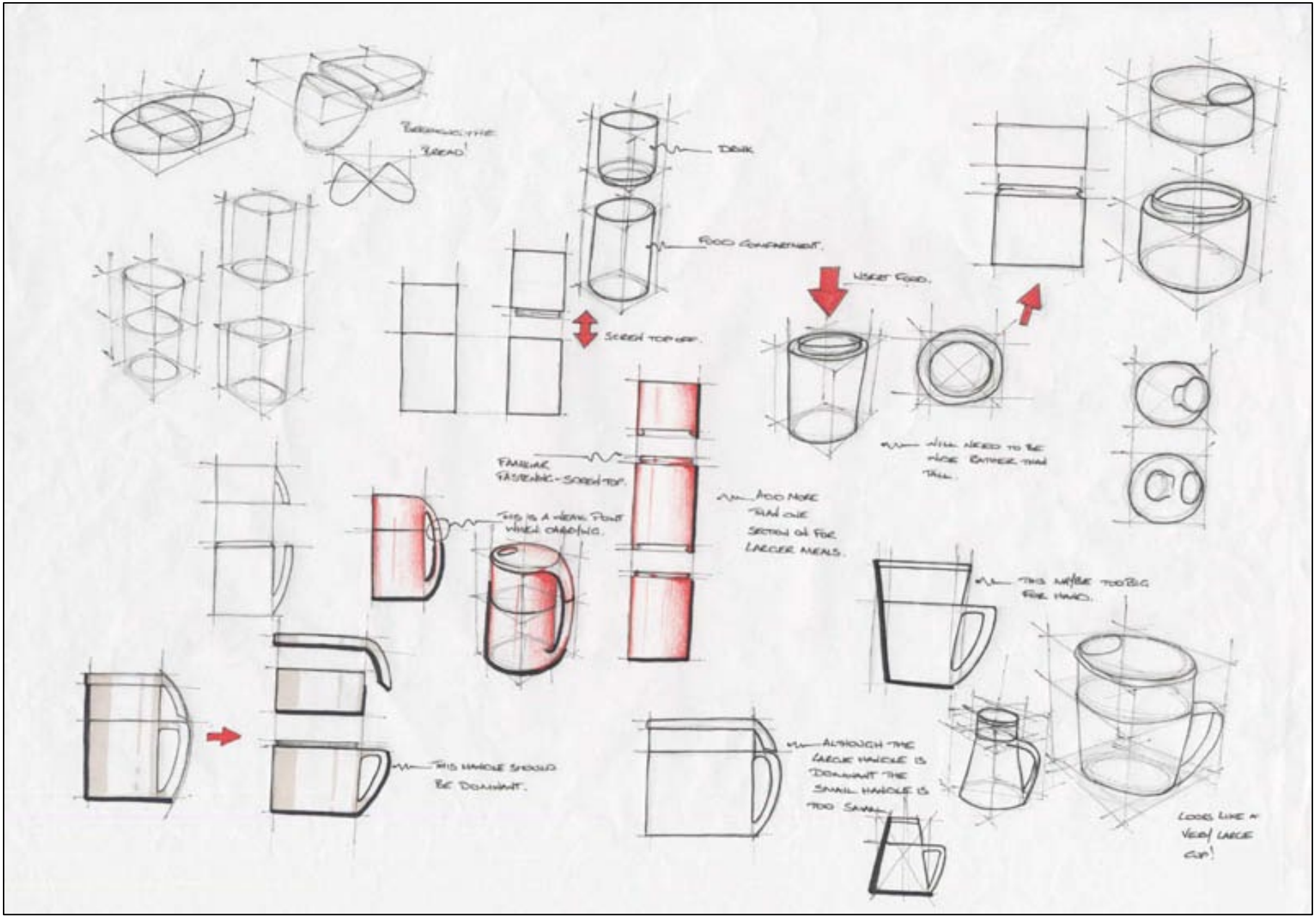


Figure 10. Design 10: Connectable bottle and food packaging.

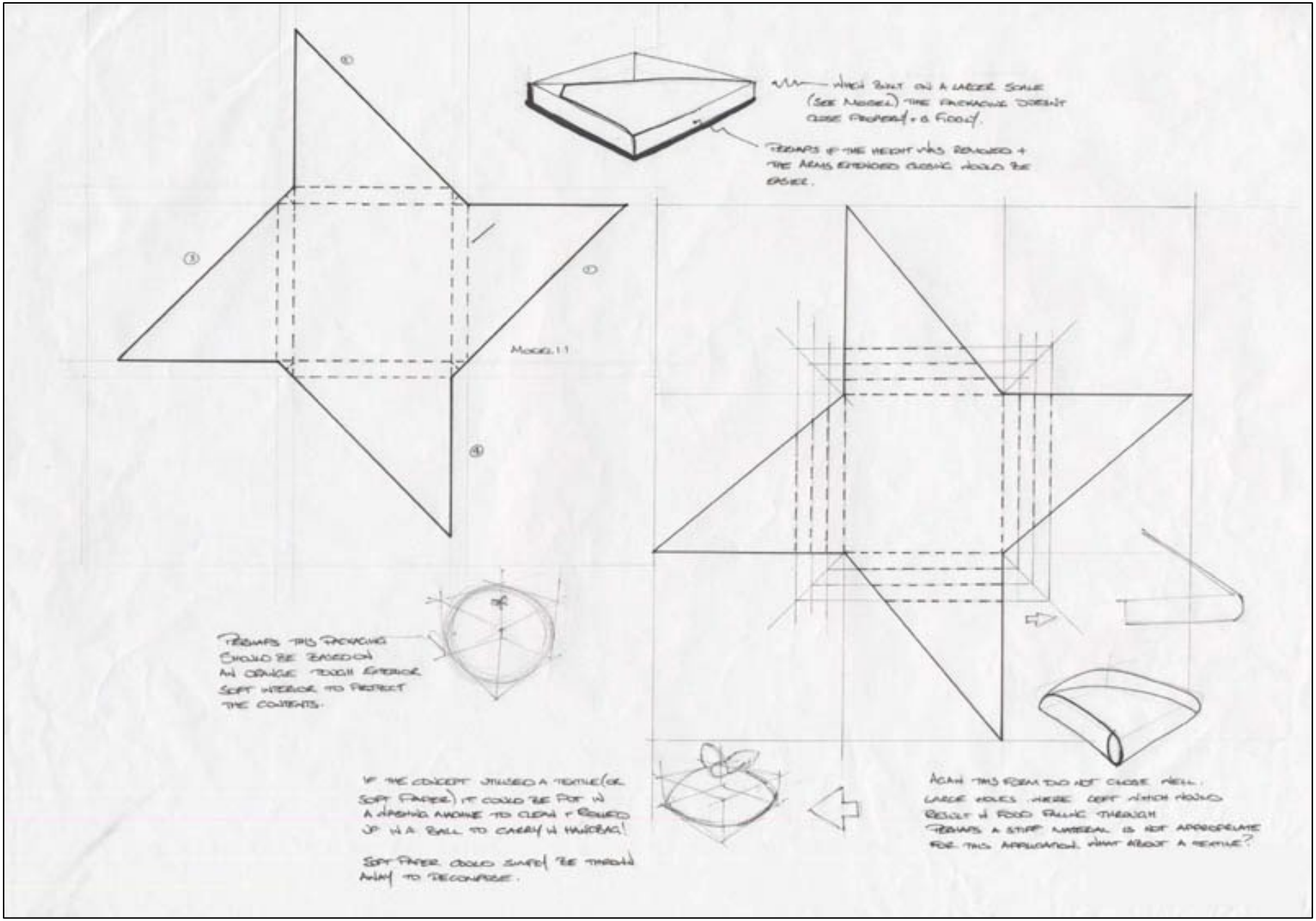


Figure 11. Design 11: Lunchbox package/tray.

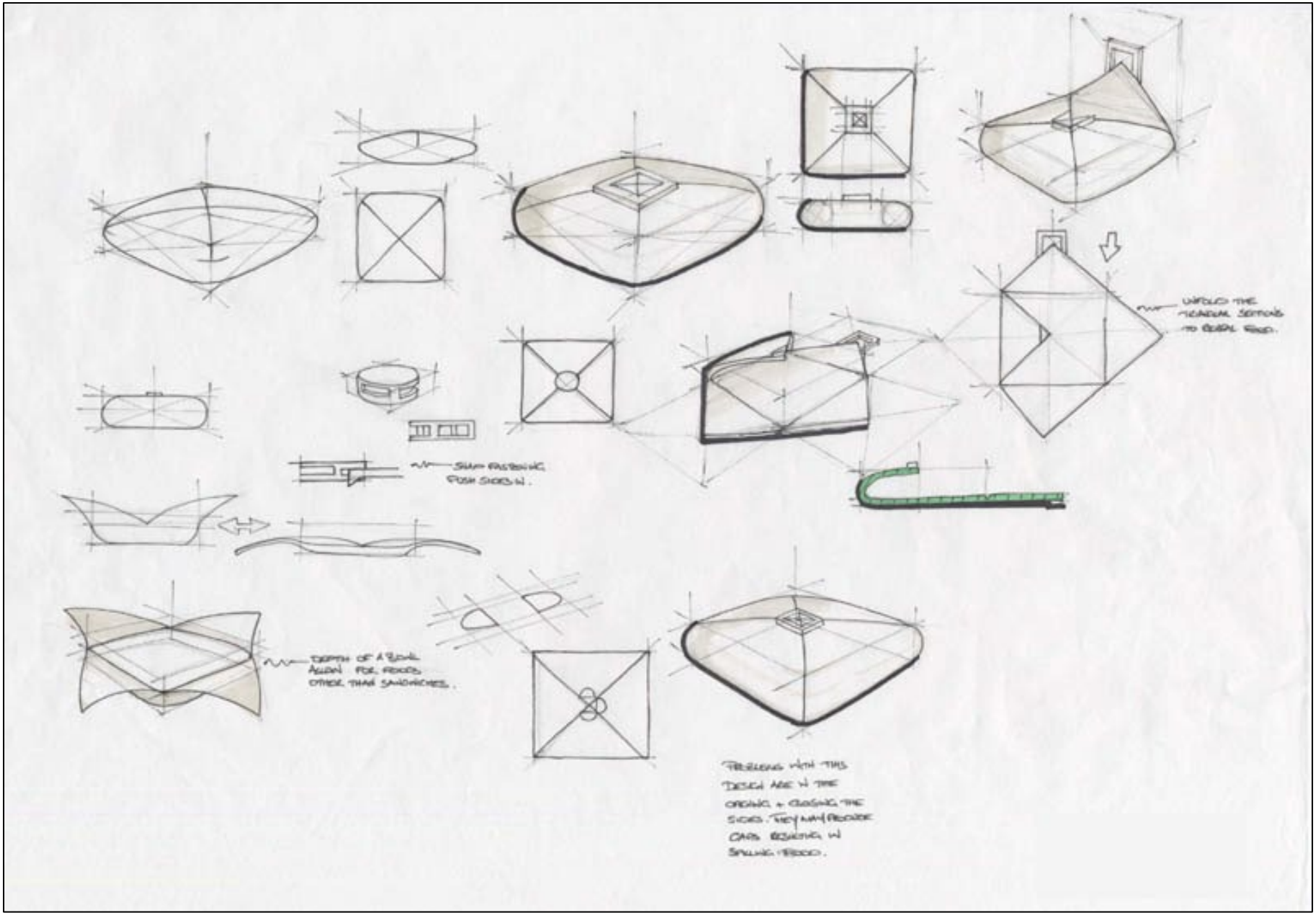


Figure 12. Design 12: Lunchbox package/tray.

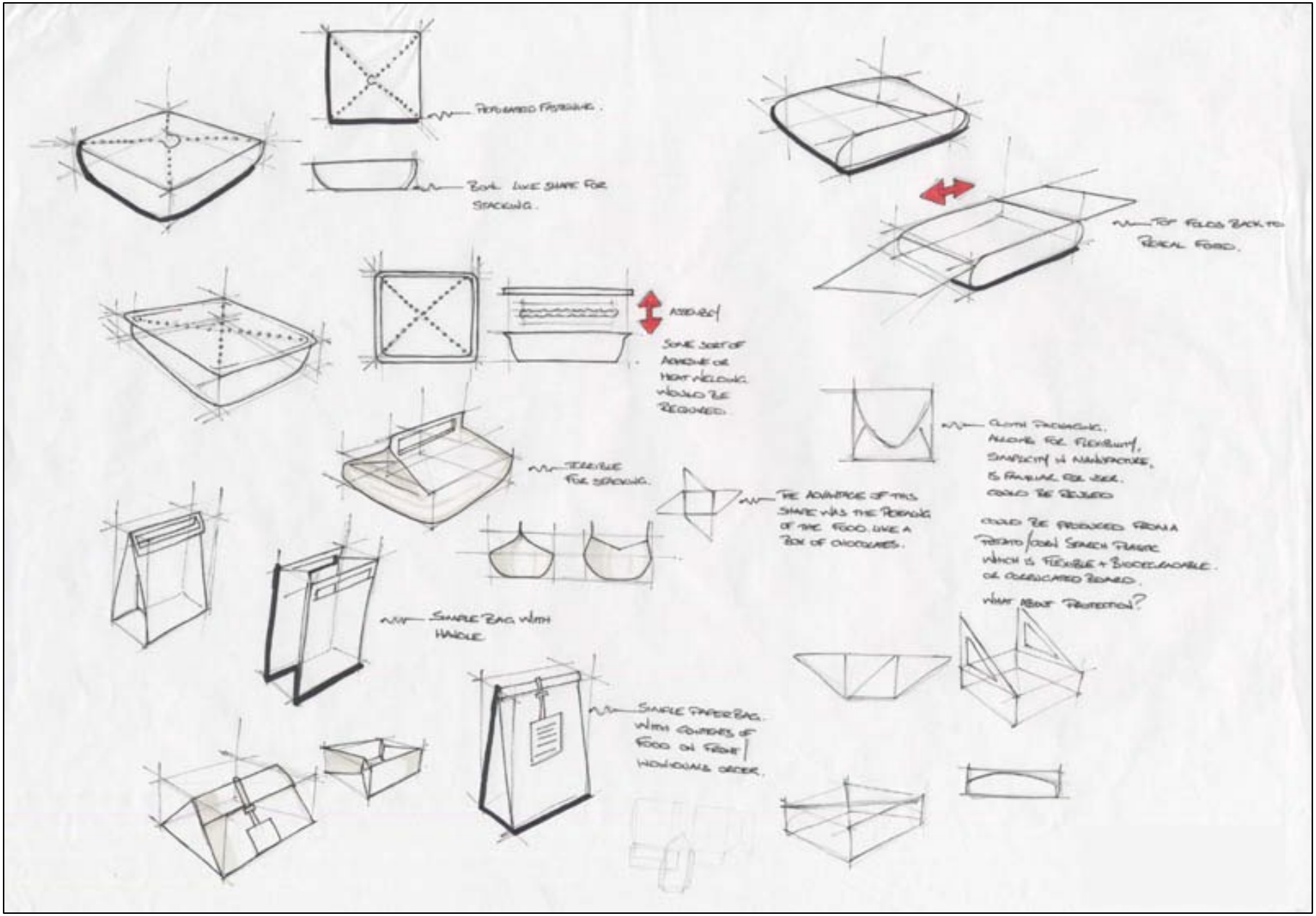


Figure 13. Design 13: Lunchbox package/tray.

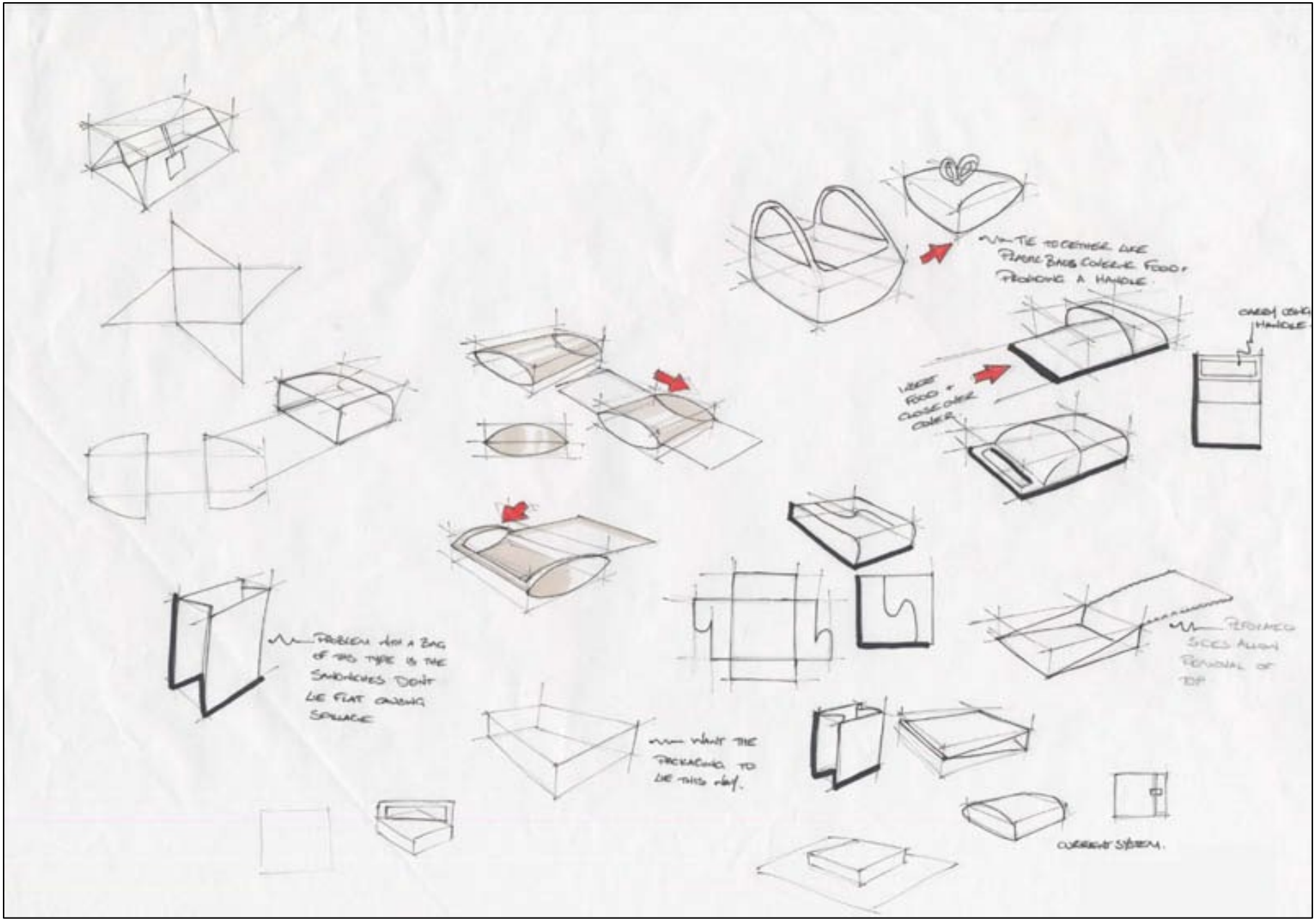


Figure 14. Design 14: Lunchbox package/tray.

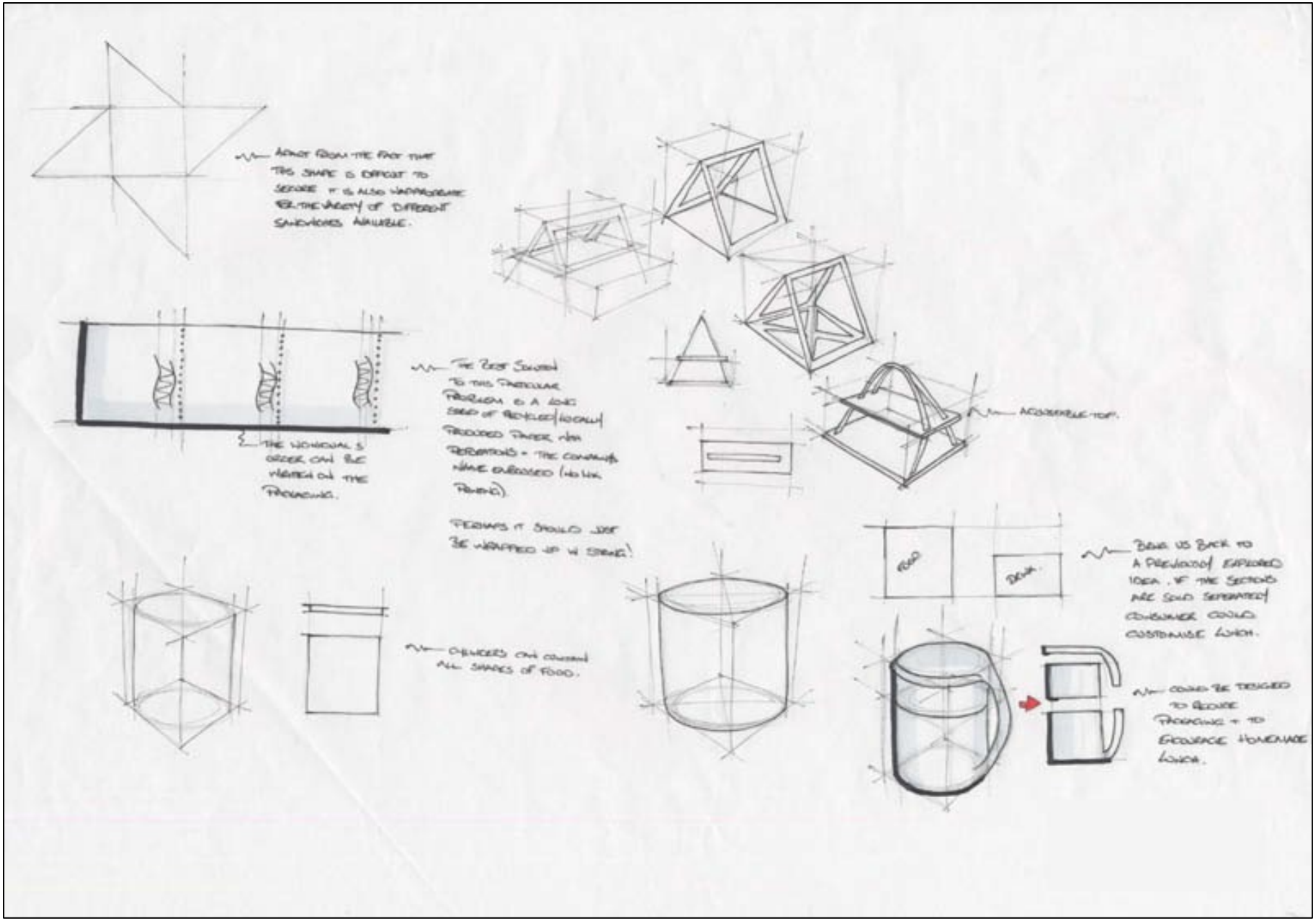


Figure 15. Design 15: Connectable bottle and food packaging.

10.3 Case Study Two: Workshop One

10.3.1 Coding for transcriptions

Code explanation		Code
Identification of sustainable problems with least sustainable product:	Pragmatic	pra-prob
	Qualitative	qua-prob
Solutions to identified problems:	Pragmatic	pra-sol
	Qualitative	qua-sol
Identified unsustainable features of redesign		uns
Rationalisation of unsustainable features		uns-rat

Transcription Key

Symbol	Meaning
[	Indicates the point at which a current speaker's talk is overlapped by another's.
=	One at the end of a line and one at the beginning indicates no gap in talking.
( )	Indicates the researcher is unable to decipher what is said.
(word)	Possible words that might have been said.
(.)	Indicates a pause
-words-	Describes an action or a sound.
R	Refers to Researcher
S	Accompanied with a number, refers to Student
I	Refers to Course Leader, Iain Irving
A	Refers to Lecturer, Richard Adams

10.3.2 Transcriptions of students presentations

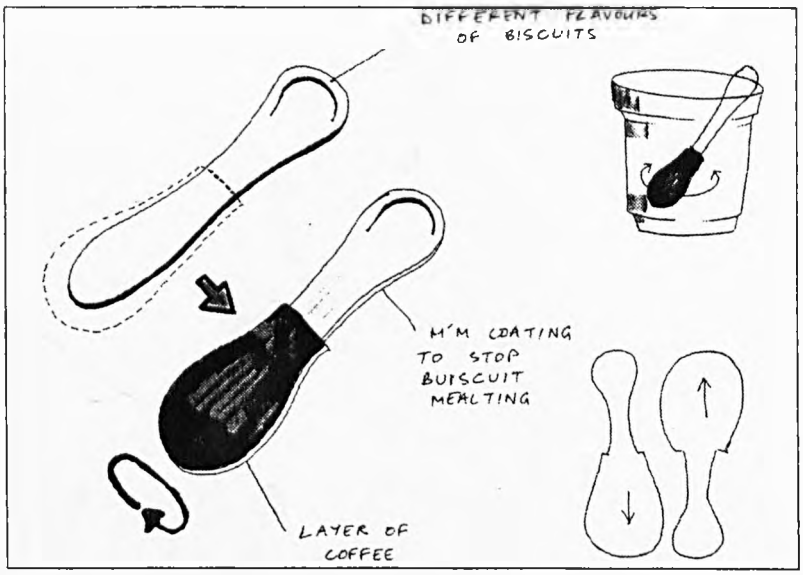
Paraphrased Transcriptions of Student Presentations

Code	Section of transcription
pra-prob-g1	Plus when you put it in the bin it's a hundred percent waste anyway cause it's like plastic coated material so you put it in the bin that's it, wasted it. You can't reuse any of the bits cause you can only be able to use it once, that's the major problem.
pra-prob-g1	It's got a really short life, so …The materials your using is just normal plastic which isn't bio-degradable and that will stay on the landfill for ages so it wont go away. It's a big thing you could probably have it smaller as well. Shape: were not gonna complain about the shape because it probably does the job fine, eh, but it's got a lot of waste, that's the major problem so it's probably gonna cost a lot to make as well so you don't really need half the stuff that's really on it. Filter you can only use once and you probably get the same effect by just using normal coffee cause the taste isn't different at all. So in every aspect it's just a waste and I mean the lifespan is really, really, really short …
rat-g1	We thought about a cup that actually had coffee lined on the inside, so basically I think there is something already out there. So basically buy lots of cups of coffee with it inside, but I thought you'd be buying more cups so your down to the same problems with waste. Em, we thought about a coffee bag, which was obvious a solution then we thought we were gonna have waste as well. Basically, what we were trying to find was something that would have minimum waste.
pra-sol-g1	And you could have it a biodegradable packaging so you've virtually got no waste what so ever at the end of the whole process. You've got coffee, you've got a snack you've got no waste cause your not chucking anything in the bin.
pra-prob-g2	…we were using the chopsticks cause we found these were the least sustainable because they're made out of plastic which is not recyclable, …
qua-sol-g2	And use that to pinch at your food, em, you keep the bits that go on your finger. You keep and are customised with your initials on them written in Chinese so you can look smart.
pra-sol-g2	…there made from recycled take-away tubs. That you get when you take away from the Chinese, so you return your tub and a couple of weeks later you'll get these. Em, there is no need for spring mechanism because it's actually in your hands already *–demonstrates using the thumb and forefinger-* Eh, the packaging is made from rice paper so you can eat it when your finished.
pra-sol-g2	And you'd be using like local materials as well cause it's just the tubs that people hand-in so.
pra-prob-g3	The battery, being a chemical battery it wasn't very, em, sustainable and that. You couldn't really do much, once it's, you wouldn't use someone else's old battery and to dispose of it is pretty tricky because it being a chemical battery.
pra-sol-g3	We looked at solar heat, solar power, heat, kinetic and clockwork. Then we thought why chose one why not use them all and if you can't have one you'd be able to find. Surely your not gonna have and be in a situation

	where you can't use one of these power sources to charge up your phone.
pra-sol-g3	That's recyclable. All the parts are recyclable as well if you take your mobile phone back to the shop at the moment all they can use is the. Sometimes they'll use certain components from it if it's not broken, they'll use (.) some of the circuitry on the inside of it. You'd be able to use most of, because it's made of rubber you'll be able to use most of the rubber parts because it's removable, all bits are removable and all the plastic parts are separated you'd be able to melt down the rubber and melt down the plastic and recycle it and we've said it's recyclable as well, so.
pra-prob-g4	...also a torch, it can't be upgraded, no other features. Eh, it didn't use a renewable energy source, it used batteries, so these batteries could be toxic if you were to throw them away.
pra-sol-g4	...we looked at how we could use a different energy source. Em, may be looking at body heat, you could power the torch holding onto it with the heat in your hands. That sort of thing. Also, solar power, good for a torch eh? *-laughter-* charging your torch up through the day and then =...= and then you can use it at night. Em, a pull cord, em, you use to get those cars, those little toy cars you use to pull the cord using kinetic energy it used to power the car. Em, also a wind-up torch would be an idea that would get rid of the battery, hopefully.
pra-prob-g4	...we also looked at packaging as well trying to minimise the packaging. Also storing the extras you get in the torch maybe into one so like, eh, you'll reduce the waste into like the packaging individually.
pra-sol-g4	We came up with the first one which was actually a radio torch, which was actually a built-in radio in it. This was powered by, I don't know if you remember the old style cameras you know you wind them up, wind the film back. Well similar to that with the bit at the end and you'd wind it and that would actually power the torch and the radio. ...We thought maybe using one of the energy saving bulbs just for the torch as well, don't know how you'd get over that but eh, a different aspect to look at. Pull cord we thought was the best idea. It's simple and small. You'd em, also it can be used for hanging mechanism.
rat-g4	Just using different accessories so even if the torch did go you'd have all these accessories so it's sustainable and you'd keep it for longer.
pra-sol-g4	The metal obviously would be recyclable.
qua/pra-prob-g5	Reasons mainly affordability so like they are usually over priced cause they are mainly brand and the cost of import and export of the trainers plus raw materials. They'd be an awful lot of waste in this trainer cause its got that many different sections in it there is a lot of stitching a lot of wasted material when your cutting in the different sections of the trainer. Packaging is binned straight away easily cause it's just a cardboard box nobody really wants to keep it for anything. Aesthetics, fashion is constantly changing so the look of the trainer could go out very quickly, ...Disassembly of the product would be quite costly cause of the amount of different sections in it and also to amount of different materials in it.
pra-sol-g5	It's basically like a vacuum mould the plastic to the exact shape of your foot so they'd be almost no waste at all. ...so eh, little waste. Both the rubber and the plastic used would be like totally recyclable, so it's like creating no waste. ...You can also take the product back into the shop, take it to bits, recycle it, trade it in for a new version of the same thing, making

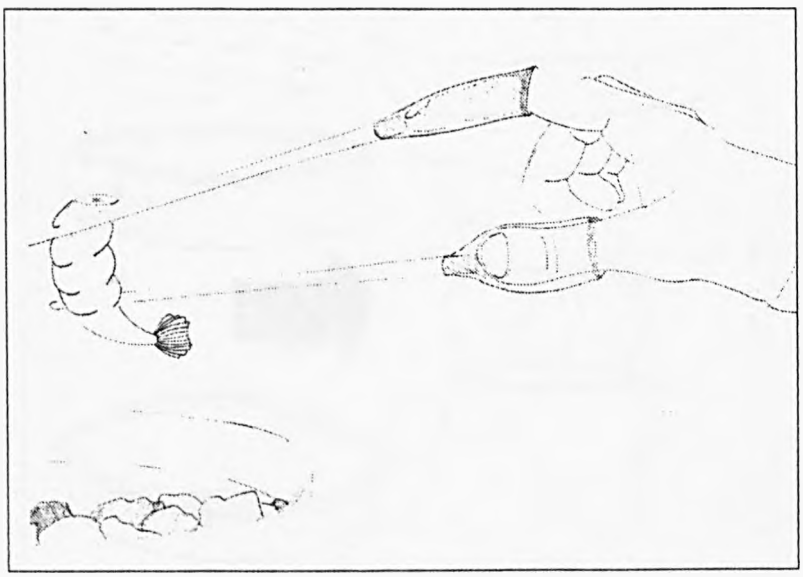
	it more sustainable.
pra/qua-sol-g5	Basically for maximum sustainability like perfect fit, no waste. You can add your own design so it's like whatever you feel is in fashion at the time you can put onto the trainer. Totally recyclable (.) for the sole and the boot. You can take it back in and trade it as I've said. And basically you'll also be able to chose whatever style, buy whatever you want when it's being made.
pra-sol-g5	Less materials.
pra-prob-g6	…it's not biodegradable so there is a lot of waste.
pra-sol-g6	It'd probably be made out of the same sort of plastic that would be durable, but more recyclable that, that *-points to kazoo-* just to make it more sustainable.
pra-prob-g7	The coffee cup, something like the first one. Em, we found that the plastic wasn't recyclable, there's not any mark on it at all. …You can only use the actual thing once and then you just have to throw it away…
pra-sol-g7	…stronger plastic so you could make (biodegradable) to throw it away, so you're just buying a disposable coffee.
pra-prob/sol-g7	To make it as sustainable as possible we thought, em, we should try to reduce the amount of waste. So the only actual part that you throw away is the filter, which you buy separately. …Em, and the plastic is recyclable so that when you do have to throw it out em, it can be all recycled.
pra-prob-g8	We also found is the only thing that you use on it is the bristles, so that's the only bit that your using the rest which you could use again. But once your finished, once the bristles are worn out you chuck the whole thing away, which means your chucking the casing away as well, I mean that's just a waste of plastic, there's no use for it at all. …So it's just a total waste of money. It's a waste of materials, so it's unsustainable.
rat-g8	…the amount of material that the bristles actually use, even although it would be thrown away it could be made out of biodegradable or if you can't get suitable material that is biodegradable the amount of material that's used is so little compared to a toothbrush today.

10.3.3 Sustainable concepts produced by students



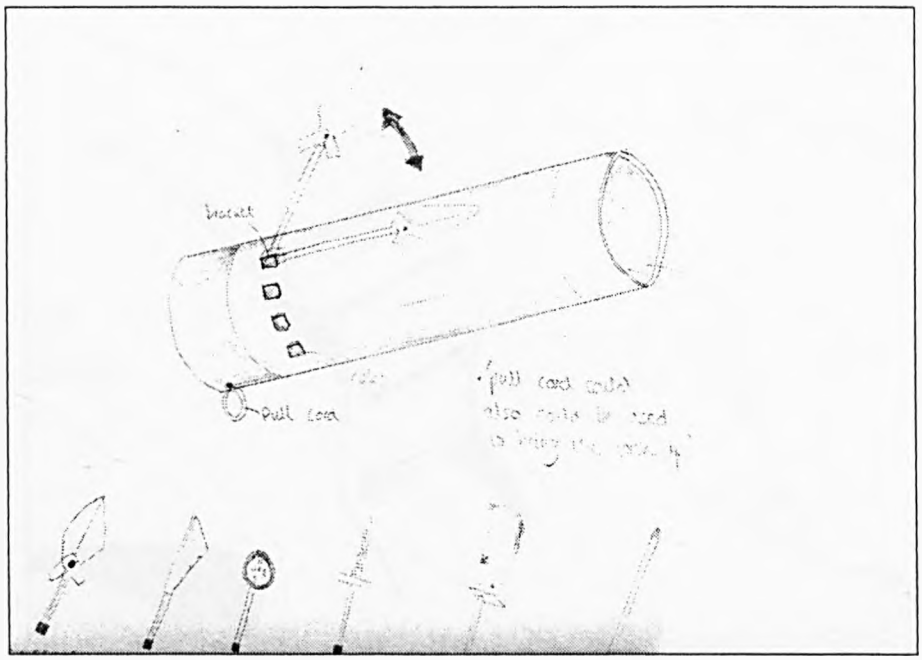
Alternative to single filter coffee cup.

- Reduction in materials, biodegradable.
- No waste.



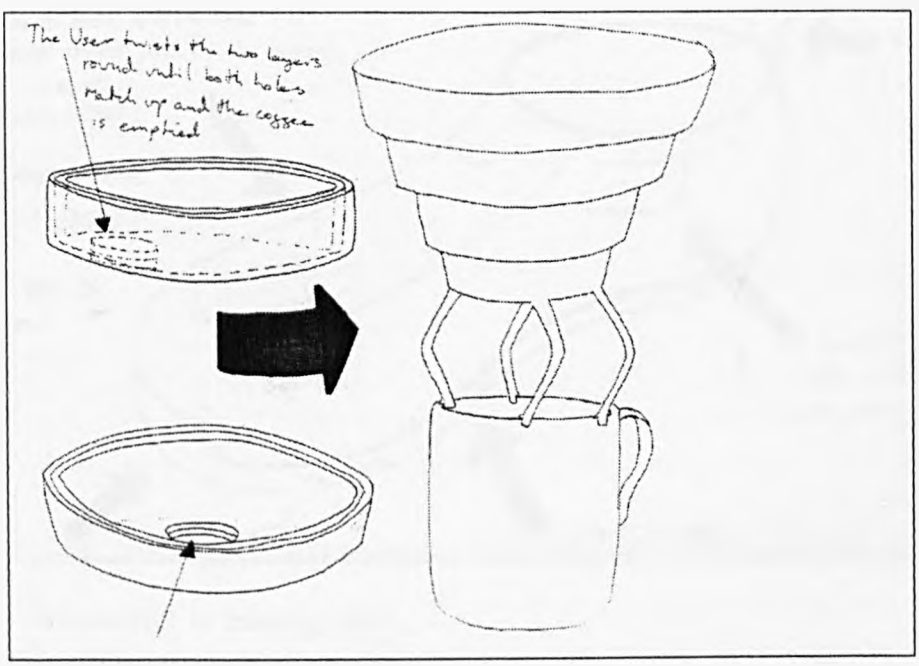
Alternative to plastic chop sticks.

- Reuse of materials. Made from recycle plastic containers.
- Easy to use.



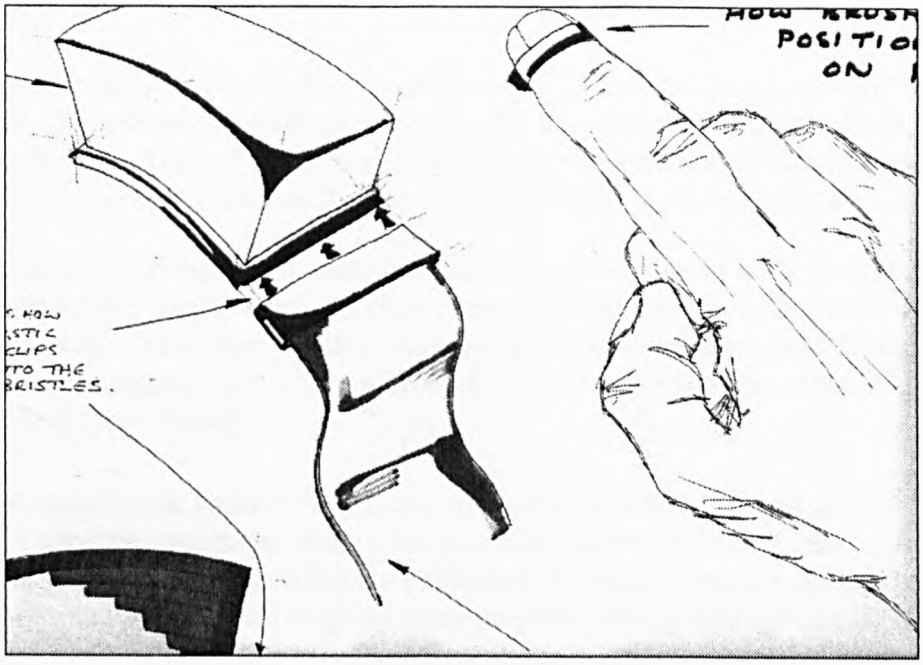
Alternative to a torch.

- Mutli-functional.
- Uses rechargeable battery.



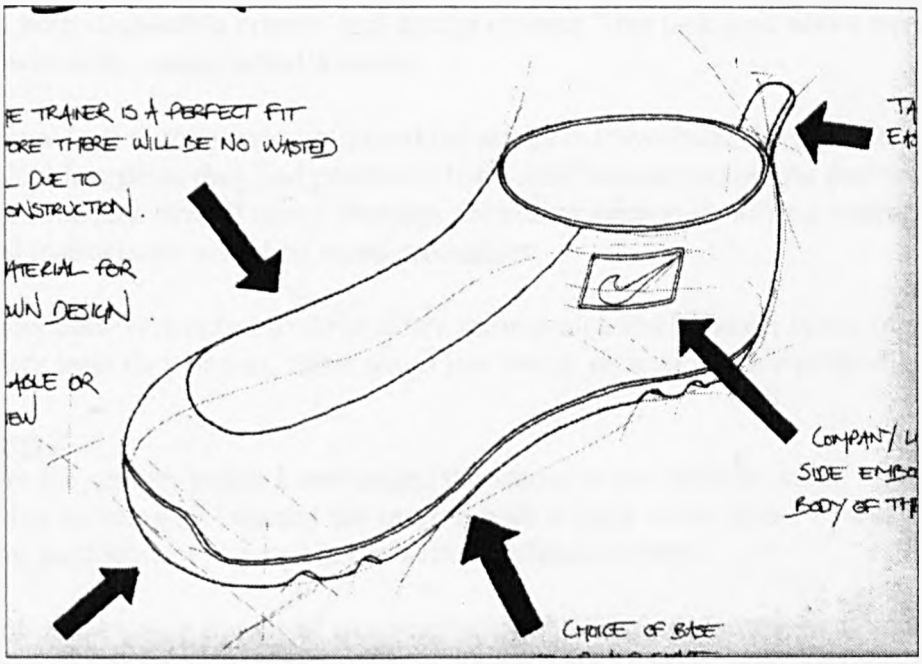
Alternative to single use coffee filer cup.

- reusable



Alternative to a toothbrush.

- Reduction in material
- disposable



Alternative to running shoe.

- Branding
- Use of materials
- Alternative form of transport

10.3.4 Field note journal

Session 1

The group consists of 40 students, combining 2nd year Design for Industry and Engineering Design. The groups the students were divided into groups. Each group had 5 copies of the project brief, 5 sheets of A3 paper, post-it notes and a marker pen. Every student in the year did not turn up therefore the pre-selected groups were rearranged.

While sitting in groups each student produced a mind map of what they understood by the term sustainable product design. They were provided with an example of a mind map although this is a familiar task for them. After a couple of minutes of blank stares they began mind mapping conferring with each other. I reminded them that the mind map had to be produced individually.

For the second task I asked the groups to brainstorm using the post-it notes and marker pen various ways designers can design an environmentally friendly product. I had to re-explain the task several times. I also briefly explained the rules of brainstorming, but again it took several minutes from them to grasp what they were being asked to do. The first twenty minutes was a struggle as I visited each group I instructed them to consider a product. One group were very successful at this exercise. Rather than considering what was sustainable they turned the question on its head and used a product to determine what was not sustainable. They managed to generate more ideas then the other groups.

The second part of this task seemed to be easier for the students. Taking what they had brainstormed they developed a list of criteria to evaluate a set of products. The students listed both sustainable criteria and design criteria. This task took about twenty minutes, after which the students had a break.

The final task of the session required the students to evaluate three products using the sustainable criteria they had produced from their brainstorming. As previously I had re-explain the task several times. Perhaps providing them with written instructions as well as verbal instructions would be more productive.

The students were asked to write down their evaluation however many of the groups wrote the very least they had to, some wrote just yes or no next to their evaluation criteria.

Session 2

Before the session began I rearranged the studio so the students sat in a semi-circle. It was a Friday morning so I started the session with a quick word game. I went around the room asking each student to provide me with a sustainable term.

I went onto explain the set of characteristics of SPD. I explained them in relation to the product design process. The following topics were covered: need and conception; manufacture; distribution and packaging; consumption; use; and end of life. After about twenty minutes the students started to lose interest. I tried asking questions but got very few responses.

After my explanation of the set of characteristics of SPD the students re-evaluated the products they evaluated previously, I did provide the groups with an instruction sheet

explaining the task. As I visited each group it was evident that the students had no problem with this task. However the groups were evaluating mainly against the tangible characteristics.

The students were then asked to identify which product they thought was the most sustainable and the least sustainable. This caused much debate amongst the groups. As I visited each group I was asked questions as to which was the most or least sustainable product, I didn't answer their questions but asked them a question back.

Session 3

As with the last session I provided the student groups an instruction sheet requiring the students to individually design a sustainable solution to the product their group identified as the least sustainable. However, this resulted in the students wanting to leave the session. The lecturer accompanying me had to intervene and request the students to stay to complete the design work. Perhaps this happened because the task required the students to design individually, it broke the group dynamic.

Session 4

Back in their original groups the students began designing a sustainable solution to the product they selected as the least sustainable. This session was much more successful.

A range of products were produced by the student groups. Each concept was presented to the class.

After the students had finished presenting their concepts they each produced a mind map individually. This was much more successful than the first map they produced – no blank stares.

10.4 Case Study Three: Design Practice Exploring the Set of Characteristics of SPD

Appendix is available on CD ROM.

10.4 Case Study 3: Design Practice Exploring the Set of Characteristics of SPD

Note: Figures in this appendix are numbered separately to those in the rest of the thesis.

Wednesday 6th November 2002

Due to the nature of the current stage of the design process (i.e. exploring the characteristics) and the difficulty in finding a block of time to actually design, I have decided to block off five hours in an afternoon to conduct the experiment. I believe five hours is an adequate amount of time, estimating that the ideas generation will take an hour, initial development of concepts two hours and two hours to develop concepts further. This journal entry has been written after the event.

The aim of the design project is to explore the appropriateness of the characteristics when brainstorming solutions for a particular product. I utilised the brief from a student competition, as I thought that developing a brief was an unnecessary complication.

The brief was taken from the RSA-Student Design Awards 2002/03:

> Background: Toilet soap is a very effective product that offers value for money in everyday personal care. The market has segmented into inexpensive commodity soaps at one end and expensive luxury brands at the other. With the advent of liquid soaps and pumps offering, for example, greater convenience, how would you rejuvenate the 'old fashioned' bar of soap? Standard branded bars offer additional sensory/functional benefits at a reasonable cost.
>
> Brief: Consider a standard bar of soap aimed at a particular consumer segment that you have researched. Decide what unusual and sensory properties your branded bar will offer. Design the packaging for the bar in a form that will:
>
> - Visually communicate the brand and product attributes to your consumer;
> - Perform additional function/sensory benefits in use e.g. act as a tray, etc.;
> - Use unusual materials for the market sector bearing in mind the environmental impact of your choice(s);

- Be practical for the supermarket that will stock your product.

I went into this design project retaining all the information I needed to use in terms of the characteristics. I did keep with me the headings I had developed for the characteristics but referred to them very little. I did not plan a structure for the five hours I was to do the project, hoping that the design process would simply come naturally. If I'm being honest, the designing did happen naturally but not fast enough.

I feel the brainstorming wasn't as dynamic and fun as I thought it should be. Being in isolation probably did not help. I am also beginning to think that simple brainstorming (visually in the form of a matrix) is not the best way to generate sustainable concepts; because it is slightly restrictive, it limits the number of concepts generated, although this is not apparent until concepts begin to be sketched. This may change when doing the brainstorming with a group of people. This may also be because of the way the characteristics are structured. Perhaps more than one technique needs to be used in order to generate sustainable concepts. The framing of the problems for which solutions have to be brainstormed is part of the difficulty with brainstorming.

Therefore, I think there are a few areas that need to be considered:

- The framing of the problem. Do you evaluate sustainability of an existing product at this point? Also the framing of the products function.

- The framing of the current characteristics of SPD.

- The ideas generation technique. Should more than one technique be used?

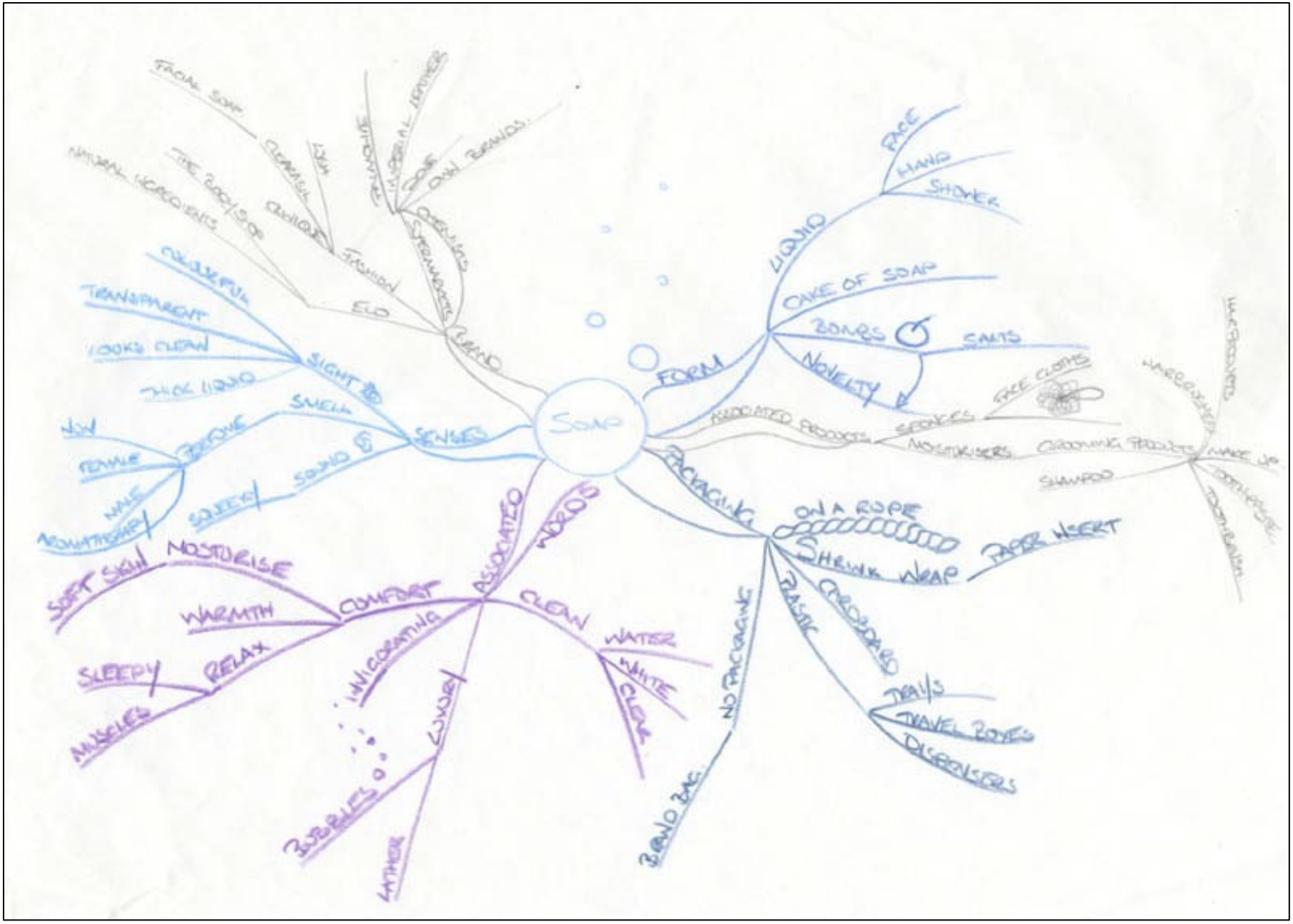


Figure 1. Mind-map 1.

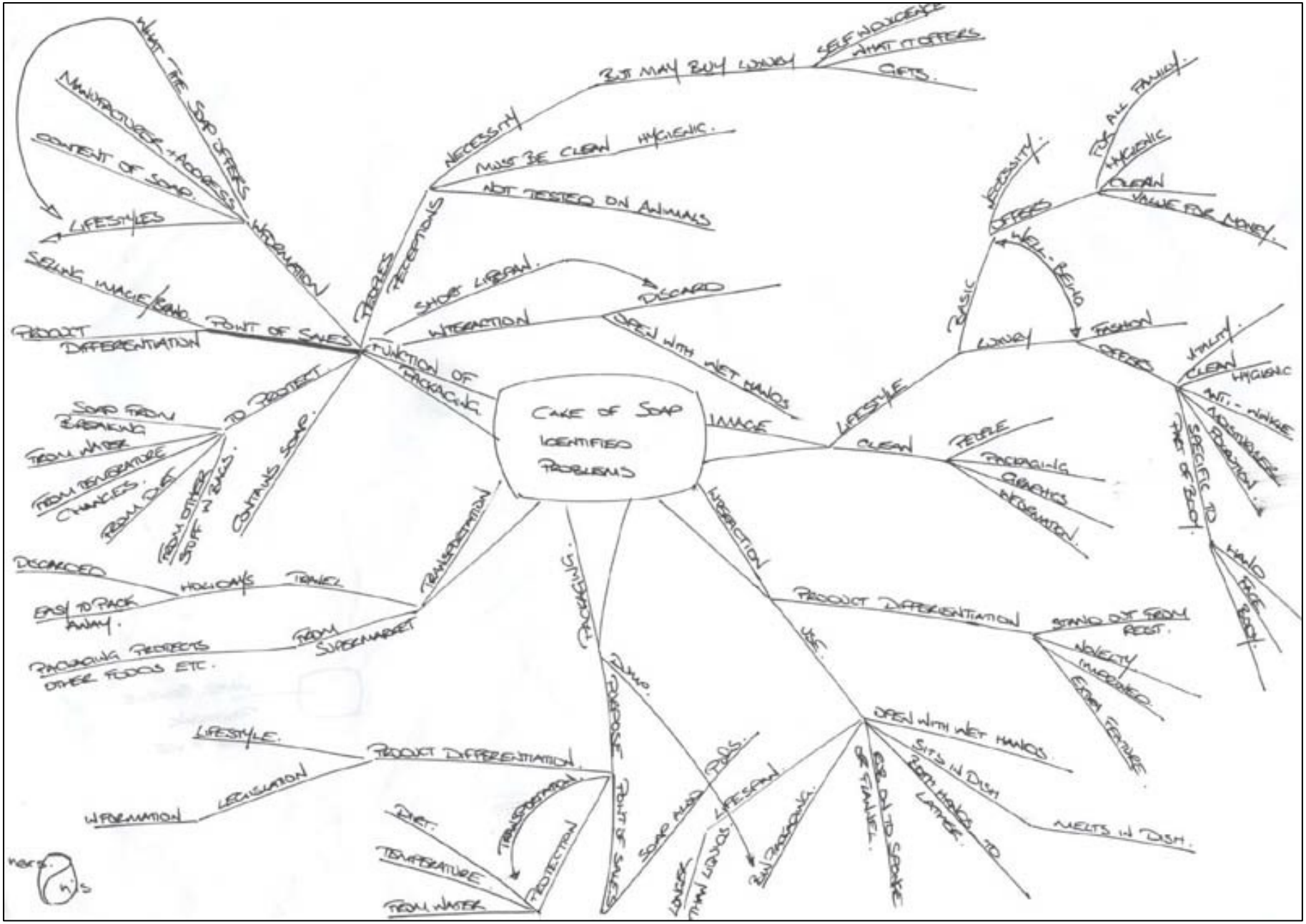


Figure 2. Mind-map 2.

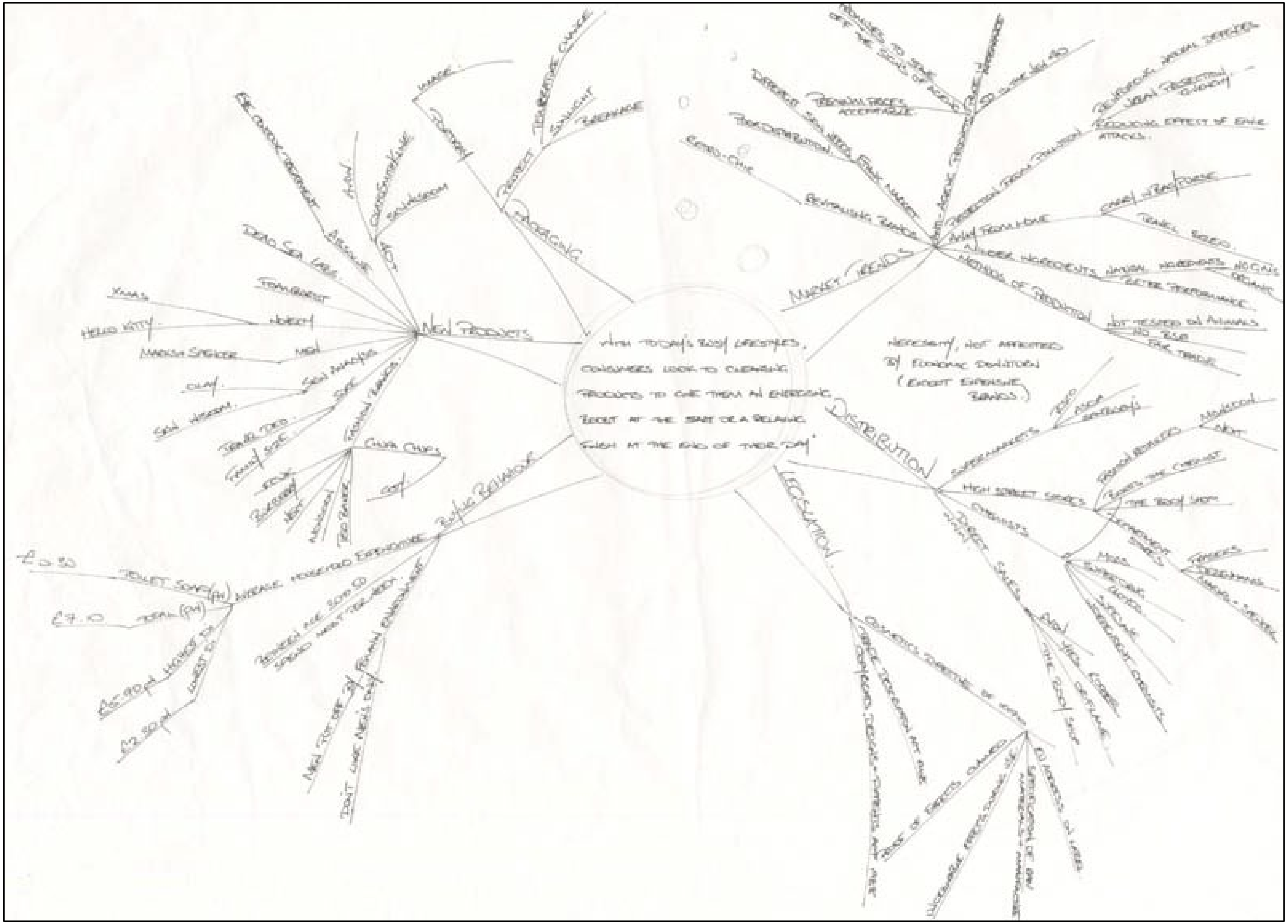


Figure 3. Mind-map 3.

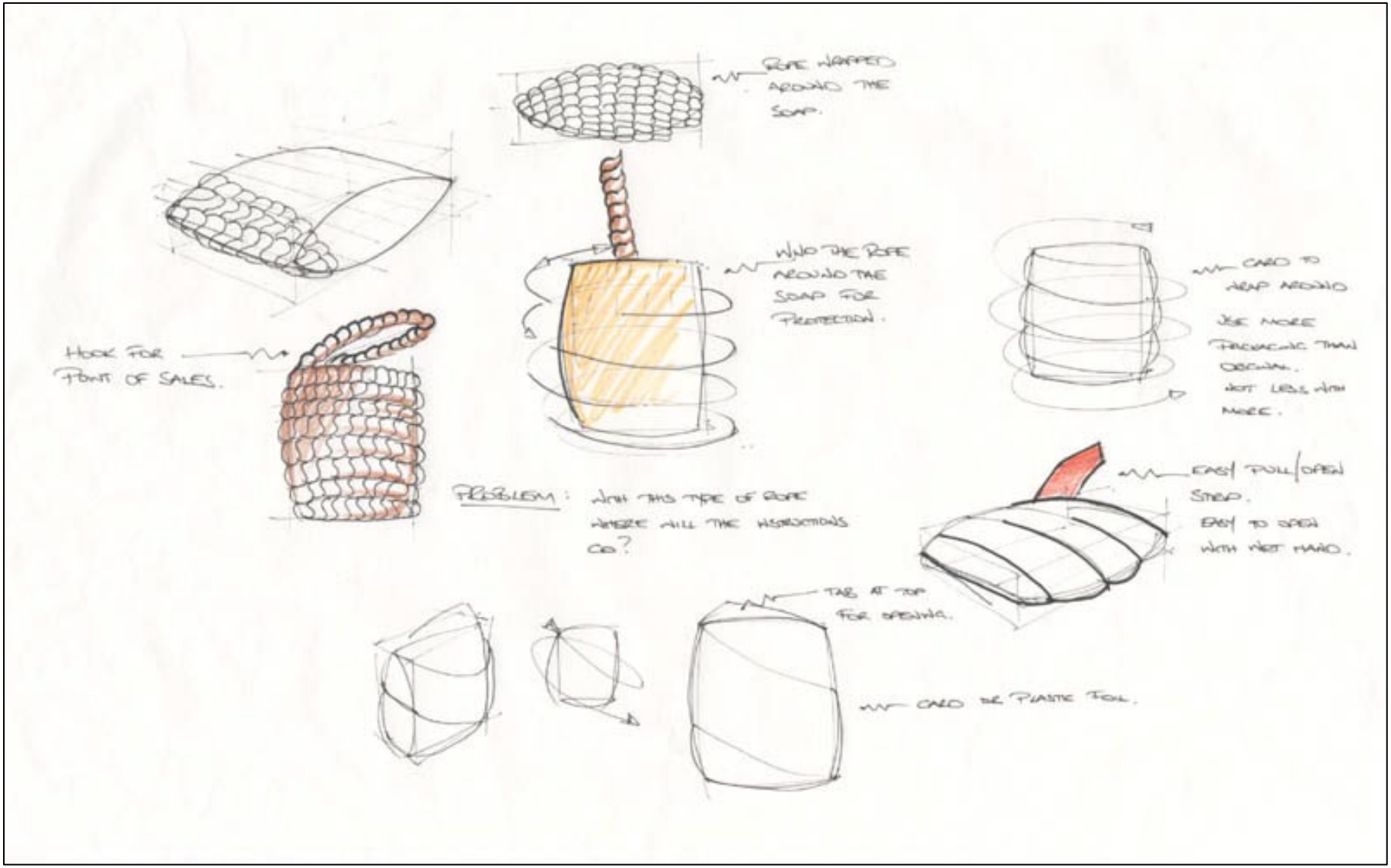


Figure 4. Concept 1: Soap wrapped in rope.

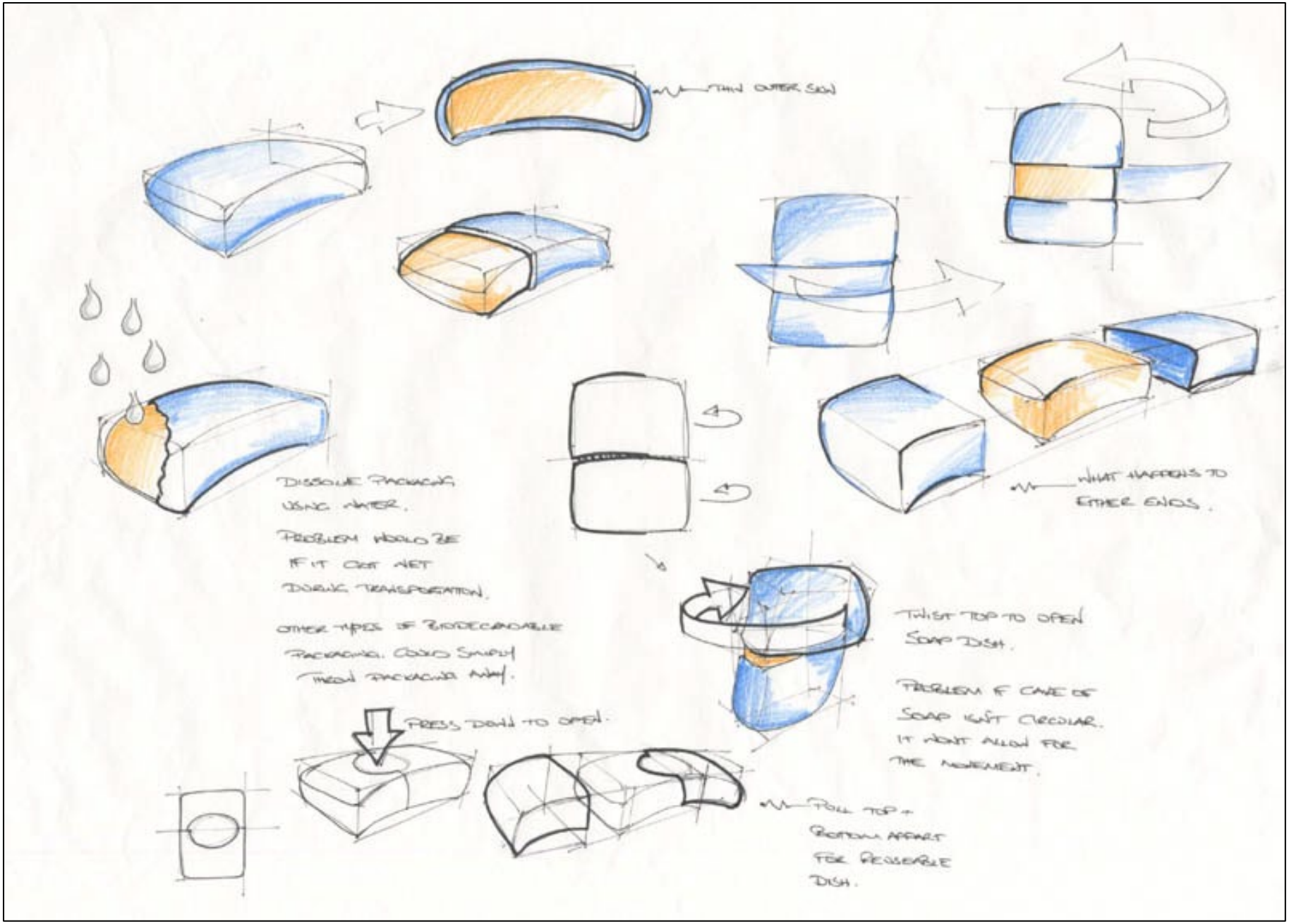


Figure 5. Concept 2: Soap in wrapper.

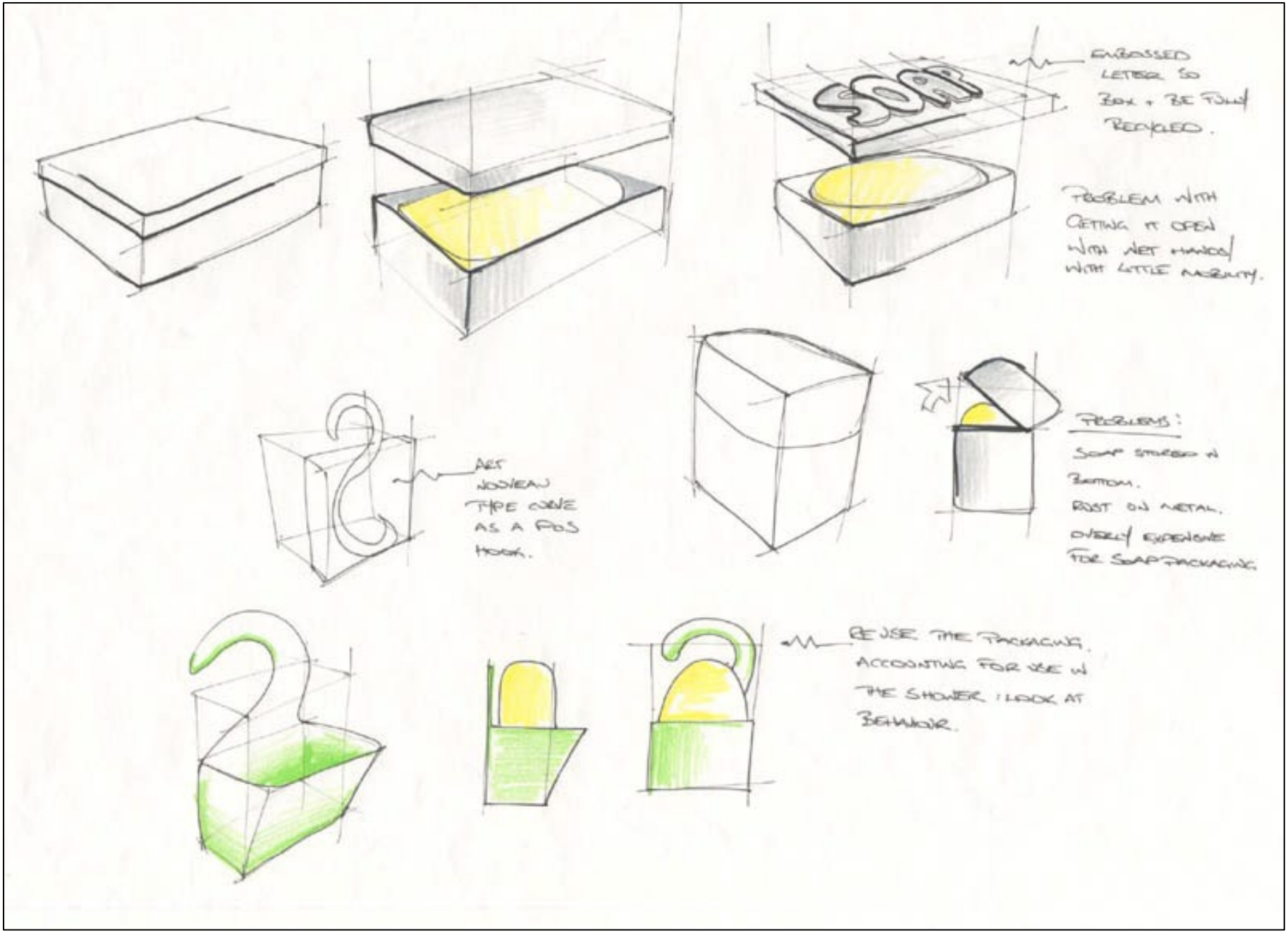


Figure 6. Concept 3: Soap in box.

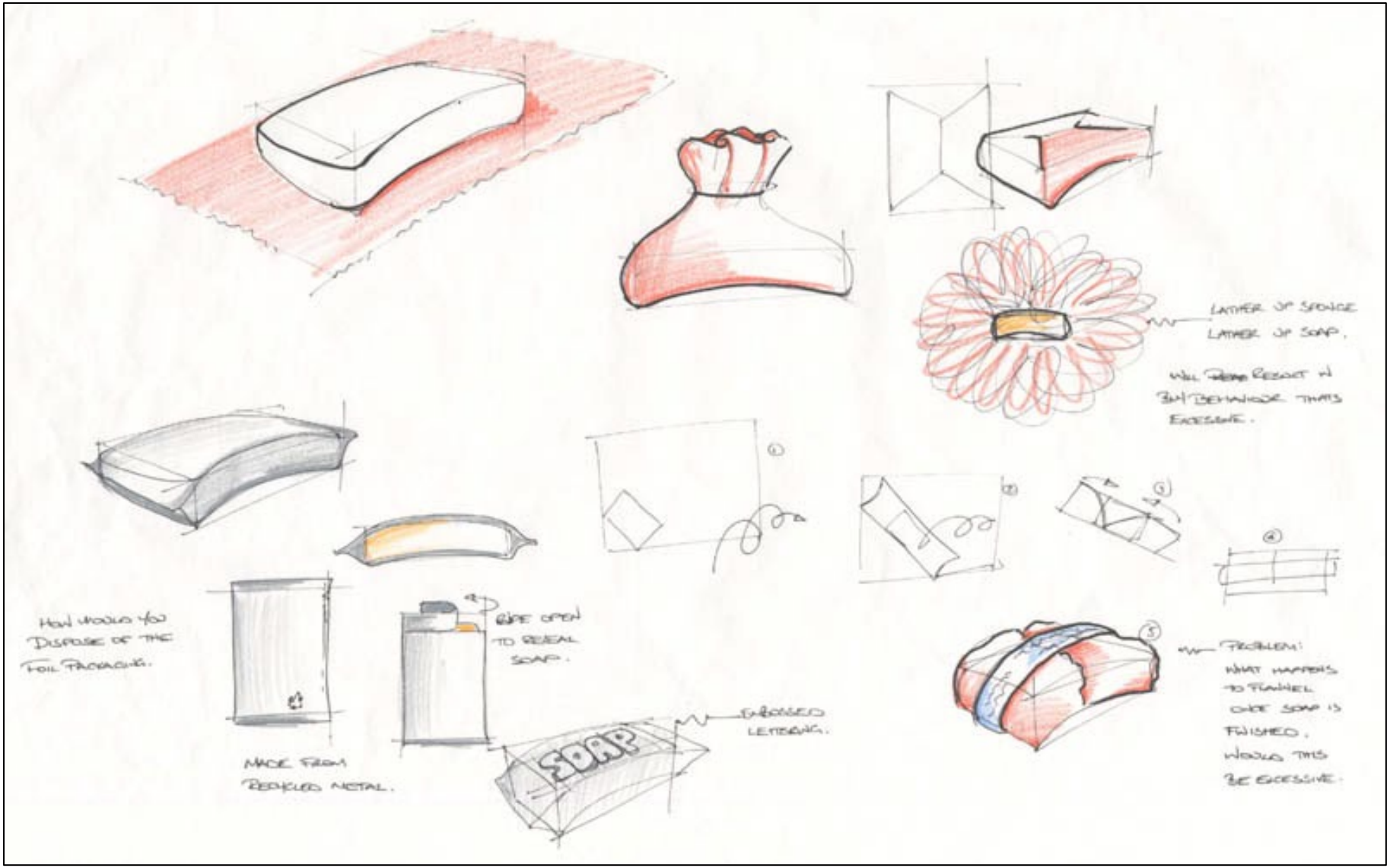


Figure 7. Concept 4: Soap in wrapper.

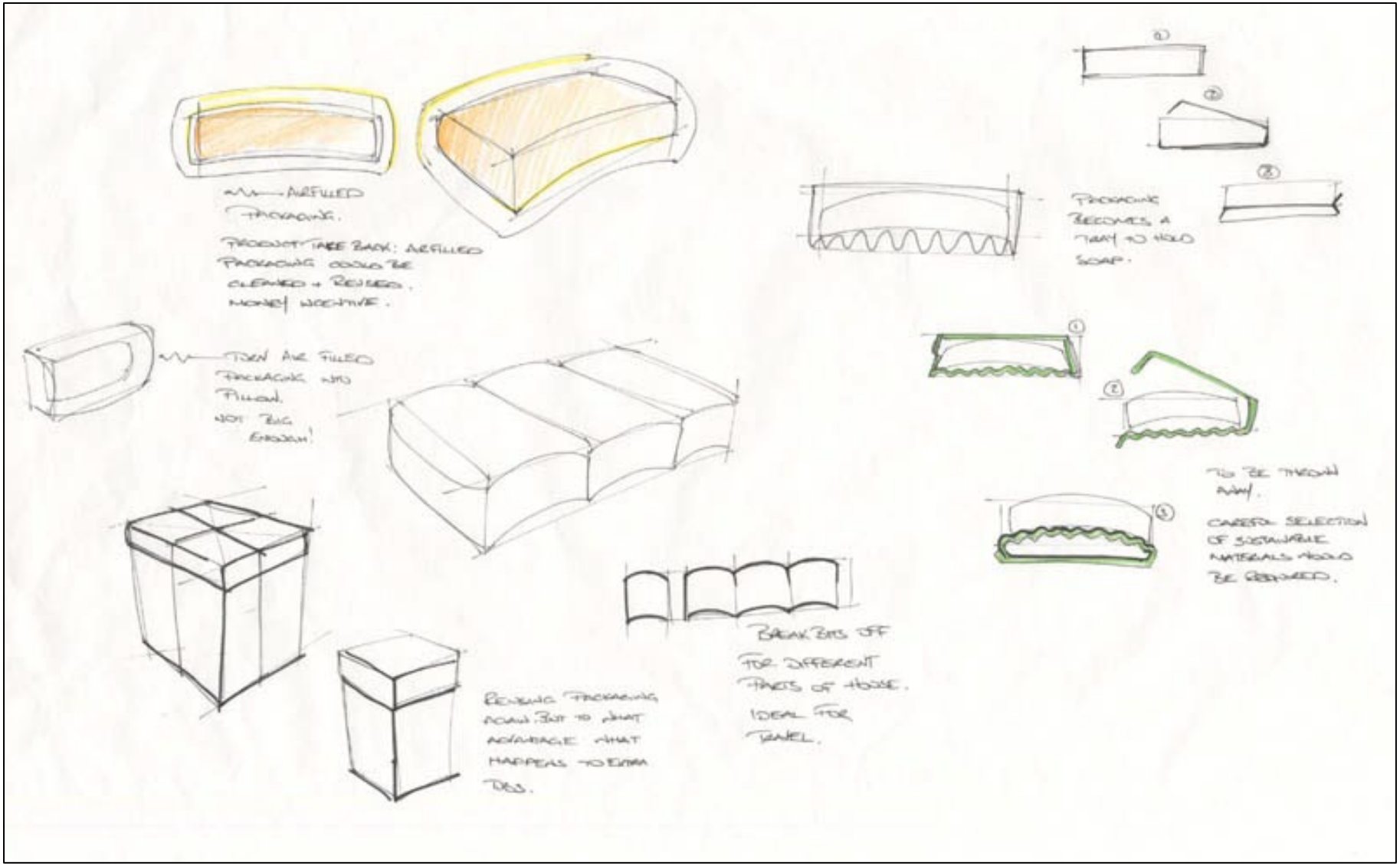


Figure 8. Concept 5: Soap in box.

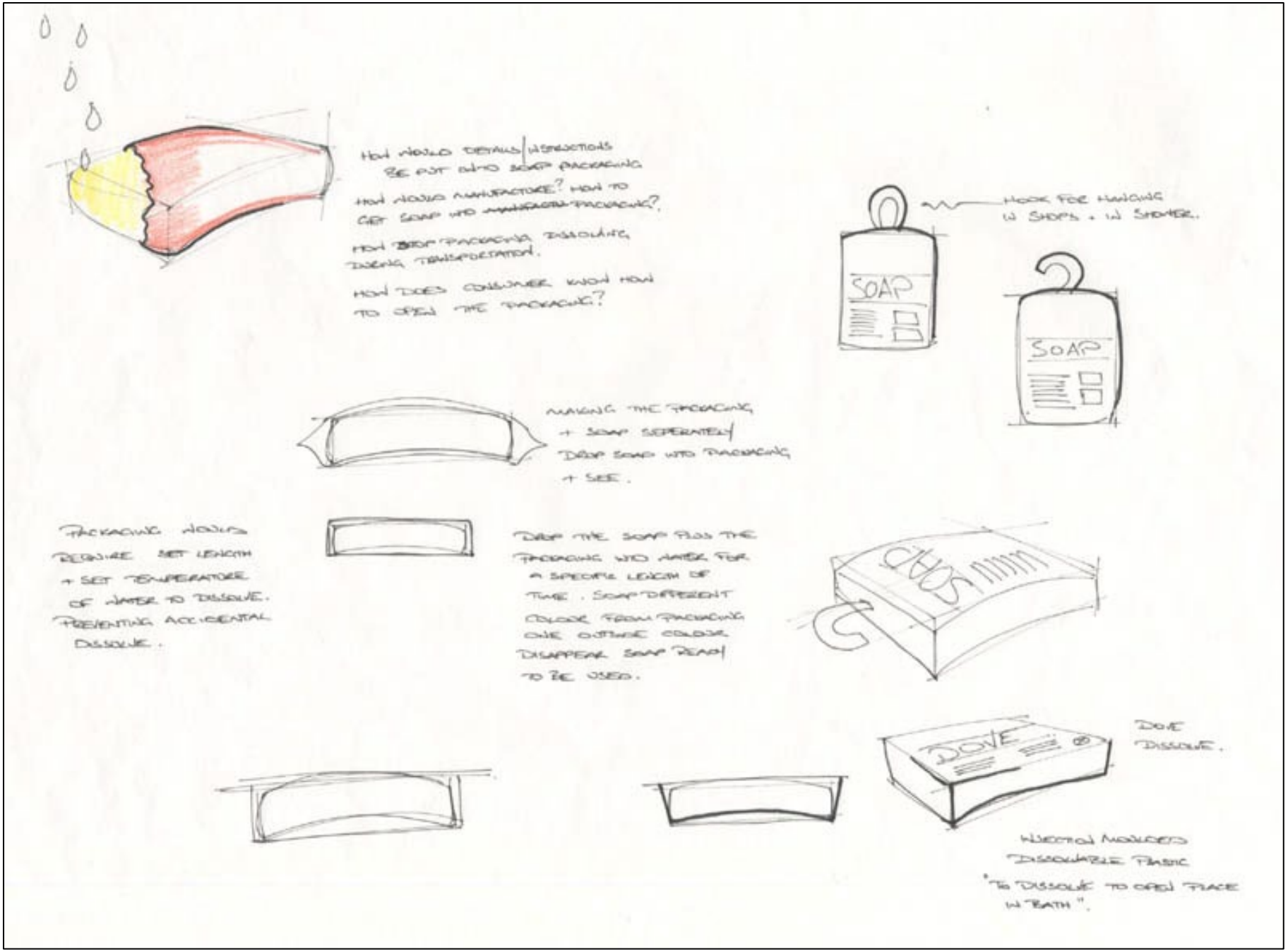


Figure 9. Concept 6: Soap in box.

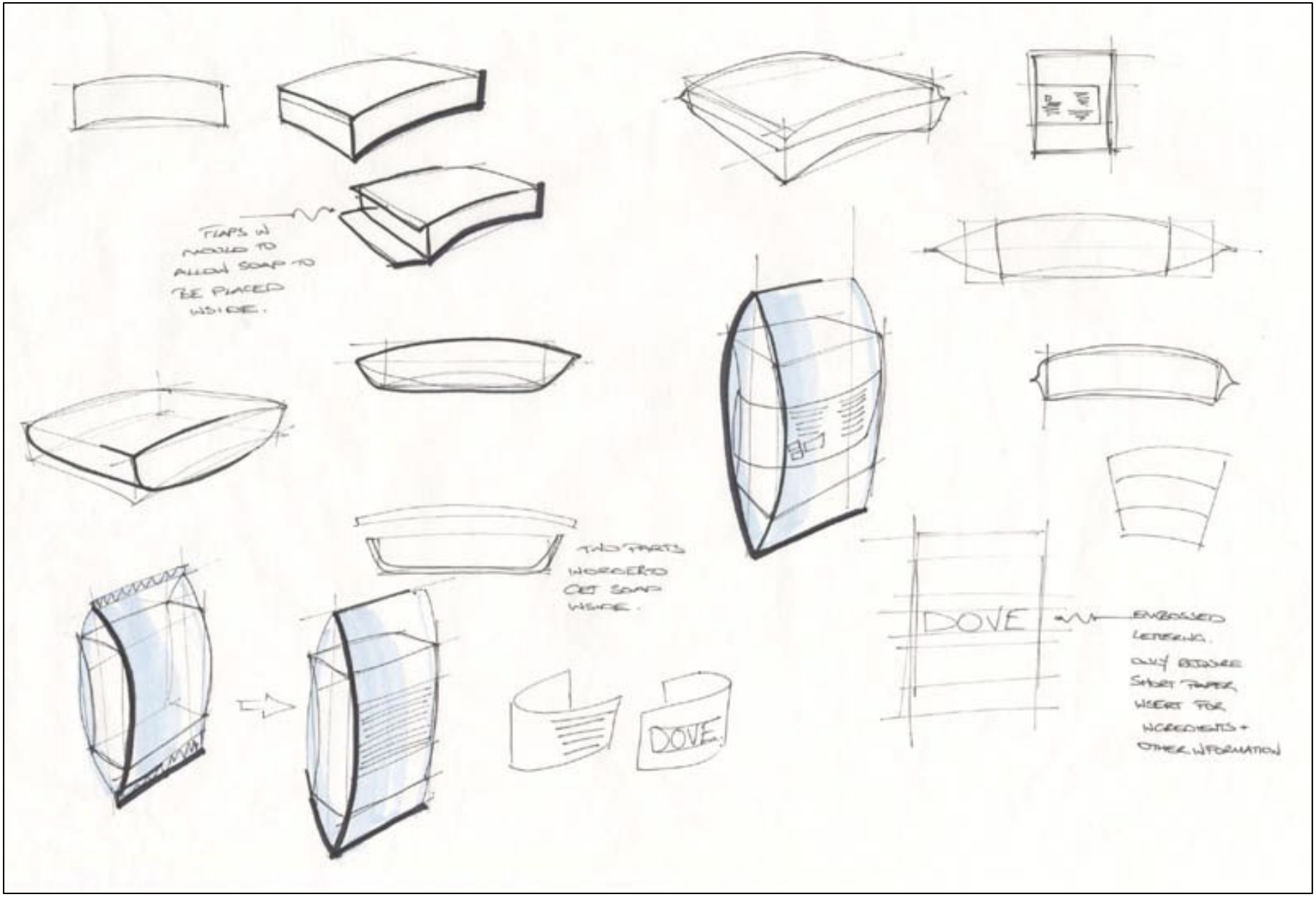


Figure 10. Concept 7: Soap in box.

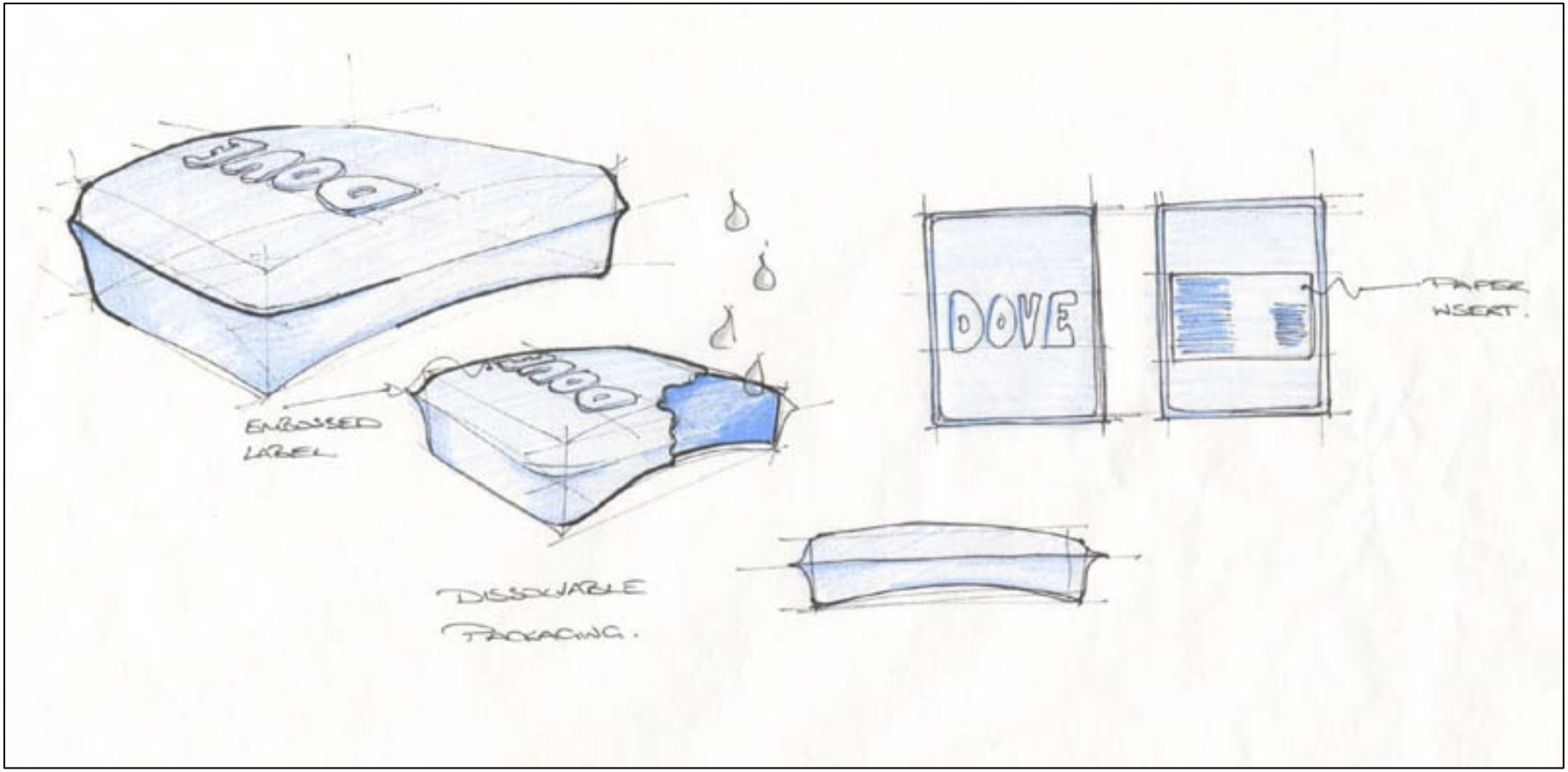


Figure 11. Concept 8: Soap in dissolvable packet.

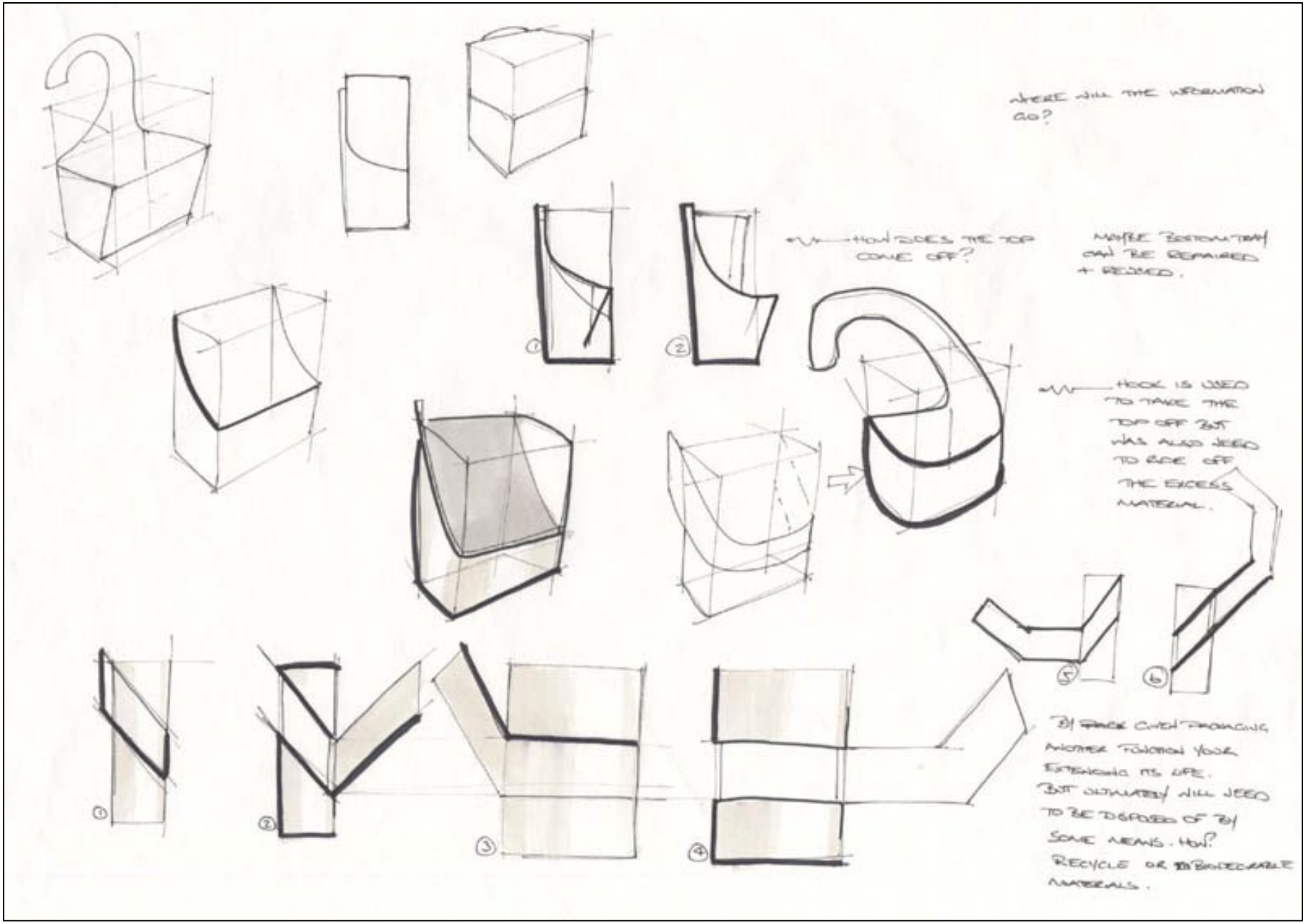


Figure 12. Concept 9: Soap in box that can be hung up.

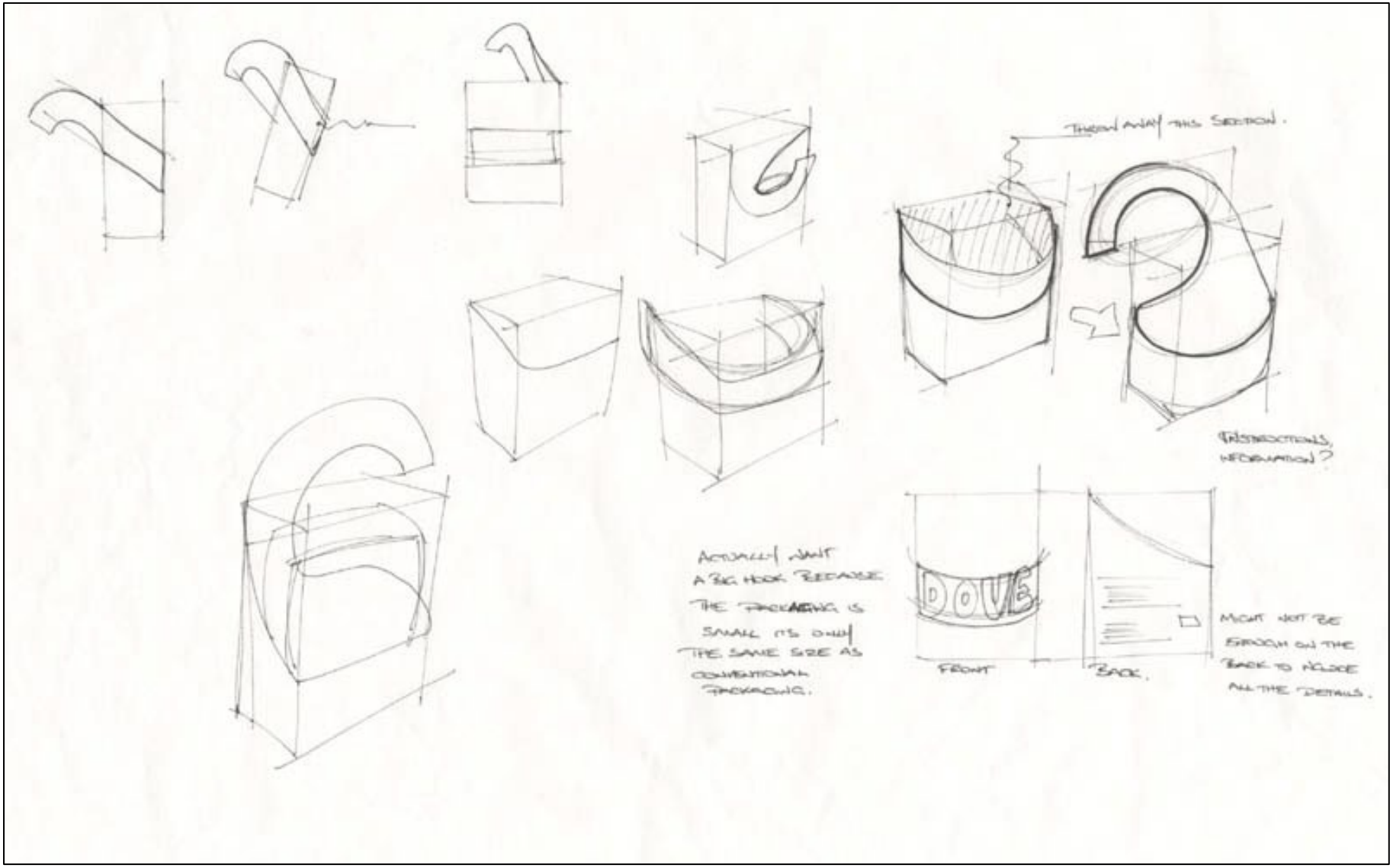


Figure 13. Concept 10: Soap in box that can be hung up.

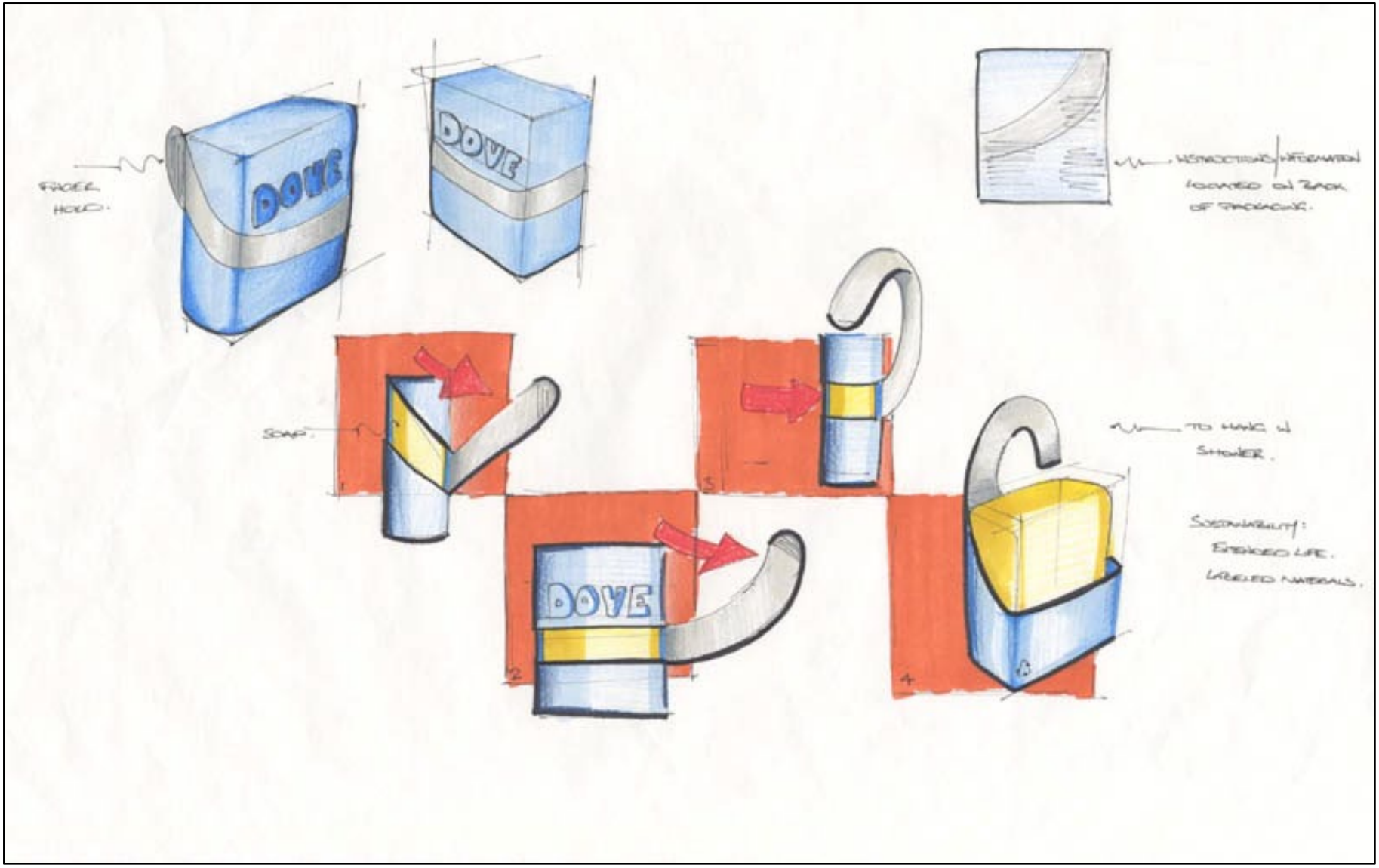


Figure 14. Concept 11: Soap in box that can be hung up.

10.5 Case Study Four: Workshop Two

10.5.1 Transcriptions of students presentations

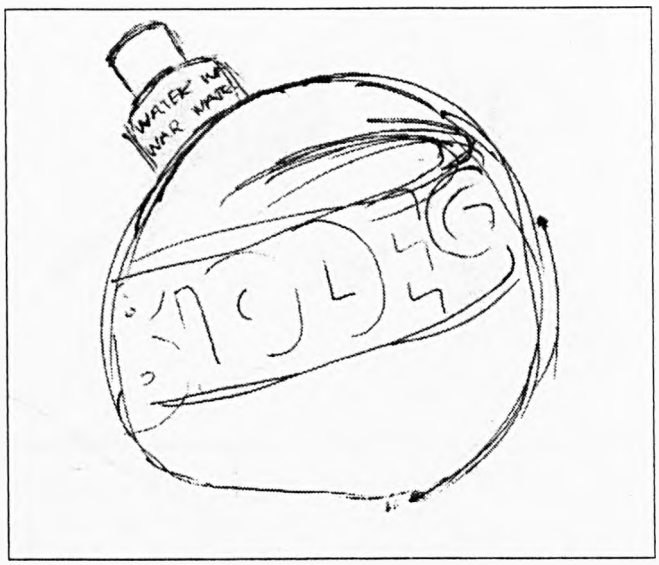
Paraphrased Transcriptions of Student Presentations

Code	Section of transcript
qua/pro-prob-g1	...we opted for the bottle as being the most unsustainable as people don't have any value with this actual bottle after they've drunk the contents. So, they just basically throw it away and even if it is, it is recyclable and it is crushable for sort of waste storage but you've maybe done it once but you never do it again you just throw away the bottle. ...
pra/qua-sol-g1	...it's made of bio-degradable...Then bio-degradable embossed on it so that you can know that it is biodegradable...And that would be the only actual sort of labelling on the product so there is no labels on it like paper or anything.
pra/qua-sol-g1	...the actual sphere is biodegradable product with sort of like a rubber sort of squeeze cap which is just bit and so the water is released. ...Obviously, the point of sale for a start would encourage the fact that it's bio-degradable so you wouldn't get it mixed up with recycling products and this would become sort of general public knowledge. ...
pra-sol-g1	I mean you could put it on you compost heap out in the back garden so it could biodegrade.
pra/qua-sol-g1	...So we moved away from the sort of standard bottle design kind a tried to use just the least amount of materials we could in the most compact package. And then we thought if your in a store and there's just bottles lined across the shelves they probably, might catch your eye. You might easily just go for it cause that's something different. Pick it up and have a look at it and it might entice into the kind of sustainable design.
qua-sol-g1	...Your not left with a hard shell at all like this *–pick up the plastic bottle-* your left with the plastic bad which is a really simple structure you can just put in your pocket until you reach a bin. ...
qua-sol-g1	...we kept the branding to a minimum is because you don't see, your never gonna see that, well currently you don't see that on the shelves alongside these products here you see these products are fairly similar but this is gonna become synonymous with Vitel water.
pra-sol-g1	And it would be sort of like, would be sort of like, embossed like your sort of like, like your markings on your bottles here *–picks up and points to embossed recycle sign on bottom of original bottle-* You'd just take that and apply it to put biodegradable around it ...
pra-sol-g1	[in response the researchers question, "is throwing it away sustainable?"] yes
uns-rat-g1	[in response the researchers question] Em, possibly the nosel, em, because it's gotta be made of a different form sort of plastic. But in saying that it em, it's smaller piece of plastic by that bottle such as this. So the nosel it can be recyclable but it's so much more smaller than this whole bottle here so, em, well actually it's just like that size there *–points to lid of bottle-* as oppose to the whole bottle. So, is a sustainable sort of feature in it. It's far more sort of, well it's far better than current bottles.
uns-rat-g1	...These type of bottles they're all a quite, a standard manufacturing process where as that is something different so you have to invent a

	manufacturing process almost which would cost it would take time and money, energy. …After a bit of research we found that there are similar products that do, there not a point of sale water bottle but they're are hill walkers bottles. They are a similar design not biodegradable obviously just plastic …
pra-pro-sol-g2	…we came to the conclusion that the razor was the most un-sustainable purely because, eh, it's got a mixture of materials so you can't deconstruct it to make it back to its living, whatever it was, original state. Eh, it doesn't get back to the ecosystem basically. Eh, the heads were attachable so your creating basically two products as oppose to one and it's not made of local materials. So basically what we've done is gone through the way the material has been put together, the construction of it. And we've been looking at making a product that is the same materials, just one material throughout the whole thing. We looked at sort of organic substances and such as plants, em, and just making it maybe out of pure steel. And we came to the conclusion that glass would be a good idea. …The actual razor head would be glass as well the whole product would be made.
pra-sol/ qua-prob-sol-g2	We don't really know how long the product life is of it but we're hoping it's a sort of contract as opposed to just buying a product and then just throwing it away. Much like the Body Shop. What you would do is go in buy the product, take it home use it, once it was blunt you'd take it back and they'd give you another one…I think when the product is eventually used up what they could do is either, cause its made of glass you could either put it into a glass bin or melt it down. And effectively glass becomes sand. Effectively. But then it goes back into its original state then it could go, be put back into the environment as a non () it's a safe product to be back into the environment once it had been broken down.
qua-sol-g2	…Because of the anti-fashion sort of philosophy add to, its quite a timeless design. …when you'd buy this thing it's obviously something you'd want to keep. …So that when it becomes, em, like blunt enough you'd have to get it re-sharpened the balm would have completely run out so you'd get the whole thing back to whereever you bought it or the manufacturer. The balm pot is refilled and the glass is re-sharpened.
pra-sol-g2	[in response the researchers question]…If you consider some of the stuff the Body Shop uses it's basically all non-chemicals all root from plant extract etc., that are good for the skin. That means you're not creating any harmful substances or stuff that would not touch your skin if you like.
pra-sol-uns-g2	Em, as I said it would probably be a contract product. So it would be a sort of elitist product. So if it was a present it would be slightly more expensive, but not too expensive.
pra-sol-rat-g2	The whole point is that the product is all made of the same material so that it can be broken down easier. The more you chop and change it ,the materials mixing them the more complicated it gets.
pra-prob-sol-rat-g3	…we decided that the travel toothbrush constructed from plastic was the least sustainable of the three. Basically because the kind of recycling properties I mean the kind of principle of a toothbrush in general was that you use it and then you throw the whole body away although it's like only the bristles that are actually getting worn down. …basically we wanted to address the situation of like pretty much separating the bristles from the rest of the brush because there's no reason for the brush to be disposed off.

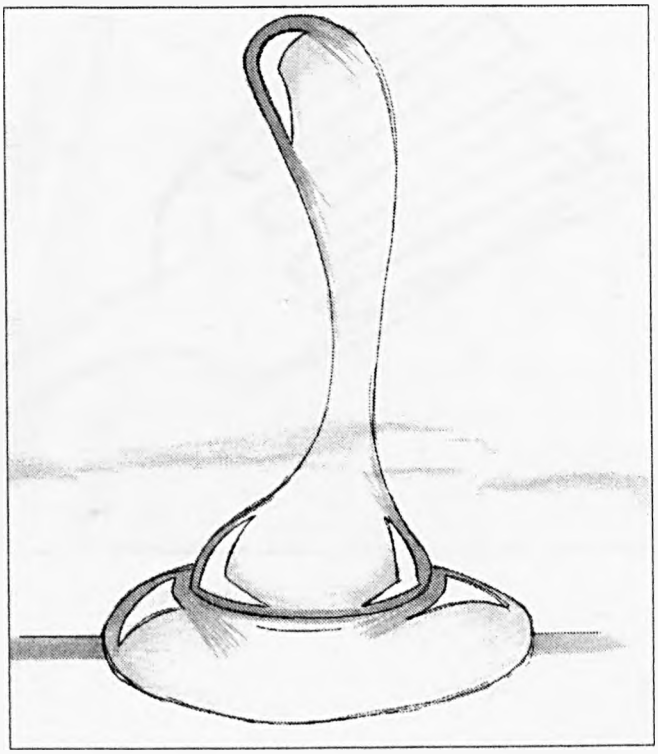
pra-sol-rat-g3	…basically one of the ideas. We didn't want the heads just to be thrown away because then you've got no way of controlling. I mean you could say you could put them in the recycle bin and be recycled but your then relying on the well-being of other people doing it. So basically, these are made of bio-plastics that dissolve in hot water…
qua-prob-sol-g3	The body of it is just like a cause we kind of like, eh, want to install going back to the feeling like personal belongings and stuff that you'd own the handle of the thing. The handle would never change. …You hold onto this handle and it could be like a bling-bling status symbol kind of thing…
qua/pra-prob-g3	We're still looking at ways of storing it cause obviously for travelling its got to be kept fairly compact. You don't want a big like electric toothbrush size thing, so, we still looked at ways of storing the brush inside the handle. Perhaps would be filled with some kind of disinfectant for the clean freaks. Also another major sore point was the toothbrush bristles themselves. We thought to eliminate the need for a tube of toothpaste if each like brush was like treated with some kind of hardened toothpaste in the fibres that would be released after a certain time. …
pra-sol-g3	[in response to the researchers question] well it's just the fact that it's only the bristles that, that your changing which are bio-degradable …it's more a minimising
pra-sol-g3	[in response to the researchers question] …Put it on your finger or something like that.
pra-sol-g3	[in response to the researchers question]we thought like the bio-plastic bits?
pra-prob-g4	we designed the Body Shop afro comb which is made from straw and plastic, eh, because it has no end of life strategy, excess packaging and it is a waste of materials, has poor design and the packaging is actually misleading…
pra-sol-g4	…So we've came up with a reinvention of such, is to take disused cutlery – *laughter in group-* and bodge it together…
pra-sol-prob-g4	…Made out of metal this thing can then be used to re-style the 'fro *–chatter in group-* the original one of this has got this extra bit of paper round it that actually gives you the bar code. We have included the bar code into the actual legs …
uns-g4	…people that make these will be out of a job…
pra-sol-g4	…it'll encourage recyclability through the product as well because we are reusing like old products, to like you know, use as something else…
uns-g4	[in response the researchers question] we were gonna actually, in fact just use your hands, just do it with your hands yourself and that was gonna be. But obviously like whoever make these the company, …put people out of a job…
rat-g4	You have to look at the bigger picture cause then, just because we're not making this and we're not harming the environment cause people out of a job, including me…

10.5.2 Sustainable concepts produced by students



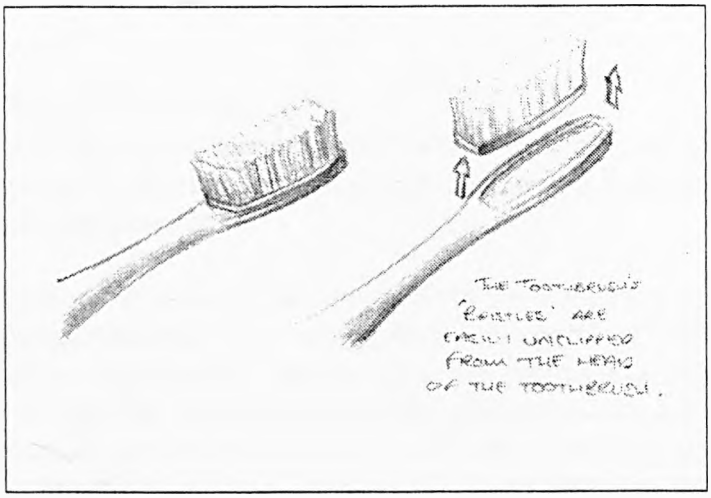
Alternative to disposable water bottle:

- Biodegradable material.
- Recycle nozzle
- Labelling of material on packaging
- Embossed branding.
- Point of sales



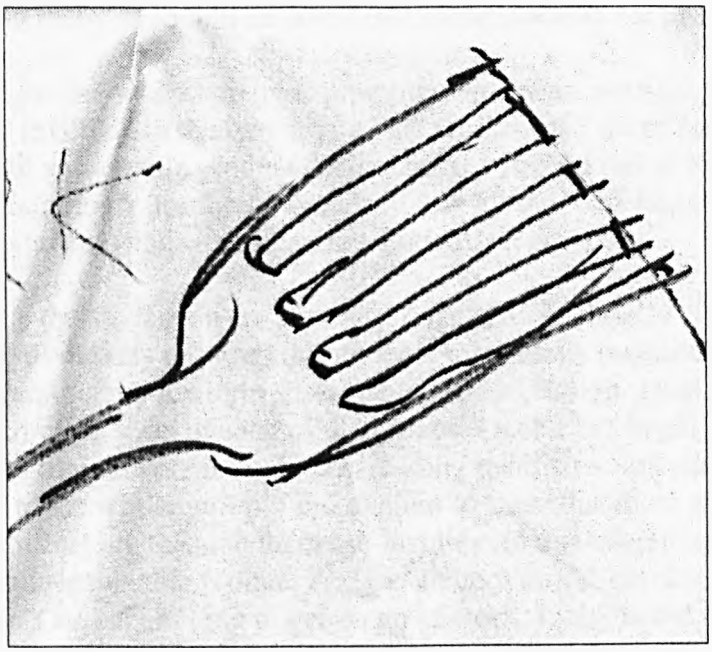
Alternative to disposable razor:

- Renewable material: glass.
- Long lasting
- Infrastructure in place to sharpen.
- Described as a classic style.



Alternative to a travel toothbrush:

- Interchangeable biodegradable bristles.
- Reuse handle
- Personalise, customise handle.



Alternative to plastic comb:

- Reuse of material
- Consideration of economy – employment.

10.5.3 Field note journal

Monday 18th November 2002

For this first day if the workshop I was to be accompanied by Libby Curtis and Richard Adams in the morning and Christine Arnold in the afternoon. Libby and Richard did turn up but Christine didn't.

As I did in the initial workshop, prior to the students arriving, I placed group numbers one to seven around the room designating wall space. At 930am it became apparent that there wasn't enough students present for seven groups. I quickly rearranged the students into four groups and removed the surplus group numbers. I discussed with Libby that I wanted the workshop morning session to be closed to late comers simply because this may disturb the groups flow of work. She agreed and placed notes outside on each door of the workshop stating it was closed to latecomers but they were invited to join in the afternoon session. This note went up at 945am. Despite this three students did wonder in late. I asked them to leave the studio and explained to them that the workshop began at 930am. The students weren't pleased. Two of the latecomers asked to get into the studio to pick up work. I said not until the workshop took a break at 11o'clock because it would disturb what was going on. It was at this point the students in the workshop were trying to generate mind maps. It should be noted that these students did turn up for the afternoon session.

I began the workshop by explaining who I was, my background and described briefly what was involved in the two days of the workshop. I described the first day as the time to learn about sustainable product design and the second day to apply what has been learnt by redesigning a product. I explained that all the work had to be done in groups and I read out the students names designating students to groups.

Once the students were at their groups station I briefly explained the first task. The first task of the day required the students to generate individually a mind map of what they understood by the term sustainable product design. I had placed A3 paper and an instruction sheet at each of the groups. Once I had briefly explained the task I observed that group 2 were individually reading the instruction sheet instead of one person reading it out to the whole group. I did explain to them that there was no right or wrong answer, I wasn't trying to catch them out just to gain an understanding of what they understood about sustainable product design. There was a slight delay and look of bemusement but it didn't take them long to get down to work. Libby noted how quiet the students were, this was unusual.

Before the workshop began I explained to Libby the layout of the workshop and how it fitted into the Ph.D. question. She asked if I was going to repeat the workshop with another design course at a different university. I explained to Libby that our role was to guide the students thinking but for the initial mind map task I requested that we left the students to do it: no interference. The mind mapping task lasted fifteen minutes. As the fifteen minutes were drawing to a close both Libby and I handed out the project briefs and an instruction sheet for the next task to each group. We also handed out post-it notes and a black marker. Even though the students were instructed to bring post-it notes, markers and drawing equipment, the majority forgot the post-it notes. Only two students brought them. This affected the ideas generation part later in the workshop.

For the second task of the day the students were to brainstorm un-sustainability. What would a product have to possess in order to be un-sustainable, to be bad design. There was a slight delayed reaction between my instructions or explanation and the students getting on with the brainstorming. Again the students were very quiet throughout, it all seemed very serious. Without any encouragement I observed all the groups thinking of and writing on the post-it notes unsustainable products. Cars, medical products, post-it notes all were mentioned. I initially encouraged this by adding products like nappies and asking the students to tell me what made them unsustainable. The students had no problems generating products. One or two groups actually generated too many products (groups one and two). As I visited each group and observed the mounting products I tried to encourage the groups to write down why the products they suggested were unsustainable. This took a lot of encouragement and for group one I had to tell them to stop generating products. Perhaps this has something to do with the way the students understood the instructions. After forty minutes I called a twenty minutes break. When the students returned they had ten more minutes to complete the task. Generally, the students were able to brainstorm un-sustainability better than sustainability.

For the next task the student groups had to turn the results from their brainstorming into a set of evaluation criteria. Taking what they had noted as the characteristics of un-sustainable products possessed they had to formulate a list of criteria to evaluate any products un-sustainability. All the groups took keywords such as pollute and expanded upon them in their criteria, the following is an example taken from group one,

- Value of product to the owner high/low?
- Forever changing. Trends.
- Functionality bad, good. Functionality high/low? Adaptability. Changing world.
- Pollution. Pollute the air. Production> use of energy?
- Length of time to biodegrade. Environmentally friendly. Green issues awareness. Disposal.
- Ozone friendly.
- Can it be recycled? Materials. Packaging.
- Lifespan. Last forever or 1 year. Maintenance. Easy/hard does it deprecate through use?
- Consumer psychology. How the consumer will accept/use product. Will they appreciate the sustainability. Culture/ethics. Public movement and generic acceptance.
- Wastage. Management.
- Innovation. Technology 'push'. Consumer demand 'market pull'

All groups had a central line of criteria from which they expanded linear from. The type of language and words used to describe each groups evaluation criteria was interesting. In every group, except group three, a mixture of un-sustainable and sustainable terms are used. For example group one's list uses words such as 'lifespan' then asks 'last forever or one year'. It's almost as if they were afraid to commit themselves – for un-sustainability they could have used short lifespan or sustainability long lifespan. Group three however, did commit themselves to un-sustainable characteristics. The following is group three's evaluation criteria:

- Unstable/short life market.

- Non-compatible – DVD's vs VHS
- Non-recyclable.
- Non-renewable resources.
- Does product pollute> during extraction of materials…during manufacture…during use…after products life?
- Fast moving market – supersedes technology.
- Short product lifespan/ lifecycle. Poor durability.
- Highly fashionable – desire etc.
- "Un-repairable", disposable. In built obsolescence.
- Not designed 'for all'.
- Cost effective maintenance?
- Product too expensive. Initial cost – running cost.

The final task of the morning was broken into three parts:
Part One: Using the pre-selected products; use the unsustainable criteria your group have formulated to evaluate the three products to determine how un-sustainable they are.
Part Two: Once your group have evaluated the products; Discuss which you believe to be the most un-sustainable and least un-sustainable.
Part Three: Place images of all three products on an index of sustainability.

A form was given out to give the students guidance on what was expected from the task and also to prevent me receiving a piece of paper with yes, no, yes as I did with the previous workshop. The form was broken into four columns:

Un-sustainable criteria	Name: Function:	Name: Function:	Name: Function:

In the 'un-sustainable criteria' column the students were asked to fill in their group evaluation criteria formulated in the previous task. The evaluation criteria for each group went through a filtering process when the post-it notes version was written down into the form. This may have had something to so with the amount of space given on the form. It is more evident in some instances the students changing the un-sustainable criteria into sustainable criteria. What is also interesting is the separation of the term 'environmentally friendly'. Perhaps for the students, at this point, this term is just another thing to think about rather than something that involves the other terms such as cost or lifespan. Group three is still the only group to develop a un-sustainable evaluation criteria, for example terms like 'non-compatible', 'non-recyclable', 'non-renewable resources', 'polluting product', 'highly fashionable'. What is apparent from each group of criteria is that this group of students possess a more holistic perspective of design; incorporating the likes of consumer psychology from another subject they study as part of the DFI programme.

This task – all three parts – took a lot longer than in the previous workshop. This is simply due to the amount of discussion and debate that took place in each group. In the previous workshop each student took one product and evaluated it on their own cutting the time it

took to complete the task, in this workshop they worked as a team, questioning each other rather than a group of individuals.

Debate was particularly evident when the groups had to decide which was the most and least sustainable. They were actually asked, at the bottom of the evaluation form to provide the most and least un-sustainable but this was ignored and in some forms the 'un' was scored out. Group three debated whether the wind-up radio or the travel toothbrush was the least sustainable. In group one debated occurred between two students stating the rookie chopsticks were the least sustainable and the Black & Decker Quatro tool. Groups one and four chose products I had evaluated as the least sustainable at this stage of the workshop. Due to the length of time it took to complete the task I had to hurry the students along in placing the product images on the sustainability index. I didn't have copies of the pictures they evaluated so post-it notes with product names had to be put in their place. Groups one, two and three placed their product images at the extreme ends of the sustainability index; the most sustainable at the top, the least sustainable at the bottom and the product left in the middle. Group four were more critical placing the most sustainable in between the middle and the top.

The workshop finished for the morning at this point. Before the students left I went over in detail what was happening in the afternoon: we would go over my characteristics of SPD, re-evaluate the products and identify the least sustainable.
More students attended the afternoon session of day one of the workshop. Although it began at 2pm I allowed students that were slightly late to join in. Before the afternoon session began I re-arranged the studio for the description of my characteristics of SPD. I didn't want this part of the session to be formal as it can hinder participation. I didn't want to stand talking in front of the class with the students listening. I had noticed in the previous workshop that only four or five joined in and answered the questions I posed. I also noticed in the previous workshop that after twenty minutes the student lost interest after thirty minutes minds and eyes began to wander. So with this in mind I made some changes to this part of the workshop. I attempted to create equality; we all sat around in a circle. I had considered everyone sitting around a large table that was already in the studio, but there were too many bodies. I tried to ensure everyone was in the circle not behind people or boards. The layout of the studio slightly hindered this.

Before we began describing the characteristics I handed out sheets of A4 paper which had keywords and descriptions on. As I handed them out I explained to the students that I wasn't going to sit and lecture them on SPD rather we were going to discuss it together. As the keywords on the top of the sheets of paper is mentioned they had to read out the explanation. I also implied that they were free to add to the discussion beyond what was on the sheets of paper. I explained that the characteristics would be explained under five headings. Once we had gone over them I would place the headings up on the wall and they had to place their sheets under what they believed – or recollected – to be the correct heading. The characteristics on the wall could be referred to later in the workshop. (For what actually was spoken see the transcript). Discussion did take place out with the characteristics in the form of students describing products. After about twenty minutes there were some tired eyes and nodding heads but I think I managed to hold their attention longer than the students in the previous workshop. I kept the characteristics moving forward not allowing any long pauses. The description of the characteristics of SPD lasted thirty minutes.

I went onto tell them what was to take place in the rest of the afternoon. I changed the plan slightly. The students had to place their keywords under the five headings; then in their groups re-evaluate the three products decide on the least and most sustainable; and again place the images on the index. Then with the least sustainable product they had to identify the problems with the product, in the form of a list. I decided that by including the list of problems in the afternoon the students could go away and consciously or unconsciously let their brains work on solutions to the problems overnight: encouraging creative thinking.

The five headings on the wall were:

- The product is designed with an end of life strategy.
- The product is designed to do more with less.
- The design of a product influences individuals to adopt sustainable and sufficient patterns of consumption.
- Product scripts address real behaviour, satisfy real needs and encourage users to be pro-active.
- The product displays seductive, simple aesthetics that express the sustainable nature of the product.

I went around each group to hand out the next instruction sheet and told the students to put their keywords underneath the headings. There was a rush and at one point a group of students (about eight or ten) standing around the headings looking and discussing with each other where to place their keywords. The keywords were not placed under the heading exactly as I described them. 'Customised' was place under product scripts rather than aesthetics, 'extending products lifespan' was added to product scripts rather than end of life strategy. 'Renewable energy' and 'local materials and manufacturing' was added to end of life strategy rather than do more with less. Both disposal and disassembly weren't added under any heading as I was responsible for them. The headings were:

	Students placing of characteristics	Original explanation of characteristics
End of Life Strategy	Recyclable	Recycle
	Reuse	Reuse
	Renewable resources	Disassembly
	Safe	Safe
	Re-manufacture	Re-manufacture
		Disposal
		Extending a products lifespan
Do more with less	Substitution	Substitution
	Miniaturisation	Miniaturisation
	Modular or multi-function	Modular or multi-function
	Efficiency	Efficiency
		Local materials and manufacturing
		Renewable resources

Patterns of consumptio	Affordability	Affordability
	Finding alternatives	Finding alternatives
	Renewable energy	
	Services and experiences	Services and experiences
	Local materials and manufacturing	
Product scripts	Product scripts	Product scripts
	Appropriate	Appropriate
	Encourage to be pro-active	Encourage to be pro-active
	Real behaviour	Real behaviour
	Customised	
	Extending products lifespan	
Aesthetic s	Stereotypes	Stereotypes
	Anti-fashion	Anti-fashion
	Durable	Durable
		Customised

The next task again involved three parts;
Part One: re-evaluate all three pre-selected products to determine how sustainable they each are. Refer to the sustainable characteristics discussed.
Part Two: Once your group have evaluated the products, discuss which you believe to be the most and least sustainable.
Part Three: Place images of all three products on an index of sustainability.

The students went back to their groups a few students who hadn't attended the morning session had to be allocated to groups. I made random choices as to which groups these student joined aiming to make the number equal.
Before the groups began the tasks at least one student from each group wrote down the characteristics of SPD. I didn't have evaluation forms to fill in for this task, it would have been better if I had.

There seemed to be a different vibe about the afternoon session. The students appeared to be slightly bored repeating the evaluation of products. The studio was a lot nosier.

The groups had different approaches to this task. Groups one and four evaluated the products under the headings. Groups three appear to grade the products under the headings and against the individual keywords, then calculated the number of characteristics each product possessed to determine the most and least sustainable. This resulted in a debate between the wind-up radio and the Body Shop packaging to determine which was the most sustainable. Group two listed all the keywords and wrote yes or no next to each.

I did not correct the wall chart of characteristics.

The groups only slightly changed their opinions on which products were the most and least sustainable. I think the selection of products made it too easy to identify the most and least sustainable. Another factor in the selection process important to note, is whether the students wanted to re-design the product or not.

Again I had to move the task along by encouraging the students to place the images on the index. Perhaps splitting the task into three is not the best approach, identifying the most and least sustainable could be part of placing the images on the index. In order to differentiate the images I placed 're-evaluation' on the images. The images must be different between the tasks, this wasn't adequate.

The final task of the afternoon was to identify the problems with the least sustainable product. The students were beginning to get tired and they were losing their ability to concentrate. I explained to them that by identifying the problems they would be able to think about solutions overnight.

The student groups had no problems in completing this task, in fact they naturally took it one step forward by discussing possible solutions. I had to interveine with some of the groups to remind them they were only to list the problems, solutions would come tomorrow.

The afternoon session finished at about 430pm.

Tuesday 19th November 2002

Day two of the workshop was more relaxed than day one. I began by bringing the students together and told them what had to be achieved in the day. I broke it down into time slots: from 930 to 1030am brainstorming solutions to the problems identified the day before of each groups least sustainable product; from 1030 to 1050am student break; then 1050am until 1230pm to generate concepts; Break for lunch from 1230 until 2pm; from 2-3pm preparing for presentation; presentations beginning at 3pm and lasting until 430pm, therefore only ten minutes each group.

Unfortunately not everyone turned up from the first day and some turned up who didn't attend the first say. So again I had to allocate people to groups. I was concerned how this affects the group dynamics. There were also a few late-comers and those who only turned up in the afternoon so the groups were no longer equal – in fact group one had seven students which was noticed by the rest of the class at the presentations. I did explain that not everyone in group one had attended all the workshop so it was of no great advantage to them.

The students were very relaxed, having fun and laughing I had to remind them of what had to be achieved in the day.

Again the students didn't bring in any post-it notes, as they were told to. So some used mind maps, lists on A3 paper or newsprint on the walls. Even though the groups had identified the problems each group revisited this task perhaps this something to do with formulating the problem in their minds.

For developing concepts the groups used newsprint. Groups two and three drew as a team, group one split the newsprint into sheets and group four used is as presentation sheets only. I intervened very little in the morning mainly to ask them what the problems they were trying to address and to get them to explain their concepts. The rest of the time I listened and observed.

Group four appeared to have the most difficulty. They decided the Body Shop afro comb to be the least sustainable due to the material used and the function of the comb. In my opinion they selected the wrong product to re-design but the selection of the product was less important then the process of redesigning to I didn't persuade them to change the product. The group decided that in fact, there was no need to design and produce such a product because using your hand was sufficient and the most sustainable option. I entered into a debate with them about how sustainable this option was stressing that they had just made themselves and other unemployed. They felt that a designer couldn't be responsible for employment. But I tried to stress that they had to think about the consequences of their actions and unemployment was not sustainable. Richard Adams joined in the debate.

I felt under pressure during this debate, even though I knew I was right I was bombarded with questions by the students in an attempt to change my views. Eventually I had to tell them that the hand was sustainable but not a practical option in terms of economics which impact on people's quality of life. These students seemed to be fixated on keywords particularly rapport as ridiculous.

During lunch I considered group four's re-design recollecting that they justified their choice of product because of the straw in the plastic which only allowed down-cycling. I queries their justification as straw could be used to strengthen a product and it was already made from recycled plastic. Again I was bombarded with questions so I would back down even though I provided them with an example of recycled plastic that included straw.

After lunch I was joined by Lenny Smith. I began the session by repeating the mind map task. I removed all evidence of the characteristics of SPD from the studio walls and the students desks. Again they had fifteen minutes to complete the task. Those that didn't attend the first day struggled. The studio was fairly quiet for this task.

Once the fifteen minutes was up I reminded the class that they had forty-five minutes to prepare for the presentation. I handed out the brief again (one per group) which provided instructions as to what was expected from the presentations.

I interfered more in the afternoon. Lenny and I visited each group asking them to explain their concept. It became apparent that the students were able to deal and grasp the concepts of doing more with less and end of life strategy, evident in the use of words like recycling or for group two product tack-back and reuse. But patterns of consumption, product scripts and aesthetics proved more difficult. Although they were aware of the concepts they did not fully explore or realise there potential group one for instance, re-designed the packaging for water deciding it would be produced from a biodegradable material but they did not until asked consider how the user would know it was ok to through the packaging away. The result was 'bio-degradable' embossed along the top of the container. I feel that a better option could have been developed if the group had considered product scripts.

Just before 3pm I tried to get hold of the video camera to tape the presentations this caused problems as the DFI office was locked with no members of staff around to open it. But I did get the camera before 3pm and the presentations went ahead as planned. Each group presented in front of their concept sheets. Group one presented a 3D computer model of their design and group four working models.

I ended the workshop by thanking them for their cooperation and asked them what they felt they had got out of the two days. It was said that they were surprised by what could be achieved in two days; they didn't realise how much they already knew about the subject; and the characteristics were a useful guidance, putting a topic which is difficult to find a definition on due to the amount of conflicting information, into five headings. They appeared to have a sense of achievement.

10.6 Mind maps and student explanation

Transcript of Semi-structured Interview to Discuss Students Mind Map

R: Ok, all I really wanted you to do is talk me through it like the beginning of the, em, tell me what you were thinking when you were writing it

S: Alright yeah [

R: I mean it was personal to you so you can't go wrong

S: Umm hum yeah [

R: OK. I just want you to tell me to start with the keywords [

S: Ah hah [

R: And then lead me through it that way [

S: OK, I suppose I started with (.) just like trying to define what sust - sustainability meant you know a little bit with sustain so like, like [

R: Um hum [

S: I don't know the dictionary, the definition, but what, just kind of what I thought of sustain, sustainable meant so, em, things like (.) longevity and that so I think sustain like, em, almost like constant so that its, em (.) constantly like, eh (.) I don't know if I, I was [

R: Um hum [

S: Trying to apply it to product design or I was just trying to (.) umm, you know trying to take sustainable part of the word in its own sense

R: Um hum

S: But, umm, as product sense I was making you know like, em, product life of something like if the long you know, how long it last and then like, em, how long that would be, I mean like if it was forever for example, em, how, how long is forever in the product (of) a lifecycle like if it's like

R: (All) right

S: for a day or a week or a month kind of thing em (.) eh then that was kind of like through the design process with constant like constant em, improvement and constant em reassessment of it

R: Right

S: Kind of thing as a theory as opposed to (.)

R: Um hum

S: - *Laughter* - So em, that's throughout was about em, I think the natural like evolving thing was about, em, like it shouldn't be kind a stuck on at the end of the thing like I think that was kind a supposed to be like inbuilt from the start so that, em, you should always be thinking about it and it should have that should have like a positive influence in the kind a design

R: Um hum

S: Because, em (.) because it's not like something you think about afterwards. Its part of your thought and that should led to diff, em, improved - *sniff*- design

R: Um hum, OK

S: em, (.) improving (.) yeah that was, em,

R: Part of evolution?

S: Yeah, ah ha, I suppose, em, like improving I mean as again as this one is, each is different for each thing so like whether improving, making something bigger or smaller or stronger, you know

R: Um hum

S: each product has its own characteristics and that defines what is better, kind of thing

R: Right

S: I suppose (.) it's not very big

R and S: - *Laughter* -

R: well then you did it in 15 minutes

S: Yeah, I couldn't think of what and (.) complete was like don't know, just I thought I suppose just again that the whole process that was involved, that kind of thing

R: So it kind of all came from that word sustain then?

S: Yeah

R: Right

S: Ah ha (.) Totally yeah, em (.)

R: OK

S: - *Nervous laughter*- Sorry

R: No this is fine. So this is the second one you did

S: Alright, yeah

R: Now if you take me through that one as well

S: OK, em, so obviously by this point I kind a understood more about, I suppose ( )

R: - *Laughter* -

S: Yeah, I think, like, shh like recyclable was, em, more of a, I found out that recyclable was more important than what I had like, really, applied recyclable as the first one, em, I think its not necessarily recyclable as in (.) the materials are going to be recycled but like, you know like, things are going to recycle, almost like [

R: Um Hum

S: Used for different applications

R: Um hum

S: em (.) and that's, so that can have environmental factors as well as

R: What do you mean by environmental factors?

S: em, like, like the renewable resources, you know, like using, it can be, involve like actual materials themselves or the way the materials are manufactured, you know like using renewable energy sources to like, in, but not just in the actual materials but like the, or another things if the raw materials

R: Um hum

S: And then the, you know, production of them until the final process so like it comes into all different levels, not just like the actual material like polystyrene is like not going to like, disintegrate etcetera thing like that

R: Um hum

S: So I think what was kind a meant by that, em, remanufactures like understood that things are going, you know, be actually like melt down and remade into something else (.) em, (.) economical was about, em, almost like, eh, I suppose almost like a theory in its own, isn't it, like minimalist

R: Um hum

S: Almost but not in an aesthetic sense, but more like, being economical with materials and not being, em, lavishly like throwing things on for decorate – decorational purposes I suppose

R: All right

S: Just them being able to exercise some restraint almost in how [

R: Um hum

S: You design so your not just sticking things on for that bit. I suppose its almost, it would be good, I suppose it's a different theory of thinking because normally you just, like you want to make your thing look, you obviously want to serve, you want your product to serve in function but also you want it to look as good as possible but maybe its, like, more a case of you stop at a certain point and people say, eh, you could make it look better if you did or that

R: Um hum

S: And you are saying well you're justifying it by saying well it doesn't need that and you know then that's where I kind of where I was coming from with that I suppose. And I suppose you could apply that to your whole, all to your design as opposed to just like one off things which are involved in sustainability

R: Um hum

S: So, eh, I suppose miniaturisation come off of that I suppose because it's about by physically by making things smaller using less materials.

R: Right

S: em, design for all is like designing for like everybody, kind of thing, not just, em, not even just like old and young people but things like, em different races. I think I was reading something that you can't find in the Western world, you cant buy like a cycling helmet that will fit a, like a, Caribbean-shaped skull you know [

R: Right [

S: like things like that I was kind of thinking of which is, em, interesting because I wasn't thinking about, when I first, you know, in the first mind map

R: Um hum

S: I hadn't even considered things like design for all. I suppose its (.) but then at eh same time it's linked through being for everyone and being for the better good of everyone, (do you know what I mean

R: yeah

S: em, with the durable thing, it's not necessarily, it has to be durable it's whether the question is should it be durable or you know [

R: Um hum [

S: Or em, should it waste away like once its product life is over or should it last forever kind of thing, so that you don't have to replace it. So I suppose that could take that in like ( ), that's, like, a you know debate it depends what application you're using it for I suppose, you know if you use a structure that has to be there for [

R: Yeah [

S: You won't have to be replacing it all the time but then if it' like some kind of disposable packaging you want it to be durable for its life but then disposable afterwards

R: Ah hah, ah hah

S: em, (.) yeah, em, cost I was quite surprised, I think I took that off of one of your, you know, the things you discussed earlier on. I didn't really consider cost 'cause I suppose it depends, I mean, you said it was to be affordable for everyone, I suppose, why make a product of not everyone can buy it. I suppose that could debated with 'cause I mean, when you're taking designing something it's with a particular target market

R: Yeah

S: So I suppose when you're designing for them you're like, well, (.) it's just if your target market can afford it and I don't suppose you consider, you know what I mean, you don't if somebody who can't afford it, you're like well that's not your target market so

R: Um hum

S: I suppose it depends that is affordable for them as opposed to everyone in general, you know

R: Right

S: So (.)

R: So it would have to be affordable for the target market rather than

S: Un hum, yeah I mean [

R: Right

S: I don't, I mean it would be nice if everyone could afford it, kind of thing, but I don't think it's practical or I don't think anyone will cotton on to designing like cars that everyone can afford 'cause then you still got I suppose that leads you onto this thing about society and how status symbols and things like that are things, you know, people don't want other people to be afford, like rich people don't really want everyone to driving around in the same kind of car. Whatever.

R: Um hum

S: As they've got that's all about status, em, and that's pushed on by more and more aesthetic, em, material goods coming into the market and stuff. It's all about fashion and that.

R: Um hum

S: And that gets faster and faster so (.)

R: Um

S: (.) shame I don't have those things that on the wall because they were quite

R: Ah, but it's about what you]

S: - *laughter* -

R: Understood, it's not about

S: Yeah I suppose, ah ha

R: It's more about what's on the mind map [

S: Ah ha

R: Rather than those things

S: OK, right yeah, em (.)

R: I think the last one is user ability

S: Oh, right yeah

R: Yeah

S: em that I suppose could be incorporated with your design for all kind of thing

R: Right

S: So that everyone can use it but then also (.) em, I think human was spoken more (to be) more about an interactive kind of thing so that like people felt more like they I don't know how to describe it but how they were more involved with the product than just like an object they used but something that had some kind of like emotional link with [

R: Un hum

S: Or, that's maybe more about that's what you like them to have more like desire I suppose and that takes it than the more literal sense of user-ability is like things like ergonomics where that physically is comfortable to use

R: Right

S: More than the emotional attachment, I suppose

R: So is there anything you would add to that mind map if you could do it now?

S: Eh (.) I don't know. I should be able to

S and R: - *laughter* -

S: Its such ( )

R: Ok, ok. So looking at the two mind maps you know side by side

S: Um hum

R: What do you think you've learnt from one to the other? I mean do you see a difference?

S: Yeah definitely I think you could argue that a lot of the user aspects are kind of like not the same one over and over again but it's like very closer link. I mean there's no mention of, eh, design for all kind of thing, you know what I mean [

R: Um hum [

S: em, it's a much bigger picture, I suppose I was more (.) on the last-ability kind of on this stage and its more specific to product design where I suppose you could argue in this design where I suppose you could argue in this sense that it's not just about material goods but its also about like, emotions and things as well

R: Right

S: em,

R: What do you mean by emotions?

S: Like, as I was talking about, the interactivity between the product and the person.

R: Right

S: As opposed to just the actual using of it, kind of thing

R: Un hum, ok, right Thank you very much

Fig. 33 Example of mind map from Workshop 2 produced prior to interaction with the workshop. This mind map corresponds with the following interview.

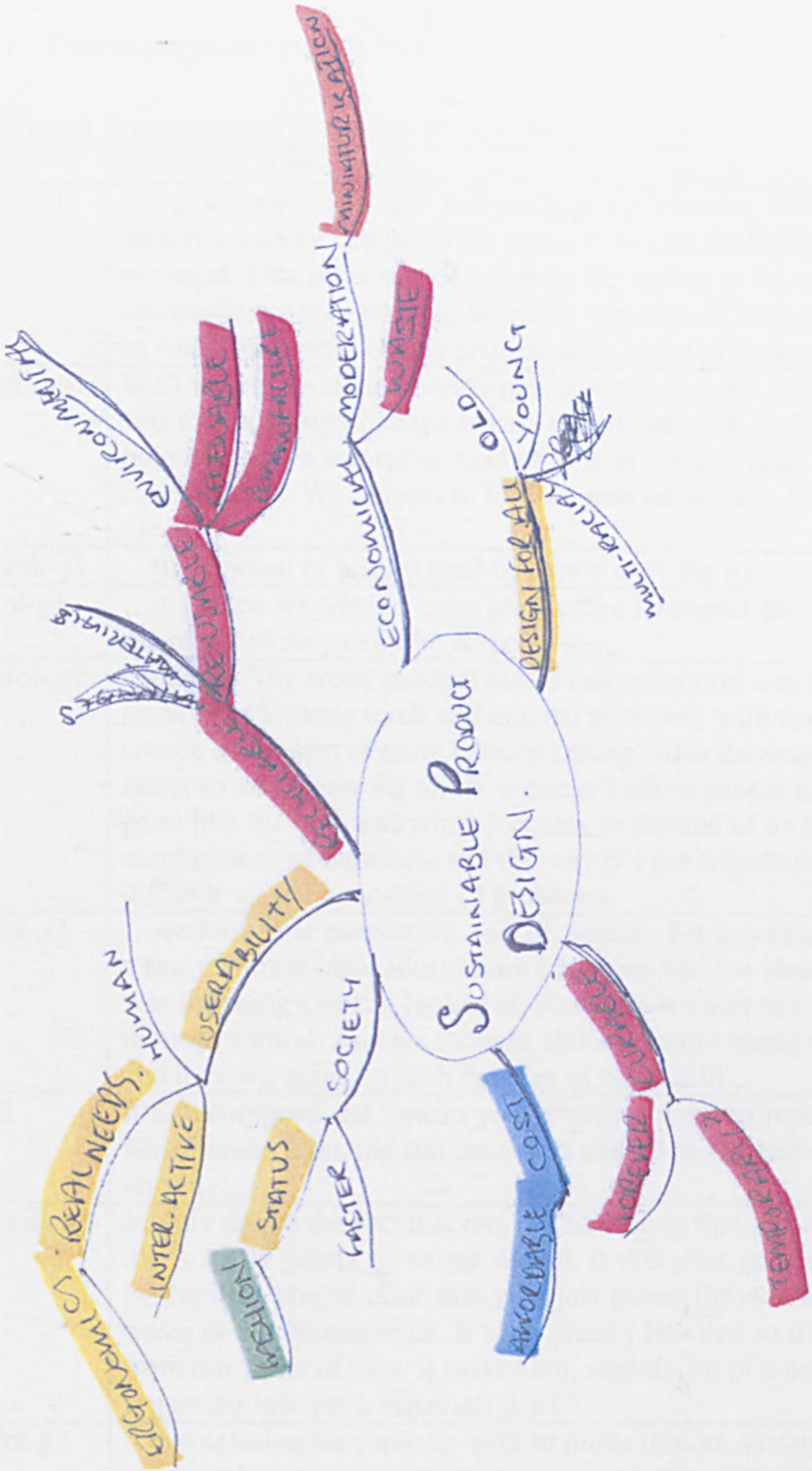


Fig. 34 Example of mind map produced by the same individual as in Fig. 33. This mind map was produced on completion of workshop 2.

10.7 Case Study Five: Workshop Three

10.7.1 Transcriptions of students presentations

Paraphrased Transcriptions of Student Presentations

Code	Section of transcription
pra-sol-g1	Em yeah, when you split that package up from the tea bag. This is going to be thrown away and that's all going to be one material so you, it can be recycled. This other one of and then the teabag in the stride and the (enormity) so then that can be easily recycled as well. So it's biodegradable as well so it would be any process with splitting the materials up.
pra-prob-g1	Well we kind a started breaking it down the, cause we just thought that it was excess design like the excess use of materials and it just became kind of pointless so we wanted to kind of look at. I mean apart from the actual function of it. We wanted to look at, you know, how the materials are really used.
pra-prob-g1	...the amount of plastic used by that is over the top, ...
pra-sol-g1	... ( ) when we tried to use a plastic like laminates from crisps bags and stuff the oils (but they can't be recycled so)
pra-prob-g2	Well our. The worst product out of our collection was this torch here, traditional looking torch and em, the problems with that is the eh, the power source of the sort of toxic batteries using. Also the way it is constructed – *starts to take apart the torch-* it doesn't allow people to replace, replaceable parts like the bulb and when it comes to the end of its lifecycle they eh, the combination of materials and the way it's put together makes it quite difficult to, to be recycled ( ) problems.
pra-sol-g2	...we looked at alternative, sort of, sources for power and em, came up with a few different ideas like clockwork or we had the idea of solar power that was the thing Duncan looked at. And then we sort of tried to bring it down to more natural. And we thought about potatoes being used for potato clocks and then we came up with the idea of citric acid.
rat-g2	It'll decompose and I mean you've only got one component to dispose of which is the light, the stainless steel can be re-smelted and the plastic can be reused.
pra-prob-g3	Mainly due to the fact that em, the first thing that's gonna go the only thing that's really gonna go wrong with it, is that your gonna wear out the bristles by the time you've done that your just gonna throw it all away and it's a waste of all the materials. It's not clearly labelled so it makes, em, certainly from our point of view it makes em, slightly bit of a problem. Just generally it uses far too much materials it's (.)
pra-sol-g3	...the solution we came up with to make it more sustainable is we broke the product down into two parts *-points to sketch-*. The first part the main body is a, you just buy as a one off piece then you keep that for however long and then cause the bristles will wear down after a few months or whatever you'd buy from the supermarket or chemist a pack of brushes which are screwed on at the end. ... The bristles just get chucked away at the end so when your throwing away your toothbrush your throwing away less material so it's better for the environment.
pra-prob-g3	...first off we tried to make a portable one like another travel like this *–holds original toothbrush-* but em, the thing is that takes up a lot of materials.

rat-g3	The advantage with that one is, when the bristles go on that one *-points to original-* you have to go throw the whole item anyway so like every few months you buying a whole new travel toothbrush. Whereas this you purchase the body and then you buy a head and then in a few months you have to replace it so.
pra-sol-g3	…we're hopefully gonna go for some sort of recycle plastic, …
rat-g3	…if that wasn't possible and you were throwing away the head instead of having to throw away the whole thing or like that bit then you'd only have to throw away like just the head so your not wasting all this material so it would be otherwise gone to waste.

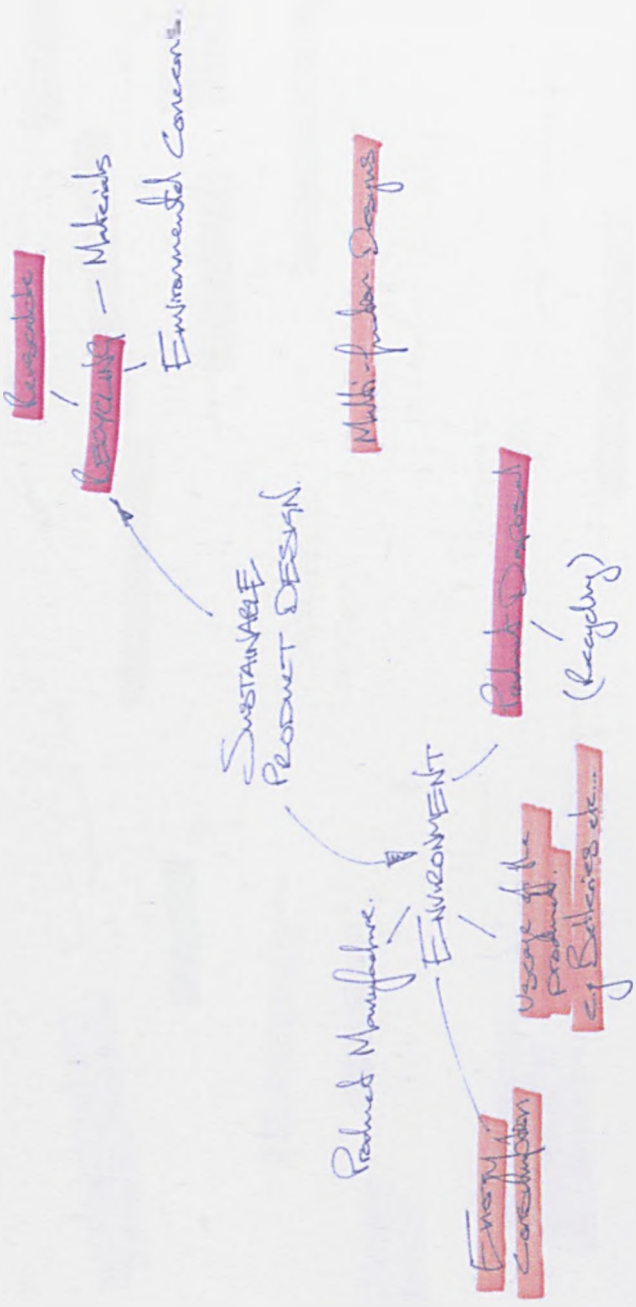


Fig. 35 Random example of mind map from Workshop 3 produced prior to interaction with the workshop.

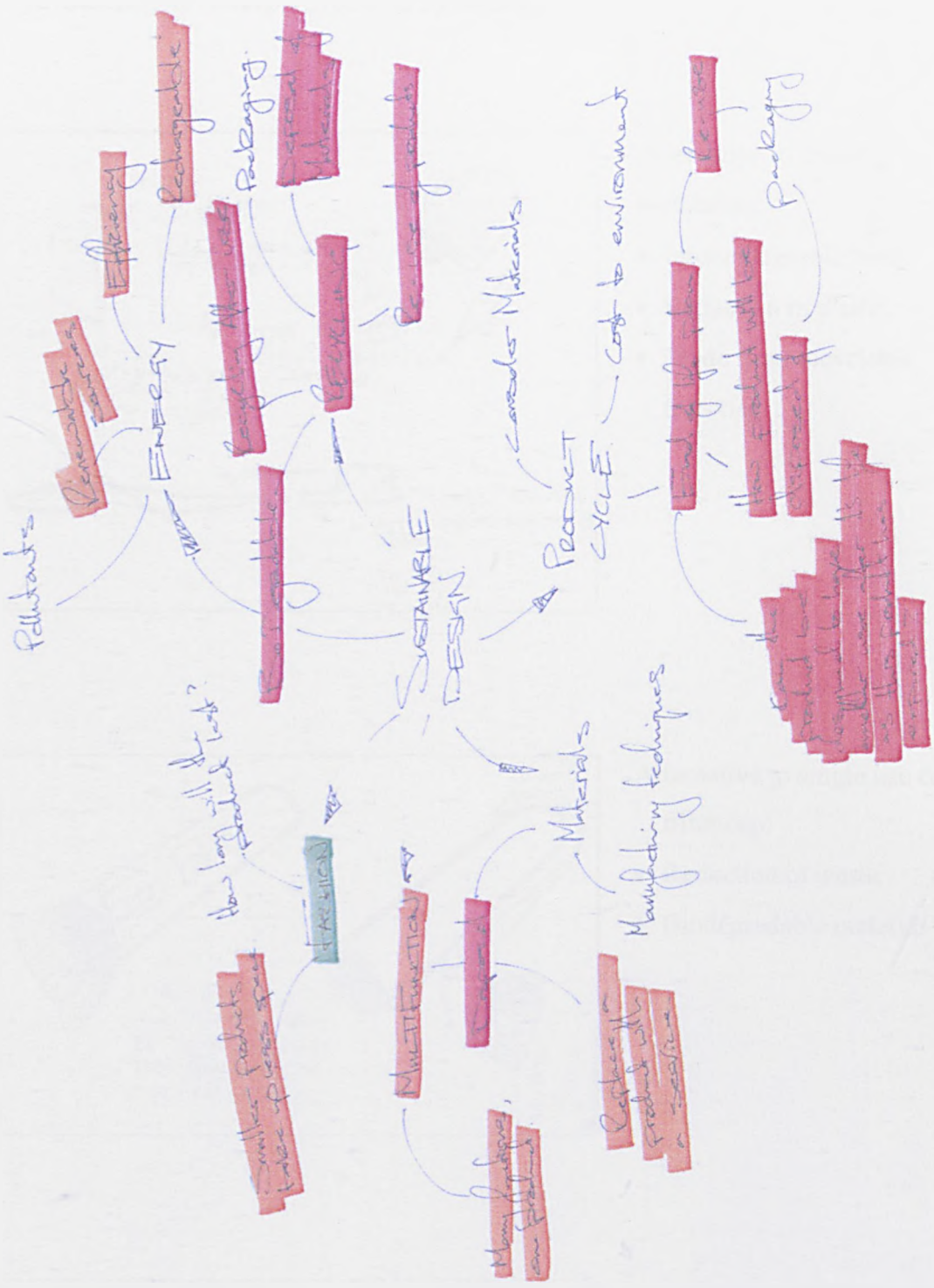
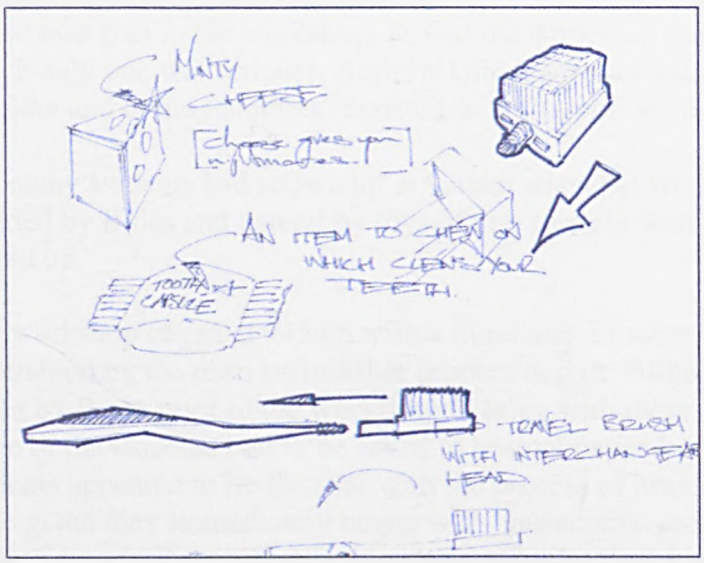


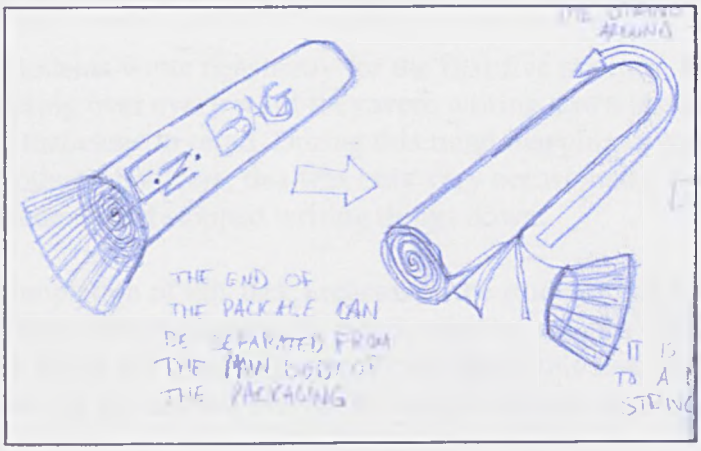
Fig. 36 Example of mind map produced by the same individual as in Fig. 35. This mind map was produced on completion of workshop 3.

10.7.2 Sustainable concepts produced by students



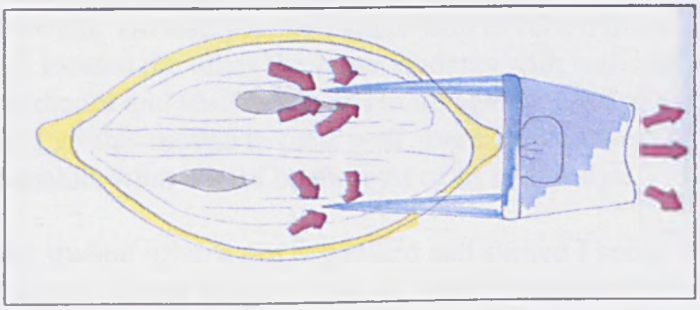
Alternative to travel toothbrush:

- Interchangeable head.
- Reduction in waste.
- Made from recyclable material



Alternative to single use coffee filter cup:

- Reduction in waste
- Biodegradable material



Alternative to a torch:

- Re-useable power source.

10.7.3 Field Note Journal

Workshop three was held on Tuesday 1st April 2003 at Napier University, Edinburgh. The participating course was BDes Consumer Product Design, the workshop was part of the Design for Society module. The course leader is Bjorn Rodnes. Twenty-five students were due to take part in the workshop. In fact the workshop began with twelve students (of which only one was female). Andrew Glidden from Glidden Design (specialising in interiors and brand identities) assisted with the workshop.

Not many students had shown up at 930am when the workshop was due to begin. It was decided by Bjorn and agreed by myself that I would wait until a few more students had turned up.

The workshop began at 945am with a mind map of what the participating students understood by the term sustainable product design. Although the students had all been asked by Bjorn prior to the workshop to bring with them A3 paper and drawing equipment, some of the students had to be asked to borrow paper from those that had A3 paper. The students appeared to be familiar with the process of brainstorming. Once the instructions were given they immediately began with 'sustainable product design' in the centre of the paper, so no further instructions on how to brainstorm was required. I asked the students to complete the mind map on their own, explaining that it wasn't a test but would provide them with visual evidence of how their understanding had moved on, when compared to the mind map generated on completion of the workshop. I asked Andrew not to aid or assist the students during this task as it would bias the results.

The students wrote constantly for the first five minutes. After this they appeared to be pondering over every word they were writing down instead of just writing down the first thing that came to mind. During this mind mapping session some students looked over each others shoulders, this was only very occasionally. Once ten minutes was over most of the students had stopped writing things down.

On completion of this task I reassured the students that by the time they had completed the workshop fifteen minutes for mind mapping wouldn't be long enough and that they would easily fill an A3 sheet of paper. To complete this task I asked the students to write their names and the number one on the bottom of their sheets of paper.

I handed out two pads of post-it notes and two black marker out, placing them in front of four students on the table. I told the students that they were going to so some brainstorming. I told them who was going to work with whom, deciding by how they were seated around the table. I had to ask one student if a dartboard could be taken down off one of the walls. He said yes, so I asked him to take it down and that their group would use that wall. I located the other the other students with wall space simply because of windows and a blackboard and stuff being pilled up against the walls out of the way of the desks. As the student groups moved to their wall space I asked them to brainstorm what was not sustainable, what would be thought of as bad design.

As the student groups got organised and started I spoke to Andrew about our role during this activity. I told Andrew that we would leave the students for the first ten minutes after which when we visited each group we would introduce product prompts such as nappies, washing machines, footwear. I told Andrew what was important about these product

prompts was not the generation of product that are not sustainable but what made them not sustainable. That is what we wanted the student groups to generate. It was at this point that Andrew informed me that the students told him that they had a lecture scheduled at 4pm therefore I would have to cut the workshop short allowing the students time to get to the lecture. I was quite concerned about this because the workshop was supposed to end at 530pm: I wasn't given much choice.

During the first ten minutes of brainstorming, as I visited each group it became evident that the student groups knew how to brainstorm. They applied little or no structure when arranging the post-it notes on the walls. Unlike the other workshops I have ran the students seemed more reserved during brainstorming, discussing within their groups the keywords they were writing on the post-it notes. After ten minutes it became obvious that the keywords the students were generating were mainly eco-design words focusing on doing more with less and end of life strategies. At this time I asked one member of each group to note down the keywords the groups were generating as and when they came up with them. This was mainly for purpose of recording the keywords.

After ten minutes I began to introduce product prompts as I visited each group. I asked them to think about why these products were not sustainable. I started each group by providing them with one or two products and asking them why they were not sustainable. This ensured that each group knew what they were doing. I asked group three to do this about trainers from which they came up with 'fashion' but didn't take it any further. As with previous workshops the groups did just generate products, especially group two. When I asked them to provide me with reasons as to why these products were not sustainable they expected me to know the answers. I had to stress to this group several times, as did Andrew, that I wasn't the generation of products but the reasons why these products are not sustainable.

I ended the brainstorming session after thirty minutes. To save time that I had lost due to the students scheduling I did not carry out a plenary session. I allowed the students to take a ten minutes break, as usual they took longer.

As the students arrived back from their break and sat down around the table they were using previously I handed each of them two keyword cards taken from different parts in the characteristics. A student who hadn't taken part in the previous activities arrived just as I was getting started. I began by explaining how this part of the workshop was going to work, how the students were to take part, put forward their opinions or ask questions. The session was recorded on mini disc.

The students did interact throughout the explanation of the characteristics of SPD, asking questions or putting forward product examples. Throughout the explanation third year students wandered in and out of the studio (the second year students shared a studio with the third years) this was not too much of a distraction as the third years kept quiet. Once I had completed the explanation of the characteristics I placed them on a wall and asked the students to place the cards under the characteristics they thought was appropriate. There was limited wall space and the students failed to put any keywords under 'end of life strategies' instead they placed them under 'doing more with less'. Again due to time restrictions I had to move the students on to the next task rather than discussing the placement of the keywords. I introduced the students to a few keywords and magazine articles, they took a note of their details.

As the students put their keyword cards under the headings that they felt appropriate I handed out three products and three copies of product evaluation forms along with the instruction sheets for the rest of the day, on the table in front of the groups. The students were still sat around a large long table. I explained to them what they were asked to do and they got on with it.

This activity took much longer with these students than in previous workshops. There was a lot of debate and discussion within the groups and with other groups – members of other groups taking part in discussions. As I visited each group it was obvious that this was not unfamiliar task. What was interesting was that all the groups appeared to be fixated on the negative aspects of the evaluation although the form they were fitting in did not ask for only negative responses. It also appeared at this point that there was a leader in each group, an individual leading and finishing the discussion. It was evident to each group which products were the most and least sustainable. Group three had a difference of opinion but one member pointed out that the two products they were discussing – fold away bike and salad cutlery – were both sustainable in their own way, they represented two different concepts of sustainability.

Group one finished this task first, when I thought they were near completion overhearing them discuss the most and least sustainable products I asked them to tell me their decision. I then asked them to list all the problems with their least sustainable product, which they would re-design in the afternoon. Group two then group three finished respectively. As group two and three listed the problems with their least sustainable product I revisited group one who appeared to be doing nothing. I asked them if they had made a list, they showed it to me. It mainly addressed the technical aspects of the product (a travel toothbrush) and neglected the human factors, I pointed this out to the group who told me that they had practically redesigned their product. I assured them that that was ok, but could they revisit their list and make sure they had listed all the problems including those to do with use and people. At this point the students broke for lunch. Before they went I provided them with an overview of what they were going to do in the afternoon.

When the students returned from their lunch I repeated the instructions for the afternoon. I reminded them that this was a blue-sky's project not to simply redesign the product but to address its function in a sustainable manner. Two new students joined the group in the afternoon. I asked them to join a group who would let them know what had happened in the morning and what the activity was. Naturally they sat next to their mates making group one a group of six rather than four students. I found these two new students a distraction and had to ask them to take part in the groups activity or leave. They got to work, but part of their problem was that the group never briefed them on what they were doing.

Group one appeared to work individually with each member coming up with a series of ideas. After about an hour I revisited the group and asked them to explain their concepts. They were redesigning a travel toothbrush.

I asked them why they thought this addressed the problems the identified they said it made the toothbrush more stable. I pointed out that the mechanism that allowed the product to spring out made the toothbrush less sustainable. I suggested they consider not only the function of the handle but the human factors and sustainability of the products as a whole. They began to discuss a few ideas such as fingertip toothbrush which was dismissed

because they felt it would be horrible over your hand; eating but this was dismissed and laughed at because they thought it was ridiculous. A leader had emerged from this group, unfortunately it was one of the new additions to the group who had no knowledge of the characteristics of SPD.

The concept group one presented was a handle with interchangeable heads. The heads were screw-in keeping the toothbrush hygienic and allowing everyone to change the bristle heads when they wore out. I tried to encourage the students to tell me that this toothbrush could have multiple users but they still had not considered the user. I also asked them about the different materials used in the head of the brush, had they considered this they hadn't. This appeared to be a restyling concept concentrating on the handle.

Group two looked at a torch. This group understood that they were designing a product to illuminate in the dark after they were questioned. Prior to this each member of the group sat down individually and restyled the torch again looking at how it could be held. As I observed the group they came up with some interesting ideas such as harnessing solar power to power the torch or candlelight. Again as a leader appeared in the group and everyone seemed to agree with his decisions. This student decided on using lemons as a power source (this group eventually concentrated mainly on the power source). For this groups final concept the group decided to encase the lemon, I questioned this as it would use unnecessary materials and hide the uniqueness of the concept. The group were very unsure about showing the lemon saying it didn't look good.

Group three looked at a single use coffee filter. This group tool advantage of the fact they could see how the filter worked. Once they tried it out I asked them a few questions about its function and told them to take the post-it notes and brainstorm for about ten minutes solutions to the problems. Like all the other groups – but especially this group – instead of brainstorming or even mind mapping solutions they discussed it within their group. Again a leader appeared who made all the final decisions. The concept this group finally came up with was a coffee bag. Even when questioned they did not indicate or discuss how a user would interact with this concept and what benefit it would provide them. They appeared to be fixated on materials saying their was the coffee bag, string, packaging to hold the bag and more packaging to hold several bags. Although they were questioned on why so much packaging was required and what type of materials could they use prior to the presentation they did not address it.
There design was an improvement on previous concepts where they wanted to make the plastic cup filter into a larger plastic cup and use the lid as a filter.

To complete the workshop the students generated another mind map about what they now knew about sustainable product design. All information, keyword cards, post-it notes etc were removed from view.

The students presented their concepts to myself, Bjorn and Andrew as well as the rest of the class. By this time them students were wanting to leave for their lecture. I thanked them, asked for feedback with very little response and they left promptly.

10.8 One Year Later

10.8.1 Transcriptions of students presentations

Paraphrased Transcriptions of 3rd Year Student Presentations

Code	Section of transcript
rat-p1	Eh, looked at the DEMI website, demi.org.uk em, and the six principles efficient, equity, scales, systems, sufficiency and appropriateness. Basically went through classifying, well defining what each of those were, em, the ones that I think that this project relates to are probably sufficiency and (.) what was the other one, sufficiency and systems. Systems is basically looking at connections between society and nature em using resources and the environment you know properly. Using the right resources for what, what's necessary, what's needed. So that's more in connection with what, you know, how it's been made.
prob-pra-p1	...you see these tri-athletes running along and as they run past tables with these cups of water or they get handed like a plastic cup and their running and they just throw it away, they just keep going. So lets say there's a hundred people in a tri-athelon and there's five of these tables that's 500 plastic cups just being thrown away. And although there is these clean up things at the end it's pretty likely that there's gonna be some, a lot of wastage even the one's that they do pick up. Do they just throw them away don't use them again.
sol-pra-p1	So I wanted to do something that was seen as a piece of the kit the same way as trainers are seen as a piece of kit. Something that they use over and over and over and over again so it's got a longer lifespan.
rat-p1	...when we did the thing last year with sustainability that was what it really looked at, it wasn't just down to the whole what needs to be made from a nice green friendly product there was other factors to it as well the whole, em, it needed. The fact that it lasts longer it might just be enough to make it you know. You know by simply buying that and if your not throwing away five cups in your event then your simply, your helping the environment type thing. So that's you know almost getting round it enough, you know that the sustainability em, plus the fact that it has been looked to be made from quite a strong material so it'll last a bit longer as well.
sol-pra-p1	So see if you were entering an event you'd just go out and buy a packet and they would give you one of each size and I've said here *–pointing to his sketchbook-* they would be made from like a biodegradable packaging because the packaging doesn't need to be strong it just needs to be something which would, enough to sell it basically so that would be either recyclable or biodegradable.
sol-qua-p1	The whole idea of that is *–points to sketch-* you'd buy that cause it's gonna last you and your gonna be using it regularly, training with it and getting your money's worth basically and it's gonna help you at the same time
sol-pra-p2	Em, the water would be bought in a plastic bag which would be disposable or refillable. Em, but I actually designed the container for it rather than the actual, the thing that keeps it cold anyway.
sol-pra-p2	So you would just re-use this bag until you didn't want to use it anymore, it's just like a handbag, you'd just keep reusing it.

sol-qua-p2	I: So in other words, is it customisable? S: yes =
rat-p2	Well I don't know, other people seem to be buying these type things, all the magazines or the letters and everything so. It is sustainable to a point but I think you could break it in slowly.
sol-pra-p3	My initial thoughts were sticking with a water bottle thinking of different ways of making it more sustainable like getting rid of the label, you know, useless piece of plastic. Eh, thinking of like embossing it, and eh making it three dimensional out of the bottle eh, just printing straight on.
sol-pra-p3	The sustainability factor of it is that it is coming out of the air you know we all use it, its always there all the time. So reuse.
sol-pra-g3	I toyed with the idea of making it out of recycled plastic bottles. You know using the. What about it, a nice sense of irony there as well. Eh, as the brief said there's, what's it, 3500 bottles something ridiculous like that em, are wasted and that's only in Goha, so what about the rest of the world. So why not use them... You could get them in all, probably get them clear as well if your making it out of bottles.
sol-pra-g3	...it's self powered. It's when your in your car you plug it into your, what do you call, the cigarette lighter and it charges and recharges the battery,
sol-pra-p3	If I'm using recycled bottles as well it wouldn't be that expensive to, to produce.
sol-pra-p4	Em, yeah and eh so people that'd be using it would be like back-packers, campers or just people going abroad. You know eh, they want, they need a water bottle but don't want to keep buying them. And eh they could refill them in there hotel or hostel or whatever. And (.) then I thought about when it's empty it's almost half, half the size so I can put it in my bag ( ) (.) And it's sustainable. The principle I looked at was efficiency, doing more with less so it is like a multi-function project, product. It's the water bottle and the solution so it's also life extension as well cause you keep it for the whole holiday and then I'm not sure what you do after it. Obviously you can't really keep it for, forever so I never really thought about that. Yeah and there's also a, it's a reduction in materials cause your getting two things here *–points to sketch-* lighter as well, yeah.
sol-pra-p5	So you'd have this bottle to carry around with you and you'd always have this bottle to reuse and filter any type of water.
sol-pra-p5	If it were made of paper, that would mean, it doesn't hold water for long enough. And then that design in the end holds about 150 mls of water so that's about just under the size of a Capri-sun and then I looked at like McDonald's air packaging and it's like past industrial recycled paper and a bit of virgin paper and water and grease-resistant. So if I change the grease-resistant bit to water resistant then it would be able to hold the water for a wee bit. So and it's main packaging that you'd just buy it in, would be recycled cardboard from like supermarkets and things cause they collect all there rubbish like all their boxes that they get all there products in so I would just make that out of that there.
sol-pra-p5	yeah you just throw them away after cause it's already made of recycled paper and it'll just, cause it is paper it'll just decompose instead of the plastic which stays around ages so (.)
rat-p5	yeah I was thinking about making it plastic and so you could have it in your

	purse all, the whole time but then you've still got the plastic in the end and would you want to reuse it. And you wouldn't put it in your purse straight away cause it would be wet. So it was like a wee bit of paper you can dispose off (.)
sol-pra-p6	Em I started off looking at different aspects of sustainability. Eh, concentrated on the reusing aspect of it. So trying to get people to reuse it, what would make people reuse it? Em, started off actually, em, looking at other uses so a water bottle could maybe be used as something completely different. Em, that led me onto looking at kids toys cause the kids will reuse it.
prob-pra-p6	… from the research I found em, also that they don't tend to recycle it, their cans or bottles or whatever em, seventy-five percent of them just throw it out all the time. So again trying to encourage them to reuse it (or may be a better way to do).
sol-pra-p6	Em, also it changes the colour it dilutes the natural colouring so to do with the environment. Em, all the sustainability kind if thing.
sol-pra-p6	Em, the only thing that actually has to be replaced is the filter itself, which lasts for about a hundred litres of water passing through it em if there suppose to drink two litres a day that's going to last a minimum of fifty days for the filter and the rest of the product should last a lot longer at least a year or depending on how rough the kids are with it. (.) Em the material function throw it out after use it is recyclable so it is fully sustained. (.)
sol-pra-p6	It's, the main feature of it is, is that it's reusable but eh it can be recycled once it's been used (.)
rat-p7	… if you go on these very statistics em, just redesigning a water bottle isn't really gonna work for about ten years time it's gonna, your gonna need something totally different.
sol-pra-p7	You can produce hydrogen and you can produce oxygen and these are two basic components to make water and if you combust them you get pure water and energy without any pollution or any harm into the atmosphere and what your taking out the system your putting straight back in. Em, hydrogen you can produce it by putting an electric current through salt water. You can do that through solar, wind power and hydro power.
sol-qua-p7	Em, one of these units I suppose it's ment to be more of an investment over a period of eh, three or four years.
rat-p7	Now if you think about the amount of water bottles an average person consumes in that time. It's em it probably wont be a lot of difference in price, if you add it up and you think about it as a lump sum. So if you spend what 50, 60p a day on a bottle of water and say you buy three hundred bottles a year over four years that's quite a sum of money.
prob-pra-p7	So if you think about that. And all you need to do is, em these hydrogen – *points to presentation boards*- canisters work like a soda stream so once there finished take them back to the shop and then get refills. And say sort of initially buying the canisters but eventually just paying for the refills so the cycle is continuous.
prob-pra-p7	I: and what happens to the cartridges when there finished? S: you just give them back to the shop and replace them. I: so they can be refilled? = S: = yeah
prob-pra-p7	But if you ignite it in small amounts so it would just be a continuous cycle.

	Produce em, at the end you'd produce heat to heat up the hydrogen and the electricity to heat up the catho so the whole process is sustainable. Once you've got it going (.)
prob-pra-p7	I mean my point is a composite shell, composite materials are really unsustainable. If your thinking about over a period of four years for the one unit it's em, your just making that amount of material for the once. I mean you could incorporate some sort of system with mobile phones once you get money back when you cash it in and use it's bits again as something else. And to personalise it I think you could buy a choice of styles or fascias you can put on [

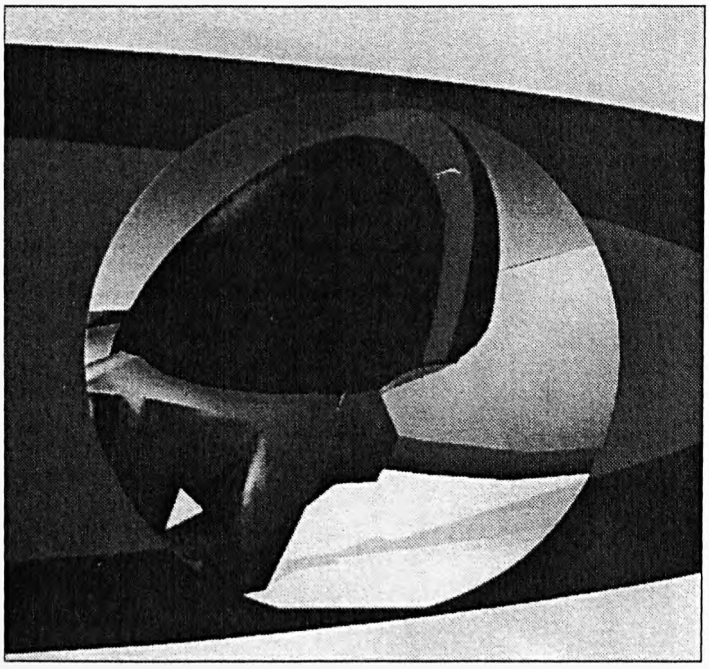
Paraphrased Transcriptions of 2nd year Student Presentations

Code	Section of transcription
men-p1	As we all kind of know it's sustainable design for a water container.
men-p2	obviously everybody knows the brief looking at sustainable design for water bottles or not bottles moving away from that to a container for water.
sol-pra-p2	What I came up with was trying to combine I suppose bio-degradable technology alongside seed germination because there's just enough water in the dregs of the bottle to germinate seeds.
Sol-qua-p2	Em, the target market is for children it's really to encourage children to actually to drink water and to encourage local knowledge and awareness of the environment.
Sol-pra-p2	This gets stuck into the ground and if you leave it for a month it eventually, the bottle will biodegrade and what you'll end up with is a plant growing a certain period later. Basically the problem, biodegradable technology is that it's not at an actual stage really to be used so this is more conceptual at this point. The other thing is from a safety point of view, your mixing water what sort of shelve life is it going to have so I looked at it having just a one month run and what you could actually have is seeds for different months.
Sol-qua-p2	...you just encourage local knowledge by having a short shelve life market.
Sol-qua-p2	And the way to do it is to just actually encourage children to grow their own rockery essentially by screwing in the bottles into the ground leaving it for a period of time. You'd actually have plants growing up.
Rat-p2	And recycling bottles requires an awful lot of energy causes a lot of pollution so by degrading them essentially it's much more energy efficient and from a sustainable point of view there is much less waste and your actually going some way of rectifying what you've taken out of the, the planet's resources by actually making the bottle in the first place.
Sol-pra-p2	it's em a biodegradable plastic it contains the ingredient solbas which I sort of mounted that to the specific plastic it actually gives you a certain length of time, a sort of period. So it's set up for six weeks so you'd probably only take it in the fridge on the shelve or whatever for a month but you have to have a little window there for transportation, whatever (.)
Sol-pra-p2	They would actually degrade anyway so there's, there's always spoilage from things they haven't sold, Mars bars that haven't sold anyway that's pretty, very in depth, there would be no waste essentially and it would actually degrade by itself. The whole thing biodegrades it's all plastic em.

Prob-pra-p3	. If you think about it create a disposable plastic bottle out of a non-renewable resource, using energy and an intensive toxic process. Then use that bottle for a day, throw it in the landfill and it remains for hundreds of years.
Sol-pra-p3	… material was the key part, factor cause basically you have it biodegradable you throw it away and it'll disappear eventually or you can eh, reuse it. I had a few ideas. I had these it was biodegradable idea initially and then I thought make it reuseable or throwaway. And I discovered the reusable ones there's just too, it too, it's got too many problems around it. Em, I can't remember ( ) Eh yeah, so I went for the, I found the materials either table starch, corn , limestone or sea alge, which it can be formed into a spongy foam material and it can be formed into any shape possible so.
Sol-pra-p3	… you throw it away and it'll bio by itself, biodegradable so it'll disappear. So that it, cause it's a hundred percent eco-friendly.
Sol-pra-p3	That's the two tear I chose at the side *–points to presentation board-* at the top and the side and at the front cover of the base em made of the potato starch, limestone and corn which is a hard plastic so it gives it more strength
Sol-pra-p4	…all the products are also really environmentally friendly they're made of recycled materials, that bags a hundred percent recycled *–points to presentation board-* this one's eight percent *–points to presentation board again-* so their really, their environmentally aware with the design of their packaging.
Sol-pra-p4	It's made all of one material which means it's really easy to recycle eh there's no need to separate the material into different types to recycle so that's pretty straightforward.
Sol-pra-p4	Say you got one of these on the Monday, one of these meals and on the Tuesday you take it and just dump you bag in this bin, something like a bin *–points to rubbish bin-* although not so grotty. And you take another bag and go and get your next meal and do the same the next day so you keep, keep the cycle going of the product and Pret will like take them away and as it's all ready to recycle
Rat-p4	Eh I thought of screw caps or valves and things but then it would be, it would make more hassle for recycling the material after.
Men-p5	Like because like the products got to be sustainable as well I was thinking of like products that use packaging that's just like another diversification and em.
Sol-pra-p5	The actual material I was looking at cause we're getting away from all the plastic, PEP plastic is like a big issue I've decided to make it out of alu-foil. It's like aluminium but laminated pretty much like the stuff they use on cat foods and lucazade. Like I said it's used in a lot of applications now a days it's like not noticed. Em, so this is where I get my sustainable thing from, that covers that side…
Rat-p5	I did consider making things reuse and stuff because there's like actual em, health issues about PEP plastics being em dangerous to health, cause cancer and all this cause of the reuse of those bottles. So I wanted to get it completely away from that I didn't want to be associated with that and because reuse as well it's not very practical you'd rather be able to use it once and chuck it away because aluminium is like really good recyclable factors about it just takes less energy to recycle materials and it doesn't give out toxins and if you do anything to it, it doesn't put like any toxic stuff in

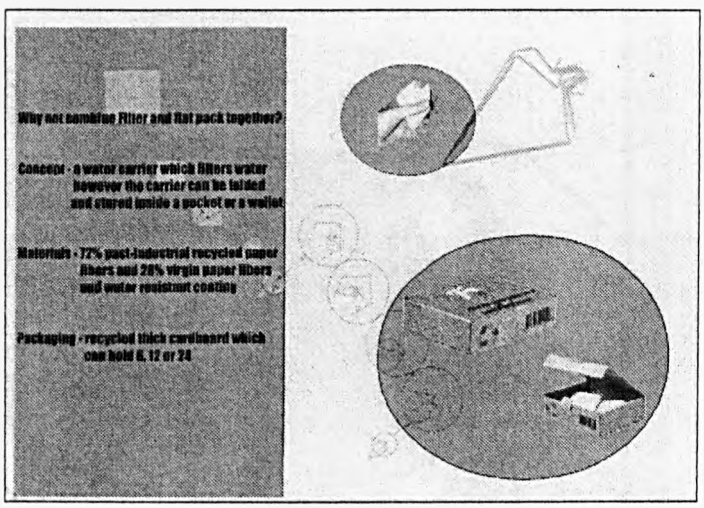
	the ground. (.)
Sol-pra-p6	Eh, it's sustainable because you just re-use it every time. You only have to buy one it should last quite a few years. It's got a point on the pack where you can just attach it to the tap, just refill it quickly, just take it off, attach it to a tap and that's it refilled.
Sol-qua-p6	Eh, it's gonna be suitable for the majority of users with em straps that can be adjusted for kids arms or the elderly or for big people.
Sol-pra-p7	… it's sustainable cause your using it all the time.
Sol-pra-p8	I looked into concepts that basically minimising waste, user friendly that sort of idea.
Sol-pra-p8	So I thought about how could I make that more sustainable I decided to add a timer and a compass to that so it could be reused time and again there's also refill value in the back.
Sol-pra-p8	I've decided to go for polypropylene as well, which can be recycled once that's finished. The timer insert can be removed then it would be totally recyclable.

10.8.2 Sustainable concepts produced by students

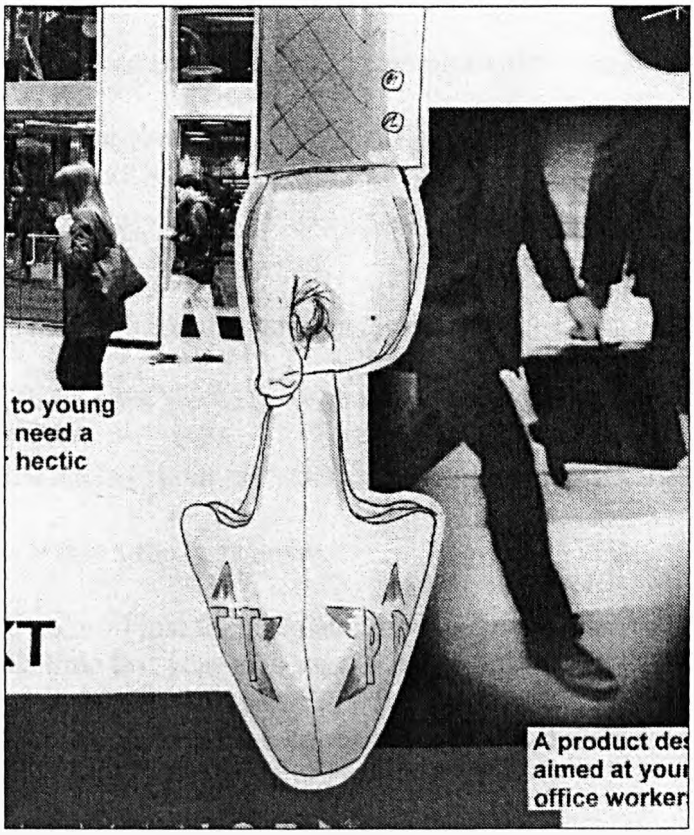


Designs produced by 3rd year students who participated in the workshop the previous year.

This concept was a water bottle to be used during a triathlon. It is re-useable and made from a durable material. Reduces waste from disposable bottles. The student has also considered how the user would interact with the product.

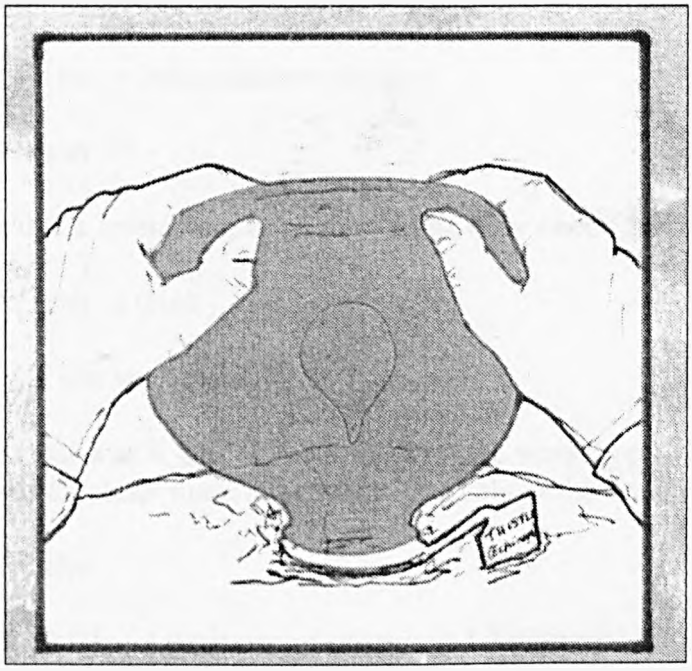


This concept is a disposable water cup using tap water rather processed water. The cup is biodegradable and can be used anywhere.



Concept product by students in second year who had not took part in the SPD workshop.

This is a concept for a water bag that also allows the user to carry their lunch in. The student suggested that the bag is returned to the producer to refill and reuse. He had not considered materials or how the user would drink the water.



Sustainable concept produced by student in 2nd year. The water bottle is made from biodegradable material. Accompanying the bottle is a bag of seeds: the bottle can be planted over the seeds to act as a small greenhouse.

I: Are these from different years or are they the same students?

R: no, the sketches are from different years and these two are from the first workshop from the second years.

I: yeah

R: this is third years and this is the latest.

I: these ones are yeah, yeah cause they were second year, now third year.

A: I mean I think the workshops (.) were good. I mean that's an easy statement to say =

R: = that's the easy answer =

A: no, no I just thinking about what the problem we had with one of the fourth years about this time last year who was looking into this who didn't turn up to the workshop and it just seemed everyone else seemed to have more of a grasp of what sustainability. Obviously there was value in the, in the workshop. I didn't, I don't know if you want me to say the name of that person or not but you all =

I: = who was that Barry Hill?

A: Barry Hill –*laughter*- no but it's true because he didn't turn up. He was invited but he didn't turn up.

I: he was a funny student anyway.

A: yeah

I: that's interesting or he thought he didn't need any of that outside

A: yeah , I think

I: he was very quiet.

A: that was it, I think the thing with the workshops was that people thought sustainability was all about materials it wasn't just about the holistic view of what sustainability is.

R: huhu

A: just that's what one of the things I definitely took out of it. That you kind of bring it up to the forefront for me as well that you know it doesn't have to be a material selection thing.

R: huhu

A: em, it's the whole product life cycle. That's one thing that I think the students did take more than anything was the whole lifecycle

I: yep

A: what happens

R: yeah

A: you know, thing about it how it's disposed of as well [

I: yeah. I mean it's definitely informed them. Definitely educated them about it, you know. I mean when you started of the workshop and you just asked them what you thought it was about without any sort of prompting what so ever you know. Furrowed brows =

R: = yeah, perplexed look =

I: = and you know they came up with the fairly sort of conventional.

A: recycled plastics

I: yeah all that sort of think and then obviously and that you told them what it could be more. You know what it really was, the bigger picture sort of thing

R: huhu

I: suddenly that made them even more aware of what it was and were able to design with that in mind.

A: and I think they have ever since =

I: more sort of skilfully

A: ever since I think they have in the back of their mind they've kind of understood it

R: right

A: whether they've actually, been able to apply it or not

R: yeah

A: I've, you know, I've had a bit of banter with them, and they've said, and they've talked to me about it. You know the whole system. Whether they've applied it we'll find out this week I suppose whether, you know with the assessments coming up whether they've looked at. And it is an integral part to what we've done now they understand it a lot more.

I: yeah, I think if they're asked. Like the third years who have done the workshop the previous year. And some of the projects that were involved were about sustainability, the RSA ones. They have been more conscious, more skilful in answering the brief and aware of what the brief's asking them than the ones in second year who have just come to it new.

A: materials, most of them have just said materials

I: well it's just, they've just. Actually when you've been starting with them when you have been working with them on the project, like this year the second year the water bottle they, you can see it's been too difficult for them. They can't deal with it and you just have to let them go because they don't know what to do it's too difficult they have to do your whole workshop again for them to try *–laughter-* which is quite interesting cause they just can't. And you just leave them to design something you just leave them to be creative with it and if it fits the bill then fair enough, which some of them did like John Chapel and stuff like that. He was quite conscious of what he was being asked to do.

A: he had a lot of contact with you as well. Though I think did he not?
(Please not this student did not have contact time with the researcher until after the presentation of his concept. This time was spent preparing his design for competition entry.)

I: oh right

A: I think that might have been. With John he's more outgoing he is willing to find like you said so he'd get help.

I: I suppose it's the student, the consciencous the students and aware of what they're suppose to be.

R: huhu

I: as oppose to some other ones who hadn't a clue just sat there exactly *–laughter-* that's exactly who I was thinking about who had no idea of the problems with what, what he was being asked to do. He didn't understand it.

A: he really did think that it was just a material choice thing. He didn't understand the whole. Cause I remember talking about cardboard stuff and things like that and he was like no, how do I make it out of cardboard and why? You know and your just thinking well what happens at the end? You know, what can you do? I think he was just playing up a little bit as well. But I mean then you've got the success of things like John who obviously, who did understand.

R: yeah it was quite clear that he understood what was going on and that it was more than just the materials.

A: but he understood that materials played a part in his particular product as well.

R: yeah

A: and looked at the whole thing and I thought it was quite smart that he knew this thing that in so many days or weeks or whatever with your help that it would degrade. Something else happens after that.

R: yeah

I: yeah

A: em , so I mean I think that was definitely a success

I: I think it's a good. I mean second year is the right year to have done it in the first place.

R: really?

I: yep

R: I mean I found that with the difference between the third years and the second years. The third years when I did it with them they got more of a grasp of the holistic and the user centred side of things.

I: yeah of course

A: that might have been that type of year. Last years third year was a very, is quite a mature year really. Whereas, you know the problems of trying to get the second years at the time. Whereas, if you ran it with this years second year I think they'll do a lot, get a lot better response. To weigh the second and third years from last year's lots is probably not fair really.

R: because of the students

A: because of the class. You saw them they were just walking out I had to stand by the door and stuff.

R: that's right

A: I don't think you'd get any second years this year doing that, they would just do it and get on which is more, cause it's their attitude towards design =

I: = yeah, yeah =

A: = and this is more information. So maybe that was the problem with the second and third years last year.

I: I think if you did it with the same. If you did it. If you do it second year and there sort of just being told what to do and there doing group sessions and working together and having to think less as oppose to just it being intuitive or anything they're having to think what your saying, that's then that goes in, they learn that. And then if you did it again in third year. Now I suppose you didn't, what we didn't do here we didn't do the workshop again we did a project that was about sustainability which I think they do, have done a better job than not having the workshop.

R: really

I: yeah definitely

R: right, so the actual workshop =

I: so if they did it again. If they did the workshop again for example having did it already we you know. We haven't really done that *–laughter-* it's just a thought, it's just a thought but do we need to do that though? They've done a project, we've done a project and your aware that they've done a workshop in the first place the previous year.

R: but do you fell like they would maybe if the workshop was done in second year and then there was something that followed up in third year.

I: yeah, there just not mature for a start. In first year, first year whooooo, you know, second year there starting to

A: so much work up

I: yeah they're coming up with stuff you know they're keen as mustard you know most of them and willing to learn I think. In third year, suddenly the penny sort of drops and they become a bit more, understand or sophisticated or whatever you want to call it.

R: so do you think the workshop =

I: they are in more control of what they are doing.

R: yeah

I: yeah

R: but the workshop itself is it pitched at the right level for the students in second year?

I: yeah, yeah.

A: yeah

R: you do think that

A: cause they could all do it, it was just when it was run it had good people who where quite willing to sit down and do it unfortunately the bad apples they just put off you know they could definitely, it is good.

I: yeah I mean it would have been interesting if you had done it as a sort of individual thing I don't know that might have been a bit more difficult for some of them because it was a group thing it was sort of they were able to sort of like work in it together you know as a group obviously that always happens with group projects you have a students but you know, I don't know I think it was. You know I think it was good as a group thing, it was good that it was a session sort of orientated thing where they sort of came and they worked together on things. I mean you gave them, I think the way you gave, broke it up was really good. It's taught me a lot of things for a start. But I mean we get things from that ourselves of how to run sessions with students now as well you know. Cause we were *–laughing-* make up as we go along. We go to things and I've been to other things as well and you pick up something you been to this and your own experience as well of being taught. You

know suddenly things ping out from years back and you go right I understand why I managed to do that after all this time and you sort of re-apply it. Bring it back in and it actually makes, it makes teaching or it makes learning more enjoyable for everybody I think. When you do wee sort of session things like that. And then they've got it, you've got them to get it and then they go off and do it you know and enjoy designing as oppose not really sure as to where their to go with things they've got a framework to work with you know. I think that's, you know, important for students of that age that they've got that. That's what first year just doing stuff, second year their starting to put it altogether. Third year their suppose to be doing it all themselves fourth year they are suppose to have got the skills and can do it. And it's amazing that they do it actually –*laughing*-

A: lets wait to see how this years third year do.

I: third year oh alright yeah.

A: in semester two it's self-directed, but anyway that's probably over a drink one night – *laughing*-

I: but again it's their sort of they've been here for four years and each year they are different beasts.

A: yeah

I: different ways of learning, different understanding of what they are suppose to do. Even like semester to semester they change and develop and progress. They don't come in, and that's what's interesting as well, they don't just come in and they can draw or they can do something what they can do they actually build skills all the way up to going out with something, you know something they didn't come in with for a start. Well a lot of things they didn't come in with you know which is quite interesting.

R: so were there any kind of disadvantages to the actual workshop anything that you could say that maybe need tweaking or needs changing slightly?

I: eh I don't know. Definitely practical things like space. I thought it was difficult to work with them in smaller rooms, like a lot of them in that room but that's just what we've got to deal with it's like engineering design and DFI in that room. We don't have that room any more anyway so. I don't know, just one thing that sprung to mind.

A: I can't think of anything but then again I was learning from it so it's difficult to be able to give you any negative feedback on that particular thing cause I was gathering the information myself so that's a positive =

I: = I think it's difficult, sorry.

A: no that's ok

I: it's always difficult like to know how to start these things as well in a sense. Cause you wanted them to do it without you telling them anything. Like what do you think give them a sort of what is the question. Just me, I know, would I know it about that (all that) sort of stuff so what do you and by getting them to think that sort of stuff and then you go

backward and ding this is what it's about with your out, out and stuff. I think they were really great actually. You know it'll give you that sort of and asking the audience when you get feedback from them what do you think it is, you know.

A: there is one thing, leave, let the pause be longer. If I had to pick on something you'd say what do you think of this, no one would say anything but you would answer almost. If you'd left to an uncomfortable pause I think somebody would say something.

R: when you actually explain the things

A: when you ask the audience. It sort of over the last two years I'll just sit there now, if I ask a questions I'll just sit there and somebody. In the end it gets uncomfortable for everyone and then you'll say well ok then what about. And at least your getting somebody to it's always the same people. So even point and say what do you think.

R: yeah

I: yeah, but I suppose if you were asking them, well take this problem what do you think about and then you were gonna tell them about something but also getting them involved in that, in you telling them but maybe not going as far as, well what's the answer cause your actually telling them the answer to start with giving them the sort of information that you thought they might have thought, you know.

R: I did find that when em, when I did the session with the third years I actually handed out sheets of paper with the answers on them. And in comparison with the second years the first lot they kind of. Obviously after a certain point in time when people are getting fed up and there not wanting to listen anymore. But when I didn't it with the third years they were much more involved because they had something to say and they felt confident in the fact that what they had in front of them was right, what they thought was right. But they felt confident adding extra bits to that adding to the discussion.

I: I know that, that's like you (.) well it's the sort of thing that we've sort of turned to in a way. You got a lot of other, you get courses like management where their given course material. Ok and it's like sheets that sort of tell them what they are gonna learn. Now it's up to them to read it and sort of take it on board and know what the person is talking about cause they've already read it. You know, so that was probably, so that was probably a good thing to have done. It creates the discussion as oppose to the you've got the knowledge and they don't have the knowledge and you just tell them and asking them wondering

A: that changes it from a lecture to a seminar

I: yeah

A: but a workshop by giving that to begin with. Cause otherwise if you don't give it to begin with they just think well we are gonna be told this so I wont participate so we'll just sit back.

I: yeah, yeah they'll just be passive. I mean it was brilliant. Workshop things are really interesting its like going to the theatre or something and audience participation, -*laughing*- choose me. But because everybody knows that's what's gonna, in a workshop thing, that's

what your there to do you sort of. You have to get use to the fact that your gonna have to do something and that's fine and everybody else is doing it so they don't worry about it they just get on with it. And you just wonder if students worry about that sort of thing or something comfortable.

A: again going back to the second years Eng. Des. And DFI and there was all these you know the eng. des. didn't want to do anything in front of DFI and DFI didn't want to do anything in front of the eng. des. Whereas in third year their, that third year and now our fourth year, they all get on, their all one group. So I think that probably helped as well that they're comfortable among each other and they don't mind speaking up and criticising stuff. And they're comfortable with each other. Whereas the second years weren't so may be that is that difference between the third year and the second year. Not just those particular years but may be they become more comfortable after being in the third years with each other to handle stuff like that.

I: yeah, yeah that's it

A: yeah it would be interesting to see if this years second year how they

I: to be honest they are a really good year I mean it's quite interesting actual I mean they'll probably deal with it really well. I mean we've already done, what have we done?

A: project wise?

I: well the RSA thing and the real needs thing that was a group thing and that was something like three weeks. You put them together as five in a group and you put them together and they go off and look at B&Q or sports centre or the art gallery and they just look and observe. Come back and do something creative and go away again. And try and then they came back and present it. No problem at all. Absolutely no problem. I mean some of the ideas were naïve to a certain extent because of the place they were having to visit like the Art Gallery, which was quite interesting. They hadn't a clue, they had never, never engaged. They had no idea what it's for.

A: I don't think they asked anybody they just assumed what would we want. But they're not going to gallery's often so they wouldn't know.

I: really interesting. Cause it obviously showed where, what they were used to sport centres, shops. *–laughter-* That was about it. You know they never, they didn't think that there might have been this other world out there.

A: culture

I: people did other things you know

A: but again it comes down to this designing for yourself. What would you want? Rather than designing for =

I: = maybe that's their age. Maybe that's the thing with the second years never mind how good or bad they are it's just their age and their own experiences you know and in third year =

A: = they are starting to understand they're not designing for themselves. And they've got to understand that there is, there is other people who will buy. I think that probably is a big thing in it.

R: the students that went on from the third years to the fourth years there is a couple of them that's actually doing sustainability. How do you think they've coped in comparison to previous years that have dealt with the subject?

I: em

R: Or is it too early to tell?

A: Darren is probably ok

I: I think they are totally aware of it. And I think some of them also like David Houston started off with a bit of a gadget boy thing about him and then got wise to the fact that hold on a minute it shouldn't be this it should be a sustainable product. And is now

A: he is yeah

I: maybe not so much as the others who are doing it as a subject for there project

A: he's just pulled it that way just in order to

I: yeah, yeah, which is pretty obvious you know suddenly he realised that other people were dealing with this, hold it, maybe this product needs to be that as well. It's really interesting cause he would never have done that before

A: no he just wanted gadgets

I: I mean really. And I think they are all there's that bit of they have a bit of pride in the ethos, no this is what we need to be doing we need to be designing in this sort of like

A: I think you'll find that every single person will touch on it in their fourth year with their, will touch on something about it. Yeah I'm positive even if it's down, if it's purely down to material choice or but I think you'll find a lot of them. So to answer your question I think their coping far better really you know =

I: = yeah I mean compare it =

R: = is it integrated then? Touching on it

A: yeah I'd admit that when we assess at the end of this semester two when we do the final I think everybody will touch on it in some way. There will be a paragraph somewhere or there'll be some designs around it or something like that. I think it'll the whole lifecycle side of things as well. I think so yeah I'm positive that would happen. Cause what they'll do, what'll happen is may be one in the group will be looking into that then someone else in the group I'll oh, I'll start looking that. And it'll refresh them and they'll go through

everything. And then you'll find that everybody has it and another person will speak up and do something else and then it'll spread out.

I: I think, I think the ones that are doing it specifically as a sort of product or subject I mean it's definitely with sustainability. It's like may be there is so much information sometimes, there's an awful lot, there's a lot of stuff, there's a lot of stuff in the press on, you know, because it is an issue. And therefore sometimes they get a bit too much, they've got too much stuff and they don't know what to do with it you know.

A: that's it, that's one thing they can't do is understand what is a theory as such and what has been applied and what should be I think a lot of them will actually say, they'll read something and say right that it, I'll just use this but not put an argument why this and this

I: there sort of gathering, there gathering all that stuff but they need to make there own decision what they want it be or what it needs to be.

A: but why is it appropriate as a recycled product where they might have read something a release which is you know that's 200 foot high by 200 foot wide. Is it appropriate for something to use the same. And that's. Some will, all of them will touch. So yeah definitely coping.

R: and the other, the other students in the other years I mean that have taken part in the workshops have they integrated any of the stuff prior or after they completed the workshop or just dealt with it only in that one project?

A: to be truthful I can't remember =

R: =You can't remember

I: I'd say second year. The first time you did it second year

A: semester two

I: was that semester two or semester one?

R: semester one

A: so what were the first projects semester two?

I: the second one was about brand, was that branding and stuff

A: yeah, I don't

I: that was a different subject, thing really that was being asked of them completely different sort of question

A: yeah that was more purely about branding it wasn't about materials or anything like that

I: the lighting, I don't know if they really did with the lighting thing.

A: nah the lighting. Cause the difference with the second years is that there are certain vehicles, which you use. Whereas with the third year obviously the product has to look at the whole lot. Now in the second year we give them snips of what we want to given them like the importance of branding within design or the importance of knowing about electronic and electrical engineering within design and stuff like that there quite tight and it's probably I don't think anybody would have looked outside that box and said right lets put this into it cause the way it was written it was pure, do this. Whereas the third year ones tend to be a little more open to give people more freedom.

I: yeah

A: but having said that

I: I don't know there might have been one or two perhaps maybe in the branding thing if they had to deal with something like McDonalds or that.

A: sorry yes

I: I was just thinking there was two who

A: what brands there was yeah, yeah sorry

I: cause what they looked at was what way the company portrayed themselves and they're seen to be

A: what did they want to be promoted as and what did they want to be perceived as. And somebody did do McDonalds, a couple of people did do McDonalds

I: yeah

A: and as a result you know obviously looked at the result of being eco-friendly and stuff like that

I: I think if we do that again we'll just need to give them companies some of them were not very good *–laughter-*

A: JCB, black and orange

I: And some of them just didn't get it either they had no idea what they were doing. Maybe that was our fault or something.

A: we'll sit down and try and think of half a dozen =

I: = I know

R: so you mentioned that there are vasts amount of information and taking that information on board. When I sat down with the students in all the workshops the information I gave them in terms of what sustainability id lasted thirty to thirty-five minutes. And you know yourself that was quite a bombardment of information. Em, what am I trying to say? Do

you think that information was clearly presented was. Was it, could it have been better? em (.)

I: don't know, I think yourself =

R: = you yourself =

I: = sit in a workshop thing I suppose if it's over days it's like you'll be able to go away and read it or something and take it in and do a research of some examples or something like that and as then when they come back to it with a clear idea of what it was as oppose to being in the environment trying to read something and take it in. It's like a bit of homework really isn't it?

A: yeah (.)

R: I was thinking in particular of the Ideas Factory when you guys sat in, in that. And there is a lot of information and you did say that to me at the time, a lot of stuff there.

A: to digest

R: yeah

A: if, it would have been nice for feedback on the, on the particularly on the Ideas Factory ones. Do you know what I mean? Do you know the designs which they'd done it just kind of em, stopped and then you went moved onto the next part of it. Or you could have done, have you thought about this, have you thought about this and then it wasn't quite the audience for it because a lot of them weren't design as such. It just kind of went, you just stopped and went very good, very good, very good move on. But you did that differently with the designers here. Because you kind of just said. It was a lot less formal as well here, which was good but maybe that was because you were much less comfortable. I know you were =

R: = I was pretty nervous =

A: = pretty nervous about it and everything that could go wrong did go wrong so you didn't start off on the best foot.

R: that's right

A: but em –*laughter*- nobody knew did they? But anyway that's a different story again. But em, I understood it better at the Ideas Factory one I think. Everything. Just going around everyone rather than here but maybe that's messed up cause that's the second shot.

R: that's interesting

A: but it was slightly different. I just found it slightly different as well. And I don't know whether at the Ideas Factory I was just the same as everyone else to a certain extent. Whereas here I was a member of staff they would probably think that I should probably know this stuff anyway

I: exactly, that's what happens we have to bluff it

A: you do, yeah you do. Whereas yes at the Ideas Factory I was

I: you were more (real) you were more informed

A: yeah totally more aware of it than at the workshops

I: I don't know I'm just trying to think through what happened day-to-day

R: it started of =

I: = session to session

R: the first session was providing them with the problem and then they had to brainstorm the problem

I: I can see all that in my head I can see them doing all that stuff, I remember doing that

R: em (.) yeah and then I did eh, I started to talk about the characteristics after that, evaluate a set of products and say which products were more sustainable and which was the least. And they did a set of evaluation before I explained the characteristics and then a set after to see you know how their decisions had changed. Cause they had to identify the problem with the least sustainable product and then from that identify the problems of the least sustainable product and then re-design it.

I: that's right

A: going back to your original question was thirty-five minutes enough. It probably is cause your giving them a taste little bit of everything. Now whereas, you know, and it's in layman's terms whereas if you get books out then you know trying to digest all so it is. I mean fair enough it's your opinion and things as well but that's good that's why your doing your PhD cause, you know. And in the context of design and the bonus thing for here is that you've done this course.

R: that's right

A: you know that marriage is very, very good. So it did work yeah. I'd have thought thirty-five minutes probably wouldn't have given them enough but it did do cause it was a success

I: I think it was absolutely fine

A: cause they had never touched on that before so it was a success so obvious thirty-five minutes was enough but as Ian said something the day before all the little hints and tips and pointers.

I: I suppose it's the, that they work as well. That they come in and do the session. I suppose it's been sort of a bit more as it was strict that they get to terms with what your dealing with to come back next time you know a bit more informed so it enables them to be bit

better at the workshop you know. As oppose to just sort of. I can't remember did you ever tell them, I can't remember if you did or not, did you say you were in groups and then you did it individually

R: that was right

I: did you tell them before that individually afterwards. Cause sometimes what you get is if people do it in groups you get some sitting around. And then suddenly you've got to do it individually, sorry, and some of them haven't really been paying attention. But if you are aware you've got to do it individually after you may get more people.

A: you may get more

R: that was one thing you commented on at the time when we were talking about the guys getting up and walking out. And you said to me at the time that if it had been kept in groups that the group dynamic would have been there and they would have may be been less likely to get in their klicks and get up and decided they were gonna do it at home.

I: yeah

A: that's also a confidence thing

I: yeah, totally I mean that's exactly what I was just thinking there I was thinking about them having to deal with that individually cause they probably can tolerate it. The ones are sort of less confident in the group. It's better for them as well, it is much better for them. It enables them, they have to engage with it just sort of

A: cause they're letting other people down in the group as well if they're not

I: yeah and they're also dealing with folk they aren't so familiar with as well

A: I think that's the thing with the Ideas Factory one cause that was all group and you got a lot of people throwing stuff into there didn't you? That was pure group. That wasn't individual at all was it?

R: no that was pure group =

A: = pure group, so I wonder if that's

R: the one thing that was done differently at the Ideas Factory was that there was no mind maps and those were done individually so maybe that's, that's the difference because the Ideas Factory was a very short very condensed, you know you've got ten minutes to do this and blah blah blah. And so there was, they were in the groups from the start to the very end.

I: I mean I think, you know, I think that's a good way individually getting the stuff out of your head and thinking what is this and then you sort of like get in your group and you can sort of can like discuss it. So you've all had a thought, had some thoughts about this and therefore you can all. And then collectively you can come up with ideas but then to do it individually as well. I don't know. May be as a group of that age group you suddenly

doing that individually suddenly you go (crack) and have excuses to go away and do something else. Which isn't so helpful but in a way may be you also need that, but that's their bit of homework or something and they have to. Come back with some thing as oppose to doing it right there. (.) you know cause it's probably easier as a workshop to do things as a group you know. As oppose to a workshop that's individual you know so if your doing like. If something suddenly becomes an exam or something you know. You know what I mean so if they're doing it individually that they need to sort of go and do it. Go do it and you give them that space to go and do it. Because they obviously felt self-conscious or something about having it there cause it isn't an exam really cause your trying to get them to be creative and understanding, understand it all.

A: it does come down to confidence quite a bit

I: cause when you do things in groups you design a thing in a group in a workshop situation there is always someone more in charge of things more than others. And you always end up with the thing that nobody really agrees on. *–laughing-* nobody thought of it in the first place, it's the donk, it's the camel you know. It's the horse, it's the camel that's meant to be the horse (.). So I don't know you never done. You're never to sure if that was. It's a good way of working together and you get something that not one of you would have thought of but you just wonder if that's the best solution. Cause sometimes =

A: = I'm all for them

I: I, I do enjoy doing it but I noticed with this one I did with the second year recently the sort of real needs thing recently, they would go out, well collectively think about the problem and they'd go out maybe in a group, mostly in a group to the venue think up things come back. But then what they would do between themselves is sort of you know all go off. You know, right well all go off and do our own ideas and then come back and then decide which idea they were gonna develop as a group. I sort of think that's ok but I'm not sure because sometimes you think there being too individual about what they got from their research and all that sort of stuff.

A: I suppose it depends on the people as well because for one of the real needs groups two out of the four had the same idea so that was very successful that was the one then and when they all came back in they said it there was something in this and that was what they went for but as you say there's probably loads. Some people aren't gonna be bothered that much but somebody thrashing stuff out.

I: I suppose they have to understand that when they design something on their own it's, they have to remember it's going back to sort of crited by the group which they are also one of. You know as oppose to this is an idea and like suddenly they come up with an idea and they go to the group and everybody goes no I'm not interested cause I think that happen in one of the groups one of the girls she came with something and thought well this is it. And one of the others said no it's not and got miffed *–laughter-* and didn't want to see anything else and just went I'm not listening and they had to compromise their design by like including a bit of technology, that was the art gallery one, which this girl just sort of thought no this thing has got to have this in it.

A: to make it more

I: to make it more trendy more right on or whatever. Actually the other ones didn't agree but they had to sort of consolidate and say right ok it's this design but it has this technology to keep you happy sort of thing which I suppose is not a very good way to design *–laughter-* you know, it's those it's like, Maybe it's the group thing as well not just the subject but to get them to understand how to work in a group, which I suppose is another project as well, you know. It's just another, which is interesting we did it after your one we did it in the school with the third =

A: = third year, yeah

I: all third years they did that first actually though they did that before yours then they did you. Cause the second year did it and then the third years. So they would have done the thing that is more is like group work (.) mmm. Maybe that might have made a difference I don't know. It might have, you know that understand of working in a group and what your trying to do, but (.) cause that's probably why they were more sort of able to cope with it vocally with ideas.

R: I found the third years quite vocal about their ideas as it was I think they had a lot of confidence

A: that's cause they're comfortable with each other

I: I know that's true. Second year are like that just now as well, but there funny as well, really funny and their not like sniddy or anything some of them can get a bit clever well one of them but there's the others that sort eh, and it's the banter that sort eh you know there quite funny actually

A: we =

I: = cause you can see, they say something and you sort a go ohoh and you can see them sort a go, any questions. Yeah I've got a question see that thing you said early on. And the guy's going I know alright *–laughter-*

A: I just couldn't get over it cause we never I don't think we asked a questions between us on the last presentation it all came from the floor

I: yeah I was trying to sort of like keep it. But they just kept asking stuff. And then at the end of the day we sort of try to sum it up in some way you know, but. Eh, it was really good, really interesting. Anyway (.) see I think I missed that one I think I missed that, I don't remember all that stuff (.)

R: the designing part?

I: can't remember (.) only one of them that I missed.

A: the designing part I think was ok. I think again they were comfortable to a certain extent it's just the individual I think which was a bit. Some the year some of them didn't like unfortunately that comes down to confidence it does.

I: I suppose it's also like some of them being well consciences and engaging with what they are being asked to do which I suppose some of that age group don't if there in the right group they will if they're in the wrong group I mean there was one group that was just sort of trying to be funny.

A: yeah

I: now (.), now I suppose if nothing, if everything matters and nothing is wrong sort of thing that's ok there allowed to do that you can't sort of criticise them, go like you lot get more focus on what your suppose to do or actually this is wrong. Can you say that something's wrong you can't do that (.) I mean I suppose we've got that in second year just now as well we did the RSA thing. We did some post-it notes and all that stuff on the wall. Five, five groups just one group just really didn't do it. Cause this group were a group of lads that really weren't that clever you know but the rest of them did it were quite able to and they were quite able to get a result. When they use it yeah and they'll remember that sort of methods (.)

R: so the actual designing itself I mean do you think that was of any advantage?

A: it was quite blue skies for them as well which is something if you look at it like that but it's not it's putting things which they probably wouldn't never have thought of before so.

I: mmm, I think so, I do think that sort of collectively designing stuff they, but also. Oh yeah I think they have come up with something that they wouldn't have designed.

A: yeah exactly cause it's stuff like this is unconventional and I think students at the time were think right you know I couldn't do that I can't do that cause it's too gimmicky and stuff so that bit in fact what they've proved to themselves is not it's actually a good solution to a problem.

I: there was a good argument to have a design like this as oppose to if you design it without that purpose without that argument you could say it was just a gimmick or two. But actually if you've got a definite argument a definite reason for it to be like this.

A: yep, which they did.

I: it makes the design more credible more

R: they did giggle quite a bit through, the transcriptions of the videos that I've done over the Christmas period, they actually presenting their work there was a lot of giggling and laughing.

A: but that could again be a confidence thing and them thinking if I giggle then people might think it's just a joke but I'm actually quite serious about this.

I: I mean I think it is, yeah, it's that fine line between the sort of novelty and the sort of heavy concept. It's like something that's very conceptual not but it's actually like a bit, like the verging on the just stupid, you know. So if you got, I don't know if it's just getting them, at that age get them to sort of cope with that whereas something that's a bit silly and not cool sort of thing. They'll see it and all their chums will sort of be going =

A: = they'll be taken the mick

I: it's like what's that suppose to be you know. And that's very restrictive that sort of age group in designing. I mean we don't care less about anybody right age *–laughs-* and he enjoys it and you can see why things are the way they are and you can see why you know things that might seem a bit far fetched are highly relevant become relevant. Your always sort of saying the Walkman or the phone or the tele you know the noises in the air how weird is that and suddenly it becomes =

A: = the norm

I: yeah. And it's trying to crack that with them as well. And I think some of them, I think the second year are quite good at that just now, there good at just coming up with ideas that and sometimes I'm just sitting there going that's silly this is a bit of a novelty factor

A: bring it back a little

I: but you don't want to restrict that creativity you know. And if they can see that being a product in society and it fills their needs and all that sort of thing you can't restrict them, you know, because it's the practicality of getting it done.

A: it's best to get it done rather at uni. And be a little bit silly and stuff like that but understand that going through the years understand what is a silly design and what is something that can be taken through and understand. Cause obviously if you go into a consultancy and somebody's paying you x thousands of pounds and you came up with a silly design they'd say give me my money back

I: exactly but if you tell them how it's happened and what it's for and there was a reason =

A: = if you had an argument for it them that's when you start changing people's views and that's when having the knowledge in order to do that.

I: yeah that's right

A: that big question, why?

I: yeah I mean that's why, that's what that's, how we assess things as well it's the process of what they've done as oppose to the thing your sort of going oh. Tick that looks like a five, six or whatever. Your actually thinking about how that came about and that's what your assessing as well sort of like you want to see that method =

R: = thought process

I: like the thought process as oppose to the thing itself =

R: = as oppose to em well it achieved it's specific target it's the thought process that's involved

I: yeah

A: how do you get to that point. It's like the cliché I always got told at school you know in the maths exams it doesn't matter the answer may be wrong but it doesn't matter if the process, you know that's the more important part

I: yeah, yeah

A: stand the steps in between that can be sorted later it's actually getting an understanding to that point

I: I mean we go about that to them all saying we'll that's what we are assessing that's what we're looking at and you have to sort of document that and show there is a process sort of. You know it's not just the fact of going through it's showing that you understand it therefore the product at the end of it has a reason to exist cause you've gone through all the stages.

R: so how do you think the workshop helped them cope with that, help them understand that process with that specific topic?

A: You were giving them little stimuli's and stuff like that in order to get them to think a little bit more and a little bit more. You were almost pushing the process by the different sessions. Do you see what I mean, which is good, which is good cause they kind of understood them. I mean it's difficult for us to teach design in a couple of days as far as you know where to look at. I mean really the design process in it could be research, concept, development, finalise and produce but it's where you're going off on that. But what you did, with your thing which was very, very good when you gave them the. Your always giving them a fingernail and then you were asking them to go and find the finger which fits to the hand do you know what I mean just to try to give them a bit more I think that was quite good about it cause they started then and then obviously they started understanding how to put it all this together you know with people going into and looking into this in their fourth year they're going into it and they understand it.

I: I mean they can also ask themselves questions they can have a sort of, another thing that we go on about is like the criteria for the design it's like through research you can pick up on certain things and say well it needs this, that and the other. It needs to be all those things so you can cross reference your final ideas of your concepts ideas with what it actually needs to be. I think second years don't really get that just now but I think third years definitely do they've done that in second year, thinking of this project that was the sort of difference, that was the sort of sophisticated understand of what it is they were suppose to do. They could actually go back and go well what are we being asked to deal with. Because that brief, you know, what was pretty specific what and that website you know they had to look at.

A: demi

I: so they, so it definitely has to do this it definitely has to relate to this and the second year lot a couple of them can deal with that but I don't think a lot of the others can I think if they did.

A: they looked at it cause they'd been told too rather than needing, that they understand that they're needing to understand this they just looked at it and printed it out probably for our benefit

I: no it think that's true cause I don't think they really. It's not like they personally believe that it's gotta be the way it is yet. Which is what fourth year do you know and some of third year I think may be

A: some went to other websites and say right well this is almost contradictory you know they had the foresight to question what they had been told on the brief to go and understand and I suppose you know at the end of the day if you can support your argument for a particular thing by using that then that's fair enough (.).

I: anything else. What else?

R: no that's it, I think you've covered all my questions

10.10 Channel 4 Ideas Factory

SPD Master Class Participant Questionnaire (Sample)

Please circle the most appropriate answer

1. On a scale of 1-5, with 1 being very enjoyable and 5 being not enjoyable al all, please indicate how enjoyable you found the master class on Sustainable Product Design (SPD)?

   1 2 3 4 5

2. On a scale of 1-5, with 1 being very appropriate and 5 being not appropriate at all, please rate the appropriateness of the master class for your designing requirements?

   1 2 3 4 5

3. On a scale of 1-5, with 1 being very much developed and 5 being not developed at all, please indicate how much this master class has developed your understanding of SPD?

   1 2 3 4 5

4. On a scale of 1-5, with 1 being very useful and 5 being not useful at all, please indicate your feelings regarding your involvement in redesigning a product as a method of exploring some issues of SPD?

   1 2 3 4 5

5. On a scale of 1-5, with 1 being very useful and 5 being not useful at all, please indicate how useful you found the discussion relating to the characteristics of SPD?

   1 2 3 4 5

6. Any other comments?

10.11 Workshop Facilitation Notes

Sustainable Product Design

A one day creative workshop exploring the integration of sustainability in product design practice.

Content

1 Introduction

1.1 Aim

This workshop is designed to:

- Allow you to explore sustainable product design through design methods and practice.
- To introduce the set of characteristics of SPD
- To encourage the integration of sustainable thinking as an intrinsic part of design practice.
- To develop a basis of understanding of SPD that can be carried onto professional practice.

This workshop has been created to provide space for new designer's to explore through design practice SPD. It invites new designer's to define what is not sustainable in order to decipher what is sustainable. It provides them with an opportunity to understand SPD theoretically and in relation to their own design practice. Throughout the workshop participants will develop a practical understanding of the role of the designer and design within sustainable development, which can be built upon and carried onto professional practice.

1.2 Learning outcomes

By the end of the workshop you should be able to:

- Think beyond the environmental impact of material selection, product and disposal to consider human factors in the generation of sustainable products.
- Integrate sustainability as an intrinsic part of the design process, being able to generate creative and innovative sustainable product solutions.

2 Workshop Programme

09:30	Introduction to the workshop
09:35	Task 1: Mind map of sustainable product design (15mins)
09:50	Overview of the workshop
10:00	Task 2: Problem-solve – what is not sustainable? (30mins)
10:30	Break
10: 45	Task 3: Discussion – what are the set of characteristics of SPD?
11:30	Plenary session: wall chart of the set of characteristics of SPD
12:00	Task 4: Product evaluation
12:15	Task 5: Identify design problems
12:30	Lunch
13:30	Task 6: Design a sustainable product
16:00	Task 7: Mind map of sustainable product design (15mins)
16:15	Plenary session: Presentation of sustainable concepts
17:15	Conclusions

3 Requirements of the Workshop

3.1 Level of prior knowledge

No prior understanding of the issues of SPD is required to participate in this workshop. Participants, product design students, must possess knowledge and a practical understanding of the product design process. This level of understanding is required to allow the students explore through problem solving techniques the issues of sustainable development relevant to product design as well as allowing them to explore the integration of these issues into design practice.

3.2 Venue

Due to the nature of the activities involved in the workshop there are specific requirements of the venue. Each student group requires wall space for brainstorming, with a design and appropriate number of chairs adjacent. Due to the nature of the set of characteristics of

SPD it is not appropriate to hold the discussion in a lecture theatre. This type of venue hinders discussion and student involvement. A less formal venue is more appropriate for the workshop, a circle of chairs with the facilitator sitting as part of the circle helps the students to feel at ease and encourages contribution to the discussion.

3.3 Facilities and Equipment

Equipment required to carry out the workshop, other than those included in the workshop package, include:

Post-it notes
A3 paper
Drawing equipment

4 Activities

4.1 Task 1: Mind map of SPD

Student Instruction

On an A3 sheet of paper:
Individually create a mind map that describes what you understand by the term sustainable product design.

Notes for the Facilitator

Purpose

This activity along with the mind map generated on completion of the workshop provides the participant with visual evidence of a shift in their thinking and understanding of sustainable product design. A comparison of the first and second mind map may show a shift in thinking from a general understanding to an understanding specific to product design that goes beyond the environmental impact of material selection and production, and end of life strategies.

Role of the facilitator

The role of the facilitator is to instruct the participants, provide further instructions on how to mind map if necessary. To ensure that the activity is complete individually.

4.2 Task 2: Problem solving – what is not sustainable?

Student instructions

Using post-it notes, in your groups:

Brainstorm the possible ways a product could be not sustainable. What are the various ways your group, as a design team, could design a product that is not environmentally friendly?

Notes for the Facilitator

Purpose

This activity allows the participants to begin to explore the problem, what is sustainable product design, by identifying what is not-sustainable.

Role of the facilitator

The role of the facilitator during this task is to answer any queries and provide product prompts if required.

Equipment

Adequate wall space for brainstorming and post-it notes is required for this activity.

Prompts

By considering products the students may be able to think further in terms of what is not sustainable. Prompts should be introduced to each group when the facilitator feels that the group cannot go further with their brainstorming. It is suggested 10-15 minutes into the activity. Once the prompts have been introduced the facilitator must ensure that the students do not continue to list more products, instead concentrate on what makes these products not sustainable.

Examples of prompts: nappies, soft drinks bottles, personal computers…

4.3 Task 3: Discussion – what are the set of characteristics of SPD?

Student Instruction

As a group:

Participants are provided with a keyword and definition. The facilitator will lead a discussion on the set of characteristics of SPD, when the facilitator mentions the keyword the participant reads out the definition.

Notes for the facilitator

Purpose

The aim of this activity is to provide the participants with an understanding of the set of characteristics of SPD.

Role of the facilitator

The facilitator leads the discussion, encouraging the students to participate and ask questions.

Venue

Space for all to sit in a circle to discuss the set of characteristics of SPD.

Plenary Session

Student Instruction

Place your keywords and descriptions underneath the appropriate characteristic heading.

Notes for the facilitator

Purpose

The purpose of this activity is to encourage reflection and discussion amongst the participants as they negotiate which characteristics heading their keyword lies under. It also illustrates that the set of characteristics of SPD are inherently linked.

Role of the facilitator

It discuss why the keywords are placed under each heading.

Venue

Wall space is required for this session.

4.4 Task 4: Product evaluation

Student Instruction

Using the information gained from the previous discussion, in your groups, evaluate three products to determine how sustainable they are. Discuss within your group, which is the most and least sustainable product, providing reasons for your decisions.

Notes for the facilitator

Purpose

The aim of this activity is for the participants to consider the set of characteristics of SPD in relation to products.

Role of the facilitator

The role of the facilitator is to mediate discussions as they visit each group. To encourage the participants to provide justification for their choices.

4.5 Task 5: Identify design problem

Student Instruction

Concentrating on the least sustainable product chosen by your group through the product evaluation, identify and list all the problems with the product. This list should cover sustainable, user and performance issues.

Notes for the facilitator

Purpose

The purpose of this activity is to provide the participants with clearly identified problems to address when re-designing the product.

Role of the facilitator

The role of the facilitator, as they visit each group, is to ensure that the participants list all problems.

4.6 Task 6: Design a sustainable concept

Student Instruction

As a group:

Re-design the identified least sustainable product to perform the same function, providing the user with the same function in a more sustainable way. Re-design the product to concept stage.

Notes for the Facilitator

Purpose

This activity allows the participants to negotiate the set of characteristics of SPD in relation to their own design practice.

Role of the facilitator

The role of the facilitator is to observe and aid the design of sustainable product solution by asking the students questions to focus their thinking.

Equipment

The participants require desk space to design, as well as standard drawing equipment.

A3 paper
Pens and pencils
Colour pencils/markers

Plenary session

As a conclusion to both the workshop and this task the participants are required to present their concepts. Each group has five minutes to address:

- The problems the group has identified with the least sustainable product
- The groups re-designed sustainable concept providing justification as to why this design is more sustainable than the original
- Describe the problems your group came across while designing

4.7 Task 7: Mind map of sustainable product design

Student Instruction

On an A3 sheet of paper:

Individually create a mind map that describes what you now understand by the term sustainable product design.

10.12 Published work

<http://www.ub.es/5ead>

Designing a sustainable future: a new approach to influence design practice

Kirsty Cull, Julian Malins

Key words: Sustainability, product design, design education, design brief, design practice

Abstract

This paper questions the basis of a sustainable approach to product design in an attempt to clarify the key issues which are liable to influence the outcome of the development of new products. The paper describes research undertaken to establish a set of sustainable characteristics for product design. It describes in detail how the characteristics can be used as a tool to influence the design process. The paper goes on to describe how the characteristics have been incorporated into an educational tool for assisting product design students to assimilate the inherent contradictions they face when addressing sustainability. Two case studies are reported: the first is based on the author's own design practice, illustrating how the characteristics could be incorporated into the design process; the second study reports the outcome of the application of the characteristics as an educational tool when applied to a group of product design students.

INTRODUCTION

With the implementation of legislation and directives forcing 'producer responsibility' through the entire lifecycle of a product, sustainability has become an increasingly prominent issue for design professionals. Many companies are now expressing the need for environmentally literate product designers, but are having difficulty recruiting as traditionally product designers have not been trained to deal with sustainability (Tischner & Charter, 2001: 122). The designer's ability to assimilate ideas, values and specifications within a single product provides them with an opportunity to influence design towards sustainable solutions. Incorporating sustainability into a design solution requires the integration of sustainable thinking as an intrinsic part of design practice. This represents an additional layer of complexity in the design process. Some of this complexity comes about because of the difficulty in defining the term 'sustainability' which is subject to a wide range of interpretations depending on the context and particular agenda of those using the term. Sustainable product design (SPD) is complex in nature; it is a multi-faceted collection of problems that are amorphous, where the information is confusing, where there are conflicting values and where the ramifications of the whole system are unclear. This complexity is characterized by the difficulty of accessing information specific to the design process. If the designer wishes to incorporate sustainable values into their design solutions they would be

required to be familiar with a substantial body of literature. A time consuming and demanding task which design professionals working to a client deadline are liable to find difficult to achieve. Complicating design's adoption of sustainability further are the inherent contradictions faced by a designer when considering

sustainability, conflicts exist between value judgments, societal norms, economic considerations and practical issues such as legislation. Sustainability also requires a designer to consider the design problems in context rather than in isolation.

The hypothesis underpinning this research states that design professionals are in a unique position to influence patterns of consumption by incorporating sustainability into new products. One way of achieving this outcome is by providing the design professional with an understanding of sustainability at the earliest phase in the design process. In order to test this hypothesis it has been necessary to formulate a set of core characteristics which represent SPD and to find ways in which these characteristics can be incorporated into design practice at an early stage. The result has been the development of an educational tool for use with product design students.

Two case studies are reported within the paper: the first is based on the author's own practice as a designer researcher undertaking a Ph.D., utilizing design practice to inform the characteristics from the perspective of a product designer and illustrating how the characteristics could be incorporated into the design process; the second study reports the outcome of the application of the characteristics as an educational tool when applied to a group of product design students. The outcome of the research demonstrates how complex ideas can be incorporated into design practice and how concepts of sustainability can be instilled into the designer's lexicon so that they in turn can become sustainable designers. The objective of this paper is to not only report results from the case studies but to point to the challenges; the types of questions that have arisen; and to describe the use of the design process as a methodology.

DEFINING SUSTAINABILITY

SPD and eco-design are terms for strategies that aim to integrate environmental considerations into the design process, but confusion exists between the definitions of these terms. Life cycle thinking forms the basis of both these terms. Eco-design aims to minimize the consumption of energy and resources and the subsequent consequence on the environment, concentrating on reducing the impact of individual stages of a products life span. SPD priorities the reduction of environmental impact in the whole system. This requires the designer to consider the design of a product in context of material extraction, production, distribution, need, societal issues, human factors, function and disposal. The United Nations conference report Our Common Future provides a definition of sustainability in relation to development, as *'meet[ing] the needs of the present without compromising the ability of future generations to meet their own needs'* (Brundtland, 1987: 48). This definition provides an aim that permeates all sectors of industry and society, however it does generate questions, such as what constitutes a need?

2 Design Explaining Sustainability

There have been a number of attempts to define criteria for sustainable product design (James, 1997; Design Museum, 2000; Dewberry & Fletcher, 2001; Fuad-Luke, 2002). Datschefski (2001) provides a comprehensive set of pragmatic criteria for SPD, addressing end of life strategies, efficiency, the prevention of hazardous emissions and doing more with less, formulated from a review of products for their

environmental innovation. Whilst doing this Datschefski pays less attention to qualitative, human factors issues such as inclusive design, consumption, interaction and aesthetics. Stuart Walker (1998) offers a set of qualitative criteria for SPD developed from an exploration of abstract and theoretical ideas through design practice based on the notion of local production.

These criteria do not address the pragmatic issues but do draw attention to the importance of the relationship between the individual with their material culture and the importance of aesthetics.

Initially this research involved the collection of criteria from an analysis of products that claim to be sustainable. Design is recognized as having its own distinct epistemological traditions; its own tacit knowledge and methods (Cross, 1999). A method used at the early stages of the design of a product, is the analysis of products informing the designer of existing design problems and competitors solutions. This method was adopted and adapted for the doctoral study allowing existing sustainable product solutions to inform the generation of the characteristics for SPD (figure 1.). This exploratory method illustrated the complexity of achieving SPD solutions, demonstrating that one product cannot embody all the characteristics of sustainability. The characteristics were derived from two sources of evidence, from the literature review which provided a range of definitions based on recognized authors and from information resulting from the product analysis which provided insight into the effective and ineffective use of aesthetics, ergonomics and product scripts.

As a conscious effort to move away from checklist based criteria for SPD, which require the completion of the design before evaluation, the characteristics were explored through visual mapping. Framing the characteristics visually and adopting an appropriate language lead to the description of the characteristics that a product should possess to be sustainable. The characteristics were re-framed from a rules based set to a heuristic set forming a set of advisory statements for adoption by design professionals. This move represented an epistemological and creative shift in methods and theories of SPD.

DESIGN PRACTICE

The process of design involves the collection and conflation of needs, observations and values in the mind of the designer. *'This suspension of thought allows a pattern to evolve, providing designers with a picture, which depicts the inter-relationship(s) between different and often contrasting elements of a problem'* (Valentine & Baxter, 2002: 238). The intention is that by exploring the characteristics of SPD through the researchers' own design practice, the

characteristics will be in a form which is more applicable to the needs of the designer. The researchers practice focused on the problem solving, idea generation and concept stages. Problem solving was employed in two steps: step one identified the problems with existing products on the market and various solutions were generated; step two involved the generation of possible solutions to problems identified by the characteristics in relation to a specified design scenario. Solutions generated from both steps were conflated

into a series of initial concepts, which were evaluated in relation to the design scenario. This iterative process resulted in the design of three sustainable product concepts (figure 2).

Following an analysis of this design practice it became apparent that a useful division of the characteristics would be between those that are pragmatic and those that are qualitative in nature. As the process of designing unfolded it became clear that the pragmatic characteristics constrained the generation of ideas, due to predetermined options. An example of a pragmatic characteristic with pre-determined options would be end of life strategies, options include recycle, reuse, repair, remanufacture, disposal or extending a products life. These predetermined options make the pragmatic characteristics easier to address, arguably this is due to their nature or the designers' familiarity with them. The qualitative characteristics do not hinder idea generation, however these are maybe unfamiliar to the designer and how to address them presents more of a challenge. The conclusions of the exploration of the characteristics through design practice illustrate that the qualitative characteristics of SPD should be addressed at the problem solving and idea generation phases of the design process and the pragmatic characteristics as concepts are explored and developed.

THE CHARACTERISTICS OF SUSTAINABLE PRODUCT DESIGN

The formulation of the characteristics of SPD is an ongoing and iterative process. The characteristics aim to provide the designer with a framework of understanding of the problems and opportunities of SPD. The designer will be able to build upon this framework as advances within the field occur. Designing a sustainable product requires the consideration of all stages of its life span: the function; manufacture; distribution; the consumers needs and desires; product performance and interaction; and appearance. Unlike other attempts these characteristics of SPD address all these aspects, describing problems with current practice and design opportunities in the framework of production and people: pragmatic and qualitative. The characteristics of SPD have been divided into five taxonomies these are as follows:

• The product is designed with an *end of life strategy*: An appropriate and safe method of disposal once the useful life of a product has expired is determined prior to production. Clear instructions, written or visual on appropriate disposal of a product are provided. This taxonomy address characteristics such as recycling and eco-labelling; reuse; familiar fastenings which allow the user to repair or remanufacture; the use of biodegradable materials e.g. in food packaging; and durability extending a products useful life.

• The product is design to *do more with less*: Efficient use of resources and energy during production, distribution, use and disposal. This includes the use of local production and resources creating employment; applying renewable energy e.g. wind, water, solar or man-powered, and renewable resources; the creation of virtual products that provide services e.g. sharing of products; miniaturization; and multi-functional products e.g. the Black & Decker Quattro tool.

• The design of a product *influences individuals to adopt sustainable and sufficient patterns of consumption*: this taxonomy maintains the need to develop alternative forms of the act of consumption in order to encourage consumers to adopt purchasing behaviour that serves their needs without having detrimental consequences on available resources, economies or the environment. This must be achieved through a period of transition that does not correspond with a scenario of giving up (Manzini, 1994). Characteristics include exploring alternative forms of products such as virtual products or services; questioning the needs the consumer is trying to achieve through the purchase of a product; and customization.

• Product scripts address *real behvaiour, satisfy real needs and encourage users to be proactive*: The intended plan of use of a product should address real, rather than ideal behaviour patterns, satisfy real needs rather than transient fashionable or market-driven needs (Fuad-Luke, 2002). It should also encourage the adoption of sustainable behaviour through product scripts. Characteristics include constraining actions that result in use that is not sustainable; research and observation; inclusive design and considering the needs and wants of a consumer.

• The product displays *seductive, simple and appropriate aesthetics*: The aesthetics of a product play a significant role in its adoption, aim to create the 'I like it, I want it, what is it?' (Seymour, 2002) element in a product. This taxonomy requires a move away from the transient styles and stereotypical aesthetics in order to design a competitive product. The characteristics ask: what type of consumer is the product trying to attract? And what lifestyle image does it offer the consumer?

EDUCATIONAL TOOL

Early investigations considered the design brief on the basis that this was in most cases the earliest point a designer is involved in the design of a new product. The conclusions from this initial inquiry were that the design brief is too late a phase in the design process to ensure that a sustainable product will result. This early conclusion might be interpreted as; the designer is powerless to influence the sustainability of a new product unless it is one of the specifically mentioned criteria for the new development. However subsequent research indicated that

provided the designer possesses an understanding of the characteristics involved in SPD it is possible for them to incorporate these concepts into design solutions whether specified by the brief or not. The most appropriate juncture to inform a product designer about SPD is as part of their training and education. Based on the information and data gathered, an educational tool aiming to inform designers of the key issues liable to influence the outcome of sustainable products. The educational tools target audience is undergraduate design students. The aim being to provide them with an understanding of sustainability in relation to the product design process through interaction with the characteristics of SPD and subsequently carry this information onto their professional practice.

It was important to consider the most applicable manner to educate product design students in sustainability. Gray (1988) asserts that the intentions of teaching, the role of the lecturer and the teaching method need to be considered. The educational tool applies a constructivist approach to learning, requiring the participants to develop and negotiate the generation of concepts. The application of problem-centered learning provides a

catalyst for generating new knowledge of how sustainable concepts can be incorporated into the design process.

Critical thinking through interaction and reflection is beneficial for design students as it allows them to interpret the characteristics of SPD developing knowledge that can be transferred to a variety of design problems. The educational tool provides a framework for a workshop. In this context the term workshop is used to describe an intense period of study focused on generating an understanding of the characteristics of SPD utilizing design methods and practice. The resulting tool is broken into three stages: stage one introduces the design students to sustainable product design through identification of their current level of understanding and the students development of this understanding using problem solving methods; stage two introduces the characteristics of sustainable product design in the form of an interactive seminar employing key phrases and product examples; stage three mediates the assimilation of the knowledge gained and applies it to design practice.

The workshop consists of a series of activities undertaken by small groups of design students instructed by a workshop facilitator. The activities were adapted from design practice as familiarity with the activity allows the design student to concentrate on the task in hand of the workshop rather than the context. The activities involved in the workshop (figure 3) are described under the three educational tool stages:

Stage One:

• Individually the design students create a mind map describing what they understand by the term SPD. This timed activity introduces the student to the problem and provides data on the level of understanding the design student already possess prior to an explanation of the characteristics of SPD.

• In small pre-designated groups, the design students generate as many as possible characteristics a sustainable product could possess using brainstorming. They answer *what are the various ways a designer can design an environmentally friendly product?* To aid this, the students are allowed to consider products.

• Evaluating the results from the brainstorming session, the students select and develop a set of sustainable design criteria that can be used to critically evaluate the sustainability of a variety of products.

Stage Two:

• Using the sustainable criteria for the evaluation of products created by the students, each group is provided with three pre-selected products to evaluate and determine the most and least sustainable. The pre-selected products possess both sustainable and un-sustainable aspects encouraging debate among the student groups. In this particular workshop products included a Nike running shoe, chopsticks, a bottle of water, a wind up radio, a plastic bag, and single use coffee filter.

• In the form of a seminar, the workshop facilitator explains to the students the characteristics of SPD, using keywords, product examples and questions. It is at this juncture clarification is gained by the students of the actions and considerations to be taken in design practice in order to design a sustainable product solution. Student preconceptions and misunderstandings are addressed.

• With an understanding of the characteristics of SPD, in their designated groups the students re-evaluated the three pre-selected products and decide which is the most and least sustainable.

Stage Three:

• Concentrating on the least sustainable product the students identify and list problems with the product. Problems involve interaction, function and un-sustainability for example, is the product harmful to the environment and people's well-being.

• Using the list of problems identified from the least sustainable product the student groups brainstorm possible design solutions.

• The student groups collectively re-design the least sustainable product to be sustainable. A sustainable concept is produced and presented describing the problems addressed and reasons are provided on why this concept is more sustainable than the original product.

• Individually the students create another mind map describing what they now understand by the term SPD. Again this is a timed task. This provides useful data for evaluating the success of the workshop. The inclusion of designing in the workshop provides design students with an opportunity to assimilate and integrate the characteristics of SPD into their design practice. This practical activity focuses and encourages sustainable thinking as part of the design process.

Design Explaining Sustainability /7

Two workshops were carried out: workshop one involved second year undergraduate students from BSc(Hons) Design for Industry and BSc Engineering Design, product design and industrial design courses respectively; the second workshop involved third and fourth year undergraduate students from BSc(Hons) Design for Industry. All courses are based at the researchers host university.

Throughout the workshops 'reflection-in-action' (Schon, 1983) was applied providing provision for alterations to take place. The researcher took the role of the workshop facilitator. Participant observation recorded as field notes provide data on the students' interaction with the workshop activities, reflection on the workshop design and how it was conducted and provided notes on areas for change or improvement. Mind maps individually produced by students' prior to and on completion of the workshop provided immediate data for the evaluation of the workshop in terms of fulfilling the objective of raising student's awareness of sustainability.

WORKSHOP ONE

The mind maps individually produced by the students prior to and on completion of the workshop portrayed a refocusing of understanding. Initial mind maps focused on environmental problems and development of the word sustain, in terms of life extension or maintaining. Mind maps produced on completion of the workshop were design focused; first level branches described alternative power sources, safe production and end of life strategies, as well as design options such as multi-functional products. Design students concentrated on the pragmatic characteristics.

Analysis of the sustainable concepts produced by the student groups also showed the students were able to address the pragmatic characteristics, but generally were not able to assimilate the qualitative characteristics into the design of their concepts. This may be due to the level of understanding the students possess on human factors or difficulties in understanding the qualitative characteristics.

Concerned with this outcome, the researcher revisited the qualitative characteristics through her own design practice. As previously stated, the inquiry concentrated on the problem solving, idea generation and concept development phase. It was concluded from this that the qualitative characteristics are applicable to the design process although problem solving methods need not be restricted to brainstorming sessions.

WORKSHOP TWO

Informed by the initial workshop, changes were made to the structure of workshop two. Due to the students' difficulty brainstorming characteristics of SPD, student groups were asked to brainstorm characteristics that were not sustainable. Explanation of the characteristics of SPD was altered to increase student involvement. Each student was given a characteristic and description, which they presented to the other students and the workshop facilitator expanding upon when necessary. After the students description of the characteristics of SPD they created a wall chart by placing the

characteristics under the taxonomies. This activity generated a substantial amount of debate amongst the students and the wall chart was continuously referred to during the design project.

Analysis of the mind maps produced individually by the students again portrayed a refocusing of their level of understanding of sustainability in relation to product design from development of the word sustain (for example product life expectancy, planned obsolescence, durability) and environmental concerns in the first mind map (figure 4), to descriptions of SPD in the second mind map (figure 5). Analysis of the mind maps produced on completion of the second workshop in relation to the first workshop showed that this group of students were able to understand the pragmatic and to a certain extent the qualitative characteristics. However the students had more difficulty addressing the qualitative characteristics in the generation of sustainable concepts, requiring assistance when including consumer/user actions.

CONCLUSION

SPD is complex. In order for sustainable solutions to be generated, sustainable thinking needs to be integrated into the earliest possible phase of the design process. To influence the design and development of sustainable product solutions, designers must be informed of the characteristics of sustainability relevant to the problems they are tackling. Finding ways to inform designers similarly needs to be achieved at the earliest possible stage, the education and training of new designers.

The design and application of an educational tool aiming to provide designers with a framework of understanding of the problems of current design practice and the opportunities SPD offers has been described. Applying design practice the educational tool, in the form of a workshop, has altered product design students understanding of sustainable product design and aided the integration of sustainable thinking into their own design practice.

SPD is a moving target of increasing importance. Legislation and initiatives place new demands on manufacturers and designers to acquire these additional skills. Design has a unique contribution to make, this should be see as an opportunity for designers to draw upon their skills to generate innovative solutions that make a difference.

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Design Explaining Sustainability / 11