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Design and the Material Cycle

An Investigation into Secondary Material Use in Design Practice

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December 2010

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KINGSTON UNIVERSITY in collaboration with LONDON REMADE

This thesis is submitted in partial fulfilment of the requirements of Kingston University for the degree of Doctor of Philosophy

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Abstract

Since the UK government's *Waste Strategy* was introduced in 2000 there has been sustained emphasis on the diversion of waste material from landfill and it has been acknowledged that stable markets for secondary materials must be developed to ensure that the resources used to recover them are not expended needlessly. This thesis looks at the issues surrounding a designer's ability to select secondary materials for the production of new artefacts and proposes a new framework for supporting that activity. While in the past recycled materials have mainly been used either for highly visible 'one-offs' or hidden components the stance taken here is that both creative design and volume production are essential for stable markets in the short term and effective materials cycles in the future. Therefore product and industrial design was the initial focus of this research.

The investigation involved three empirical enquiries: Enquiry 1 employed a survey method to explore the design scenario of product and industrial designers and its influence on their ability to select secondary materials. Enquiries 2 & 3 looked at the issues involved in recovering and using secondary materials (focusing on plastic in London), and the tools currently available to support designers.

The primary research suggests that the scenario of product and industrial design consultants is not generally conducive to the consideration and use of secondary materials. Specifications for two tools that could improve the situation are proposed: 1) to build knowledge and awareness of secondary materials, and; 2) to improve materials information for design. However the issues with using secondary materials in design practice are manifold and so the research concludes with a framework identifying five central considerations for supporting the use of secondary materials in design practice.

This thesis contributes original knowledge in the field of design research by:

- proposing specifications for new tools to support the use of secondary materials in design practice;
- presenting a range of approaches to sourcing and using secondary materials in design practice;
- furthering understanding of the design scenario and how it may inhibit or enable designers to act in specific ways;
- challenging existing approaches to material information provision for designers with a new emphasis on dialogue with specialists and the important role of materials librarians.

Acknowledgements

First my great thanks go to Paul for his unwavering support and tolerance of my lengthy essays. I am also grateful to the AHRC for funding the project and to London Remade for their support and collaboration. My thanks go to the two previous industry supervisors Tina Perfrement and Robin Snook, but mostly to Hugh Smith for taking on this project when key decisions about its direction had been made by others. Hugh's input has been invaluable; the time and effort he contributed to see the research through to its conclusion is most appreciated. My special thanks go to long-time friends and talented graphic designers Rhydian Peters and Sarah Howard for donating their time and expertise to the project. Thanks also to Dr. Yorick Benjamin and Prof. Hilary Dalke for bringing formidable experience, expertise and judgement to the examination room.

At Kingston University I would like to acknowledge the support of the Post-graduate Research Department and other academics who have guided me along the way. In particular I would like to thank Jakki Dehn, firstly for giving me the opportunity back in 2005 to get to know this field through the *Rematerialise* and *Creative Resource* projects; then for finding the resources to take me back after three years absence while I explored my own ideas about the relationship between design and secondary materials.

I would like to thank the students who have attended the London CDA Network and others I've met at workshops and conferences who took part in thought-provoking conversations.

My gratitude goes to all of the designers who took part in the survey, to Keith Freegard of Axion Polymers and his team for being open-minded and enthusiastic, and to all of the designers and experts from industry who spared their time to meet with me or be interviewed throughout the project.

Finally I would like to thank my family for their unrelenting love and tolerance: Robyn for giving up his summer so I could write this thesis; my mum for reading it; Megan and Dad for always being willing to listen and offer advice; and Rhyd for responding generously with every request for help.

Rosie Hornbuckle

December 2010

Despite a conscious effort to conserve, over a metre of stacked A4 paper (mostly printed back-to-back) was used in the research and drafting of this thesis. Printed on 100% recycled paper.

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PART I CONTEXTUALISING THE RESEARCH

This first part of the thesis introduces the project background and context, positions the research within the relevant fields of research and industrial activity, and outlines the research methodology.

CHAPTER ONE Introduction

This chapter introduces the subject context, the project partners, the proposed aims and objectives and the author's background.

1.1 Subject background

1.1.1 UK Government Material Recovery Policy

Since the UK government's Waste Strategy was introduced in 2000 (Department for Environment, Transport and the Regions 2000) in response to increasing European Union (EU) pressure, there has been a sustained period of emphasis on the collection and diversion of waste material from landfill. This has included significant new legislation and regulation including Landfill Tax, Packaging Waste regulations, the Waste Electrical and Electronic Equipment (WEEE) directive, Restriction of Hazardous Substances (RoHS) directive, and End of Life Vehicles (EoLV) directive (Department for Environment, Food and Rural Affairs 2009).

With the increasing abundance of recovered material it has also been acknowledged that new markets need to be developed for that material to ensure that the additional resources needed for recovery are not expended needlessly. Indeed, studies by the Waste and Resources Action Programme (WRAP) suggest that in order to achieve a positive environmental outcome from material recovery (based on current evaluation methods), near-equivalent value and/or material properties must be retained in subsequent applications (WRAP 2006b:100-2; 2008:5). Founded in 2000, WRAP is a government-funded organisation tasked with improving material recycling throughout the UK, by supporting the development of infrastructure, technology trials, feasibility and Life Cycle Analysis studies, public awareness campaigns and industry support. A substantial part of WRAP's remit is to develop stable markets for recovered material.

The emphasis of targets has, from the outset, been on the quantity of material recovered (by weight) which has led to a waste management infrastructure which struggles to produce the high quality secondary material necessary for new products and stable markets. This is one of many contributing factors which mean that the ideal of recovering material value through multiple cycles at scale is a significant challenge.

1.1.2 London Context

Due to the involvement of London Remade as industry partner to the current project, the geographical focus of this study is Greater London, which has its own material recovery framework following the reestablishment of Mayoral powers in 1999. The Capital's current waste and recovery strategy was set out under then Mayor Ken Livingston whose ambitious targets included 85% regional self-sufficiency, and the reuse, recycling or composting of 45% municipal, 70% commercial/industrial and 90% construction/demolition waste by 2020 (Greater London Authority 2008:230, 221). Since these targets were first set significant changes have taken place; in July 2005 London was announced as the host for the 2012 Olympics, in May 2008 Mayor Boris

Johnson was elected, and in October 2008 a global economic downturn took hold, devastating material markets.

London also has a substantial 'creative industry'[1] and some of the best UK universities for art and design education[2]. The design industry has an important role to play in the UK and London context, both from an economic standpoint[3] and for sustainable[4] development[5]. Yet a large proportion of the consumer products designed and purchased in the UK appear to be manufactured abroad[6] which poses significant barriers to reincorporating secondary materials into production.

This project integrates the pragmatic and immediate problem of effectively utilising materials recovered from London and the creative wealth and influence offered by the UK design industry, much of which is concentrated in London. Meaningfully combining these two elements so that secondary material can be effectively incorporated into new products is at the heart of this project.

1.1.3 Design Interest in Using Recovered Material

There is some design interest in the use of recovered materials as one of the methods contributing to improved sustainability of designed artefacts, but this has been a niche interest of designer-makers[7] or large multinationals whose business strategy involves the consideration of sustainability[8]. While this is a good starting point a different approach will be necessary to build a sustainable future for materials in the UK and to meet the Mayor of London's targets, stated above. Using secondary materials in one-off or batch-produced designs may enable a designer to reduce the impact of their produce and raise awareness but, if effective material cycles are going to be a realistic part of our future, as much secondary material needs to be put back into production as is recovered. Currently that means working towards the use of secondary materials in volume manufacture and, in order to recover value and properties from those materials, they need to be considered in the design of high-value mass-produced artefacts where virgin material is substituted.

The terms used in the thesis to describe different types of material are defined in figures 1.1.1 and 1.1.2.

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[1] One in seven jobs in London are in the creative industries, and London accounts for 40% of jobs in the UK's creative industries (Greater London Authority 2004)
[2] Seven of the top thirty UK universities ranked for Art and Design education are based in London (Times Online 2009)
[3] In 2005 the Design Council estimated that 31% (20,436) of UK design businesses were based in London (Design Council 2005)
[4] The term 'sustainability' is used throughout this thesis in the specific sense of social and environmental sustainability, (a concept which is explained at the beginning of section 2.1) rather than the general meaning.
[5] In 2006 the DTI (later renamed the Dept for Business, Enterprise and Regulatory Reform, BERR) recognised that innovation has a critical role in meeting the challenges of improved sustainability with the formation of the Environmental Innovations Advisory Group (Department for Trade and Industry 2006b)
[6] In 2005 The Guardian reported that China "makes about 15% of the worlds manufactured goods", while UK manufacturing "now accounts for less than a fifth of national output", and "a million manufacturing jobs have been lost under Labour" (Seager 2005: online). The designers interviewed for the survey in Chapter Four reported that a large number of the products they design are manufactured abroad.
[7] Represented in the [Re]Design exhibitions, shown during the London Design Festival 2005 and 2006, see www.redesigndesign.org (last accessed 30/04/09), the Haute Green exhibition in New York (Wood 2006) and previously by the Creative Resource and re-f-use exhibitions see www.re-f-use.com (last accessed 30/04/09)
[8] Such as Herman Miller (2009), Interface Global (2008) and Ford Motor Company (2008).

Figure 1.1.1: Definition of terms used to describe 'material' in this thesis

Term	*Definition of use in this thesis*
Material cycle	**The general process by which material circulates either in industry or in nature so that its value may be retained through subsequent cycles. This concept also informs Cradle to Cradle thinking (McDonough & Braungart 2002).**
Secondary material	**The overarching term used here for any material that has previously been used, or made ready for use, by end-users; any material that is not from a 'primary' or 'virgin' source (see definition below).**
Primary/virgin material	Material that is extracted or harvested directly from original sources rather than material that is already in industrial circulation or 'use'.
Recyclable material	'Recyclable' is often used to describe a materials' potential for future recycling. However this can be misleading as a material can be, technically-speaking, recyclable but has no chance of being recycled because the necessary infrastructure or markets are not yet in place.
Artefact	When referring to specific types of products is not appropriate, 'artefact' ("Something made by human beings" Crozier 2006:38) appears the most fitting term for 'things' which are designed and made/manufactured by people.
Waste material	A material that is no longer valuable – a concept that is redundant in sustainable practices and therefore infrequently used here.
Recovered material	Material that has been recovered from the waste stream prior to its (material or energy) value be recouped.
Recyclables / Recyclate	Both these terms are used by the waste management industry for material that is intended for further reprocessing and eventual use in new products. Material is usually described this way at any stage from recovery through to being compounded into manufacturing feedstock.
Recycled material	'Recycled' refers to a material that has been recovered, reprocessed and reintroduced back into the market in a new form. Although 'recycled' is a popular term, it is often misused. 'Recycled' should only be used when describing an artefact (made from recycled material) that has been bought by an end-user. Therefore its proper use is fairly limited.

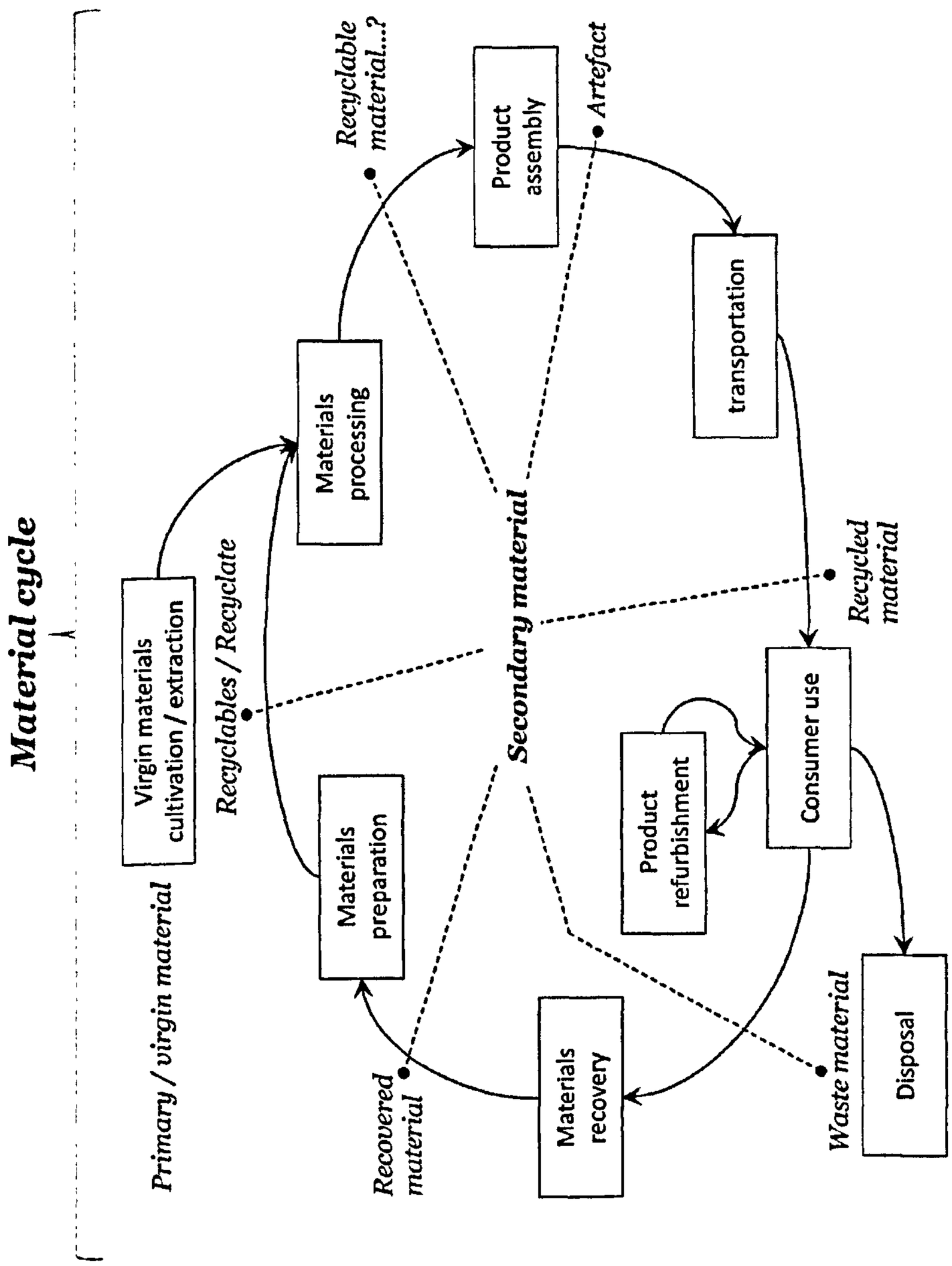

Figure 1.1.2: Terms used to describe 'material' in this thesis mapped onto a typical product lifecycle diagram (lifecycle diagram adapted from Fletcher, Dewberry & Goggin 2001)

1.2 Project Background

1.2.1 Project Partners

This project is funded by an Arts and Humanities Research Council (AHRC) Collaborative Doctoral Award (CDA) which aims to "to encourage and develop collaboration between Higher Education Institution (HEI) departments and non-academic organisations and businesses [...] providing access to resources and materials, knowledge and expertise that may not otherwise have been available and also provide social, cultural and economic benefits to wider society" (Arts and Humanities Research Council 2009). Under this scheme an academic institution and an industry organisation become partners in supporting a PhD student through a mutually beneficial research project. In this case, the partners are Kingston University (Academic) and London Remade (Industry).

London Remade could be described as the capital city's equivalent of WRAP, being a not-for-profit business initially funded by the London Development Agency (LDA) and tasked with developing markets for secondary materials. The organisation was founded in 2001 under the new Mayor of London Ken Livingston. Recognising the role design could play in creating high-value applications for recycled materials, London Remade began an enduring collaboration with researchers in the Faculty of Art, Design and Architecture (FADA) at Kingston University, contributing to a number of research projects in the area of secondary material use in product and furniture design[9].

1.2.2 Proposed Aim, Objectives and Anticipated Outcomes

The *Redesigned Futures* proposal document for this Collaborative Doctoral Award outlined the project aim: *to create new models for utilising surplus and waste resources in design practice.* This formed the framework for the research which remained constant throughout the project despite a critical interrogation by the author through the Initial Literature Review (Chapter Two).

The original objectives proposed to satisfy this aim were:

1. Investigate designers' perspectives on secondary material use in relation to their own professional practice, particularly in London;
2. Identify key potential product and design sector applications for secondary materials within London
3. Investigate current processes and tools by which designers are enabled and supported in creating high-value applications for secondary materials;
4. Critically reassess these processes and tools to support design practice;
5. Develop innovative models to support designers in finding new applications for surplus and waste resources.

Although these objectives were largely adhered to, minor alterations were made as the research unfolded.

[9] These have included the *Inspired Recycling* and *Inspire Recycle* projects (Chick & Micklethwaite 2004a) and the *Creative Resource* research (Dehn 2008) and exhibition which launched at Barnsley Design Centre in April 2007

Several possible outcomes were also suggested in the proposal, which indicated some assumptions about the direction the project might take. These are returned to in the Conclusions (Chapter Nine):

- A suite of resources in appropriate media to motivate, inform and support designers in finding new high-value applications for secondary materials;
- A model for a workshop in which designers, manufacturers etc. collaboratively respond to an identified surplus (eg. 'manufacturing waste' surplus printed circuit boards which may otherwise be disposed of in landfill) to generate new applications;
- A browseable on-line database of available surplus waste materials. Designers could source materials from this database and respond with new uses for featured materials. Materials should be featured in sufficient detail, including images, material qualities and condition, dimensions, volumes etc., with samples available on request.

1.2.3 Author's Background

It is inevitable when dealing with the non-absolutes, open systems and flexible designs inherent in real-world enquiry, that the researcher may influence the direction and interpretation of the study. There are various ways of reducing this effect, for example in the validation and rigour of research methods used, and also in the method of reporting (Robson 2002). In addition Robson writes: "the stance now taken is that all potential biases should be brought out into the open by the researcher" (Robson 2002:98) which is the purpose of the following account.

During my design education I was an ethically-driven student; my interest was in the improvement of the built environment (products, furniture, and spaces rather than buildings) for the benefit of people affected by their design. Although I was generally sympathetic to environmental sustainability, this was not the focus of my personal design ethic and I was somewhat sceptical of the purpose and benefit of so-called 'green' activism.

Following graduation I worked on the *Creative Resource* research project at Kingston University (led by Jakki Dehn) which focused, from a historical perspective, on the role of designers in the development and use of recycled materials. Although I came to know the materials, their potential uses and characteristics, I did not have the opportunity to demystify for myself the environmental and social benefits of recycling and its contribution to sustainability. At the beginning of this research project I wrote in my research diary, of recycling:

> *I know I should do it, it's the only thing I can do in my daily life to 'save the planet' which doesn't involve spending more money or significantly changing my behaviour, but I don't quite know what happens to it – and I mustn't forget this because it will be my only way of relating back to an external perspective.*

Although a little naïve and ignorant of the subject area, these thoughts echo some of the main criticisms of recycling as part of the wider sustainability agenda, as well as the contradictory feelings towards recycling

expressed by members of the public. This initial scepticism was fundamental to my ability to critically interrogate the project assumptions about the purpose of recycling and develop an objective view of the role of material recovery for the benefit of people as well as the environment.

There are two further events that shaped my perspective on entering this project. First, my inability to find an appropriate work 'scenario' where I could practice the people-centred design approach I had developed during my studies. Second, a work placement where I observed the constraints often experienced by designers within a commercially-driven design scenario. These experiences particularly influenced the direction of theory-building around the 'design scenario' during the early stages of this research.

1.2.4 Project Plan

The duration of the project funding and collaboration was three years full-time. An initial plan anticipated that the background research and Objective 1 be completed in year 1, Objectives 2, 3 and 4 in year 2 and Objective 5 including 'writing-up' in year 3. The project was completed within the three year period but the amount of time needed for each objective unsurprisingly changed over the course of the project; figure 1.2.1 shows when the work for each objective took place.

The survey (Objective 1) took on a larger role in the empirical research than had been anticipated and formed the main body of the research and new knowledge contribution. The investigation of secondary material use in London (Objective 2) and the investigation and critical analysis of existing design tools and models (Objectives 3 & 4) subsequently took on lesser, but nevertheless important, supporting roles in achieving the project aim. The development of project outcomes, based on the knowledge gained from the three empirical enquiries, was undertaken at the beginning of year 3. Conclusions were then drawn and the thesis was written.

Project Objectives

Objective 1 Investigate designers' perspectives on secondary material use in relation to their own professional practice, particularly in London.

Objective 2 Identify key potential product and design sector applications for secondary materials within London.

Objective 3 Investigate current processes and tools by which designers are enabled and supported in creating high-value applications for secondary materials

Objective 4 Critically reassess these processes and tools to support design practice

Objective 5 Develop innovative models to support designers in finding new applications for surplus and waste resources.

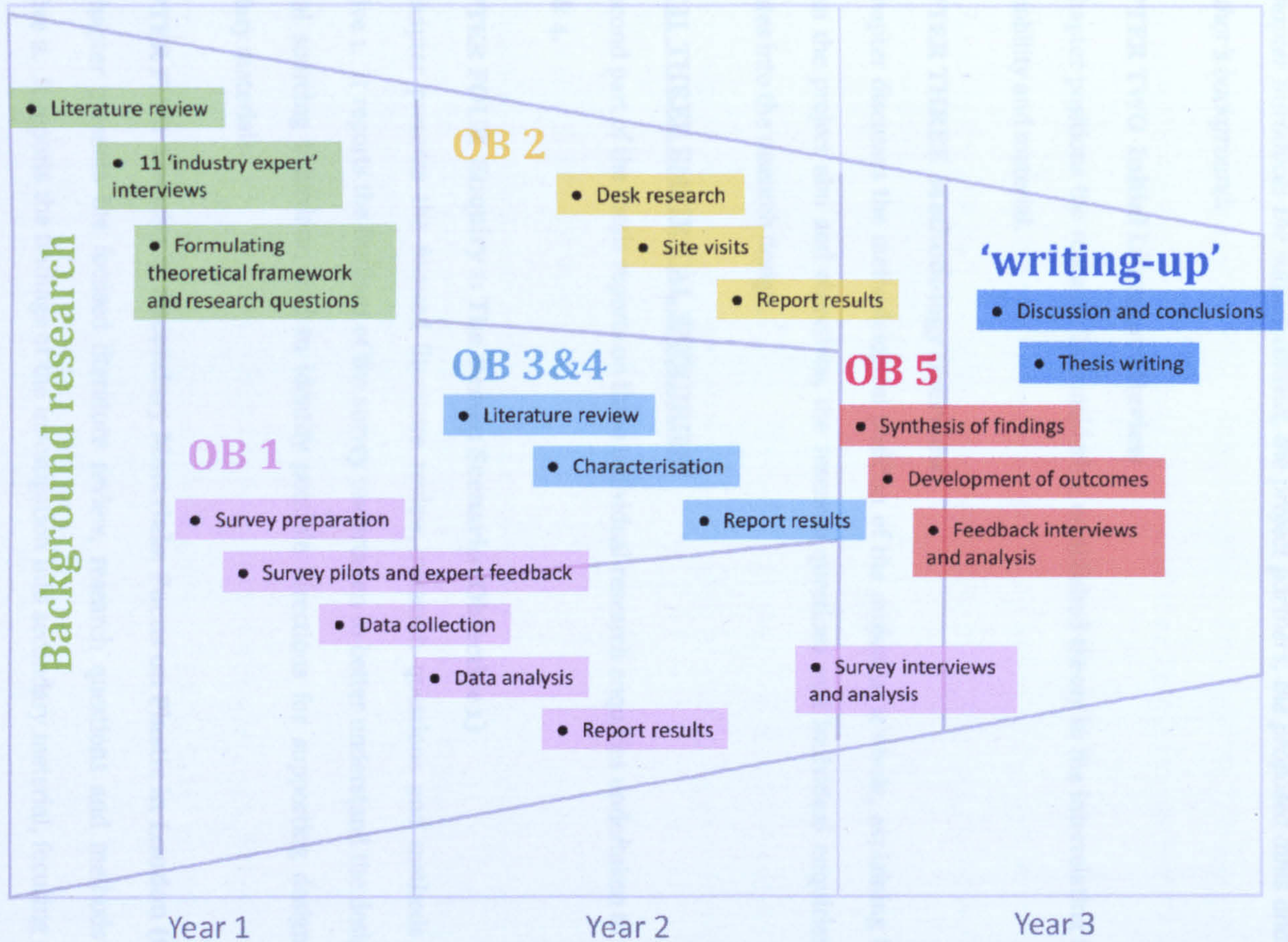

Figure 1.2.1: Diagram showing the sequence of events undertaken to complete the Objectives over the three year period of the project. The survey (OB1) forms the most substantial part of the research in both time and contribution to knowledge, while Objectives 2, 3&4 (OB 2, 3 & 4) performed supporting roles in achieving the project aim.

1.2.5 Chapter Overviews

PART I CONTEXTUALISING THE RESEARCH

This first part of the thesis introduces the project background and context, positions the research within the relevant fields of research and industrial activity, and outlines the research methodology.

CHAPTER ONE Introduction

This chapter introduces the subject context, the project partners, the proposed aims and objectives and the author's background.

CHAPTER TWO Initial Literature Review

This chapter positions the research by considering established theory in the interrelating fields of design, sustainability and material.

CHAPTER THREE Methodology Overview

This chapter discusses the methodological position of the project as a whole, explaining the relationship between the project aim and objectives, the research questions and individual enquiries, and how this translates into the research design.

PART II THREE EMPIRICAL ENQUIRIES

This second part of the thesis reports on three individual research enquiries undertaken to meet Objectives 1, 2, 3 & 4.

CHAPTER FOUR Enquiry 1: The Design Scenario (Objective 1)

This chapter presents the focused literature review, research questions and methods for addressing Objective 1. It reports the findings of the survey undertaken to better understand the design scenario and material sourcing behaviour, and to identify possible directions for supporting designers in utilising secondary materials.

CHAPTER FIVE Enquiry 2: Secondary Materials: Focus on Plastic in London (Objective 2)

This chapter presents the focused literature review, research questions and methods for addressing Objective 2. It reports the findings of the investigation into secondary material, focusing on the 'story' of plastic in London. The purpose was to understand the processes and specific issues involved with material recovery and possible approaches to use, to inform the development of a new model for supporting designers in the utilisation of secondary materials.

CHAPTER SIX Enquiry 3: Tools and Models to Support Designers (Objectives 3 & 4)

This chapter presents the focused literature review, research questions and methods for addressing Objectives 3 & 4. It reports the findings of an investigation into tools and models for supporting designers generally, and in the use of secondary materials. A categorisation method was used to understand the

nature of different design tools and to extract attributes that are more appropriate for supporting designers.

CHAPTER SEVEN Integrating and Interpreting the Empirical Findings (Objective 5)

This chapter synthesises the findings from all three empirical enquiries using two methods. First, the findings are **discussed** to reveal themes that may contribute to answering the overarching research questions and meeting the project aim. Second, these themes are used to **explore possible tools or processes** to support designers in the consideration of secondary materials. The aim is to further process and understand the empirical findings whist also 'demonstrating' the practical application of the research.

PART III PROJECT OUTCOMES AND CONCLUSIONS

This third part of the thesis presents the main outcome of the project: a framework for secondary materials use in design before drawing together the main conclusions of the research. The thesis concludes with recommendations for further work.

CHAPTER EIGHT A Framework for Supporting Secondary Materials Use in Design Practice

This chapter presents the main outcome of the study: 'a framework for secondary materials use in design' devised to meet the main project aim to 'create new models for utilising surplus and waste resources in design practice'.

CHAPTER NINE Final Conclusions

The penultimate chapter draws together the main conclusions from the research and how they answer the research questions, the project aim and objectives. The original contribution to knowledge and the limitations of the study are then presented.

CHAPTER TEN Recommendations for Further Research

This chapter concludes the thesis with recommendations for further work focussing on the use of secondary materials in design practice and more generally in the fields of design, materials and sustainability.

1.3 Chapter One Summary

This chapter has described the project context involving *the immediate problem of effectively utilising material recovered from London, and the creative wealth and influence offered by the UK design industry.* The project aim of *creating new models for utilising surplus and waste resources in design practice* was then introduced as well as five objectives which were set out in the original project proposal. The author's background was also acknowledged.

The next chapter will consider the project position within the wider debate around design, sustainability and material, with reference to the literature.

CHAPTER TWO Initial Literature Review

This chapter positions the research by considering established theory in the interrelating fields of design, sustainability and material.

The aims of the Initial Literature Review were to:

- Gain a better understanding of the subject areas (design, sustainability and material);
- Explore the arguments for and against the main aim of the research (material recovery and re-use in design) and;
- Develop a theoretical foundation for the research.

The following discussion draws on key texts and theory to address these aims.

2.1 Sustainability and Design

2.1.1 The Origins of 'Sustainability'

Despite earlier attempts to draw widespread attention to the impacts of rapid growth (for example Meadows 1974; Forrester 1971), interest in 'sustainability' only really took hold following the publication of *Our Common Future* (also known as the Brundtland Report) in 1987. This was not a report formulated by green activists for a specific cause, as had become common during the '70s, this was a call for global and all-encompassing change for the sake of humans rather than for the environment or wildlife. The enormity and ambition of the task is summed up by the report's chief author: "'A global agenda for change' - this was what the World Commission on Environment and Development was asked to formulate" (World Commission on Environment and Development 1987).

The succinct definition of sustainability detailed in this report is frequently paraphrased. Here it is presented in full to demonstrate the true extent and ambition of the changes proposed:

> Humanity has the ability to make development sustainable to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs.
>
> The concept of sustainable development does imply limits - not absolute limits but limitations imposed by the present state of technology and social organisation on environmental resources and by the ability of the biosphere to absorb the effects of human activities. But technology and social organisation can be both managed and improved to make way for a new era of economic growth. The Commission believes that widespread poverty is no longer inevitable. Poverty is not only an evil in itself, but sustainable development requires meeting the basic needs of all and extending to all the opportunity to fulfil their aspirations for a better life. A world in which poverty is endemic will always be prone to ecological and other catastrophes.
>
> (World Commission on Environment and Development 1987: Overview: Para 27)

The tone is optimistic, yet in one breath it calls for limitation, social and technological reorganisation, economic growth and an end to poverty. What individual, business, organisation, or government can act in a way that may effect these kinds of changes? As the slow progress of the last thirty years has demonstrated, the challenge of sustainability is inevitably in the absolute global change it necessitates.

2.1.2 In the Name of Sustainability[10]

Despite the clear focus of the Brundtland Report on the long-term well-being of people, there is much confusion about the many values and motivations played out through the sustainability agenda: the perpetuation of a 'green movement' often appearing to advocate the suppression of human development; a point of differentiation in the marketing of goods, sometimes termed 'greenwashing'; or as a political or economic tool. Writing from a social-sustainability perspective, Larson considers that this confusion is largely due to differences in worldviews:

> This juxtaposition [between material and social worlds] sets up a potential clash of worldviews because the material world is often most appropriately explored within a positivist and post-positivist worldview typically employing quantitative methods, whereas the social world is often most appropriately explored within a constructivist or critical worldview typically employing qualitative methods. Much of the confusion and many of the disagreements surrounding sustainability can be traced to differences in worldview
>
> (Larson 2008:50)

The use of the term 'sustainability' by those with very different worldviews[11] and value systems, to describe or even advocate their activities, is not only the cause of much debate and disagreement over the concept of sustainability, but can also be seen to cause disillusionment, suspicion and scepticism among laypeople.

This scepticism perhaps has its roots in a wider mistrust of the information continuously fed to the public by government, by the media and, in this case, environmental groups. In the early '90s foreboding about 'peak oil' was common among environmental teaching. But when it became clear that the situation wasn't as serious as had been claimed the fight to reduce oil-dependency[12] was severely hampered. This confusion doesn't just affect the general public but also those who make decisions that could influence

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[10] This phrase was used by a student; when asked 'what does sustainability mean in your practice?' they replied (with an air of scepticism) 'what... you mean *in the name of sustainability?*'

[11] In recent years the predominant model of juxtaposing worldviews has been the tri-polar model of society, economy and ecology. However, Findeli (2008) argues that 'ecology' and 'economy' should be combined as they both measure resources. Findeli's repositioning of the model therefore leaves the two poles of 'economics' and 'society' which reflects Larson's (2008) opposite poles of 'material' and 'social' worlds. Findeli however adds a third; 'social creativity' which is the realm of design and human agency. Findeli claims that this new tri-polar model is the key to delivering successful and sustainable projects because the poles are not in opposition.

[12] In 1979 James Lovelock wrote: "Biological arguments which would appear to have a sound scientific basis are often used to support environmental causes, but usually they carry very little weight with scientists. [...] Whatever an ecologist may feel as an individual about an imminent problem, his hands are tied by a lack of hard scientific evidence. The result is an environmental movement which is thwarted, bewildered and angry." (Lovelock 1979:145). More recent examples of green movement scepticism exist in the media, for example Deming's (2003) *'Are We Running Out of Oil?'* and more recently Lucy Siegle, ethical columnist for The Observer Magazine wrote: "It seems that every day there's a conflicting story about the future of fish. Activists tell us they'll all be gone in 40 years. The fishing industry says the shoals are coming back." (Siegle 2006).

sustainable activity such as designers who, it has been suggested, "are not informed by expert opinion on these issues, but by popular debate" (Fletcher 1999:254). What is more any move towards sustainability implies some degree of change in activity, which inevitably involves more effort and risk, and scepticism develops: *'why should I put in extra effort if I don't really know if it will help?'* This feeling has been strengthened further by reports of goodwill activities such as 'carbon-offsetting' having a negative impact on the local environment (Randerson 2005). The slow pace at which we learn about the most beneficial, or least damaging ways of doing things is clearly at odds with the fast pace of development.

2.1.3 Current Concerns under the Banner of Sustainability

The all-encompassing nature of sustainability means that there are many individual concerns which are interrelated in complex ways. 'Sustainability' now covers the majority of global challenges, many of which have been known for some time. The difference perhaps is that now they have a collective name and there is general acknowledgement that they need to be addressed. Figure 2.1.1 lists the *UK Government Sustainable Development Framework Indicators* as an example of the variety of, often conflicting, concerns considered part of the broader problem of sustainability. This list is considered again, later in the discussion.

Interest and awareness of sustainability has increased dramatically in the last ten years. The focus can also be seen to have shifted; based on a survey undertaken in 2003 and 2006 in the USA, Curry, Ansolabehere & Herzog (2007) reported that attitudes to the most important 'environmental problems' had changed:

> In 2003, global warming ranked sixth on a list of ten environmental problems (it lagged behind water pollution, destruction of ecosystems, toxic waste, overpopulation, and ozone depletion). In 2006, global warming was the number one environmental concern.
>
> (Curry, Ansolabehere & Herzog 2007:8)

Figure 2.1.1: UK Government Sustainable Development Framework Indicators representing the current, often conflicting concerns under the banner of Sustainability (DEFRA 2008)

Greenhouse Gas emissions	Employment
Resource use	Workless Households
Waste	Childhood poverty
Bird populations	Pensioner poverty
Fish Stocks	Education
Ecological impacts of air pollution	Health inequality
River quality	Mobility
Economic growth	Social justice
Active community participation	Environmental equality
Crime	Wellbeing

Although these are separate issues they are nevertheless inextricably linked to concerns over sustainability. It is not the aim here to comprehensively document the various areas of concern, but to acknowledge that the subject area of this project is located within many different and often conflicting agendas. Currently the predominant measurement for 'un-sustainability' is the emission of Carbon Dioxide (CO_2) which is linked by many to climate-change[13]. Although CO_2 emissions alone may not accurately reflect the complexities of the situation, their measurement does provide a simple and convenient indicator for unsustainable patterns of human behaviour that was lacking previously, and has now largely been accepted by politicians, individuals and industry[14].

2.1.4 The Strata of Sustainability

Society can be seen to be made up of a number of layers, macro to micro, whether in terms of politics (from the level of international policy through to local authorities and community groups) or industry (from multi-nationals through to small and medium-sized enterprises (SMEs)), and both sustainability and design can also be seen to operate in this way. Thinking in terms of 'strata', as the following discussion will show, is important for understanding how and why different perspectives and worldviews have been formed around the meeting of design and sustainability, and to discover how the agenda of this research project sits alongside other worldviews and approaches.

Sustainability can be seen essentially as a macro-level concept, yet change of any kind inevitably involves change at lower levels. Larson's (2008) *Typology for Discourses about Sustainability* (first two columns in fig. 2.1.2) shows how 'institutions' at different societal levels perform various macro and micro functions towards sustainability, which is evident in their discourse around the subject. Larson recognises the importance of the "practical orientation" and "purposeful nature of the many individuals, groups, and organisations rising to the quest for sustainability" (Larson 2008:59) enabling the formulation of goals and implementation of best practice.

As well as occupying different societal levels, approaches and attitudes to sustainability can also be seen to operate in different time-scales. In *The Clock of the Long Now* Stewart Brand proposes "six significant levels of pace and size in the working structure of a robust and adaptable civilisation," arguing that "in a healthy society each level is allowed to operate at its own pace, safely sustained by the slower levels below and kept invigorated by the livelier levels above" (Brand 1999:35-6) (note: the order of Brand's levels have been reversed in figure 2.1.2).

---

[13] The Intergovernmental Panel on Climate Change (IPCC) produced its first Assessment Report on Climate Change in 1990 followed by subsequent issues in 1995, '97, 2001 and '07, strongly suggesting a link between anthropogenic Green House Gas (GHG) emissions and global warming (IPCC 2007). This view was famously popularized by Al Gore, whose documentary *An Inconvenient Truth* (2006) persuaded many of the human responsibility for climate change.

[14] This is demonstrated by the numerous carbon calculators and carbon foot-printing methods, for example www.carboncalculator.co.uk (accessed 27/07/09)

Figure 2.1.2: The Strata of Sustainability, disclosed through discourse and in reference to shorter or longer terms of concern

A Typology for Discourses About Sustainability (Larson 2008:60)			The clock of the long now (Brand 1999)
Institutional Setting	***Nature of Discourse***	***Time-scale of sustainability thinking***	***The order of civilisation***
Academia	Theory	Now – distant future	Nature
UN organisations	Ideology	Now – 100 years	Culture
Multilateral organisations	Policy, plans, and goals	Now – 50 years	Governance
Governments—national, state, and local	Organising	Now – 25 years	Infrastructure
Corporations	Implementation and best practices	Now – 10 years	Commerce
Civil society	Monitoring / controlling	Now – 5 years	Fashion

Brand's levels of pace have been added in the fourth column of the table above, as well as some timescales in the third column which approximately relate to both Larson's and Brand's categories. With regards to Larson's typology, the decisions, actions and approaches taken by individuals or organisations at the micro-level, where concerns are immediate, are likely to be quite different from those operating at a macro-level who have their sightlines firmly fixed on the future. This can be seen as a source of great tension when deciding the best approach to take, and how all activities contribute to the obscure goal of sustainability. Meanwhile, Brand's 'slowest' levels of *Nature* and *Culture* are key to the challenge of sustainability yet are very difficult for people to successfully manage, while our management of the faster levels of *fashion* and *commerce* so far appears to be insufficient for promoting sustainable activities across all levels.

The implication is that the 'levels of pace' Brand speaks of have been disrupted or ignored by humans in recent years, and these changes have contributed to what is perceived to be unsustainable ways of living. Therefore making changes in a sustainable direction will require working with timescales which are largely outside of our knowledge, experience and arguably our control. Whether or not we are up to this challenge is yet to be seen, but it is clear that the task of building a sustainable future will push our ability to manipulate these timescales to the limit.

2.1.5 The Strata of Design

A similar strata-construct has been observed in the design profession. *The Four Domains of Design*, a phrase coined by Margolin (1996), were originally proposed by Buchanan in 1992 to define the conventional areas of design thinking, those of:

1. Symbolic and visual communications
2. Material objects
3. Activities and organised services
4. Complex systems or environments of living, working, playing or learning

(Buchanan 1992:9-10)

Buchanan did not wish to identify any one of these areas with a particular design profession (although to this day strong divisions of this kind remain dominant in the design industry) but rather to suggest that the many interconnections that can and often do occur between these four domains enrich design's ability to solve complex problems. Furthermore Buchanan makes the important observation that fourth-domain design "is more and more concerned with exploring the role of design in sustaining, developing, and integrating human beings into broader ecological and cultural environments, shaping these environments when desirable and possible or adapting to them when necessary." (Buchanan 1992:10)

The potential for design to operate across four domains from micro to macro levels therefore represents the potential for design to visit the various strata of sustainability in order to address a complex array of problems. Furthermore, Buchanan's repositioning of Rittel's theory of wicked problems in relation to design thinking offers an alternative view of sustainability as a problem to be solved by designers. Rittel's ten properties of wicked problems could read, not only as a description of design problems as Buchanan interpreted them, but also as a description of sustainability and the challenges it presents:

(1) Wicked problems have no definitive formulation, but every formulation of a wicked problem corresponds to the formulation of a solution.
(2) Wicked problems have no stopping rules.
(3) Solutions to wicked problems cannot be true or false, only good or bad.
(4) In solving wicked problems there is no exhaustive list of admissible operations.
(5) For every wicked problem there is always more than one possible explanation, with explanations depending on the Weltanschauung of the designer.
(6) Every wicked problem is a symptom of another, "higher level," problem.
(7) No formulation and solution of a wicked problem has a definitive test.
(8) Solving a wicked problem is a "one shot" operation, with no room for trial and error.
(9) Every wicked problem is unique.
(10) The wicked problem solver has no right to be wrong-they are fully responsible for their actions.

(Buchanan 1992:16 after Horst Rittel)

Margolin picked up on the link between Buchanan's theory of design thinking and the problem of sustainability, using it to identify possible changes in design practice:

> For designers to participate in sorting out these problems and inventing productive courses of action, they will have to move from second domain design, where product design has been located since the nineteenth century, to fourth domain design. [...] This does not mean abandoning product design. It means connecting it to a larger situation of production and use.
>
> (Margolin 1995:23)

Wahl & Baxter (2008) add a further dimension to this concept. Drawing on psychologist Graves' model of human development, they view the strata of sustainability and design as a spiral where complexity increases as it ascends. They consider that different levels on the spiral correspond to different "worldviews and value systems" (Wahl & Baxter 2008). Design or designers may be positioned at any level of the spiral with 'bad design' often occurring at the lower levels whereas 'good design' is only enabled at the upper levels. Yet as designers develop their understanding they move up the spiral and at each turn an 'awakening' occurs. Wahl & Baxter propose that "transdisciplinary design dialogues" are necessary for this to happen as only through a broader exchange of knowledge can such an awakening take place. Ultimately the goal is for designers to move up the spiral, representing a change in their worldviews and value systems towards more sustainable practices and the realisation that "The solutions to the 'wicked problems of design' are more likely to be new processes, lifestyles, and changes in meaning, rather than purely material artefacts." (Wahl & Baxter 2008:82). Importantly therefore, for Wahl & Baxter, the move towards sustainable design is one involving teams with multi-views rather than individuals with single-views and conventional methods, which would inevitably necessitate that improved sustainability in design is the common goal of the whole team rather than just the individual designer.

Also advocating a cross-disciplinary approach to sustainable design, Wood's paper for the international conference *Changing the Change* (which aptly describes the design community's current preoccupation with finding appropriate routes towards sustainability), *A Fractal Framework for Metadesign,* proposes an additional step up the design domain strata or spiral above the fourth domain, or literally 'beyond' design. Wood writes:

> We have been exploring the idea that specialist designers can work in a higher-level, cross-disciplinary design system that, for the moment, we are calling 'metadesign'. One reason for this is that we are still trained to offer relatively narrow, specialist skills, rather than addressing deeper needs. This has alienated us from our wider economic, social and ecological potential. Many designers feel uncomfortable with ethical aspects of their predicament, but their specialist role makes them too weak to affect positive, radical change. For many designers, positive options may seem remote. Others face what seems to be a 'no-win' situation.
>
> (Wood 2008:3)

Here Wood identifies with design's potential to effect change at a macro-level but acknowledges that currently individual designers can do very little to make that leap from their current situation in the micro-level. He also draws attention to designers' apparent discomfort with the ethics of design which is discussed in more depth later in this chapter.

The recent history of design's approach to sustainability can be seen as a gradual progression up the strata of design domains and the strata of sustainability as designers and design thinkers become increasingly frustrated and dissatisfied with the ability for design to 'solve' the sustainability problem from the micro level alone. The deciding factor in design's struggle to influence sustainability will arguably be its ability to change its own operation and situation within society (Manzini 2009), and to influence political and economic situations. Changing the current unsustainable paradigm of production and consumption, fuelled by a capitalist economy, will inevitably involve what Manzini describes as "a radical change in ways of being and doing" (2009:5). Design historian Heskett (2001) has recognised that design has always had to embrace change and will continue to do so:

> The evidence of history is that design, as a basic human ability, is constantly required to adapt and redefine itself to meet the needs of its time. We should expect no less for our age.
>
> (Heskett 2001:26)

2.1.6 Current Approaches to Sustainable Design Practice

Much of this discussion so far has been around the philosophical discourses of design and sustainability, many of which suggest significant changes to the current paradigm of professional design. Yet as the strata of sustainability suggests, this is pointless without implementation and pursuit of those macro-level ideals in the here and now. Pearson, for example, assures the design management community that "a sustainable system will only be achieved as a synergy of millions of design decisions pulling collectively in positive ways toward a complete system redesign" (2008:20).

Argument, Lettice, & Bhamra (1998) have illustrated the strata of industrial design practice approaches ranging from "design for disassembly" to "environmentally conscious design and manufacture" (Argument, Lettice, & Bhamra 1998:68). In the last ten years there has been significant development, with a wider variety of approaches to improved sustainability being explored by designers. It is unnecessary to go into great depth about all of the work in this area, but it is nevertheless important to highlight the common threads that have emerged in order to position this research project within the field.

Continuing with the 'strata' analogy, approaches to sustainable design practice can be seen to include the pursuit of change across three levels which increase in complexity and timescale (fig. 2.1.3). In line with the complex nature of worldviews and value systems linked to sustainability, there is much contention over which is the 'best' approach. However, given the range of challenges that we face, it is perhaps encouraging

that a range of approaches are being developed. Their existence will mean that we will be better prepared at a micro-level for whatever occurs higher up the strata, be that political, environmental, social, economic or technological change. Some of these approaches will be discussed in more depth in the next section in relation to the specific focus of this study: sustainability and material.

Figure 2.1.3: Prevalent approaches to sustainable design practice across three levels or 'strata'

Level of focus	***Approaches***	
Systems and service-oriented "design for sustainability" (Manzini 2009) *For example Ezio Manzini & Francois Jégou[15], and John Thackara[16]*	Service-oriented rather than product-oriented	Social entrepreneurship and job creation
	Co-design and demonstration in the local community	Localism
Product-oriented "sustainable design" (Argument, Lettice, & Bhamra 1998) *For example Jonathan Chapman, Studio de Lucchi[17], Alastair Faud-Luke[18], Tracy Bhamra and Vicky Lofthouse (2007), and Stuart Walker 2006*	Avoid unnecessary products/parts	Encourage sustainable behaviour
	Slow-design: fewer, high-quality products	Second-life use
	Encourage longevity (emotional attachment)	Disassembly (DfX)
	Reduce energy during use	Design-life
Material-oriented sustainable or "eco-effective" use of material (McDonough & Braungart 2002) *For example McDonough Braungart Design Chemistry[19]*	Material minimisation	Material toxicity
	Waste prevention	Single recyclable materials
	Cleaner manufacturing	Energy reduction in production
	Material recovery and re-use	

Design is capable of visiting sustainability at various levels, but this requires a redesigning of design. Those working at the macro level need to make significant accomplishments before the work of others, working at a micro level, is affected. Activity at any of these levels therefore, it has been suggested, must surely be embraced as part of a 'pluralistic' attitude to design and sustainability (Fuad-Luke 2002). As Brand (1999) has suggested, these levels need to be allowed to operate at their own pace. The diversity or plurality of approaches is essential for change to happen; just as there are passionate people working at the macro level, likewise it must acknowledged that micro-level concerns must be met.

Although material recovery and reprocessing would appear to be a micro-level concern, what is done with material has implications across all levels, as the next section will discuss further. Moreover, to be really

[15] See www.sustainable-everyday.net (accessed 05/05/09)
[16] See www.doorsofperception.com (accessed 05/05/09)
[17] See http://www.amdl.it/en/index.asp (accessed 05/05/09)
[18] See www.slowlab.net (accessed 05/05/09)
[19] See www.mbdc.com (accessed 05/05/09)

successful, those who operate with sustainability as their goal will need to consider the implications of their work across all of these levels; thinking of the macro when decisions are made in the micro. While there is never likely to be agreement on the best approach, or indeed the best direction, this is characteristic of a democratic society and a 'pluralistic' approach to sustainability and design.

This section has focused on 'sustainability and design'; the next section will consider the relationship between 'sustainability and material'.

2.2 Sustainability and Material

2.2.1 How to Think of 'Material'

The word 'material' is commonly used to describe things as diverse as textiles, production feedstock, and even information. However, the etymology of 'material' relates to 'matter', the substance of any physical thing. Lovelock (1979) points out that all matter, whether manipulated by nature (natural) or by humans (manmade), is derived from the elements that make up Gaia (the living earth):

> In our persistent self-imposed alienation from nature, we tend to think that our industrial products are not 'natural'. In fact, they are just as natural as all other chemicals of the earth, for they have been made by us, who surely are living creatures. They may of course be aggressive and dangerous, like nerve gas, but no more so than the toxin manufactured by the botulinus bacillus.
>
> (Lovelock 1979:80)

How humans manipulate matter is of course a problem associated with unsustainable activities, but for the moment it is Lovelock's way of thinking about material that is important. As far as possible an 'objective' attitude to materials may be essential for the pursuit of sustainable activities; understanding and making decisions about materials based on the empirical information available rather than socially-constructed views about what is the 'best' material. This is of course problematic; it was discussed previously that sustainability is inherently value-laden and this tension when thinking about materials is returned to throughout this thesis.

A central concern is that matter only describes the physical: water is matter, but the life it supports is not; fibre optics are matter, but the communication they enable is not; the fridge is material but the way it is used is not[20]. The extraction, transformation, movement, processing, absorption (human and environmental), scarcity, and security of material are physical positivist concerns, but they also affect and are affected by non-material, constructivist concerns (Larson 2008). The difference in worldviews implied by material and non-material concerns was introduced earlier in relation to the work of Larson (2008), but

[20] This relates to the work of Bhamra, Lilley & Tang (2008) which suggests that the way a product is used can account for a large proportion of its sustainability performance.

this also demands an acknowledgement that in making decisions about material we inevitably make decisions about the non-material, such as energy use, life, and human experience.

On a more pragmatic level, this research project is primarily concerned with the material that is used by humans for producing artefacts (therefore excluding water, fuel and food) and from this point on the term 'material' will be used in this more limited way while 'matter' will be used in the broader sense described above. A contradiction is inevitable here; what is done with the material of production inevitably relates to other material resources.

Returning to the table of global concerns under the banner of sustainability presented earlier (fig. 2.1.1), material relates directly to only two concerns, highlighted in figure 2.2.1.

Figure 2.2.1: UK Government Sustainable Development Framework Indicators representing the current, often conflicting concerns under the banner of Sustainability: directly implicating material

Greenhouse Gas emissions	Employment
Resource use	Workless Households
Waste	Childhood poverty
Bird populations	Pensioner poverty
Fish Stocks	Education
Ecological impacts of air pollution	Health inequality
River quality	Mobility
Economic growth	Social justice
Active community participation	Environmental equality
Crime	Wellbeing

However, tracing back through the greyed-out headings other implications come to mind, many of which are inextricably linked. For example, starting with 'Greenhouse Gas emissions'...

- Many materials utilise large quantities of fuel in their extraction, transport and processing which leads to CO_2 emissions[21];
- Many materials are extracted from poor countries where local people are unable to benefit from the wealth contained in their land, and local environments are often destroyed in the process leading to reduction in habitats and extinction of species[22];

[21] For example, recycled aluminium uses only 5% of the energy used to extract it from a virgin source (WRAP 2009b)

[22] For example it is claimed that the increase in mining in India threatens local environments and displaces indigenous people (Mok 2008)

- Developing economies, growing populations and wealth create high demand for materials that are scarce, meaning that for poorer nations to live with the same material wealth as rich nations at least three earths worth of resources would be required (Bioregional 2008);
- Many materials have been linked to adverse health effects in those involved in the extraction and processing of that material[23];
- All materials use energy and most use water in their extraction, growth, transport and processing (Chapagain 2009);
- There is an ongoing debate about whether cropland which could be used for food production should be used to 'grow' production materials and fuels[24];
- A link has been reported between material-rich lands and the location of conflict, which of course is detrimental to the wellbeing of local people[25].

While the truth in these types of claims is often difficult to establish, and this is by no means an exhaustive list, the aim is simply to show how material can be seen to play a significant role in affecting sustainability and also to demonstrate the power of thinking about material sustainability holistically.

However, it is concerns over 'resource use' and 'waste' which provide the motivation for those who believe that effective material cycles are essential for a sustainable future. That effective material cycles could improve some of the other issues is an additional benefit.

2.2.2 The Material Cycle

In nature all matter moves in cycles whether over a month, a year or millennia[26]. It is the ability of nature to manage matter in this way that enables the continuation of life. Lovelock writes:

> The second law [of thermodynamics] states unequivocally that the entropy of an open system must increase. Since we are all open systems, this means that all of us are doomed to die. Yet it is so often ignored or deliberately forgotten that the unending death-roll of all creatures, including ourselves, is the essential complement to the unceasing renewal of life.
>
> (Lovelock 1979:125)

It is inevitable therefore that in the process of living humans will produce a *lower-grade* form of matter than that which is input, but it doesn't necessarily follow that it cannot then be used in the creation of a new *high-grade* form. The cycle of matter determines this; matter is never 'lost' and therefore can be used again and again in the creation of the new. This principle can be equally applied to the cycle of matter that

---

[23] The most established example is asbestos-related illness, but numerous other substances used in material production have been linked with health-problems in employees. For example the risks of Chromium have been highlighted by the Health and Safety Executive (1991)

[24] See for example, the BBC's coverage of *Food versus Fuel*, a broadcast in BBC Radio 4's *Costing the Earth* series (Ayre 2007)

[25] This is said to be due either to resource abundance or scarcity, see for example *The Coming Resource Wars* (Klare 2006) March 07, 2006 last accessed 05/05/09

[26] For example water has a short cycle, plant matter a slightly longer one, carbon and minerals cycle over a much longer period of time.

we use in our industries as well as that which we consume as living creatures. Indeed Lovelock suggests that rather than being inevitable, the continual cycling of matter resulting from our industrial processes is to our advantage and the only 'sensible' solution:

> Criticism is only justified if we fail to find neat and satisfactory solutions which eliminate the problem while turning it to advantage. To grass, beetles, and even farmers, the cow's dung is not pollution but a valued gift. In a sensible world, industrial waste would not be banned, but put to good use.
>
> (Lovelock 1979:27)

McDonough & Braungart (2002) have created a new language around the idea that *'waste equals food'*, with the aim of applying the principles of nature's cycles to the contemporary challenge of managing cycles of material used in human activity. McDonough & Braungart's chief accomplishment is arguably in recognising that, although all matter is derived from the same natural elements, once humans have manipulated that matter nature is not always capable of reabsorbing it into natural cycles. Instead, two separate cycles are proposed:

- *Biological cycle* operating in the *biosphere*, the cycle of *biological nutrients*.
  Describes material that can be readily absorbed into natural cycles;
- *Technical cycle* operating in the *technosphere*: the cycle of *technical nutrients*.
  Describes material manipulated by humans, particularly in industry, that cannot be readily absorbed back into natural cycles.

McDonough & Braungart argue that, if matter resulting from human activity is managed separately within these two cycles, human activity and growth can be sustained with little impact on quality of life or the environment. There are intricacies to the *Cradle to Cradle* protocol, including the emphasis on control of toxic substances, and criticisms could be made of the McDonough & Braungart's apparent dismissal of concerns over sustainable energy supply, current rates of production and consumption, and use of land for non-food crops. However, the principle of *waste equals food* is useful in the context of sustainability and material use, if only in providing a suitable language and framework for further exploration and discussion. Datschefski's (2001) *Five-fold Path* follows a similar logic to *Cradle to Cradle* protocol, but usefully includes the 'social' and 'efficiency' dimensions: the right flow of materials (100% cyclic), sources of energy (100% solar), types of materials (100% safe), use of materials (ultra-efficient), and treatment of people (social) (Datschefski 2001:1 abridged).

In the face of looming legislation, the waste management industry has also had to address the challenges of material cycles. Being involved in an industry tasked with reacting to whatever 'waste' society throws at it, has led some to seek more effective ways of managing resources. Beginning in 1996, the Landfill Tax

Credit Scheme[27] enabled the waste management company Biffa to initiate Biffaward which distributed over £10 million to more than 60 research projects under the banner of the *Mass Balance Research Programme* which aimed to:

> Quantify the movement of resources through economic sectors or geographical areas as these resources are extracted / imported, manufactured into products, used and disposed of or recycled. The aim of the programme is to provide accessible, well-researched information about the flows of different resources through the UK economy.
>
> (Biffaward 2006:26)

In 2006 the projects were consolidated in *The Mass Balance Movement,* a report asserting that "we need to know how to measure our resource efficiency. Because the old adage that 'what gets measured gets managed' and even more surely its corollary 'what doesn't get measured doesn't get managed' apply to resource use." (Biffaward 2006:3). In other words the complexities and details of material cycles involving human activity need to be 'known', because not knowing means not understanding how the cycle or 'flow' of material can be managed more effectively.

Thinking in terms of material cycles, therefore, is helpful for understanding how to manage material resources in a more sustainable way. Yet the simplicity of the concept is deceptive and doesn't represent the real challenge of making material cycles as effective as is necessary for there to be any significant gain for the general aim of sustainability. The success of industrial material cycles can be seen to rely on the development of approaches which succeed in delicately balancing economic and technological feasibility, fiscal support and consideration of other sustainability concerns such as energy, water and toxic chemical use. There is also a strong will for approaches to demonstrate social benefits, and so it is easy to see why in many cases the challenge remains.

2.2.3 The Beginnings of Material 'Recycling'

The clues to why Western society has come to think of recycling as an important contributor towards redeeming our unsustainable behaviour can perhaps be seen in the history of our awakening to issues of environmental sustainability. Realisation on a large scale that human activities were having a negative impact was perhaps first triggered by the visibility of pollution. There were, for example, several major oil spills in the 1970s[28] leading many to look for methods of prevention.

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[27] This allowed monies derived from Landfill Tax to be used and distributed by waste management companies for projects focusing on the waste issue (Biffaward 2006).

[28] According to the International Tanker Owners Pollution Federation (ITOPF), Large oil spills (over 700 tonnes) were frequent in the 1970s, peaking at 34 large spills in 1979 alone compared to just 1 in 2008 (International Tanker Owners Pollution Federation 2009)

The visibility of waste in the environment gave rise to the popularisation of recycling[29] and schools began introducing environmental issues by teaching children the principal of recycling (Potter 1992). Not only was waste and pollution the most visible sign of unsustainable behaviour, it could also be seen locally in the hedges and waterways of the UK. Misuse of materials was central to this awareness-raising; the idea that 'throwing things away equals waste' is a simple concept to grasp. This, and the proliferation of government and legislative backing, has meant that general optimism about recycling has been difficult for sceptics to shift. Other ideas about how to behave in more sustainable ways have not had the beneficial head start that recycling has.

Recycling seems to make sense in the here and now; we have huge quantities of waste, what should we do with it? Bury it, burn it or recycle it? Most people would opt for the latter because somehow it makes more sense. Ruston & Denison state in their 1996 article *Anti-Recycling Myths: Commentary on "Recycling is Garbage" (John Tierney, New York Times Magazine, June 30, 1996)*:

> The growth in recycling programs reflects the common-sense instinct of Americans to conserve resources and not foul their own nests. The very success of recycling has spawned detractors, who question its merits. Yet there is now compelling evidence that, by transforming waste materials into useable resources, recycling provides our society with several major benefits:
>
> - Recycling cuts pollution and conserves natural resources.
> - Recycling conserves energy.
> - Recycling programs that are sensibly designed and implemented can be cost-competitive with solid waste landfilling and incineration.
> - Recycling creates jobs and reduces costs in manufacturing sectors that are an important part of our economy.
>
> (Ruston & Denison 1996:no pg. no.)

This claim is further supported by Denison's review of Life Cycle Analysis (LCA) studies, also in 1996. The review concluded that "Systems based on recycled production plus recycling offer substantial system-wide or "life-cycle" environmental advantages over systems based on virgin production plus either incineration or landfilling, across all four parameters examined." (Denison 1996:192).

2.2.4 The Waste Hierarchy

As Denison suggests, the prioritisation of recycling in the early '90s by government and industry attracted much criticism. The '*what shall we do with it?*' approach to waste issues – reacting to the problem rather

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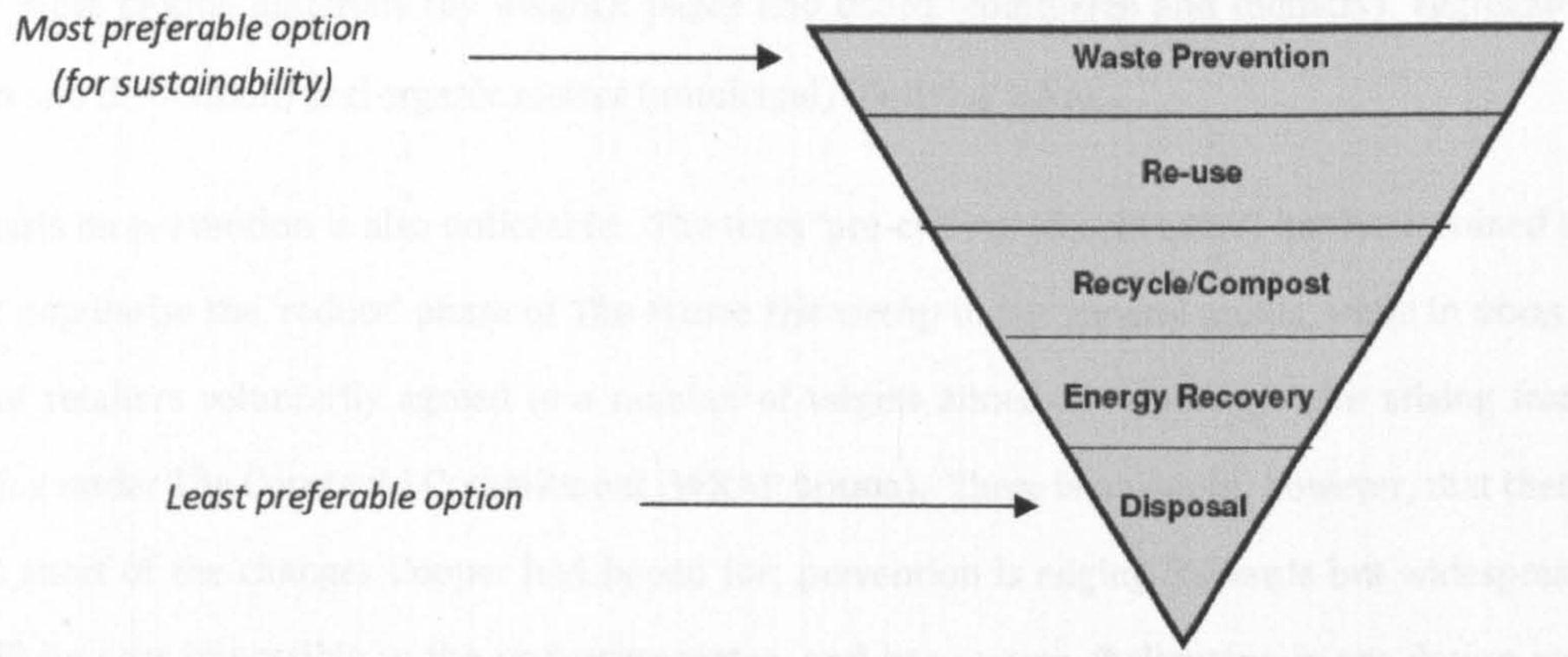
[29] *The Story of Stuff* aptly demonstrates the 'visibility' of waste and hence the (relative) popularity of recycling compared with other costs that are 'invisible' to the US public (Leonard 2005). Further examples of this mindset are present in popular culture: *The London Paper* (13th June 2007) implores its readers to "Save the Planet – Start with Soho" in an attempt to curb the increasing stream of its free newspapers in landfill. While, in the title track to his 2006 album *Kingdom Come*, hip hop artist Jay-Z admits "there's much bigger issues in the world, I know, but first I had to take care of the world I know". Although recycling clearly wasn't on Jay-Z's mind when he wrote this lyric, he speaks of a common (perhaps innate) sensibility for dealing with what's immediate and visible which may differentiate recycling from other sustainable activities that are distant and 'invisible'.

than attempting to prevent it – was, and still is, a major cause of concern for many. These views are largely represented by *The Waste Hierarchy,* a model which identifies the order of preference for approaches to dealing with waste materials. Importantly *The Waste Hierarchy* recognises that there are other options for addressing the waste issue other than the 'end-of-pipe' solutions of recycling, energy recovery and disposal.

Figure 2.2.2: The Waste Hierarchy: adapted from Waste Strategy 2000, (DEFRA 2000)



Cooper presented this 'prevention over cure' argument in 1994 in *Beyond Recycling: the Longer Life Option* for The New Economics Foundation:

> The order in this [waste] hierarchy suggests that increasing the durability of products and improving after-sales services, in order to extend their use, ought to take precedence over recycling, which is third.
>
> (Cooper 1994:10)

Cooper puts forward a strong case for reducing the overall quantity or 'throughput' of materials not only by improving the efficiency of manufacturing methods but by making products last longer. Cooper claims that designing 'consumer durables' would have far-reaching indirect positive impacts as well as the obvious reduction in waste and throughput of materials; benefits ranging from energy reduction to social and individual wellbeing. Critiques of recycling such as this could easily be misunderstood as *anti*-recycling, but Cooper clearly states that his criticism is aimed at the prioritisation of recycling in policy and industry, not recycling itself. This view has also been played out to a large extent through the various approaches to considering sustainability in design practice, presented earlier (fig 2.1.3), in particular the use of *product-service systems,* where repair is an integral part (Cooper & Evans 2000), as well as a move towards *emotionally durable design*, a concept popularised by Jonathan Chapman (2005).

Although most would admit that effective materials cycles are necessary in addressing immediate and future concerns, the majority would also agree with Cooper, that recycling is not the first priority and this should be reflected in government policy and industrial activity.

2.2.5 Evolving Attitudes to Material Cycles

In the fifteen years since Cooper's report there have been numerous threats to public opinion of recycling[30] and, although they remain relatively low, recycling rates have risen[31]. The policy around recycling has seen some significant changes including a great deal of legislation and regulation around diverting material from landfill, which is now becoming the most expensive option for dealing with waste and is rapidly reducing in capacity.[32] This has led the Mayor of London's Office to concentrate landfill diversion efforts on the three most prolific materials (by weight): paper and board (commerce and industry), aggregates (construction and demolition) and organic matter (municipal) (Dedring 2009).

A new emphasis on prevention is also noticeable. The term 'pre-cycling' (Siegle 2008) has been coined to describe and popularise the 'reduce' phase of *The Waste Hierarchy* to the general public; while in 2005 a consortium of retailers voluntarily agreed to a number of targets aimed at reducing waste arising from their packaging under The Courtauld Commitment (WRAP 2009a). There is no doubt, however, that these activities fall short of the changes Cooper had hoped for; prevention is edging forwards but widespread durability will be near impossible in the packaging sector, and has proven challenging in the design and production of electronics[33].

Most relevant to this project is the change in approaches to dealing with material that has been already been diverted from landfill. The introduction of the Packaging Regulations, and the Waste Electrical and Electronic Equipment (WEEE) and End-of-Life Vehicles (EoLV) directives has led to a massive increase in secondary material, varying enormously in composition and contamination. The debate around the most beneficial method for recovering value from this material has continued since Denison's 1996 review, fuelled by the introduction of new technologies each offering different benefits. However, a more recent review of Life Cycle Analyses (LCAs) of end-of-life options for dealing with waste material, conducted by the Waste and Resources Action Programme (WRAP), supports Denison's earlier findings: "The results are clear. Across the board, most studies show that recycling offers more environmental benefits and lower environmental impacts than other waste management options." (WRAP 2006b:1). Importantly however, WRAP states that its findings take for granted that the reprocessed material is used to replace its virgin equivalent; down-cycling is no longer a desirable option in most circumstances. The implication therefore is that where material properties can be retained material recovery and reprocessing is the best option, but where only a lower-grade material can be achieved other treatments may be more beneficial. This view

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[30] For example the outrage over export of recovered materials (Vidal 2004)

[31] Household recycling in London increased from 9% in 2001/2 to 26% in 2007/8 (Capital Waste Facts 2008)

[32] In 2009 it cost around £60 per ton (Landfill Tax gate-fee plus operator fee) to dispose of waste in a UK landfill site (Jones 2009). It was reported that at the close of 2007 there was seven years landfill capacity remaining in England and Wales based on 2007 rates of disposal to landfill. This of course varies from region to region. (Environment Agency 2008b)

[33] Improvements in efficiency, changes in fashion, and new technologies mean that the turnover of electrical and electronic equipment seems set to continue. Possible alternatives to recycling include remanufacturing of components and designing for repair and upgrade, however this is still not a popular choice for consumers and recycling remains the most prolific sustainability option for Waste Electrical and Electronic Equipment (WEEE).

was strengthened when the global recession hit in October 2008 with a sudden fall in material prices[34]. WRAP conducted a survey of 200 organisations and found that "quality materials are still moving at good volumes, generally having less trouble finding end markets and securing long term contracts"; materials that easily retain their properties can weather changes in the market much better than those with "variable quality" (WRAP 2008c: no pg. no.).

As highlighted above, material properties must be retained following reprocessing and the cycle is not considered 'complete' (recycled) until that material has replaced virgin material in a product that is sold, continuing the material's path around the cycle into use. With some materials, for example metal and glass, this already works quite well but with others, such as plastic, there is much room for improvement. Infrastructure adds to these difficulties. There is very little reprocessing capacity in the UK; it has been suggested that 199 new reprocessing facilities will need to be built in London in order to achieve the Mayor's target of 85% self-sufficiency with regards to waste arising in London and 80% diversion from landfill by 2020 (Greater London Authority 2008: sections 4.70-4.79). The UK's ability to process and use all of this material is clearly limited in the short term.

It would appear that at the current rate of material throughput, end-of-pipe methods will not be sufficient alone. There clearly needs to be a combination of tactics which consider the whole of the material cycle from prevention through to reuse, reprocessing then reincorporation into production; minimising throughput and maximising re-use, longevity and retention of properties in secondary material where possible and appropriate. Quite simply this requires the consideration of recycling as one part of a sustainable and effective material cycle; a holistic view of what is best for the cycle is essential.

2.2.6 From Recycling, to Effective Material Cycles... to Sustainability

It is important for this project that the role of recycling in promoting an effective material cycle is fully explored. It has been proposed that the recovery and reprocessing of material is the most desirable *end-of-pipe* option for material when properties can be retained, but is less important than the prevention of material throughput and the longevity of a product that may enable it to be reused and repaired. However, as already stated above, recycling has a commonsense simplicity and a head start over other methods of sustainable behaviour change, not to mention significant political momentum, which offers it up as a possible starting point for encouraging people to think about more complex issues of material sustainability. Moreover, the literature suggests that these are also the views of designers and design organisations. Van Hemel (1997) for example found that the introduction of 'recycled material' was the third easiest eco-design principal for organisations to adopt after 'recycling' and 'product reliability', while

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[34] Material prices for secondary materials echoed those for virgin, *all* material prices fell and then re-stabilised by early 2009 (see material price graphs in Appendix). WRAP also identified the close of the Beijing Olympics as a probable contributing factor in the fall in demand for all materials and suggested that the pre-collapse material prices were unsustainable. (Goodwin 2009).

Fletcher reports "the preferred method of reducing the impact of a respondent's particular 'product' was materials-focused and chiefly natural and recycled materials-focused" (Fletcher 1999:239).

Earlier it was argued that focusing on material was a good starting point for thinking about sustainability and so, in turn, *the material cycle* can be used to start to think about material sustainability. This suggests a "path" (Argument, Lettice, & Bhamra 1998:67) towards the type of awakening that Wahl & Baxter (2008) consider necessary for higher-level awareness of sustainability; while this is not the *only* path towards such an awakening, starting with 'the material cycle' appears a suitable candidate because of the political and cultural momentum it carries.

This method has already been used to apparent effect by London Remade. In June 2001 *The Mayor of London's Green Procurement Code* (MLGPC) was introduced where companies with an intention to buy more products made from recycled material register their intent as a sign of goodwill. London Remade has since expanded the MLGPC to encourage the procurement of products that:

- use fewer natural resources;
- contain fewer hazardous or toxic materials;
- have a longer life span;
- consume less energy or water in production or use;
- can be reused or recycled on disposal;
- generate less waste, for example be made from recycled materials, use less packaging or be recycled by the supplier.

(London Remade 2009: no pg. no.)

London Remade maintain that "recycling is the UK's no. one green activity" (London Remade 2007:6) and have demonstrated the potential of using this popularity to introduce a broader range of concerns.

Recycling, reuse and repair have one further benefit highlighted by Cooper (1994) and llustrated through London Remade's work[35]; as opposed to current methods of production, they are 'labour-intensive' rather than 'resource-intensive'. The benefit of this is the generation of jobs locally through the collection, sorting, processing and repairing of secondary materials and products. However, Cooper highlights that a labour-intensive process makes for a more expensive process which undoubtedly decreases the economic value of recovered materials. It makes sense, therefore, for companies who are enforced by legislation to recover their products to reduce the cost of labour through automation and easier disassembly. This possibly weakens the argument for recycling as a tool for social gain through job creation and strengthens the case for durable products that can be repaired. Unlike the labour involved in recycling, repair requires a certain level of skill which would generate jobs with greater overall social worth; the cost of repair to companies could be off-set by the higher price paid by people for a more durable product. Once again,

[35] This is demonstrated through London Remade's emphasis on job creation, supporting projects which provide employment (London Remade 2006b:3.1)

recycling in this situation is not the first priority but a necessary process when the product is beyond repair, at which point the process must be highly efficient and effective so that the material recovered is more valuable. The point here is the importance of a *local material cycle* for job creation and social well-being. Cycling materials locally through re-use, repair and then eventually disassembly and reprocessing, could encourage a more responsible attitude to material use; by keeping the consequences of our activities close we can better respond to undesirable impacts[36].

2.2.7 Towards an Effective Material Cycle

This discussion has highlighted the strategic place of material recovery and reprocessing within an effective material cycle and within the sustainability agenda. However, closer examination has revealed that there are many criticisms of current systems of material recycling and that there could be many improvements. So, what is effective material recovery and recycling? In what ways does the current system need to be changed? Figure 2.2.3 first highlights Cooper's main criticisms of recycling and then the implications for a more effective system.

Reviewing the numerous flaws in the current system, it would appear that overall improvement relies on the successes of each of the individual suggestions. This echoes the work of London Remade, who in 2000 began looking at recycling infrastructure and came to realise that engaging every stage of the material cycle is crucial to developing a more effective system. As a result they have worked on programmes in the areas of supply, demand, infrastructure, awareness and design; a holistic approach is central to their activities (London Remade 2006a).

It was proposed in Chapter One that the focus of this study on mass-produced artefacts was justified because as much secondary material must be reincorporated back into production as is collected for recycling to be effective. A further implication of this argument is that material cycles do not necessarily need to involve gargantuan flows of material tied to mass-production. Rather the size and 'shape' of material cycles mirror the dominant size and shape of production and, in the event of a slow-down in production and consumption, materials cycles too will slow down and reduce in scope. The current inflexibility in the system of production, reflected in material cycles, will be discussed further in Chapter Five.

The improvements highlighted in figure 2.2.3 are ambitious however, it is important to consider an ultimate end-goal for effective material cycles; only with an ideal system in mind can we take informed steps and more importantly convince critics that this work is worthwhile and necessary.

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[36] This is not to suggest total localism but, in the interest of preventing externalisation and promoting the reduction of material 'throughput', waste materials are one resource that could benefit from cycling locally.

The previous two sections of this literature review have considered the relationships between 'sustainability and material', and 'sustainability and design'. The next section will discuss the third pairing: 'design and material'.

Figure 2.2.3: Towards more effective material cycles; criticisms and their implications for future improvements

Cooper's (1994) criticisms of recycling	***Implications for more effective material cycles***
Prioritisation of recycling over more sustainable methods	Increased understanding of the hierarchy of sustainable methods. The material cycle understood as a tool for 'minimising input, maximising retention and minimising output', not just a tool for promoting recycling.
Energy used in collection and transportation	Keep material flows local or closed loop and ensure value is retained through subsequent cycles: "Proximity" and "self-sufficiency" (Greater London Authority, 2008).
Materials are not designed for cycling, causing hazardous by-products	Reprocessing potential considered at the material development and product development stages of the material cycle; identify existing materials that can be effectively cycled.
Recycling creates a demand for waste materials, increasing 'throughput'	Recycling's political and cultural momentum used as a foot-in for other methods, creating a gradual shift towards other more sustainable methods that will reduce 'throughput'.
Materials lose their value through down-cycling	Increased understanding that some materials cycle more effectively than others, and that absolute separation of materials is key in recovering value. Consideration of other treatment methods if properties cannot be retained.
Recycling will always involve energy use and material dissipation: the laws of thermodynamics	Improve efficiencies in recycling methods: this is already much improved since Cooper's report. Use renewable energy sources and ensure secondary materials replace virgin ones, therefore saving energy and CO_2 emissions
Raw materials are too cheap and recovered material is often worth less than the cost of recovery	The growing interest in sustainability is leading to increased demand for recovered materials with comparative properties[37]. Meanwhile the scarcity of virgin materials, which is likely to increase in the near future, will enable secondary materials to be more cost-competitive than at present. Improve the property retention of recovered materials. Decrease labour and other costs in the recovery process (design-in easier recovery of materials). Find appropriate high-value applications for recovered materials.
Recycling is at odds with other sustainable design criteria such as using materials that are lighter weight, more durable, in greater abundance, and dematerialisation.	Responding to changes in material use and considering the reprocessing needs and implications of those materials. Continuing to encourage the use of fewer types of materials and easier separation at End of Life (EOL).

[37] For example meeting demand for recycled PET (R-PET) is currently a challenge for producers (Gander 2007)

2.3 Design and Material

2.3.1 A Designer's View of Material

So far it has been acceptable to talk about 'design' in general terms because the focus has been on aspects which could be seen to be applicable to all designing. However, as the discussion begins to hone in on the specific focus of the project, it is perhaps wise to identify the type of design being considered, which is more difficult than it sounds. Primarily it is "designers of 'things'" (Cooper & Press 2003:175) that are the main focus of this study, but not buildings or large constructions, graphics or print, and not clothes. The traditional terms 'product', 'industrial', 'furniture' and 'vehicle' could be used, but it seems more appropriate and less prescriptive to say *the design of small and medium-sized artefacts*[38].

In the types of design being considered here, the term 'material' is used specifically to refer to matter that can readily be processed and shaped to create form. The purpose of that form is most commonly to deliver functional and aesthetic value and, in a capitalist economy, to create consumer desire and satisfaction (Ashby & Johnson 2003) that will deliver profit. This is the fundamental relationship between material and design, and can be seen to largely dictate how designers think about material in relation to their work. This convention also implies that the consideration of material as a means of improving sustainability is not likely to come naturally to mind when a designer is working. In her study of textile designers' attitudes to eco-design Fletcher suggests:

> Expanding the basis for materials selection from the current focus on aesthetics, performance and price to cover a range of lifecycle criteria will inevitably add complexity to the task of designing. What is more, the requirement will be for selection which satisfies these environmental demands in addition to meeting the more conventional requirements.
>
> (Fletcher 1999:254)

Ashby & Johnson's (2002) practical guide *Materials and Design: The Art and Science of Material Selection in Product Design* offers some useful commentary on the role of material in design. Interestingly, Ashby & Johnson identify "four dimensions of materials information" one of which is "the environment" (Ashby & Johnson 2002:49):

- Engineering (technical attributes)
- Use (ergonomics and the product interface)
- The environment ("green" design)
- Perceptions: Aesthetic (the senses) and Personality

Ashby & Johnson discuss these different dimensions explaining that *Engineering* differs because it can be presented quite easily in numeric data or visual property mapping (Ashby & Johnson 2002:52), but the

[38] The focus of this research was originally defined by the conventional boundaries of professional design (i.e. interior, product, engineering, furniture etc.), yet the ways of thinking about design and materials that have been encountered during this work render those boundaries unsatisfactory. Nevertheless the traditional fields of professional design do have conventions of practice and understanding, and have their uses here.

ease of understanding what this data means for a given application will depend on the knowledge of the designer. Communicating how a material will perform with regards to *Use* and *Perceptions* is more difficult as these are subjective criteria and near impossible to quantify in the same way[39]. Ashby & Johnson explain that when designers select materials they must consider 'data' relating to the physical aspects of the material, but also how that material affects less tangible non-physical concerns such as how it feels, the cultural perception, how it affects or enhances use. The difference between the *technical attributes* and those relating to the other dimensions again echoes the relationship presented earlier between the material and the non-material.

Therefore it would appear that, when selecting material, designers already need to consider multiple tangible and "intangible characteristics" (Karana 2008:1087) relating to a material in order to decide whether it is suitable for a given application, which would imply that these skills could be adapted for the consideration of aspects relating to sustainability. However, *Use* and *Perceptions* are related to how people interact with material and for this the designer can, with varying success, draw on his/her other experiences as a user and a designer of things to empathise with the end-user and understand which material will achieve the results he/she is looking for. This is often referred to as *tacit knowledge* (Schön 1991) or *designerly ways of knowing* (Cross 2007); the designer's ability to 'know' instinctively the best solution. How a designer would consider the *Environment* dimension or sustainability when choosing a material can be seen to be quite different. As discussed earlier, material sustainability includes elements that can be quantified directly, such as Co_2 emissions, but also other potentially beneficial aspects which are difficult to quantify within the constraints of a design project such as wellbeing or behaviour change; drawing on experience or tacit knowledge here is unlikely to yield results for the designer.

Furthermore, even apparently quantifiable data on material sustainability are difficult to locate, are absent or value-laden which brings the reliability of such data into question. In his white paper for the development of the CES Eco-selector[40] Ashby writes:

> Eco-data of any sort exist only for a tiny handful of materials and processes (perhaps 100 out of 60,000 or more); the advice offered by LCA practitioners to those who ask for data for a non-documented material is "assume it is like one that is documented". This sits badly with the precision demanded by other aspects of LCA, and supposes a deep enough knowledge of materials to be able to make an appropriate choice.
>
> (Ashby *et al* 2005:16)

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[39] van Kesteren, Stappers & de Bruijn (2007) have developed a tool for aiding communication of Use and Perception characteristics of materials between designers and end-users and have reported positive results, despite Manzini's earlier claim that "an ideal new language spoken by all the actors involved in the design process" would "lead to an impoverishment of design." and "in fact, invention is the result of an unprecedented linguistic game, created by the new contact of different languages." (Manzini 1986:63)

[40] Cambridge Engineering Selector is a material selection tool developed by Ashby at Cambridge University and is now distributed and managed by Granta Design; the Eco-selector is the Environmental version of that tool.

Several researchers have attempted to address this problem and these will be discussed in more detail in Chapter Six. The point to highlight here is how differently a designer is positioned when considering the potential sustainability of a material compared with other more conventional or intuitive aspects such as the dimensions of *Engineering, Use* and *Perceptions*[41].

2.3.2 New and Unfamiliar Materials in Design

The constraints imposed on material use by tradition can be seen to restrict innovation in design and production, and design's ability to maximise the potential of the new. Commenting on this issue in his 1986 book, *The Material of Invention,* Manzini states:

> Designers and manufacturers are faced with an enormous and expanding field of possibilities, where the selection of materials and the selection of transformation process can be combined into one selection which we have defined as a 'hyper-selection'. For a given product, there is no longer a single material that presents itself as the obvious choice, almost as the only real candidate. Now there are different materials that compete one against another. Only an in-depth and wide-ranging analysis of the entire manufacturing process and – in some cases – of the successive life of the product itself, can lead to the selection of the most satisfactory solution.
>
> (Manzini 1986:37)

Importantly Manzini recognised the impact that an influx of so many new materials and processes would, or *should,* have on the design process and the opportunities that change represents. The prevailing idea in *The Material of Invention* is that increasingly designers need not refer to past associations of materials, processes and types of object; material can be considered in terms of possibility, only constrained by its properties and the processes available. The main challenge for those supporting designers in the consideration and selection of materials, therefore, is identified by Manzini as making "the new fields of the Possible more easily Thinkable for a designer" (Manzini 1986:17). This is an opportunity for design, but it could also be an opportunity for introducing sustainability into the frame of material and design. As Manzini sees it, designers will need to become more accustomed to approaching a project ignorant to what material may be most appropriate and in this way they may be more open to new possibilities, including the consideration of materials that may be more sustainable.

Benjamin, Edirisinghe, & Zwetsloot (1994) also recognised that the introduction of new materials had implications for sustainability in their report *New Materials for Environmental Design*:

> The mixing and combining of materials, both of traditional and new ones, which can also lead to new properties, is of growing importance. This will certainly have its impact on the processing and manufacturing of materials. It will however also influence the possibilities

[41] That is not to say that these elements are easy for a designer to understand and incorporate, indeed much of Ashby & Johnson's work has focused on making these aspects easier for the designer to consider because they are challenging to communicate and weigh-up.

> for material reuse, the nature and efficiency of waste treatment, occupational exposure and the associated environmental pollution problems.
>
> (Benjamin, Edirisinghe, & Zwetsloot 1994:13)

The cautionary tone of this excerpt refers to the potential negative impacts of pursuing the new while not fully understanding the consequences of that endeavour. Benjamin, Edirisinghe, & Zwetsloot's believe that material science has a role to play in determining the implication of materials for sustainability; that in the development of new materials sustainability performance should be considered. Here the relationship between sustainability, design, material and 'the new' becomes more interesting; science and design are both fixated on the discovery or creation of the new, and consideration of sustainability would appear to place restrictions on that goal. Yet sustainability is also new and unfamiliar (to industrialised society), posing new challenges and in many ways relies on the spirit of change and revolution that the recent proliferation of new material technologies has instigated. What is more, if the direction of change towards sustainability is cemented – as is beginning to look probable in the near future – it will undoubtedly offer opportunities for innovation rather than being seen as a distraction from the pursuit of new and exciting possibilities as has often been the case in the past.

So it would appear that there is a real, if challenging, opportunity for material sustainability to make a place for itself within the changing discipline of material development and consideration in design, not as a separate concern but as an integral part.

Manzini makes a further observation about newness which is worth considering, especially as this current project is concerned with how to make paths from the current situation towards the ideal. He considers that in order for 'the new' to be accepted it must first follow existing routes:

> First the new makes its way along secondary routes, modifying as little as possible the existing manufacturing systems and organisational models. This is the phase in which, for instance, new materials are employed as imitations, that is, as pure substitutes of materials used previously. In the second phase, instead, the entire system is redefined as a function of the innovation available. For this to happen, however, it is necessary that the ripening of economic opportunity for change should coincide with the cultural maturity of the various social entities involved, as well as coincide with the inventive capacity to overcome the traditional reference model, so as to exploit all the possibilities of the new.
>
> (Manzini 1986:49)

In some ways this reflects the situation faced by secondary materials, as unfamiliar materials to designers who are used to specifying virgin ones. Yet the recent history of secondary material use in the creation of artefacts shows that often they didn't take the path of existing materials. Designers motivated by a belief in

the sustainability agenda have attempted to find new and very visible uses for 'waste' material[42]. As Manzini explains, in order to become accepted in the mainstream secondary materials must run the paths that already exist for virgin materials before the innovative qualities and opportunities for design and production processes, that support truly effective material cycles, can be fully explored and realised. There is currently an atmosphere of possibility building around sustainability that could represent the "ripening of economic opportunity for change", the "cultural maturity of the various social entities involved" and the "inventive capacity to overcome the traditional reference model" which Manzini (1984:49) believes necessary for 'the new' to transform the norm.

The final section of this chapter considers one of the central concerns of design and sustainability thinking; the individual designers' responsibility for the ethical implications of the things they design.

2.4 The Individual Designer

2.4.1 The Designer's Responsibility

Design has evolved from a tradition of making artefacts from materials; the processing of material is seen as central to design (Pedgley 1999). Louridas (1999) explains that originally this was *unselfconscious*; people made things to solve problems for themselves and their immediate relations. In recent history this then evolved into *selfconscious* professional design; solving problems for other people:

> In selfconscious design tradition no longer filters occasion, execution, and purpose contingencies. The designer is free to resolve them and use them in appropriate ways. In fact, he is not only free to resolve them, he is also responsible for resolving them and using them in appropriate ways. Some innocence is lost.
>
> (Louridas 1999:526-7)

Thus modern professional design involves a strange juxtaposition of objectives; the joy of creating with materials which is deeply rooted in the *unselfconscious* design of the past, and the professional service which enables the designer to make a living through his or her skill and passion, which inevitably must be *selfconscious* and implies responsibility. There are two important points here about the designer's relationship with his or her 'art' and the pursuit of the sustainability agenda. First, the activity of creating artefacts using materials, which is in the designer's nature and tradition, can be seen as inherently unsustainable given the existing proliferation of artefacts and dominant methods of mass-production. Second, the designer finds that he or she is in some way *responsible* for the artefacts that are produced to his or her design, in turn leading to a sense of responsibility for the current culture of unsustainable production and consumption. Lloyd (2009) considers that this responsibility particularly comes to the

[42] Some example of these designs are presented in Chapter 5 and also represented in the [Re]Design exhibitions, shown during the London Design Festival 2005 and 2006, see www.redesigndesign.org (last accessed 30/04/09), the Haute Green exhibition in New York (Wood 2006) and previously by the Creative Resource and re-f-use exhibitions see www.re-f-use.com (last accessed 30/04/09)

fore when designers can imagine the consequences of a particular design decision that may be 'bad'. In such a situation there is a conscious decision to be made about 'whether to act or not act', and without an ethical framework, designers make these decisions intuitively (Lloyd 2009:167).

A number of authors have argued the case for or against the designer's responsibility for products that appear inconsiderate of sustainability principles (Whiteley 1994, Papanek 1995, Burall 1996). Thackara, for example, draws on the popular notion that "eighty percent of the environmental impact of the products, services, and infrastructures around us is determined at the design stage." (Thackara 2005:1) to explain the impetus behind his acclaimed book: *In the Bubble: Designing in a complex world.* Thackara goes on to claim: "We may not have meant to do so, and we may regret the way things have turned out, but we designed our way into the situations that face us." (Thackara 2005:1) This statement does not directly point the blame at designers, design decisions are made by a number of internal and external stakeholders in the design process, but Thackara's following remark confirms his belief that designers own the responsibility for putting the situation right: "If we can design our way into difficulty, we can design our way out" (Thackara 2005:1). In saying this, Thackara is appealing to design individuals to effect change in the macro-level of sustainability; the difficulties of which were introduced earlier. Christensen however, directly criticises Thackara's position:

> [According to Thackara] the designer is to aim at fulfilling the design brief in such a way that the items designed (products, services, structures, infrastructures, etc.) constitute cures (or parts thereof) to wider socio-political ills (or at least do not further entrench them). The true explanation lies in the real constraints to which most designers, in the conduct of their design activity, are subject most of the time. The real context in which real design must always occur is frequently such that design can only accomplish its objectives at the cost of numerous undesirable unintended (which is not to say unknown) consequences.
>
> (Christensen 2006:no pg. no.)

Christensen emphasises the difficulty for most designers in crossing the gap between micro and macro-activities in design and sustainability which results from the commercial nature of the majority of their work. He argues that, regardless of the presence of "ethics and responsibility" that "can inform design decisions" which Thackara describes as "design mindfulness"(Thackara 2005:7), designers are subject to constraints in their day-to-day practices which prevent any real engagement with the issues.

Van Gorp (2007) acknowledges the criticisms of pragmatists such as Christensen commenting that, while some people consider it part of the designer's responsibility to consider the ethical implications of their work, others (for example Florman 1983) believed that the requirements for a design are governed by politicians, customers and managers and that the designer's role is simply to "carry out a task formulated by others and to do so in a competent way." (Van Gorp 2007:118). However, Van Gorp is in agreement with Thackara's ideal arguing that this cannot be the case; briefs, he argues, are never made up of a well-

defined set of requirements and therefore designers have to make choices, some of which are ethically significant:

> If design problems are indeed ill-structured problems then there is more than one solution; a range of these solutions can be valid. Designers, in that case, have to choose; it is not the case that the requirements lead to just one solution.
>
> (Van Gorp 2007:118)

The two positions are distinct but not necessarily opposed; design decisions do determine many aspects of signs, products, services and systems, but the individual designer's ability to influence those decisions in all situations should not be taken for granted.

2.4.2 Personal Ethics and Design

There is good reason to believe that design individuals can use their personal motivations to influence design projects. In their study of engineering designers in Germany, Pahl, Badke-Schaub, & Frankenberger (1999) observed personal values influencing individual design practice: "...some subjects also pursued goals that corresponded more to their personal idea or own preferences, rather than addressing the task objectively." (Pahl, Badke-Schaub, & Frankenberger 1999:489). In engineering this may be less desirable than in the more aesthetically-driven design disciplines; Pahl, Badke-Schaub, & Frankenberger noted it could lead to a negative impact on the time taken to perform design tasks. Louridas, however, sees the personal element as fundamental to differentiating designing from other tasks:

> There is always a personal element in design; and for design to be successful, the designer must recognise that and pour himself into the process. Design is not just a process; it is an affective process. The designer must make his materials disclose themselves; but he must also disclose himself through the design. If design is not affective, we do not have design any more: we have results. Design is this result that does something more than simply solve the problem; it is the result that carries some part of the designer in it.
>
> (Louridas 1999:534-5)

Terms such as 'altruism', 'moral agency', 'activism' and even 'existentialism' (Julier 2007, Thorpe 2009; Manzini 2009) have been used as possible alternative descriptors for design. Landa (2002) writes:

> [Sartre] wrote that "we are condemned to be free" and that there is "no exit" from our personal responsibility; in this sense, whether a project's impact is social, creative, or environmental, responsibility rests with the designer and only the designer-not the client, nor a team member, nor anyone else. That is the plight of the individual. It is a burden that generates angst but a charge that can also be empowering and liberating. Taking final responsibility for what we design moves us in a positive, productive direction, one that benefits society and the individual... If a portfolio often functions as the means by which we assess our actions, the existentialists would no doubt have appreciated its symbolic resonance-an aggregate of all decisions, right or wrong, good or bad, it is physical evidence of one's fiber. Your portfolio reveals you, defines you, is your lasting legacy.
>
> (Landa 2002:174)

In his 2007 paper entitled *The Existential Self as Locus for Sustainability in Design,* D'Anjou proposes that the formation of the design 'self' (in design education) is the fundamental point at which a design individual will accept or reject concerns over sustainability. Again drawing on Sartrean principles, D'Anjou proposes that, when making decisions, a student refers to a hierarchy of *projects* and the decisions which best support the 'higher' projects are those that are most likely to be taken. The studio project forms the base; here decisions are made in reference to the higher project of graduating which in turn is in reference to the "the fundamental project" (D'anjou 2007:3):

> The fundamental project consists in a desire for being; it is the project of providing the individual with being. Hence all the trivial expectations of the real, all these commonplace, everyday values, derive their meaning from an original projection of myself which stands as my choice of myself in the world ... the unique and original project which constitutes my being. [...] It is the fundamental project of the student that determines his/her design choices and actions in a design project.
>
> (D'anjou 2007:3)

D'Anjou proposes that reflection and dialectic during the design studio project, encouraged by the tutor, could lead to the inclusion of sustainability as part of the existential self of the design student. However, the inherent tension between design and sustainability also means that the student may need to alter their 'fundamental project' in order to incorporate the pursuit of sustainability with that of designing. D'Anjou suggests that changes will not occur if the cost to the student's 'fundamental project' is too high.

One of Schön's (1991) central arguments in *The Reflective Practitioner* also emphasises the importance of reflection on one's decisions and framing of the professional role, suggesting that this is a necessary first step towards questioning the norms of practice and tacit understanding, which currently exclude sustainability issues. Furthermore, Schön relocates the practitioners' ability to solve complex problems from the application of pre-established knowledge to the setting of the problem to be solved:

> In real-world practice, problems do not present themselves to the practitioner as givens. They must be constructed from the materials of problematic situations which are puzzling, troubling, and uncertain. [...] When we set the problem we select what we will treat as the "things" of the situation, we set the boundaries of our attention to it, and we impose upon it a coherence which allows us to say what is wrong and in what directions the situation needs to be changed.
>
> Schön 1991:40

If sustainability issues do not form part of the designers' perceived problem-space they are unlikely to address these issues in their practice.

The concept of sustainability is fundamentally at odds with modern commercial design, a profession captivated by material, form and function, and "concerned with the new" (Frayling 1993:1), whose job it is

to provide a service for a fee. On realising the impact of design on sustainability, does the designer or design student give up the conventional notion of design? This perhaps divides those who abandon commercial design as Papanek (1984) and Whitely (1994) have suggested[43], and those who leave sustainable concerns "unresolved" (Lloyd 2009:164)[44].

2.5 Conclusions from the Initial Literature Review

Based on the discussion presented here, some conclusions can be made about the relationships between sustainability, design and material, and the implications for the positioning of this project within the broader context.

- Design's 'shape' – described here as strata – would appear to be well-suited to the problem of sustainability. Yet numerous challenges stand in the way, not least the different worldviews and opposing issues encompassed under the broad sustainability agenda, and the current paradigm of design which appears ill-equipped for these challenges.
- This study would appear to be positioned in the micro-levels of both design and sustainability, yet activity at any level must consider implications across all levels. Material recovery is not a solution in itself, but must operate in reference to improvements across the material cycle corresponding to the broader aim of sustainability. The cultural and political momentum behind 'recycling' offers a potential starting point for considering more complex issues and awakening designers to issues of sustainability.
- Although cross-disciplinary teams would appear to offer the best opportunity for improved sustainability in design, the current situation (on which this study focuses) is one where individual designers are implored by design critics, commentators and academics to take ethical responsibility for their work, in commercial work scenarios which don't appear to be conducive to pursuing sustainability in design practice.
- The traditional relationship between design and material poses a significant challenge to designers' consideration of secondary or 'sustainable' material. However, the effective communication of the possibilities of any unfamiliar material seems problematic in industrial

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[43] Papanek's (1984) position was that designers could act responsibly by designing and making things that ultimately benefitted people, without necessarily abandoning material. Whiteley (1994) (writing during a recession, following a decade of growth in which commercial design had flourished, similarly to the current time), makes the case that designing for commerce has inevitably meant sacrificing morality and responsibility to society, and calls for a design profession which rejects marketing- or consumer-led briefs and instead refocuses on "society and the world", "the needs of individuals and social groups that have little power in the market-place" (Whitely 1994:3). The relatively recent development of 'service design' seeks to find a new position for design practice which both benefits society and is not coupled to material production in the same way as conventional commercial design (see for example Hollins (2006) What is Service Design?)

[44] Further evidence for the possibility that designers might ignore ethical issues in favour of the greater task of designing, is provided by Lloyd (2009), who observed design meetings in which ethical consequences of designs emerged in the discussion but were "left unresolved" and which Lloyd suggests might be "because to make a definitive judgment about its ethical nature would be to put a brake on the associative process driving the underlying technical discussion" (Lloyd 2009:164).

design. In raising designers' awareness of unfamiliar materials generally, they may also be more open to the merits of secondary material.

2.5 Chapter Two Summary

The aim of this Initial Literature Review was to consider the three themes – design, material and sustainability – which form the context for this study with its focus on the use of secondary materials in design. To this end the interconnections between 'sustainability and design', 'sustainability and materials', and 'design and material' have been explored in relation to the literature and the specific focus on secondary material use in design practice. In addition, the responsibility of the designer was considered as this is seen as central to addressing the project aim. Focused literature reviews were undertaken for each of the empirical enquiries and are included in the corresponding chapters.

The next chapter presents an overview of the project methodology which was chosen to meet the project aim and objectives.

CHAPTER THREE Methodology Overview

This chapter discusses the methodological position of the project as a whole, explaining the relationship between the project aim and objectives, the research questions and individual enquiries, and how this translates into the research design.

3.1 The Design Inquirer

Research with 'design' as its focus is relatively new and is still in a formative phase, where the purpose, definitions and scope are the subject of much debate (Durling & Niedderer 2007). One of the most succinct and relevant categorisations of design research was proposed by Frayling, after Herbert Read, as research *into, through* or *for* art and design (Frayling 1993:4); distinguishing the 'objective' investigator from the design practitioner in relation to the research project. This project can be described as research *into* design because the author is investigating the practices of other designers. However, it is worth noting that the author is also partially located within the design community, being educated in design thinking.

An element of research *through* design has also been used in this project. In addition to the more conventional method of using discussion to integrate and make sense of the empirical findings, possible solutions to the problem of supporting designers in the consideration of secondary material were explored. This served as a way of further processing the findings and understanding how they may relate to the project aim.

Durling and Neidderer, who have criticised the methodology and rigor of some uses of design practice in PhDs, have proposed "five categories of designing within PhD study which, to a lesser or greater extent, may assist in generating new knowledge and its dissemination" (Durling & Niedderer 2007:16). The term "Investigative Designing" is used to describe these methods but Durling & Niedderer maintain that they are speculative and not exhaustive of all uses of designing in research. Each category is summarised in figure 3.1.1. A further contribution to this discourse is provided by Pedgley & Wormald (2007) who advocate the use of a design project within the PhD to "find out about design practices", to "devise improvements in design methods" or "to make improvements to designed artefacts" (Pedgley & Wormald 2007:85). Pedgley & Wormald also advocate 'designing as enquiry' although their focus is on the role of a design project within a PhD, rather than the role of designing as a more flexible method of enquiry outside of practice-led PhDs.

Figure 3.1.1: Five Categories of Designing within PhD study with summaries adapted from Durling & Niedderer (2007:10-14)

Designing to Test	Designing prototypes to test some aspect other than the design process itself, typified by a project where rapid prototyping technologies were tested for the benefit of design practice
Designing Quick and Dirty	Making 'quick and dirty' improvements within a given context and analysing the improvements gained; concerns are expressed over robustness of data and generalisability
Designing as Demonstration	Producing a specification for improvements following a valid research enquiry; a 'conjectural design' may be produced to demonstrate the feasibility of the specification but is not tested
Designing as Ideal	A valid research enquiry identifies possible improvements, a design prototype is created and users' views elicited to validate improvements made. Some concerns are expressed for the research methodology if the 'testing' does not validate the design
Designing as Creative Exploration	"The working through of a research problem through designing" Designing is used to better understand phenomenon where deduction is insufficient or inappropriate

The design research method used in the current project is similar to what Durling & Niedderer describe as *Designing as Demonstration*:

> The researcher has identified a number of features of a product which, if incorporated into a design, would lead to product improvement and better user satisfaction. Let us take as a given that the research is valid, and the specification is the product of a line of robust enquiry which demonstrates research competence suitable for the award of PhD. The candidate might, as an additional aide to visualising the possibilities for product improvement arising from the specification, choose to operationalise the specification in the form of a conjectural design. This would not be an 'ideal' product, or the ***only*** possible manifestation of the specification, but would have the sole purpose of demonstrating that the specification could have practical outcomes. The thesis argument would not rely upon this artefact, which might not progress beyond a conceptual stage, and would not for example be tested with users.
>
> (Durling & Niedderer 2007:11-12)

In the case of this project the empirical findings, which involved 'robust enquiry', were explored and integrated from which a 'specification' was made for improving the support for designers when considering secondary materials. Possible solutions were then explored which sought to 'demonstrate' the practical application of the research as well as further process and understand the findings as described above. Design therefore is used here as a research method in contribution to a fully written thesis where no part of the design practice is examined as an outcome in itself. The specifications and the resulting conjectural

designs could be further developed by the author following the PhD or used to inform future work in this field by other researchers.

3.2 Responding to the Project Proposal

This project was introduced in Chapter One as being a product of the Arts and Humanities Research Council's (AHRC) Collaborative Doctoral Award (CDA) scheme. The main difference between this and the more conventional PhD project is that it was initiated by two collaborating partners who wrote the project proposal which the author then responded to and brought to fruition.

3.2.1 Collaborative 'Real-world' Research

The position of the collaborative partner (London Remade) within industry necessitated that the project investigate current issues, practices and challenges. Unlike the majority of CDAs funded by the AHRC, which are historical and located in collections (museums, galleries, libraries...), this project is contemporary and situated in the 'real-world'. Robson (2002) comments:

> One of the main challenges inherent in carrying out investigations in the 'real-world' lies in seeking to say something sensible about a complex, relatively poorly controlled and generally 'messy' situation.
>
> (Robson 2002:4)

The real-world is an 'open-system'; variables cannot be controlled in the same way as in a closed-system such as a laboratory, or indeed an archive. Inevitably this project emulated approaches common in social research where rigorous and systematic enquiry is adopted with the aim of getting as close to the 'truth' as is possible in an open-system.

One benefit of real-world collaboration is that the study is addressing a 'real' and immediate problem which indicates that the research could be of particular benefit to society. This potentially beneficial 'impact' of research is now acknowledged in the Research Excellence Framework (REF) which states that "recognition will be given where researchers build on excellent research to deliver demonstrable benefits to the economy, society, public policy, culture and quality of life" (Higher Education Funding Council for England (HEFCE) 2009:no pg. no.).

This project did not involve a common outcome which the doctoral student and the collaborative partner were working towards in synergy setting it apart from other CDAs which, for example, may explore histories or archives contributing towards exhibits[45]. Rather, London Remade's anticipated involvement was to offer a gateway to industry contacts, insight and expertise, and supervision outside the academic institution. To a large extent the collaboration performed this role successfully.

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[45] For more information about the types of projects funded by AHRC CDAs see http://www.ahrc.ac.uk/FundedResearch/BrowseResearch.aspx (accessed 01/05/09)

There is often some concern that 'sponsored' research can lead to a biased enquiry. However, in this case both industry and academic supervisors were supportive of the author pursuing a critical interrogation of the project assumptions.

Some complications limited the potential success of the collaboration, such as the turnaround of staff within London Remade which resulted in the original supervisor leaving the project at the end of the first year. In addition, a change to London Remade's funding has meant that their focus has shifted to commercial consultancy work, resulting in a move away from the more 'worthy' projects such as the role of design in developing markets for secondary materials. This unfortunately means that the project is not as aligned to London Remade's current remit as it was at the start. Alternative routes for the dissemination and use of the research may include design education, materials information providers and design workshop providers.

Nevertheless, London Remade's involvement in the project has resulted in many opportunities which would not have been available otherwise, including industry contacts, site visits, giving talks, consultancy work and attending conferences. These are listed in Appendices B(i) and C(i).

3.2.2 Translating the Objectives into Enquiries

The project objectives were presented in Chapter One and are reiterated here to enable easy reference:

1. Investigate designers' perspectives on secondary material use in relation to their own professional practice, particularly in London;
2. Identify key potential product and design sector applications for secondary materials within London;
3. Investigate current processes and tools by which designers are enabled and supported in creating high-value applications for secondary materials;
4. Critically reassess these processes and tools to support design practice;
5. Develop innovative models to support designers in finding new applications for surplus and waste resources.

These objectives dictated the shape of the project, outlining a logical progression from investigating design practice through to potential design uses for recovered materials, then existing methods of supporting designers, and finally the development of new models. However, the original research proposal does not provide the theoretical framework for the investigation or the specific focus of the objectives and these, therefore, needed to be established by the author before planning or undertaking any primary research.

The key to critically interrogating the original project aim and objectives was the Initial Literature Review presented in Chapter Two. Subsequent 'focused literature reviews' were then necessary in order to respond to each of the objectives independently, which allowed the formation and answering of questions about the

focus of each enquiry (Objectives 1, 2, 3 & 4 were translated into Enquiries 1, 2 & 3, outlined in figure 3.2.1). In addition to the literature reviews eleven semi-structured interviews were conducted with 'experts' from different areas of industry. The purpose was to gather different perspectives from within industry to add relevance and up-to-date information to the background research. This is discussed further in Chapter Four.

As each objective was approached separately the particulars of the methods used, rationale and specific research questions are included within the corresponding chapters in Part II: Three Empirical Enquiries.

3.2.3 Research Questions

The structure of the research project involved *overarching research questions* informed by the Initial Literature Review and relating to the project aim, and *enquiry research questions* relating specifically to the individual enquiries.

The overarching research questions in essence translate the project aim (of *creating new models for utilising surplus and waste resources in design practice)* into enquiry:

Question 1 asks: ***Are designers in a position to utilise secondary materials?***

This discloses the theoretical framework behind its formulation (explored in the Initial Literature Review) that the scenario of a designer may hold clues as to whether or not they are able or inclined to use or specify secondary materials in their design work. This question is addressed in the empirical research carried out through Enquiries 1 & 2.

Question 2 asks: ***What can be done to support designers in utilising secondary materials?***

This involves the appropriate application of the knowledge gained in response to Question 1, and is addressed through Enquiry 3 and the integration and interpretation phase of the project (Chapter Seven).

The purpose of the *enquiry research questions* was to direct each of the three enquiries so that they contribute to answering the *overarching research questions,* and consequently the project aim. These are outlined along with the corresponding chapters in figure 3.2.1.

3.2.4 Project Outcomes

Although the project proposal was open to interpretation by the author, there was an expectation in the original proposal that there would be practical outcomes to the project; these were made explicit as 'anticipated outcomes' (outlined in Chapter One). However, developing these outcomes to an appropriate standard to be considered the main outcome of the PhD would have required a large proportion of the project time, so the author chose to develop possible solutions only in the service of making sense of the empirical findings and understanding how they relate to the aim of finding new ways of supporting designers.

The main outcomes of this PhD are the conclusions drawn from the research and the recommendations for how designers might be better supported. These conclusions and recommendations constitute the 'new model' cited in the project aim.

Figure 3.2.1: Research questions for the investigation; two overarching research questions for the project followed by a series of questions related to the specific enquiries.

	OVERARCHING QUESTIONS FOR THE PROJECT: *Are designers in a position to utilise secondary materials? and;* *What can be done to support them in this activity?*
	↓
	ENQUIRY RESEARCH QUESTIONS:
Enquiry 1: The Design Scenario (Objective 1) Chapter Four	*Are designers' **individual situations** conducive to considering material sustainability, and the use of secondary materials?* *Are designers' **work scenarios** conducive to considering material sustainability, and the use of secondary materials?* *Does the product and industrial **design scenario** offer any opportunities for improving the likelihood of designers considering and selecting secondary materials for high-value mass-produced artefacts?*
Enquiry 2: Secondary Materials: Focus on Plastic in London (Objective 2) Chapter Five	*How is secondary plastic in London currently **recovered, treated and processed,** and what are the **trends** for future developments?* *In **what forms are these materials then available** for use in the manufacture of new artefacts in London or the UK?* ***What approaches have been taken by designers** for utilising secondary plastic in the production of new artefacts?* *Are there any **common characteristics of the designers' scenarios** that could have contributed to their ability to utilise secondary plastic?*
Enquiry 3: Tools and Models for Supporting Designers (Objectives 3&4) Chapter Six	***What tools are available** to support designers in the consideration and use of secondary materials, and within the broader context of the material cycle, sustainability and design practice?* ***What are the characteristics of these tools (content, format, delivery)** and in what ways are they aligned to design methods?*
Integration and interpretation of empirical findings: (Objective 5) Chapter Seven	*What do the findings of Enquiries 1,2 & 3 say about how designers could be better supported in the consideration and use of secondary materials?*
	↓
	PROJECT OUTCOME: *Conclusions and recommendations for utilising surplus and waste resources in design practice – a 'new model'*

3.3 Research Design

The methodology for each enquiry is described in full in the corresponding chapter in Part II of the thesis, however some general points can be made about the research strategy as a whole and how this fits within conventions of research design.

3.3.1 Fixed and Flexible Designs

Robson (2002) explains that the most useful distinction between research strategies is not whether they obtain qualitative or quantitative data (although this is a feature to be carefully considered) but rather whether they use 'fixed' or 'flexible' designs. A fixed design is more typical of a scientific approach characterised by "a substantial amount of pre-specification" (Robson 2002:4) of the tasks to be undertaken and what it is the research intends to find out. Flexible designs are more exploratory in nature, with "much less pre-specification", allowing the design to "evolve, develop and unfold" (Robson 2002: 5) as the research progresses.

Shoe-horning a research project into one or other of these strategies is not necessarily to the benefit of the project aim. Indeed, Robson argues that "there can be considerable advantage in using *mixed-method* designs, that is, designs which make use of two or more methods, and which may yield both quantitative and qualitative data." (Robson 2002:5). When considering this project as a whole the structure would appear to be largely 'fixed' in nature with predefined objectives and the use of a survey (Enquiry 1), a method often employed in fixed designs. However, each objective evolved as new findings emerged from parallel enquiries and, although each enquiry was conducted in relative isolation, there was a great deal of cross-fertilisation which is perhaps more characteristic of a flexible design. What is more, while the survey was based on a conceptual framework or hypothesis, it was also intended to be partly exploratory; for example, asking some open questions and following the questionnaire findings with semi-structured interviews to tease-out some themes that were largely unanticipated.

The structure of the research, with five separate objectives within a central aim, arguably lends itself to a mixed-method strategy with different approaches suiting the different objectives. Figure 3.3.1 provides an overview of the strategy and methods used; again, the methodology and rationale for each objective are described in more detail within the corresponding chapters in Part II.

RESEARCH DESIGN

Fixed structure; *flexible* direction and focus

Project Structure	*Research Methods*		*Validity Generalisability Reliability*
Background research *Design, Material, Sustainability*	Literature review 11 'industry expert' interviews		A broad range of sources were used
Enquiry 1 (Chapter Four): Exploring the Design Scenario **Objective 1:** *Investigate designers' perspectives on secondary material use in relation to their own professional practice, particularly in London*	Literature review Survey questionnaire Survey semi-structured interviews	*Fixed* quantitative and qualitative	Validated in follow-up interviews Careful representative sampling Explicit methodology that can be reliably replicated
Enquiry 2 (Chapter Five): Investigating Secondary Plastic in London **Objective 2:** *Identify key potential product and design sector applications for secondary materials within London.*	Literature review Desk research Site visits and meetings	*Flexible* qualitative	Careful and accurate note-taking Limited generalisability A broad range of sources were used
Enquiry 3 (Chapter Six): Characterisation of Tools and Models **Objective 3:** *Investigate current processes and tools by which designers are enabled and supported in creating high-value applications for secondary materials*	Literature review Desk research Site visits and meetings		A thorough literature review and accurate note-taking Limited generalisability A broad range of sources were used
Enquiry 3 (Chapter Six): Characterisation of Tools and Models **Objective 4:** *Critically reassess these processes and tools to support design practice*	Characterisation		A broad range of sources were used across different tool types which were then compared
Integrating and Interpreting the Empirical Findings (Chapter Seven) **Objective 5:** *Develop innovative models to support designers in finding new applications for surplus and waste resources.*	Discussion Development of possible solutions Semi-structured feedback interviews		Validated by user feedback Keeping a record of the development process

Figure 3.3.1: Research Design... identifying the project structure, design strategies (fixed/flexible), research methods and steps taken to address validity, generalisability and reliability of the research.

3.3.2 Validity, Generalisability and Reliability

Research is a quest to find out the 'truth' in the area of study and, particularly in real-world or social research, there is a responsibility to ensure that the subjects of study are not misrepresented. Robson (2002) describes this as the 'trustworthiness' of research which can be considered as three related concerns:

Validity:	Are the findings really about what they appear to be about?
Generalisability:	Are the findings generally applicable outside the specifics of the situation studied?
Reliability:	If the study were to be repeated, would the same result be obtained?

(Robson 2002:93 abridged)

Robson (2002) suggests that these queries can be more easily addressed in *fixed* than in *flexible* research designs, both of which were utilised in this project. However, measures can be taken to acknowledge the limitations of, or avoid the threats to, the trustworthiness of the research. These are presented in relation to the enquiries in figure 3.3.1, and further comments relating to the trustworthiness of the Original Contributions to Knowledge are included at the end of the thesis (section 9.3).

3.4 Chapter Three Summary

This chapter has described an overview of the project methodology, which employed a mixed-method design to meet the proposed project aim and objectives. The two *overarching research questions* were presented along with a number of *enquiry research questions* which translated each of the objectives into enquiries.

Part I Summary

The three preceding chapters form Part I of the thesis, presenting the project background and context, positioning the research topic within the wider debate, and providing an overview of research design. Part II will present each of the three empirical enquiries designed to meet the project objectives and the integration and interpretation of the findings.

PART II THREE EMPIRICAL ENQUIRIES

This second part of the thesis reports on three individual research enquiries undertaken to meet Objectives 1, 2, 3 & 4.

CHAPTER FOUR Enquiry 1: The Design Scenario (Objective 1)

This chapter presents the focused literature review, research questions and methods for addressing Objective 1. It reports the findings of the survey undertaken to better understand the design scenario and material sourcing behaviour, and to identify possible directions for supporting designers in utilising secondary materials.

4.1 Introduction

One of the challenges when working with predefined objectives is critically interrogating the premise whilst ensuring that subsequent research contributes to the overarching research questions and project aim. The purpose of this specific enquiry was to address Objective 1:

> Investigate designers' perspectives on secondary material use in relation to their own professional practice, particularly in London.

It was decided at an early stage in the project that the research would focus on designers of artefacts who offer the greatest potential for utilising a large quantity of secondary material, where material value and properties could also be recovered (discussed in Part I). Designers involved in the design of high-value mass-produced artefacts therefore appeared to be the most appropriate focus for this enquiry.

The Initial Literature Review (Chapter Two) highlighted some important considerations which needed to be explored when addressing Objective 1. Namely this was the concern that, while designers represent an opportunity to consider material cycles and select secondary materials for the artefacts they design, the situations they work within may not be conducive to those types of choices and practices. This was explored through a focused literature review, presented in the next section.

In addition nine semi-structured interviews were conducted with industry 'experts' who could offer up-to-date industry-focused perspectives. Events attended during the first three months of the project provided ample opportunity to meet potential interviewees. The aim was to gather a range of 'expert' perspectives on one or more of the following topics:

The use of materials	*Design practice*
The sustainable use of materials	*Design in manufacturing*
Secondary materials	*Sustainable design practice*

The interviews were conducted by telephone which has the advantage of enabling "data to be collected from geographically scattered samples more cheaply and quickly than by field interviewing" and "tends to proceed more briskly" (Thomas & Purdon 1994). Concerns over the quality of telephone interview responses have been largely refuted (Thomas & Purdon 1994). The interviews lasted between 20 and 40

minutes and were audio-recorded. The questions were semi-structured and tailored to the expertise of the interviewee. In the following discussion interviewees are identified as:

Pr Des:	*Product design co-coordinator for a solar panel producer*	*Rec Man:*	*London Remade manufacturing expert*
Sust Eng:	*Sustainable engineering expert and academic*	*Rec Mat Man:*	*WRAP materials and manufacture expert*
Des Man:	*Design Council manufacturing expert*	*Mat Eng:*	*Materials and engineering expert and academic*
Des Sust:	*Design Council sustainable design expert*	*Mat Sci:*	*Materials science expert and academic*
Rec Des:	*London Remade design expert*		

The interviews were explored to reveal key themes (codes) which are included in Appendix A(i) with interview summaries.

4.2 Focused Literature Review: The Design Scenario

The following discussion is organised into three themes that were highlighted in the Initial Literature Review as having a potential influence over whether designers are likely to consider materials cycles and select secondary materials in their practice: the individual designer's situation; the work scenario; and what happens when the two are combined. The aim is to build a theoretical framework for the empirical enquiry which will address Objective 1. The literature was drawn predominantly from the field of design research relating to design practice, and material selection.

4.2.1 The Individual Designer's Situation

Different Types of Designer

The types of designers involved in the design of high-value mass-produced artefacts vary on a spectrum between technical design (typically engineering and the design of complex artefacts) and aesthetic design (typically craft, the design and making of 'simple' artefacts) (Rees 1997). Ashby & Johnson (2002) make a useful distinction between two types of design located towards the technical end of this spectrum:

> **Technical (or engineering) design** includes the aspects of design that bear on the proper technical functioning of the product: it's mechanical and thermal performance, cost, and durability.
>
> **Industrial design** includes the aspects of design that bear on the satisfaction afforded by the product: the visual and tactile attributes, associations and perceptions, historical antecedents.
>
> (Ashby & Johnson 2002:27)

This description can be seen to reflect the current, rather narrow, focus of the majority of professional design on commercially-driven projects.

When technical expertise is required in the process of 'new product development' an engineering designer is involved, which typically occurs in the latter stages of the design project, while industrial design involvement is focused at the front-end of the process (Lofthouse 2001; Pedgley 1999). Many researchers have suggested that for sustainability to be successfully incorporated into a product's development, it must be considered as early in the design project as possible (Lagerstedt 2003; Lofthouse 2001). Therefore, it has been argued, the position of industrial designers at the beginning of the design process means that they offer great potential for improving the sustainability of a product (Lofthouse 2001; Sherwin 2000). The consideration of material by an industrial designer is, therefore, likely to be earlier in the design process than an engineering designer, but still not until after design ideas have been formed (Pedgely 1999) so that the material can be chosen to meet the functional and aesthetic requirements of the design. This is in contrast to the approach of designers for whom the consideration of material is integral to the very first development of ideas. Ron Arad, for example, summarises his attitude to materials as being a "two-way process"; either "an idea looking for a material" or "the material comes first and prompts an idea" (Aldersey-Williams 2006). These two approaches to material selection are perhaps also reflective of the difference between commercially-led design and maker-led design which has its roots in craft[46], as Rees (1997) writes:

> The difference is that innovation in design is often, but not always, market-led, whereas innovation in the crafts is likely to be maker-led. The craft object may thus reflect an exercise in personal choice, self-expression or an experiment with materials and techniques.
>
> (Rees 1997:117-18)

One explanation for the use of secondary materials in design being predominantly the reserve of designer-makers[47] is that they can address unfamiliar material properties in the concept phase of design development rather than trying to adapt the design to the material later on.

A difference in worldviews can also be perceived in the extremes of this spectrum of designers. Pedgley (1999) makes a clear distinction between how artists and engineers attend to materials and considers that these approaches come together in the industrial designer. The artistic roots of industrial design, which relate to aesthetics and the consequential focus on material "qualities that cannot be measured" (Ashby & Johnson 2003:24), has resulted in the use of qualitative reasoning based on the designers' experience of the material (Pedgley 1999; Swann 2002). The engineering approach, however, has evolved from the scientific tradition (Cross 2001) and is more likely to involve working with quantifiable data (Ashby &

---

[46] The overlap of craft and design was perhaps most recently evident in the *Design/art* movement, fuelled by sustained economic growth in the early 2000's, in which designers were able to produce one-off designs that (like art) could sell for thousands of pounds; as co-founder of *Design Miami/Basel*, a fair devoted to high-end design, explains "Design/art is different and therefore collectible because it has none of the constraints that restrict those who have to consider industrial processes" (van der Post 2008:69).

[47] There are several contributing factors which are explored in more detail in Chapter Five.

Johnson 2002) and to be concerned with using material primarily to create function (Pedgley 1999; Swann 2002).

These observations suggest that different types of designer may approach the sustainability of materials in different ways. It was argued in Chapter Two that understanding the sustainability of materials involves some aspects that can be quantified but many that cannot (or the information is not available) (Ashby *et al* 2005). For example, although comparable property data exist for many reprocessed materials these do not communicate the main benefits of using that material, such as the 'story' of the material's origin, the feeling of well-being associated with personal contribution to the cause, and the actual contribution to future sustainability, all of which are perceivable but not quantifiable. While the engineering designer may be best placed to consider some technical aspects which can be quantified, such as improving efficiencies, industrial designers are perhaps better placed to explore potential improvements of a design against these less tangible sustainability criteria. Writing from an outside perspective, Hyde makes an interesting observation in his celebrated book *The Gift*:

> One classic way of evaluating the production, sale, or purchase of a commodity is cost-benefit analysis, in which a balance sheet is drawn up for some undertaking, weighing its expenses against its rewards. Cost benefit analyses have met with justifiable scorn in recent years because they often involve a hidden confusion or deliberate obfuscation in the difference between worth and value.
>
> (Hyde 1983:64)

Here Hyde associates 'value' with commodities (that can be quantified by the engineer), whereas 'worth' describes "those things that we prize and yet say 'you can't put a price on it'" (Hyde 1983:62) which could describe issues of sustainability. Many efforts have been made to quantify information relating to sustainability[48] apparently in an attempt to distance it from the 'worthy' arguments of green activists and become better aligned to the dominant spheres of business and science. However, the 'worth' of sustainability is currently a more accessible and often a more appropriate 'measure' than its calculable cost/value. Designers who can take 'worth' into consideration in their decision-making process, therefore, may be better placed to incorporate some aspects of sustainability than those who rely wholly on cost/value-based comparisons. Industrial designers, with their roots in craft and involvement in the manufacturing industry, may offer the best opportunity for considering and utilising secondary material in mass-produced artefacts, providing they are able to communicate these values to their clients.

[48] The move towards quantifying the sustainability of artefacts is reviewed in Chapter Six, and the benefits and limitations discussed.

The Influence of Established Values and Experience

In the Initial Literature Review (Chapter Two) it was argued that a designer's personal ethic could influence the pursuit of sustainability concerns in their work. This is reflective of the wider influence that established values and previous experience may have on the decisions a designer makes. Newton (2004) for example suggests that the influence of the designer is so important to design practice that it is 'disclosed' through the eventual outcome:

> A conception of designing as disclosure is important (over non-disclosure based conceptions) specifically because: it requires that the impulsion of a designer be recognised as a formative element in what might eventuate as a design product.
>
> (Newton 2004:108)

The influence of the designer on the design outcome is seen as significant. In addition to values, the literature suggests that the experience of the designer can influence design decisions. Pahl, Badke-Schaub, & Frankenberger (1999), for example, noted that experience may restrict the options an engineering designer might consider, later implying that novice designers who lack that experience were more likely to consider a wider range of options:

> The engineering designer tends towards one or other procedure, due to his or her individual ability and experience, without however always being aware of the advantages or risks of the respective paths taken. Experienced designers are principally at risk of wanting to minimise the work effort. This aim is essentially positive, but bears the danger of a solution not optimally matured.
>
> (Pahl, Badke-Schaub, & Frankenberger 1999:485)

The constraining effect of experience in relation to material selection was reported by Emmitt (2001) in his case study, *Observing the Act of Specification*. Emmitt describes the material selection process in architecture, highlighting the important stages of decision making:

> The specifier will pass from first exposure to information about the innovation (knowledge), through a period of gathering more information to consider its characteristics (persuasion), to making a decision to use or reject the innovation (decision), to construction on site (implementation) and the intention to use the product again (confirmation). Before this process starts, however, the specifier must have identified a problem that cannot be resolved from the information contained in the collection of favourite products, hence triggering a search for information and the start of the innovation–decision process.
>
> (Emmitt 2001:400)

Importantly Emmitt identifies that the designer will not consider unfamiliar alternatives until his past experience and existing knowledge of material fails to provide a solution. This was also the opinion of one of the expert interviewees who stated:

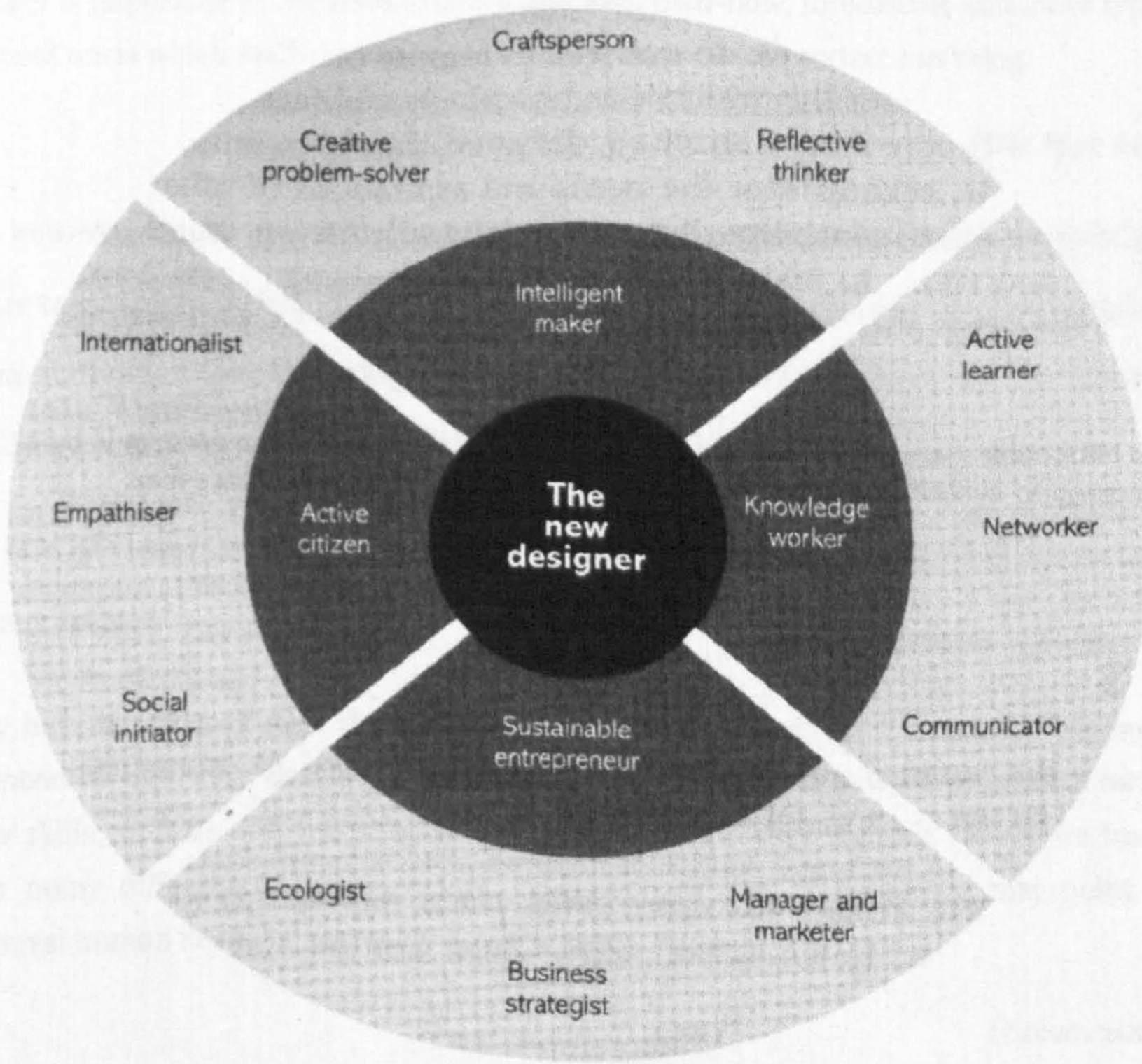
> We're all basically fundamentally lazy and engineers are all lazy. We go to a book, we look up a specification with brand new virgin materials supplied in bulk to order [...] what we're not very good at doing is looking to see if we can use recycled materials.
>
> [Sust Eng expert]

These observations imply that established values and existing knowledge are important influences to consider when understanding how design decisions are made, and can have restrictive as well as informative effects.

Knowledge & Skills

The skill-set necessary for a designer to tackle issues of sustainability in their work is frequently discussed in the literature. In *The Design Experience* Cooper and Press (2003) present 'the new designer' (figure 4.2.1); four areas of expertise encompassing twelve skill areas believed to be desirable for future design practitioners.

Figure 4.2.1: The new designer (Cooper & Press 2003:199)



A designer or a design theorist will often advocate one of the areas represented in this wheel more strongly than others. For example, proponents of sustainability may argue that 'ecologist', 'empathiser', 'internationalist' and 'craftsperson' are the most important skill areas for designers to develop, whereas design managers would perhaps argue that 'communicator', 'networker' and 'problem-solver' are more important traits. Interestingly Cooper & Press' diagram portrays all skill areas as of equal importance, and

distributes them differently than one might expect in a conventional model. For example, 'manager and marketer' and 'business strategist' are placed under 'sustainable entrepreneur' implying that these are skills a designer will need in order to challenge current unsustainable business and marketing practices. There is also less emphasis on traditional design skills such as drawing, modelling and computer operation. Although these skills could be included under 'craftsperson' or 'communicator' the fact that they are not given specific attention may indicate that Cooper & Press are presenting the designer with a whole raft of new skills - in addition to expected competencies – that they believe will be needed in order for the designer to challenge the norm.

There were also particular skills that the expert interviewees recognised as important for influencing design decisions in a sustainable direction. When trying to assist designers in incorporating secondary materials in their products one expert interviewee observed that the difficulties were rooted in the designer's general lack of business knowledge or awareness. This was also emphasised by another interviewee:

> It really is important to understand profit and loss, cash-flow, forecasting and these types of business areas which really run alongside the opportunities a product can bring.
>
> [Des Man expert]

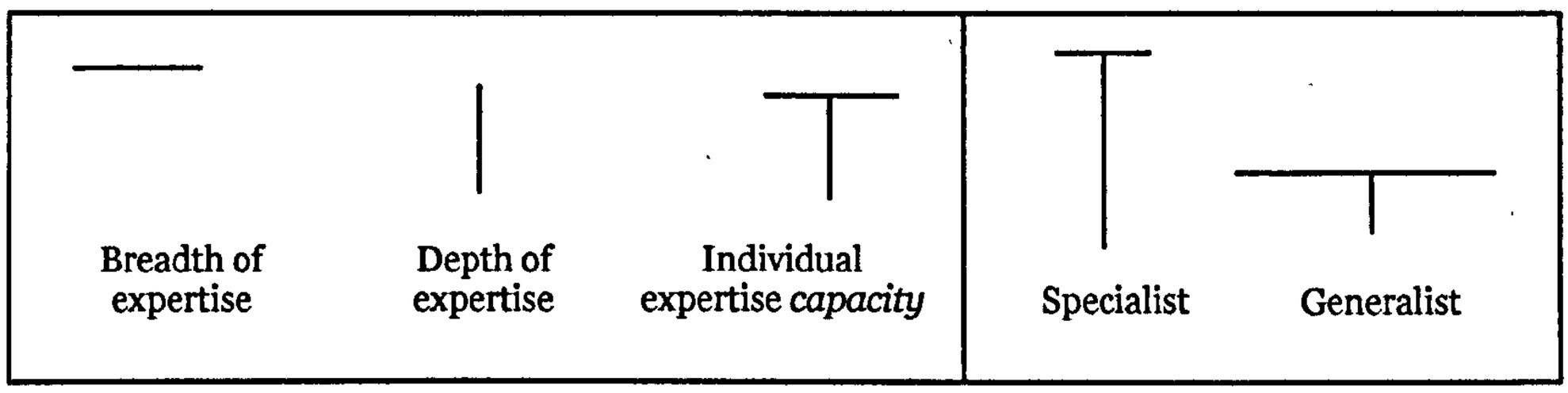
There are, however, limits to every person's capacity for general and specific knowledge. Whereas engineers are technical specialists, industrial designers are skilled at drawing on other people's expertise when they need it, rather than becoming specialists themselves in all the areas they must consider in their design practice; this is particularly true of design consultants (Lofthouse 2000, Pedgley 1999).

Tim Brown of IDEO speaks of 'T-Shaped People' to describe the breadth and depth of knowledge that some designers demonstrate:

> They have a principal skill that describes the vertical leg of the T -- they're mechanical engineers or industrial designers. But they are so empathetic that they can branch out into other skills, such as anthropology, and do them as well. They are able to explore insights from many different perspectives and recognise patterns of behaviour that point to a universal human need.
>
> (Brown 2005:2)

This model could also be used to describe the capacity of individuals (fig. 4.2.2). The total ability of the individual can be represented by 'T'; the horizontal line illustrates the breadth of their expertise (generalist) whereas the vertical represents the depth of their specific expertise or skills (specialist).

Figure 4.2.2: T model of individual capacity, breadth and depth of expertise



James Woudhuysen[49] referenced the 'T-model' in September 2005 to imply that, in seeking to broaden an individual's awareness, there is a danger of compromising the depth of skills. This suggests that there may be limited capacity for the skills, knowledge and awareness that each individual can acquire. The ability of some exceptional designers is not in question, but the feasibility of 'the new designer' as a model for the majority seems flawed.

A number of MA courses have been initiated in the UK[50] which aim to give designers the additional knowledge and awareness deemed necessary for addressing sustainability issues, including the ability to work in multidisciplinary teams. The *UK Design Industry Skills Development Plan* has also recognised a need for "professional, complementary skills" such as "business management, understanding industry and markets, operating in global contexts and working in multi-disciplinary teams" (Design Council & Creative and Cultural Skills 2007:43). This suggests that these skills have been absent from the design profession and are not therefore part of existing design "know-how" (Schön 1991); new competencies must be learnt in addition to conventional design training if designers are to meet the challenge of sustainability. Schön (in agreement with D'Anjou (2007) discussed earlier) suggests that through reflection a practitioner "can surface and criticise the tacit understandings that have grown up around repetitive experiences of specialised practice, and can make sense of the situations of uncertainty or uniqueness which he may allow himself to experience" (Schön 1991:61). Reflection, therefore, may be an essential skill if designers are to attend to issues of sustainability, or even to consider whether their practice scenario or "role" allows them to attend to it (Schön 1991:62).

For designers to bring about change towards sustainability, the necessary diversity of knowledge and skills may not be best achieved in one individual designer, but by many working in multi-disciplinary teams in diverse areas of industry and society. Organisations need to accommodate these new ways of working (Schön 1991; Senge 1994) otherwise design activities may be limited; this is explored in the next section.

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[49] During a talk given at *Futureproofing Design: Signposting the Future*, Design Council, London 30th September 2005

[50] For example Kingston University's MA Design for Development and Lancaster University's MA Sustainability, Innovation and Design.

4.2.2 The Work Scenario

Other Stakeholders in the Design Process

Although a large proportion of a designer's work is independent (Pahl, Badke-Schaub, & Frankenberger 1999; Sherwin 2000), involving reflection and internal conflict resolution through an iterative process (Schön 1991) which often relies on the designer's own values and experience (Pedgley 1999), the design of mass-produced artefacts is necessarily one with a number of actors and stakeholders[51]. The design of a mass-produced artefact is a team effort as Cooper and Press explain:

> The rugby approach characterises cross-functional integration, in which a team of specialists from each department involved in the project is brought together, working as a team from start to finish. Design becomes a cyclical process of individual work and group discussion, where solutions evolve through developing and refining a series of increasingly informed proposals.
>
> (Cooper & Press 2003:148)

This process is often called 'product development' which varies, in terms of the purpose and ambition of the design activity, from simple alterations of an existing product to new concept development and 'blue-skies' thinking. The designer is positioned either in a design team situated 'in-house', within a manufacturer[52], or as part of a design agency or consultancy external to the manufacturer. Numerous authors have described this process (recent examples include Cooper & Press 2003, and Ulrich & Eppinger 2008) and it is not necessary to go into too much depth here, other than to consider how the involvement of various other parties affects a designer's ability to make decisions about the artefact they are involved in designing.

In his doctoral study of *Industrial Designers' Attention to Materials and Manufacturing Processes* Pedgely (1999) states that the nature of mass-production necessitates that many of an industrial designer's choices are subject to the practical constraints of manufacturing and those who are involved in producing the artefact.

---

[51] The stakeholders considered here are those directly involved in the design process, however the author acknowledges that there are others such as the end-user or 'consumer' who have an indirect but nevertheless significant role in how design decisions are made. See for example Short & Harvey (2008) Lightbulbs & Nappies: Sustainable Development and Consumer Perceptions, which concludes that 'green' design products need to "meet the expected, traditional, normal functionality but with added green functionality" (Short & Harvey 2008:26). Barbara Ellen's *Secret Trysts with Mr Muscle, a Lifelong Love of Packaging... an Eco-Sinner Confesses All,* provides a candid end-user perspective (Ellen 2006).

[52] 'Manufacturer' is used throughout this thesis to describe a company whose business involves producing artefacts. However, it is understood that these companies may not be 'manufacturers' in the traditional sense, they could be a retailer or producer whose primary operation is the production and sale of artefacts but they may outsource some of their activities.

The designers' choice of material or process may, therefore, be challenged in many different ways and his success in influencing those decisions may be reliant on a number of factors.

Yet Pedgley concludes:

> Despite the pressing constraints [discovered in the study] industrial designers do have opportunities to suggest the use of materials and processes that are unusual and against current trends and product precedents (and, therefore, inclusive of some added risk). Central to this, however, is a parallel activity to provide convincing arguments of the benefits of adopting the unusual manufacturing route
>
> (Pedgley 1999:310)

Importantly Pedgley highlights the need to be able to communicate the benefits of any decision to the project stakeholders, a skill that may be lacking from current design pedagogy and practice (discussed in section 4.2.1).

Mutual Understanding and Communication

Any team-based activity is most effective if all parties involved understand each other's roles and can communicate effectively. Although the business-focused manufacturing industry has begun to understand the role that design can play in increasing profits (Smith 1981), and designers know that they need clients in order to practice, integrating design into business is challenging, as Jonas (2001) describes:

> Design, for the most part, is a matter of fuzzy, changing, cultural criteria, as opposed to scientific criteria. There is an ongoing negotiation between stakeholders of perspectives, with the goal of understanding each other's viewpoint.
>
> (Jonas 2001:67)

Whereas the more established business world is based on procedure, rules and black-and-white thinking, design is organic with a propensity for bending rules and not sticking to procedure (Rieple, Haberberg & Gander 2005) which can be seen to result in difficulties in understanding one another's perspectives.

The expert interviewees discussed the problems experienced when incorporating design into a conventional manufacturing organisation; one spoke of a lack of understanding of design at a managerial level:

> The clear, single most important challenge is the role of the Managing Director inside manufacturing companies who usually have, shall we say a tainted view of good design, so really it's a challenge within the boardroom, and also adapting language a Managing Director is familiar with, so using more business-type language rather than design language in getting that message across.
>
> (Des Man expert)

The Design Council has framed this issue in *The Good Design Plan* by suggesting that 'good design' involves "the work of good designers (and good clients)" (Design Council 2008:9).

Designers working in consultancies may face different difficulties to those working in-house. Using a 'gap analysis' method which focused on the difficulties in relations between design consultancies and their clients, Hakatie & Ryynänen (2007) report:

> The design consultancy services have been considered something to be subcontracted in association with R&D, a hierarchic relation in need of control, where the subcontractor provides the product, or some part of it, as the client intended.
>
> (Hakatie & Ryynänen 2007:31)

This describes the manner in which a business would traditionally source external expertise, seeing it as a technical function rather than a creative and organic intelligence that could benefit the company beyond expectations. The difficulty for designers is that if they are not involved in the original conception of what is to be designed then they can have little influence over the direction of product development and much of the original potential for innovation is lost before they begin work on the project. Hakatie & Ryynänen also observed that this was heightened by the designers' inability to explain the function and value of their expertise, pinning the reason for these 'gaps in understanding' on communication and awareness between both parties: "In shifting the focus of consulting from dealing with projects to developing mutual understanding, establishing good communications, and generating creative tensions, new innovations can be achieved."(2007:46). The advantages of a consultancy being external to the manufacturer were highlighted by one of the expert interviewees who reported that this had enabled more sustainable routes to be suggested and taken up by an organisation she had been working for:

> It took an outside influence almost in a consultancy role of neutral territory to force many of the senior managers to take notice.
>
> [Sust Eng expert]

However, the insights of Hakatie & Ryynänen (2007) and Cooper & Press (2005) offer some explanation for why problems might arise in the product development process and why designers may not have an equal share of influence over decisions. Lauche (2005) also touched upon this in her study of *Job Design for Good Design Practice*. A lack of "heedful interrelation" (Lauche 2005:193), communication and understanding between functions, it is suggested, can lead to problems and sometimes failures, which in turn can lead to hostility and a blame culture. Therefore, through a continuous process of "keeping each other in the loop" (Lauche 2005:194), it is thought that a situation where the design outcome significantly conflicts with the aims of one or more stakeholders can be avoided, leading to a reduced likelihood of tension between stakeholders, demotivation, loss of respect for design functions and unsuccessful projects. The need for improved communication and collaboration between project stakeholders was also

mentioned repeatedly by the expert interviewees. For example the Materials and Engineering expert commented:

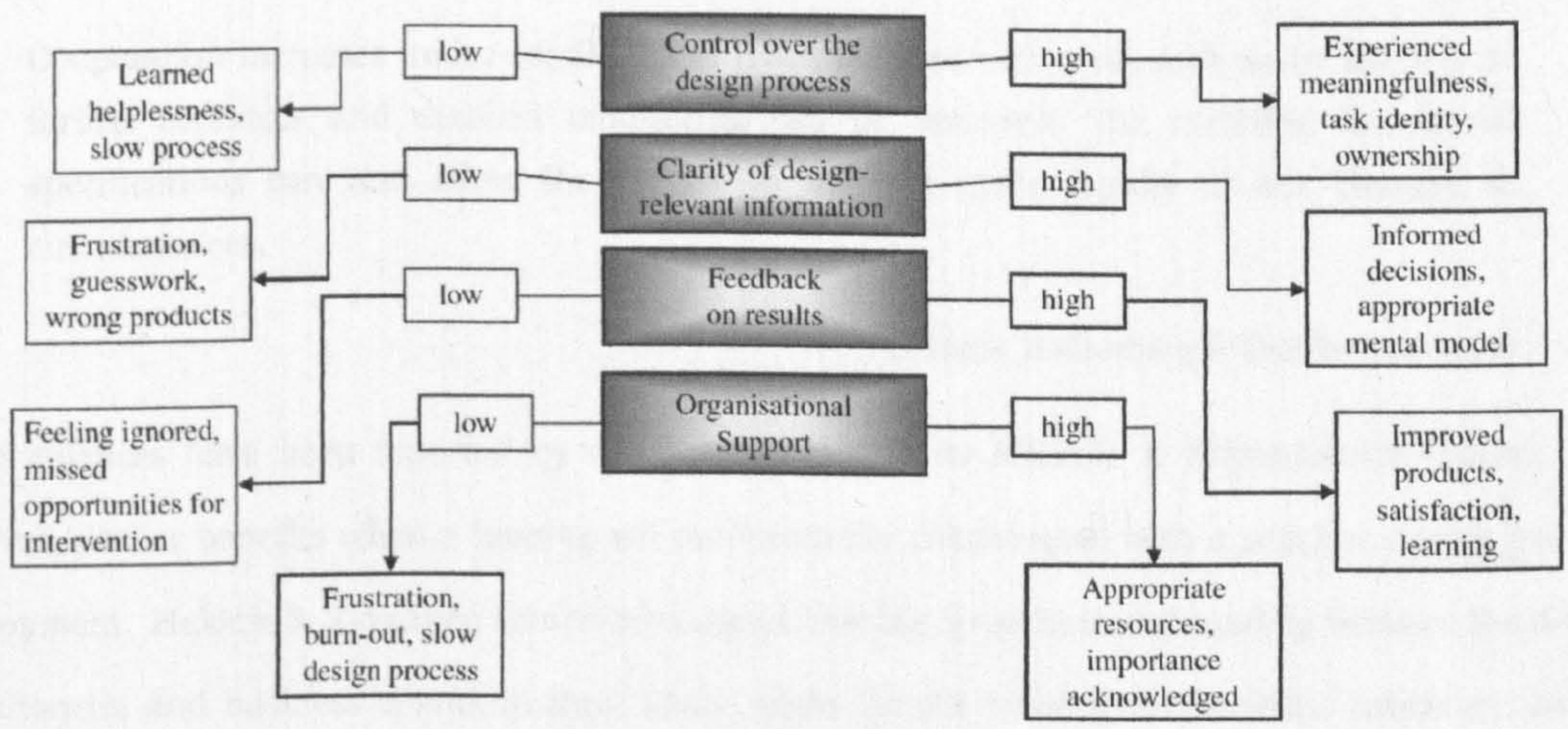
> The problem comes when there isn't any communication, when the designers don't talk to the manufacturers and quite often design something that they can't make [...] What we do try to do is bring a project to bear where all the parties are involved in that project. For example it has to be multi-disciplinary, it has to be multi-facetted, it's no good having just your designer to talk to, you want your materials engineer, you want your application engineer, you might even want the equipment manufacturer in, you certainly would want a materials supplier in and quite often at the end of the day you'll have the value engineer in, someone who can do the costing.
>
> [Mat Eng expert]

Lauche's study also offers evidence for how a designer's work scenario may influence their ability to make decisions, recognising that "organisations are made and shaped, and the way design tasks are allocated and supported can have a huge effect on the work of the individual designer (Lauche 2005:192).

Types of Organisation

The central argument in Lauche's study is that the designer's ability to operate effectively is governed by four mechanisms resulting from their 'job' scenario, identified in figure 4.2.3, which may have either a positive or negative impact on design decisions and as such must be carefully managed.

Figure 4.2.3: Criteria for job design and their influence on design outcomes (Lauche 2005:194)



Lauche's study also offers some specific guidance on the effect of different types of organisation on design practice. The findings are summarised in figure 4.2.4 and again suggest that designers working in different scenarios face different constraints (echoed by Fletcher 1999).

Figure 4.2.4: Summary of findings from Lauche's (2005) study of job design: the effect of job scenario on design outcomes

Type of organisation (as defined by Lauche 2005)	***Control over the design process***	***Clarity of design-relevant information***	***Feedback on results***	***Organisational support***
Medium-sized companies	High	No information and trouble sourcing it	Lacking	Management understanding and support of the design process is lacking
Large-sized companies	Low	Information but no time	Indirect and slow	Management understanding and support of the design process is lacking
Service companies (design consultancies)	Medium	Trouble sourcing information but see it as part of their task	Trouble sourcing from clients	High but clients are a restriction

Rieple, Haberberg & Gander (2005), in their insightful essay *Hybrid Organisations as a Strategy for Supporting New Product Development,* sought to discover how organisations deal with the risk of taking on external creative expertise. In addition to 'in-house' and 'consultancy' they identified a third approach to sourcing creative expertise: "within strategic alliances or partnerships" (Rieple, Haberberg & Gander 2005:49). Rieple, Haberberg & Gander argue that the difficult relationship between business and design can be eased through a long-term alliance between two organisations providing a situation of lessened risk, trust and loyalty:

> Cooperation increases under conditions of trust, because with trust such costly barriers as formal contracts and detailed monitoring can be removed. The resulting less-formal specifications can also allow the parties to respond more rapidly to any changes in circumstances.
>
> (Rieple, Haberberg & Gander 2005:50)

These alliances have been reported by other authors, such as Mikkola & Skjøtt-Larsen (2006), who observed similar benefits when a hearing aid manufacturer collaborated with a supplier during product development. Hakatie & Ryynänen (2007) too suggest that the 'gaps' in understanding between the design consultancies and business clients in their study might be alleviated if relationships continued over a longer period of time and that "open communication and teamwork are critical, and relationships are built on key attributes such as trust, openness, reliability, and performance." (2007:44).

Rieple, Haberberg & Gander observe that these design alliances are facilitated by a phenomenon they call 'boundary-spanning':

> [Trust develops with] frequency of contact, affection and social similarity among the people who move between the organisations – the boundary-spanners, who are likely to increase in number as the relationship progresses.
>
> (Rieple, Haberberg & Gander 2005:50)

'Boundary-spanners' are described as 'bilingual' representatives within each organisation, people who can translate the concerns, needs and desires of one organisation into a language that those working in the other organisation can understand. The boundary-spanners therefore require a unique set of skills: understanding of business and design functions, social and verbal communication abilities, loyalty, trustworthiness and dependability. Rieple, Haberberg & Gander's (2005) definition of this role proposes a newly defined vocation that could be invaluable in a number of scenarios, not least in any situation where there are communication failures between designers and project stakeholders. Moreover, this observation indicates that designers themselves could benefit from having these qualities, putting them in a better position to influence decisions. This theory builds on the earlier discussion around the new skills designers may need to address issues of sustainability, highlighted in Cooper & Press' model for 'the new designer', and could be positioned with the category of "knowledge worker" (Cooper & Press 2003:199).

Accessing Material Information

Understanding how designers encounter materials, in general, is important for understanding how they might encounter secondary materials; Chick & Micklethwaite (2004b) found that the provision of information about 'recycled' materials was seen as one of the greatest obstacles to specifying them.

There have been some useful studies undertaken in this area. Emmitt's (2001) study of material specification in architecture (introduced earlier) highlighted the importance of the designers' previous experience of materials when deciding which material to specify in a given project. Emmitt suggests that only when this experience fails to produce a satisfactory solution will the designer consult an alternative source. However, a designer's access to a range of sources can be seen to depend on their work scenario.

Pedgley (1999), and Karana (2004) both undertook studies which involved identifying industrial designers' use of material information sources. Chick & Micklethwaite (2002) have also added to knowledge in this area; their study related specifically to the use of recycled materials and the majority of their respondents were architects. The findings of all three studies are outlined in figure 4.2.5. A list of sources that designers might use can be drawn from this existing research, but there are inconsistencies between the studies perhaps resulting from differences in focus, making it difficult to identify a pattern of behaviour or one favoured source. Karana's (2004) findings state 'the supplier' as the most useful source yet concludes that a 'materials library' would be the most successful way of delivering material information to designers.

Pedgley (1999) reported that printed literature was particularly useful to designers (although he noted that it goes out of date quickly) which is also echoed in Karana's findings, but there is some suggestion that this is dependent on the size of the company which the designer works within, as larger organisations are likely to have better in-house resources (Karana 2004). This is far from ideal for designers to encounter unfamiliar materials, as a large proportion of designers work in companies with less than five employees (Design Council 2005). The architects in Chick & Micklethwaite's study didn't find the 'in-house library' particularly useful for finding recycled materials, perhaps indicating that suppliers of secondary materials are not providing the right information or delivering it to designers in the right way. All three studies are in agreement that 'time' is an important consideration when accessing material information, which reasserts the importance of understanding designers' existing material behaviour when considering how to deliver information about secondary materials effectively so that it doesn't require extra time and effort.

Figure 4.2.5: Findings of three studies which looked at designers' use of material information sources

Pedgley (1999:319-321) ***No identified order of preference***	***Karana (2004:81)*** ***In order of preference***	***Chick & Micklethwaite (2002:21)*** ***In order of preference***
Client/colleagues	Suppliers catalogues	Partners
Designed artefacts and the wider world	Internet	Guide & handbook
Experiments (Designer R&D)	Fairs / seminars	Organisation
Internet sources	Advisors	Specification database
Liaison with material suppliers/manufacturers	Magazines	Internet
Physical samples [company archive]	Books	Trade press
Printed sources [company library and trade press]		Product database
Specialists/specialist services		Personal Knowledge
		In-house library
		Books
		Other

It is clear that understanding the material sources that designers find useful, and why they are useful, may be important for identifying opportunities for supporting designers in the consideration and selection of secondary material. These existing studies have done valuable work in building knowledge in this area, however, to meet the project aim an up-to-date survey, which represents the design population (largely involving small organisations) and includes the various sources in figure 4.2.5, would be beneficial.

The previous two sections have considered the individual designer's situation and the scenario they work within; the next section will consider how these two elements combine to form 'the design scenario'.

4.2.3 Combining the Individual Designer's Situation and The Work Scenario

The Design Scenario

Lauche states that "people do not just receive and carry out orders but that they make sense of what they are being asked to do on the basis of their own experience and motivation." (Lauche 2005:193). In this statement the individual designer's situation and the work scenario are combined, suggesting that the two are inherently interconnected in what is here termed 'the design scenario'. An exchange during one of the expert interviews also revealed the combination of these two elements of the design scenario:

> *[Interviewer] One of the interesting things that I'm looking at is whether or not individuals have the support or the space if you like...*
>
> [Sust Eng expert] To think for themselves...
>
> *To think for themselves and to challenge briefs that are given to them, whether they've got, not only the experience and knowledge, but also the time and the resources to investigate alternative solutions...*
>
> And I would say also passion, because a lot of my research is done out of hours because it's a passion. If it's not a passion then you're never going to achieve what you want to do. You always have to go that extra mile, you have to be a bit of a rebel in the pack and do things under your own steam to get on, otherwise you're just going to follow the run-of-the-mill.
>
> *Is it then that designers use it as an excuse, that they don't have enough time or they don't have enough resources to make a difference, to challenge preconceptions?*
>
> I think with some, yes. I think for some it is genuine, it really depends on the scenario for the individual. Some are actively encouraged not to challenge, some are actively encouraged to be whacky.
>
> [Sust Eng expert]

Another of the interviewees commented that, despite her motivation and 'passion' for sourcing secondary materials, the combination of time constraints, limited knowledge and elusive information had resulted in an unsuccessful outcome:

> I was really enthusiastic and my enthusiasm's waning a bit, it would probably be at least two solid weekends, that kind of thing, on looking at recycled polymers.
>
> (Pr Des expert)

This aptly demonstrates how the two elements can be interdependent and can result in negative as well as positive outcomes.

Drivers and Obstacles for Sustainable Design Decisions

There are several existing studies that have identified specific factors, relating to the designer's situation and their work scenario, that may influence decisions about sustainability or materials selection during the design of mass-produced artefacts.

Based on a literature review, Chick & Micklethwaite (2004b) identified six potential obstacles and asked survey respondents to select those "that currently prevent you from specifying recycled products and materials in your designs" (2004b:257). Similarly, van Hemel & Cramer (2002) identified a set of "motivating stimuli and discouraging barriers" (2002:443) to determine why some eco-design methods were more successful than others when introduced into Small and Medium-sized Enterprises (SMEs). They then divided these factors into three categories: *external stimuli, internal stimuli* and *barriers* and found that *internal stimuli* most commonly provided the greatest incentive to implement eco-design methods, although it seems quite possible that some of the *internal stimuli* had roots in *external stimuli.* The combination of a number of *internal stimuli* with at least one *external stimulus* was most frequently the recipe for successful implementation of eco-design methods. Pedgley's (1999) *opportunities* and *practical constraints* were extracted from interviews with industrial designers to understand what affects their attention to materials during the design process. As slightly different terms are used in each study, for clarity, the general terms *drivers* and *obstacles* will be used throughout.

These three studies each identify factors that may affect the design of mass-produced artefacts, but from three different perspectives relating to design, sustainability and materials; Chick & Micklethwaite's (2004) respondents were individual designers and the focus was the use of recycled materials, Van Hemel & Cramer's respondents were answering on behalf of the company, not as individual designers and the focus was eco-design, Pedgley (1999) was writing from the perspective of individual designers but the focus was materials. The findings are therefore not directly comparable, but together they cover the main elements involved in the selection of secondary materials. To assist in building a more complete picture, the common themes observed in the studies have been identified and translated into six *areas of influence over design decisions* presented in figure 4.2.6. The drivers and obstacles from each study have then been assigned to the relevant area. The study corresponding to each entry is identified by the corresponding author's initial.

Figure 4.2.6: Drivers and obstacles to sustainable design decisions organised into six areas of influence. Van Hemel and Cramer 2002 (VH), Chick & Micklethwaite 2004b (C) and Pedgley 1999 (P)

Areas of influence on design practice	***Drivers***	***Obstacles***
Legislation / Industry	Government (VH)	Not yet required by legislation (VH) Health and safety (P)
	Industry sector (VH)	
	Environmental action groups (VH)	Not perceived as responsibility (VH)
Supply	Suppliers (VH)	Supply issues (C) Availability of materials and manufacturing processes (P) Detail preferences of the toolmaker/manufacturer (P)
		No alternative solution available (VH)
Client requirements	Customers (VH)	Not yet required by customers (VH) Client (C) Design brief and the client (P) Budget (P)
	Competitors (VH)	Commercial disadvantage (VH) Product precedents [competitiveness] (P)
	Cost reduction (VH) Scope for capital expenditure (P)	Cost (C) Volume-cost relationship (P) New technology [cost] (P)
	Image improvement (VH)	Corporate identity (P)
	New market opportunities (VH) Market differentiation (P)	Directives from in-house marketing departments (P)
	Other commercial benefit (VH)	Investment is fruitless (VH)
Work organisation		Lack of information (C)
		Practice constraints (C) Insufficient time (VH)
Individual designer's endeavour, approach and responsibility	Personal objectives and aspirations (P)	
	Increase of product quality (VH) Advancement of design (P) Cosmetic details (P) Fashions (P)	Quality (C) Problems with mixed materials [aesthetics] (P) Limitations for form creation (P)
	Innovation opportunities (VH) Miniaturisation (P) New technology (P)	No innovation opportunities (VH)
	Environmental benefit (VH)	No clear environmental benefit (VH)
	Synergy with other product requirements(VH) Obsolescence/longevity [design-life] (P)	Conflict with functional product requirement (VH)
Individual designer's knowledge and Experience		Insufficient knowledge (VH) Unfamiliarity (C)

Several observations can be made from combining these studies.

First, it is evident in figure 4.2.6 that the *'client requirements'* area has the majority of drivers and obstacles and therefore is likely to have a strong influence on design decisions. This was also highlighted by several of the expert interviewees:

> Generally [senior management in medium or large organisations] bonuses will be tied into the performance of the company, if you take too many risks and you fail, you don't get the bonus, you may even get a pay cut or sacked. Ok, so the higher up the chain, the less risk they'll take which means you end up stifling the very creativity you're employing these people to do.
>
> [Sust Eng expert]

> You know it's hard enough getting a client to understand the value of design without adding the issue of sustainability as well. Although [...] if you had the means of saying to a client 'if you do this it will actually not only put you in a better position in the market but it probably will save you some money as well' then maybe they'd sit up and listen.
>
> [Des Sust expert]

The second interviewee also demonstrates the link between obstacles (client) and drivers (better position in the market; saving money).

Returning to figure 4.2.6, in *'designer approach, endeavour and responsibility'*, the majority of drivers and obstacles are to do with the ability to improve conventional aspects of the design such as function and aesthetics, which implies that sustainability methods must compliment these other aspects of the design and not restrict them. Pedgley (1999) was the only author to identify *personal objectives and aspirations* as a possible driver.

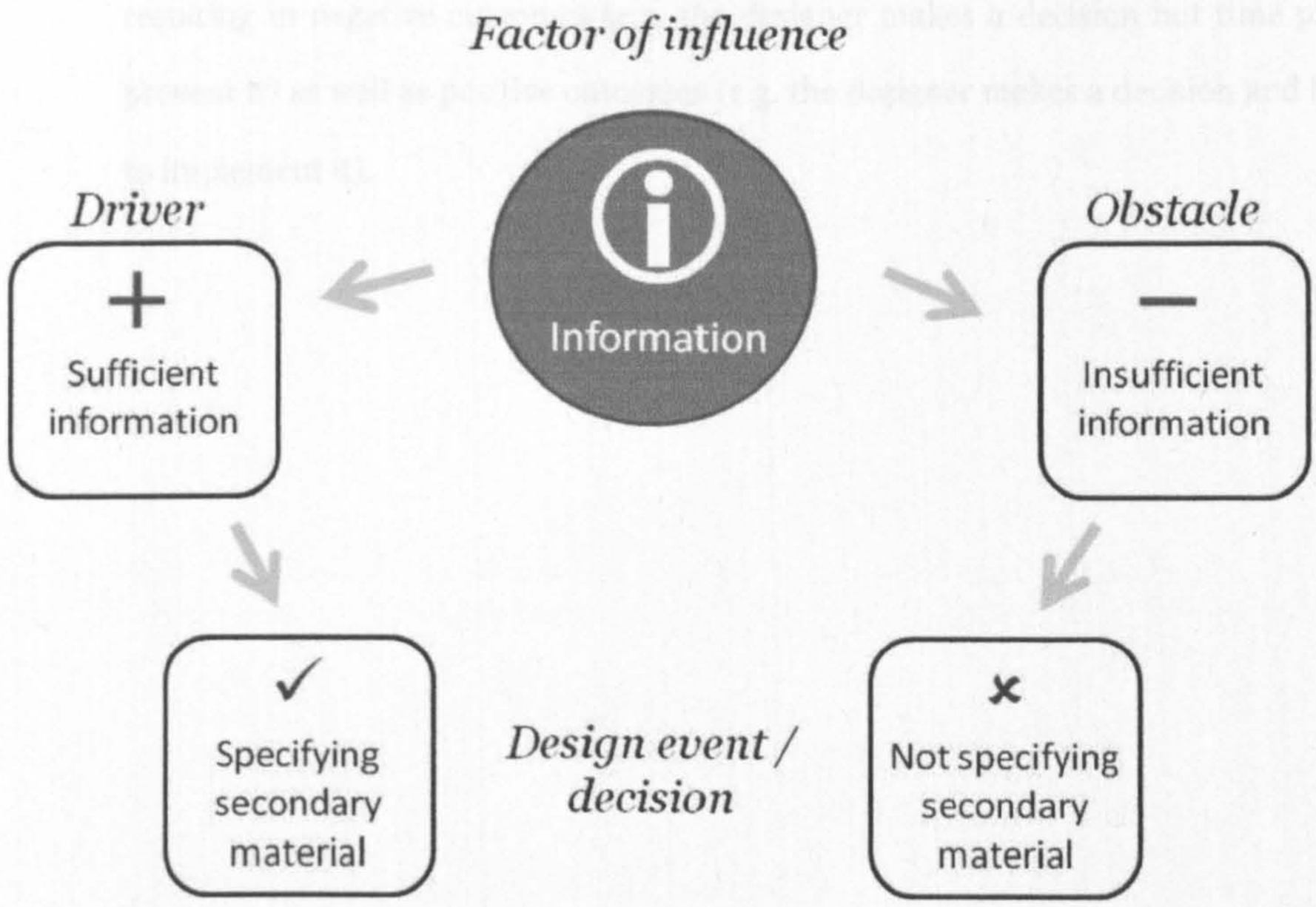
Chick and Micklethwaite (2004) found *lack of information* to be the main obstacle to specifying recycled materials in their study (echoed by Fletcher 1999 and Argument, Lettice, & Bhamra 1998), but they do not identify types of information which makes it difficult to turn this obstacle into opportunity.

A final observation is that many of the drivers and obstacles form pairs which can be seen to relate to a common 'factor of influence' over design decisions; the driver being the mechanism that allows an event to happen, while the obstacle may prevent it. This is expressed in figure 4.2.7, where 'information' is the example given as the factor of influence.

As stated previously, van Hemel and Cramer (2001) found that a number of drivers were necessary for successful implementation of eco-design methods which indicates that a number of obstacles must also have been avoided. It is not intended therefore for this diagram to suggest that adequate information alone

would result in the specification of secondary materials, but simply to illustrate how a driver and an obstacle may relate to one another and to a common factor of influence.

Figure 4.2.7: Each driver and obstacle pair may result from a common factor of influence over design decisions



4.2.4 Summary

This focused literature review highlighted the following points (these contributed to the development of research questions for Enquiry 1):

- The designer's individual situation includes a number of elements that may affect how decisions are made:
    - What type of designer they are (technical/industrial/maker) affects how they attend to materials;
    - Their values and experience can have negative as well as positive effects;
    - Additional skills and knowledge may necessary for the challenge of sustainability.
- The work scenario may have an impact on whether the designer can influence design decisions:
    - 'Product development' is often commercially-driven involving a number of stakeholders;
    - Understanding, and being able to communicate with, other stakeholders can aid the design process;
    - Consultancies and in-house designers may face different challenges;
    - Designers' access to material information sources may depend on their work scenario.

- The individual situation and the work scenario combine in *The Design Scenario*:
    - There are a number of drivers and obstacles to pursuing sustainability in design, some relate to the individual designer and some to the work scenario;
    - Drivers and obstacles can be seen as pairs which relate to a central factor of influence;
    - The individual designer's situation and the work scenario appear to be interdependent resulting in negative outcomes (e.g. the designer makes a decision but time pressures prevent it) as well as positive outcomes (e.g. the designer makes a decision and has time to implement it).

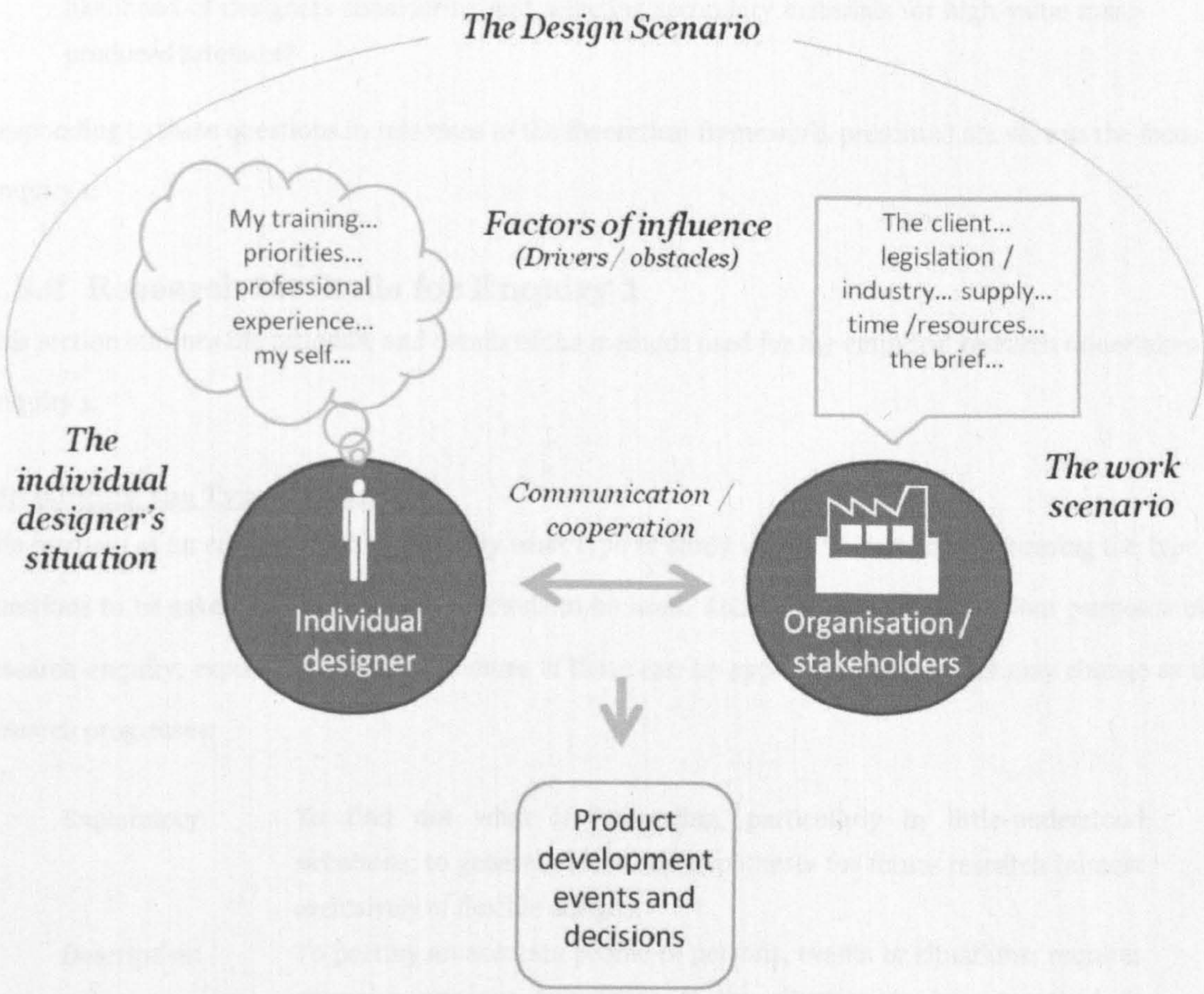
4.3 Research Strategy for Enquiry 1

Following the focused literature review it was possible to reposition Objective 1 which originally stated:

> Investigate designers' perspectives on secondary material use in relation to their own professional practice, particularly in London.

The decision had already been made to focus on designers of high-value mass produced artefacts. In addition the initial and focused literature reviews suggested that there are a variety of factors that may affect a designer's ability to select secondary materials other than 'designers' perspectives'. The factors identified in the focused literature review informed the development of a model for *The Design Scenario*, combining the two elements explored, the *Individual Designer's Situation* and *The Work Scenario* (fig. 4.3.1).

Figure 4.3.1: Model of 'The Design Scenario', expressing how the individual designer's situation and the work scenario may reveal drivers or obstacles to design events and decisions (theoretical framework for Enquiry 1)



This 'Design Scenario' model formed the theoretical framework for Enquiry 1, from which two propositions were made:

i) The combination of the individual designers' situation and their work scenario currently results in a design scenario for product and industrial designers which may not be conducive to considering secondary or more sustainable materials choice.

ii) By exploring these two elements and the corresponding factors of influence on design decisions, which were identified in the focused literature review, opportunities for change can be identified.

4.3.1 Research Questions for Enquiry 1

The theoretical framework was translated into the following research questions for Objective 1:

Are designers' *individual situations* conducive to considering material sustainability, and the use of secondary materials?

Are designers' *work scenarios* conducive to considering material sustainability, and the use of secondary materials?

Does the product and industrial *design scenario* offer any opportunities for improving the likelihood of designers considering and selecting secondary materials for high-value mass-produced artefacts?

Responding to these questions in reference to the theoretical framework, presented above, was the focus of Enquiry 1.

4.3.2 Research Methods for Enquiry 1

This section outlines the rationale and details of the methods used for the empirical research undertaken in Enquiry 1.

Identifying the Type of Enquiry

The *purpose* of an enquiry describes exactly what type of study will be undertaken, informing the type of questions to be asked and appropriate methods to be used. Robson (2002) identifies four purposes of a research enquiry, explaining that one or more of these can be applied to a study and may change as the research progresses:

Exploratory: To find out what is happening, particularly in little-understood situations; to generate ideas and hypotheses for future research (almost exclusively of flexible design);

Descriptive: To portray an accurate profile of persons, events or situations; requires extensive previous knowledge of the situation to be researched or described, so that you know appropriate aspects on which to gather information (flexible and/or fixed design);

Explanatory:	Seeks an explanation of a situation or problem, traditionally but not necessarily in the form of causal relationships; to identify relationships between aspects of the phenomenon (flexible and/or fixed design);
Emancipatory:	To create opportunities and the will to engage in social action (almost exclusively of flexible design)

(Robson 2002:59-60 abridged)

The purpose of this enquiry was primarily *explanatory,* as it sought to explain the situation of product and industrial designers in relation to their ability to consider the sustainable use of materials in their work. In line with the description above, the data analysis focused on potential *causal relationships* that had been identified during the survey design, in reference to the theoretical framework (presented in the previous section). However, the survey also contained *exploratory* elements which were designed to discover designers' perspectives and their behaviour when sourcing materials, to highlight areas which could be improved and further explored during Objective 5.

In Robson's definition of purposes there is also a distinction made between *fixed* and *flexible* research designs. In Chapter Three an overview of the methodology for the research project was presented; identifying the project as having a *fixed* structure (predefined objectives), but a *flexible* research design (responding to research findings as they unfold). However, this specific enquiry was identified as predominantly *fixed* in nature, whereas the other objectives were flexible.

This enquiry involved research questions that were based on a theoretical framework, allowing a significant amount of pre-specification of questioning and data analysis tasks, which is characteristic of a fixed research design. The flexible part of the enquiry which is implied in the description above, by the inclusion of exploratory elements, was largely exploited in the subsequent stages of the project and in particular is explored in Chapter Seven.

Appropriate Methods for Collecting Data about Design Practice

Research into design practice is a relatively young field of enquiry and there is very little tradition in the research methods used. The principal approach has been to borrow methods from the more established research fields of psychology, sociology and business, such as observation (Emmitt 2001), protocol analysis (e.g. Jin & Chusilp 2006), surveys (e.g. Fletcher 1999) and case studies (Swann 2002 e.g. Pedgley 1999; Sherwin 2000). These methods vary in terms of their qualitative and quantitative approaches, their generalisability and the purpose of the research. Case studies, for example, are often advocated for establishing best practice (Swann 2002) or for developing and testing new methods especially in a field where existing theory is sparse (Pedgley 1999). Case study findings, however, are not generalisable. As research in the field of design has gathered momentum so has the use of theory-based methods which build on previous work in the field. It was important to take the context of design research into

consideration, but also to select the most appropriate method for the research purpose and questions of this enquiry which were presented in section 4.3.

The theoretical framework for this enquiry suggested a wide variety of specific data needed to be gathered relating to the individual designer's situation and their work scenario, and from a significant number of respondents if an 'explanation' of the design scenario was to be established. It was also important to take into account the practical constraints of the enquiry; the skills and expertise available to the author, the timeframe (anticipated 1 year from the start of the literature review to completion of the analyses), the geographical and cost limitations.

Combined, these considerations strongly suggested the use of a survey; Floyd and Fowler (1995) comment:

> There is an almost limitless body of desirable and useful information that can be gathered only by asking people questions. In some cases that is because we want to know facts that are difficult to observe systematically.
>
> (Floyd & Fowler 1995:1)

This is particularly relevant to the choice of method for this enquiry as the breadth of information sought was unobtainable by any other means than questioning the designers themselves. Ready access to a statistician who could advise on the survey design and analysis of the data was also crucial to the selection of this method.

Strengths and Limitations of Surveys

In addition to the appropriateness of the survey to the research purpose and questions, Floyd & Fowler describe some benefits of a survey:

- The representation of a population afforded by "a properly chosen sample" rather than "a sample of those who attend meetings [and] speak loudest";
- A consistent standardised measurement ensuring "comparable information is obtained about everyone who is described" and providing "meaningful statistics";
- In some cases "the only way to ensure that all the data needed for a given analysis are available and can be related"

(Floyd & Fowler 2002:3 paraphrased and abridged)

However, the use of 'scientific' research methods in real-world enquiry, such as an explanatory survey which produces quantitative data, is the subject of much debate (Robson 2002); *Are all of the contributing factors represented? How are unquantifiable factors taken into account? Is it certain that the target population is represented in the survey? Could richer data be obtained using a qualitative method?* These concerns are valid, and in many situations a quantitative survey is not the most appropriate method. These pitfalls can, to a large extent, be avoided; by ensuring that a survey is the best method available for

providing the data needed to answer the research questions, as discussed above; by using mixed methods such as qualitative follow-up interviews to explore findings, providing depth and clarity (Robson 2002), discussed later; by acknowledging weaknesses in the survey design and data (Floyd & Fowler 2002); by being aware of the errors associated with surveys and taking measures to avoid them.

Floyd & Fowler (2002:17) define two *inference* errors associated with survey quality. The first is *sampling error* or *external validity* (Robson 2002:231) which may result in some members of the population not being represented and therefore biasing the results. The second is *question error* or *internal validity* (Robson 2002:231) and is to do with whether the question resulted in a true representation of the values of the respondent. There is also the possibility of misreporting, a type of *question error* which is often a source of criticism for surveys. The survey was designed to avoid these errors as far as possible, which is discussed in more depth shortly.

Survey Methods

There are various ways of conducting a survey, defined by the type and structure of questions involved and how the survey is to be administered and distributed, with various advantages and disadvantages. Robson (2002) highlights the distinction between *self-administered* and *interviewer-administered* surveys. The former offers the advantages of minimal time and cost, and the opportunity to present "long or complex response categories" (Floyd & Fowler 2002:81), but the risk of low response rates and hence a less representative sample. Meanwhile interviewer-administered surveys tend towards qualitative data, open questions and have the advantage of the interviewer being able to ensure the questions are answered correctly; they benefit from a higher response rate, whilst risking interviewer bias, higher costs and longer lead times (Robson 2002).

Taking these factors into consideration, a self-administered survey questionnaire was chosen as the most appropriate method for obtaining a broad range of data about the subjects from mostly closed, fixed-choice and complex questions, and within the project constraints. To avoid some of the disadvantages of the self-administration method potential respondents were contacted directly – eliciting a response rate of 34% - and special care was taken to design the survey instrument to avoid any misunderstanding when answering questions, *question error*, or *internal validity* issues.

The Survey Instrument

Based on the focused literature review and theoretical framework three areas of enquiry were identified within which specific themes were suggested:

The Individual designer's situation:	Training
	Experience
	Design priorities
The Work Scenario:	Job scenario
	Ability to challenge the brief
	Communication with other actors in the design process
	Time allocation
Material Sourcing Behaviour:	Materials used (including secondary)
	Ownership of materials decisions
	Information sources most useful

This was the skeleton on which the questions for the survey instrument were developed. Floyd & Fowler (1995) identify five challenges to writing a good question:

1. Defining the objectives and specifying the kind of answers needed to meet the objectives of the question;
2. Ensuring that all respondents have a shared, common understanding of the meaning of the question... the same as that intended by the person writing the question;
3. Ensuring that people are asked questions to which they know the answers;
4. Asking questions that respondents are able to answer in terms required by the question (questions must fit the reality being reported);
5. Asking questions respondents are willing to answer accurately.

(Floyd & Fowler 1995:9)

Due consideration of these challenges was taken during the development of the survey questions and feedback was solicited from a variety of sources to ensure that the questions met this criteria. A total of five iterations of the survey were developed in response to five sources of feedback shown in figure 4.3.2.[53]

Figure 4.3.2: Feedback received in response to iterations of the survey instrument

Survey Iteration	*Feedback received from...*
1 & 2	Industry and academic supervisors
3	An 'expert' from the Design Council's research department
4	Six industry 'experts' (some of whom had been interviewed)
5	Three designers who took part in a modest pilot The statistician

[53] A summary of this feedback is included in Appendix A(ii)

The final survey instrument included twenty-five questions across ten sections; four types of question were used:

- Multiple choice (single and 'all that apply')
- Yes/no
- Open response (limited in length)
- Likert scales

While it was decided that open questions should be kept to a minimum for ease of response and analysis, and a variety of response methods should be utilised to keep the respondent's attention, choosing the most appropriate response method for each question was the ultimate concern. The question order was also given much consideration; for example, it was noted in the feedback that easy-to-answer and non-probing questions could be used at the start to ease the respondent into the questionnaire. More complex questions were positioned in the 3rd quarter of the questionnaire and the remaining easy-to-answer but slightly more personal questions were positioned at the end. An opportunity to comment was also provided at the close of the questionnaire should the respondent feel their views had not been fully represented. Although anonymity was granted at the beginning of the questionnaire, respondents were asked to provide their email at the end so that they could be included in a prize draw, which was an additional incentive, as long as they were happy to be recontacted.

To avoid *question* or *sampling errors* resulting from respondent biases towards or against the sustainability theme of the project, this focus was not made explicit in any of the communications leading up to participation in the survey. 'Sustainability' or 'recycled materials' were only mentioned where it was imperative to understanding a question.

This thorough approach to developing the survey instrument meant that every question was interrogated on its contribution to the research, the appropriateness of the question type, the ease of understanding, the terminology used, the representation of responses and accommodation of alternative responses. The result was a concise questionnaire which was easy to complete, and most importantly returned complete data which could be analysed to address the research questions. The variety of feedback received on the design of the survey instrument also helped to diminish the effect of *question error* or *internal validity* issues, discussed earlier. The full survey instrument and the rationale behind each question are also included in Appendix A(iii).

Sampling

Along with a carefully designed survey instrument, sampling is considered the most important consideration in survey design. Floyd & Fowler (2002) state "A major development in the process of making surveys useful was learning how to sample: to select a small subset of a population representative

of the whole population" (Floyd & Fowler 2002:4). The challenge for this enquiry, therefore, was to access a sample representative of the broader population of designers of high-value mass-produced artefacts so that the findings would be generalisable. There are three key aspects of sample selection which are now discussed in more depth and summarised in figure 4.3.3.

Figure 4.3.3: Summary of sampling for the survey

Three aspects of sample selection	*Sample definition for this enquiry*
Population All the cases (Robson 2002:260)	UK-based product and industrial designers working as consultants to UK manufacturers and product and industrial designers working 'in-house' for London-based manufacturers
Sample frame The set of people that has a chance to be selected, given the sampling approach that is chosen. (Floyd and Fowler 2002)	Designers working for agencies registered with British Design Innovation's (BDI) Directory Designers working in-house for manufacturers who sought advice from the Manufacturing Advisory Service of London (MAS)
Sample A selection from the population (Robson 2002:260)	64 companies comprising: 35 where design consultants were located, and 29 where designers were working in-house

Target population	*Sampling process*
Design consultants Working in the UK with UK manufacturers of high-value mass-produced artefacts	**The British Design Innovation's (BDI) Directory** lists around 1000 design businesses. ***Purposive sampling*** was used to isolate companies specialising in the design of three-dimensional consumer products, 173 in total, 40 of which were London-based. ***Systematic sampling*** (1 in 5) was then used to reduce that number to 35 companies to be contacted, 8 of which were London-based.
In-house designers Working within UK manufacturers of high-value mass-produced artefacts	**The Manufacturing Advisory Service of London (MAS)** provided listings for 942 London-based companies (predominantly SMEs) who had sought manufacturing advice in the past year. ***Systematic sampling*** method (1 in 3) was used to reduce these numbers down to 314 companies. ***Purposive sampling*** isolated companies that batch- or mass- produce goods in the UK, using materials that are potentially recyclable, and have an in-house design function. 29 companies were then contacted from this list, all of which were based in Greater London.

Population

To begin a sampling plan, the population from which the sample is derived and to which the findings will be applicable, must first be defined. In addition to the focus on product and industrial designers it was decided that an effort would be made to include in-house and consultant designers. Freelance designers were not intentionally discounted but, as a dispersed segment of the industry, they would be difficult to access. The geographical focus was *design consultants* and *in-house designers located in the UK and working with London-based manufacturers,* because artefacts produced locally offer the greatest opportunity and the most desirable situation for the use of secondary materials[54].

One of the challenges of sampling in this enquiry is that very little is known about the population. The Design Council (2005) has conducted the only industry-wide study of the UK design sector; the findings give a clearer picture of design businesses, but very little about individuals:

- There are approximately 60,900 designers in 12,450 design consultancies and 77,100 designers in 5,900 in-house design teams
- 31% (20,436) of UK design businesses are located in London
- 14% of design businesses (2,569) are in the product and industrial design sector
- Of 154,926 UK manufacturing businesses 44% have no design activity which implies that 86,759 businesses utilise design.

Sample Frame

The sample frame is the "set of people that has a chance to be selected" and, as "a sample can only be representative of the population included in the sample frame" (Floyd & Fowler 2002:19), it is imperative to the generalisability of the results that the sample frame is equivalent to the population. The challenge was finding a route to accessing individual designers, whilst also adhering to the rigor of sampling methodology, in order to avoid sampling errors and *external validity* issues which would threaten the quality of the results. The only option was to focus the sample frame on organisations rather than individuals, which is a recognised approach; for example households are frequently the focus of sampling frames to gain statistical data on the general population (Robson 2002).

The aim was to achieve a sample frame which included near equal numbers of design consultancies and in-house design teams (to mirror the proportions in the population and to facilitate comparisons), and to ensure that London-based designers and manufacturers were sufficiently represented as this was the geographical focus of the project[55].

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[54] The implication of manufacturing location for using secondary materials is discussed in more depth in Chapter Five.

[55] Inevitably design consultants and in-house designers had to be treated differently with regards to location; whereas designers working in London-based manufacturers could be identified fairly easily because they are based within the

Two lists of companies were selected which offered the best available representation of the target population: The British Design Innovation's (BDI) Directory[9] which lists around 1000 design businesses (consultancies) and the Manufacturing Advisory Service of London (MAS)[10] which included listings for 942 companies (predominantly SMEs[56]) who had sought manufacturing advice in the past year.

Sample

A *sample* is a selection from the population; if the *sample frame* is representative of the *population*, extracting the *sample* should be a fairly straightforward. However, there are procedures which must be followed to ensure that the sample is representative of the sample frame, the most common of which is called *probability sampling*, meaning that the probability that each subject within the sampling frame will be selected, should be calculable (Floyd & Fowler 2002).

For this enquiry the sampling frame was already *stratified* into two lists of in-house teams and consultancies, which allowed a sample to be selected that looked more like the total population than a purely random sample (Floyd & Fowler 2002:25), containing near equal numbers of in-house designers and design consultants. *Purposive sampling* was used to ensure the correct profile of respondents were included, and *systematic sampling* to select the final sample which has the "precision equivalent to a simple random sample and can be mechanically easier to create" (Floyd & Fowler 2002:24). The sampling methods are summarised in figure 4.3.3.

Conducting the Survey

A number of potential distribution options were considered and it was decided that, because of the limited time and resources available to the author, the survey would be deployed via a link from an email to an online questionnaire. This not only allowed for easy access by the respondent, but also saved on paper and envelopes, time taken to send and receive, work required to input data manually, as well as reducing the risk for human error (Robson 2002). There are of course increased risks with this method, such as technical faults or loss of data, but these were seen as minimal when weighed against the advantages of a digital survey. Moreover, this method appears to have worked well; data was easily retrieved and processed, and cases were complete.

The sampling frame only included the names of organisations so contact information first had to be sought before contact could be made. In total 64 companies were contacted by telephone and invited to take part

---

company they are working for, finding a sample frame for design consultants that have worked with London-based manufacturers was much more difficult. Instead, the geographical focus of the sample for design consultants was extended to the UK, first because it was presumed that focusing on London-based designers was unlikely to achieve a higher proportion of respondents who had worked with London-based manufacturers; second because knowledge of the population of UK design consultants is available (Design Council 2005) and could be used to check the sample representation, whereas knowledge of the population of London-based designers is not available. This was seen as a legitimate sampling method as the data analyses did not involve geographical comparisons between responses.

[56] SMEs were considered a useful segment of the manufacturing organization population to target; they are numerous and therefore have a significant contribution to make, they are also currently less likely to be proactive on sustainability (van Hemel & Cramer 2002).

in the survey; this was seen as the best way of avoiding non-response and, in many cases, was the only way of obtaining personal email addresses. An email was then sent with a link to the online questionnaire. As an additional incentive, respondents were entered into a competition to win a crate of organic wine. Follow-up telephone calls were necessary to elicit the response rate of 34% (22 cases) all of which were complete. To ensure that the respondents fitted the target population two screening questions were included at the start of the survey; if respondents selected the 'wrong' criteria and therefore did not fit the target profile, they were politely directed away from the questionnaire.

Data Analysis

Crucial to the analysis of the survey data was the involvement of statisticians from the School of Psychology at Kingston University – principally Professor Philip Terry – who reviewed the results of the modest pilot and advised modifications to the survey instrument, reviewed the feasibility of the analysis plan (included in Appendix A(iv)), and guided the statistical analysis.

There are different types of fixed research design and, as this project did not involve the control of variables, it is considered to be *non-experimental;* containing both *relational* and *comparative* elements (Robson 2002). The analysis plan was developed during the design phase of the survey to identify variables where relationships and comparisons should be sought. This was invaluable for recalling the intention of each question when working with the statistician.

The analyses were conducted using SPSS (Statistical Package for the Social Sciences) software and included three types of statistical test:

Difference testing	To test differences between groups against specific variables
Tests of association	To test the degree of association between two variables
Correlation	To test the strength and direction of the relationship between two variables

In typical statistical analysis, for an effect to be statistically significant, the probability of a chance occurrence must be low, conventionally less than $p=0.05$. However, as the sample in this investigation is small, any difference, association or correlation had to be very strong for it to produce a significant outcome as Robson (2002) explains: "The chance of obtaining a statistically significant result increases as the sample size increases, [...] if one is relying on statistical significance, there is much to be said for keeping the sample small so that only robust effects are going to be picked up." (Robson 2002:401). Therefore a probability of $[0.05<p<0.099]$ is interpreted as being *marginally* significant. Where correlations are referred to, it is generally accepted that a strong correlation will correspond to a value of 0.4 or higher, a moderate correlation being 0.3 to 0.4, and anything lower is considered weak (Robson 2002:423). Therefore only correlations above 0.3 have been considered in this analysis. Three open

questions were also included in the survey questionnaire. These were manually coded to extract common themes.

In addition to statistical analysis the survey data was translated into twenty-two A4 *respondent profiles,* each containing the all of the responses for one case, represented in graphical format (examples are included in Appendix A(v)). Tufte comments: "we envision information in order to reason about, communicate, document and preserve that knowledge" (Tufte 1990:33). The purpose of this method relates to *reasoning and communication*: to aid exploration of the data; as a quick reference during the follow-up interviews; to present the dominant profile characteristics; and preserve a sense of the individual respondent.

Semi-structured Follow-up Interviews

Following the conclusion of the data analysis from the survey questionnaire, semi-structured interviews were undertaken with four respondents to solicit feedback on the findings and to add greater depth and clarity. The list of respondents was narrowed using the following criteria:

- They had agreed to continue with the research;
- They worked in a design consultancy rather than in-house;
- They lived in or near Greater London.

Design consultants were chosen to be interviewed because they work on a greater variety of projects than in-house designers, across many sectors, and were therefore seen to offer greater potential for encountering projects where the use of secondary materials might be possible. Pedgley observes:

> Consultancies are involved with a diverse range of design briefs and this necessarily results in the specification of a wide range of materials and processes. This can make consultancy work especially engaging but, at the same time, provide additional pressures of designing for unfamiliar materials.
>
> (Pedgley 1999:315)

The Greater London region was chosen as a convenient location for the author and also fitted with the remit of the collaborative partner, London Remade. Three of the designers interviewed were senior designers and all had different levels and types of training: two predominantly 'arts-based' and two with 'other' backgrounds. Interviewee profiles and the interview schedule are included in Appendix A(vi)

A semi-structured interview style was chosen to achieve a richer quality of data which would complement the more structured survey data. Robson advocates the use of interviews, to follow on from quantitative surveys, as one of five *Circumstances in which a qualitative research interview is most appropriate:* "Where a quantitative study has been carried out, and qualitative data are required to validate particular measures or to clarify and illustrate the meaning of the findings." (Robson 2002:271).

A draft summary of the survey findings was emailed to each of the four designers prior to the interview as a lead-in to the discussion. Interviews took place at the designer's own work establishment which was convenient for them, but also allowed them to meaningfully refer to aspects of their work environment during the interview. Each workplace had a large table where meetings with clients take place and this was also where the interviews were conducted. The designers were informed of the interview format:

- The interviewer (author) reminded them of their own response to each survey question and then explained how it compared to the overall findings;
- They responded;
- The discussion was allowed to develop freely, returning to the survey responses when appropriate;
- Interviews lasted between 30 and 50 minutes and were audio recorded;

Having read a summary of the survey findings, all four designers agreed that they were largely representative of their own experiences and situation. Indeed, after the interviews had been completed it was clear that the survey had quite successfully revealed the shape of the individual designer's scenario and the interviews would allow a fuller picture to be developed.

To analyse the interview data, each recording was transcribed and coded manually (an example transcript is included in Appendix A(vii)). Respondents are identified by BG, PB, SF or JB (refer to Appendix A(vi).

4.4 Results & Discussion

The results combine analyses from the survey questionnaire and follow-up interviews, and are divided into three sections relating to the theoretical framework, outlined below. The order here is different to that used in the survey instrument, which is included in Appendix A(iii):

The Individual Designer's Situation

1. How many years have you been working as a designer?
2. How did you receive your design training?
3. What factors are most important to you as a designer?
4. Do you feel that these factors as you've rated them above are reflected in your work with manufacturing companies?
5. To what extent to you disagree or agree with the following statements? (materials training and confidence in selection)
6. What does 'sustainable' mean to you in this context?

The Work Scenario

7. Which of the following best describes your work environment?
8. How many people do the company you work for employ?
9. Where is the company located?
10. What type of products have you been involved in designing for UK manufacturers?
11. How often do the following events occur? (involvement in design brief development)
12. Try to think of a typical project where you wanted to challenge the brief and consider this in relation to the following statements (experience of challenging the brief)
13. Do you feel your access to the following area of knowledge is adequate?
14. Consider the time and information resources you require to source materials effectively, do you mostly disagree or agree with these statements? (time and access to resources)

Material Sourcing Behaviour

15. What types of materials do you most commonly specify?
16. Have you ever specified recycled materials? What was the source of the waste material?
17. What is your opinion of recycled materials?
18. To what extent are your materials decisions affected by a contractual obligation to a particular material or material supplier?
19. Are you aware of any legislation or regulation that affects yours or the manufacturer's materials choices?
20. Tick the (material information) sources that are a) most useful for initially looking for materials and b) for finding materials that are used in the final specification.

Within the results each question is presented in italics within a plain box, phrased as it was in the questionnaire, followed by the type of question in brackets. A discussion of the findings relating to that question is then presented. Statements of statistical significance, which describe the analysis findings, are numbered and included in Appendix A(viii); these are then referenced within the discussion e.g. *statement 1* or [stat 1].

In addition, the results were summed up in two graphical representations as described earlier in the Research Methods section; these are included in Appendix A(v).

Respondent Profiles

There were four questions included in the survey to provide grouping variables, so that differences between defined groups could be identified; two were aimed at grouping respondents by their *design experience* and two by their *working environment*. Due to the small sample, the best results are achieved by re-grouping the variables so that there are two near-equal subgroups in each. Appendix A(ix) presents these re-groupings.

The majority of the sample was highly dispersed in terms of the type and size of the organisation they were working for, their experience and type of background. However, one respondent profile was dominant, accounting for 27%of the sample (6 of 22 cases):

> *Senior designers with an arts background, working in a design consultancy with 9 or less employees*

Design consultancies were more likely to be small companies with 1-9 employees and in-house teams to be in medium or large companies with 10 or more employees [stat 1].

4.4.1 The Individual Designer's Situation

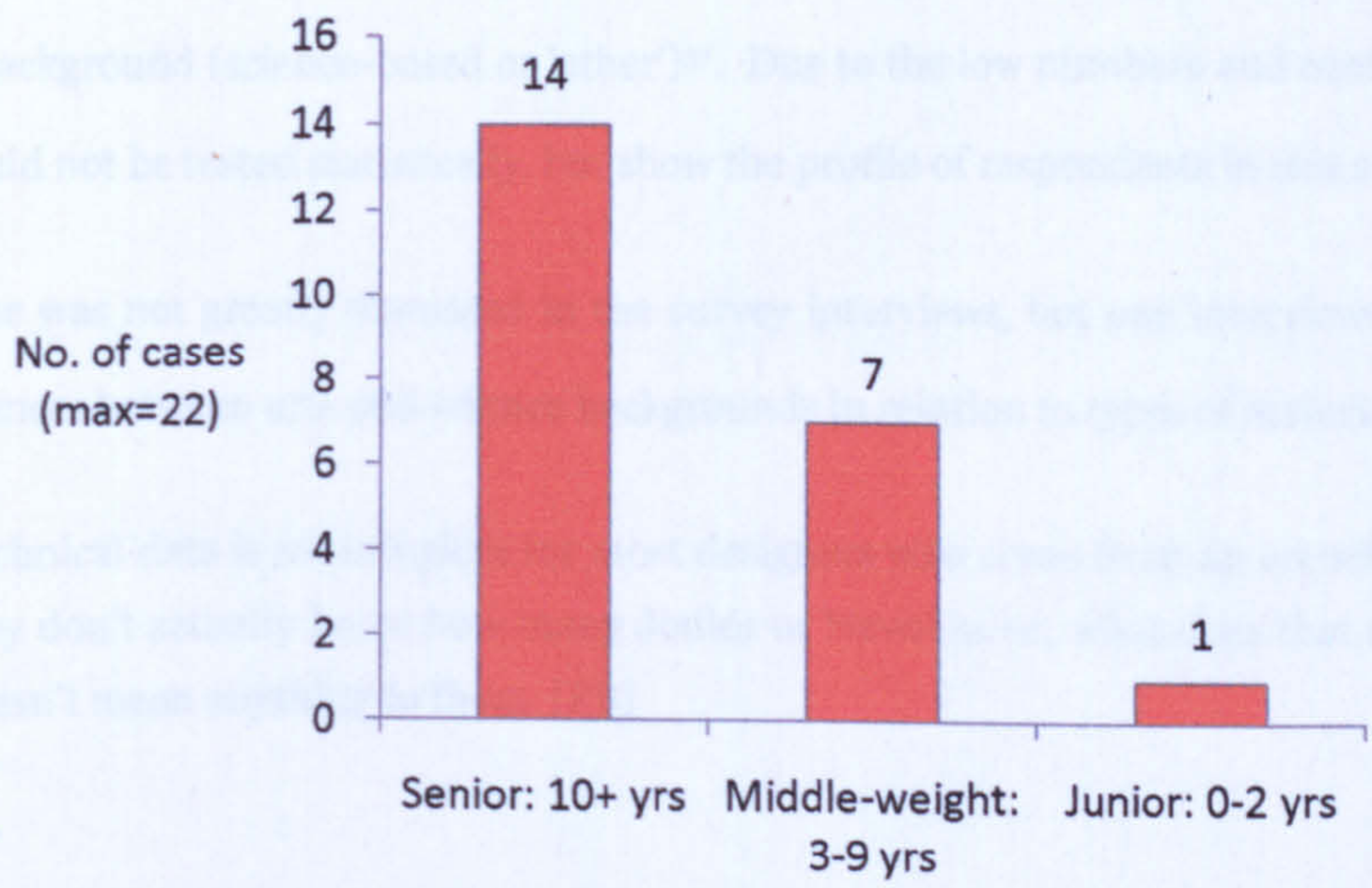
This first section of the results relates to the individual designer's background, experience and priorities; the mix of factors that they bring to design decisions in relation to material selection.

Experience

Q1	*How many years have you been working as a designer?* (Multiple choice)

This question was included to differentiate the sample in terms of their experience. However, the disparity between the numbers of respondents in each group, shown in figure 4.4.1, prevents any meaningful comparison of length of experience. This distribution echoes the Design Council's report of experience in the design industry which found that 30% of designers had less than 10 years experience, implying that the other 70% were senior designers (Design Council 2005). This indicates that the experience distribution of this sample is consistent with the broader population.

Figure 4.4.1: Respondents' design experience (years)



Background (training)

Q2	*How did you receive your design training?* (Multiple choice – all that apply)

Respondents were asked to select all of the types of training they had received. Figure 4.4.2 shows that almost half of the respondents said they had received some training 'on-the-job'; two of those cases received no other training. Bachelor of the Arts (BA) was the most common educational background. Two respondents had received both arts and science-based training. HND courses can be either arts or science-based so, when analysing differences, they were included in the 'other' group.

The relationship between background (training) and company type was explored and can be compared in figure 4.4.3: 62% of respondents working in design consultancies had at least one arts qualification (8 of 13 cases), compared to only 22% of respondents working in-house (2 of 9 cases). The two respondents who had only received on-the-job training were working in-house, while the two respondents with both arts and science education were working in a consultancy.

Therefore, designers working in consultancies tended to have an arts background or at least one arts qualification (arts-based), whereas in-house designers were more likely to have a science or on-the-job training background (science-based or 'other')[57]. Due to the low numbers and complexities involved, these trends could not be tested statistically, but show the profile of respondents in this survey.

This theme was not greatly discussed in the survey interviews, but one interviewee freely commented on the differences between arts and science backgrounds in relation to types of material information[58]:

> Technical data is meaningless for most designers who come from an art-school background, they don't actually know how many Joules or Newtons or, what does that actually mean? It doesn't mean anything to them. [PB]

[57] Throughout the remaining analyses respondents with a BA or MA degree are described as having an 'arts background' while designers without an arts-based degree are described as having a 'non-arts background' or as being part of the 'other' group with regards to training background.
[58] This is discussed in greater depth in section 4.4.3 Materials Sourcing Behaviour

Figure 4.4.2: Repondents' design training

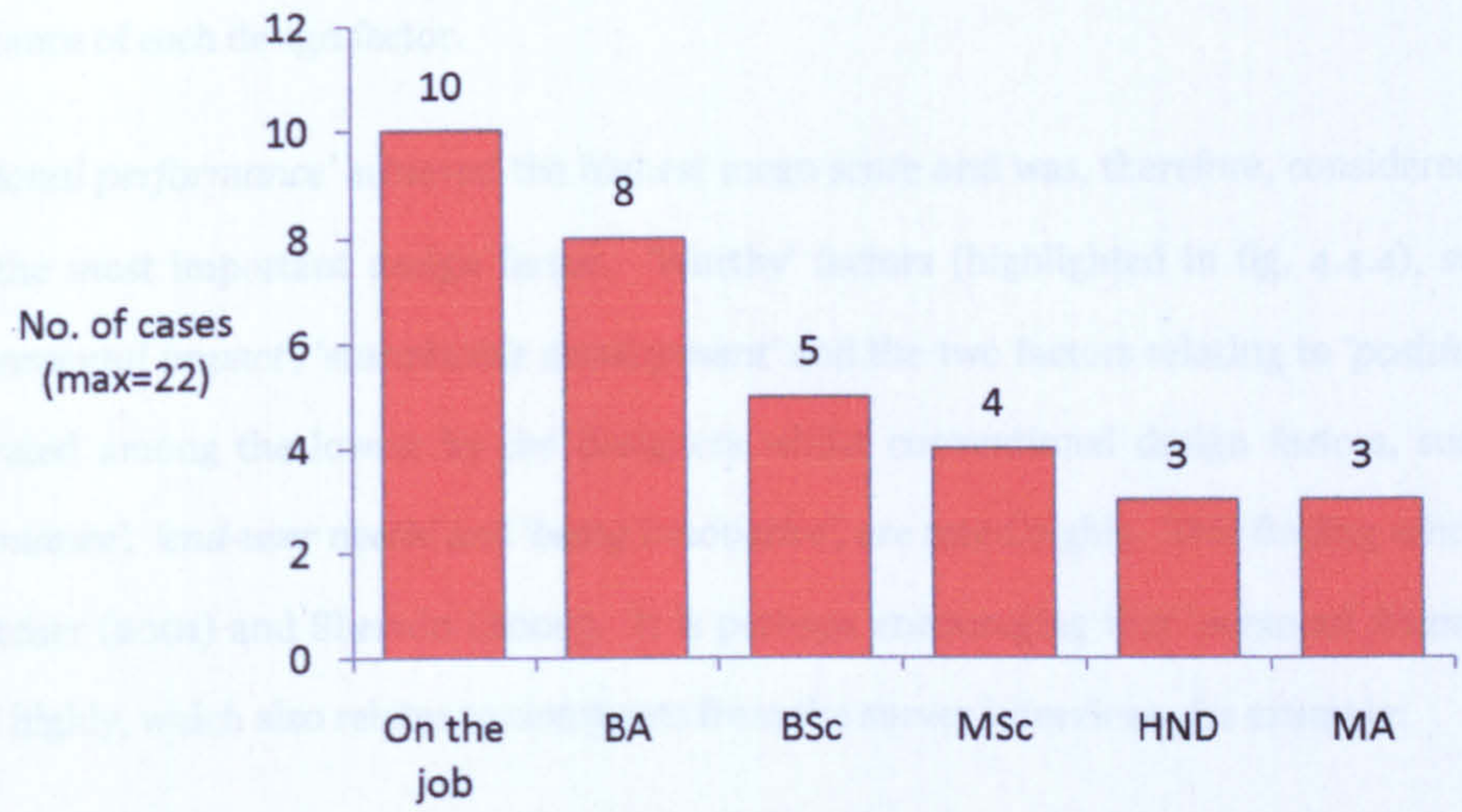
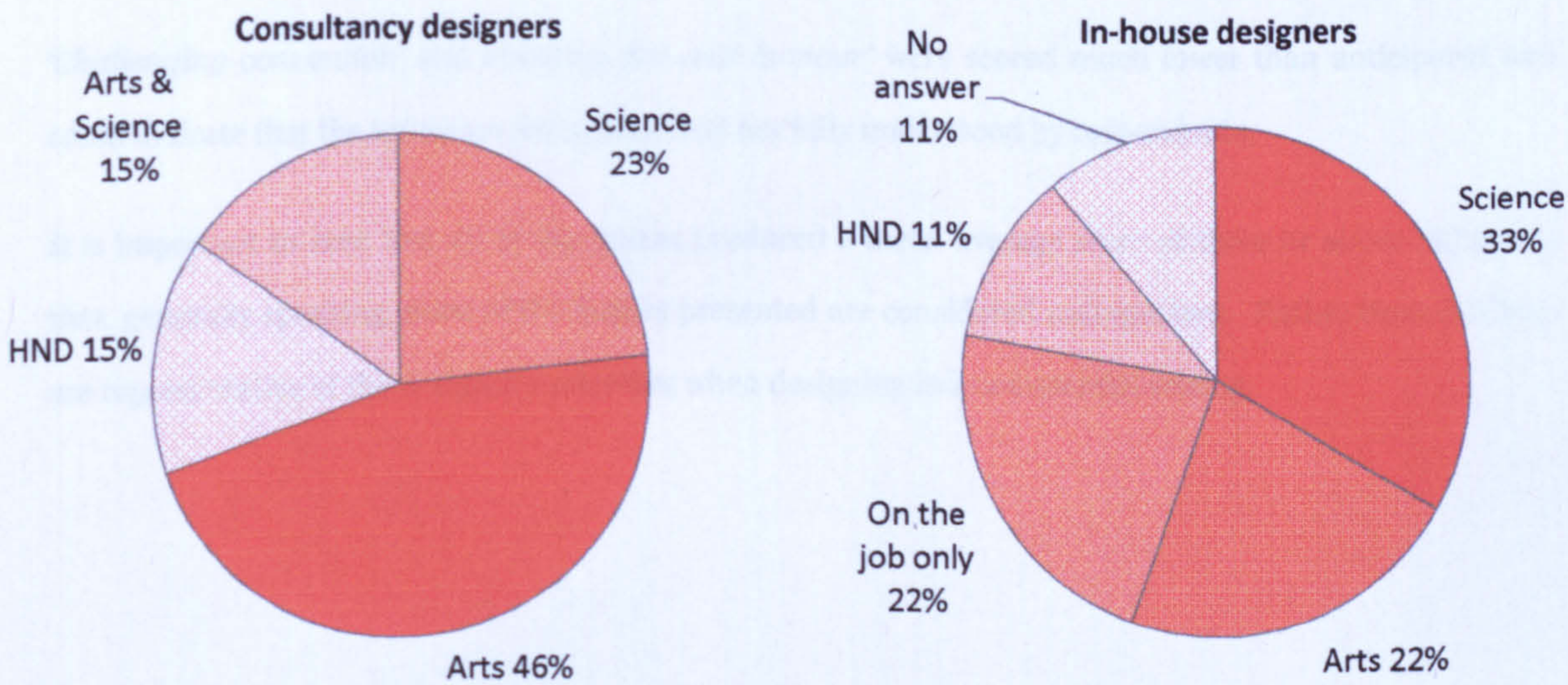


Figure 4.4.3: Respondents' training backgrounds by type of company they work for



Important Factors in Design

Q3	*What factors are most important to you as a designer?* (Scale: 1=less important 5=more important)

This question aimed to understand designers' values (here termed 'factors') in relation to their practice which constitute priorities when designing. Figure 4.4.4 shows the mean scores respondents gave for the importance of each design factor.

'Functional performance' achieved the highest mean score and was, therefore, considered by respondents to be the most important design factor. 'Worthy' factors (highlighted in fig. 4.4.4), such as *'reducing environmental impact'*, *'sustainable development'* and the two factors relating to *'positive social impact'*, were rated among the lowest by the designers whilst conventional design factors, such as *'functional performance'*, *'end-user needs'* and *'being innovative'*, are rated highly. This finding echoes earlier studies by Fletcher (2001) and Sherwin (2000). It is perhaps encouraging that *'personal financial success'* isn't scored highly, which also relates to comments from the survey interviews, for example:

> I think we want to have good quality products we don't want to design rubbish, we're not interested in doing that at all, because we don't charge very much money for [designing], it's not a reason for being a designer. [SF]

However, *'satisfying the brief given'* is ranked fourth which is indicative of the, perhaps necessarily, reactive approach of commercial design. This was also reflected in the interviews where phrases such as "It's just completely assumed that it's going to be made out of..." [SF] and "it would be up to the customer" [JB] were used frequently to explain the situation.

'Challenging convention' and *'creating fun and humour'* were scored much lower than anticipated and could indicate that the terms are ambiguous and not fully understood by respondents.

It is important to note that all of the factors produced a mean average score of three or above indicating that, generally speaking, none of the factors presented are considered unimportant. Rather these findings are representative of the designer's priorities when designing in a commercial setting.

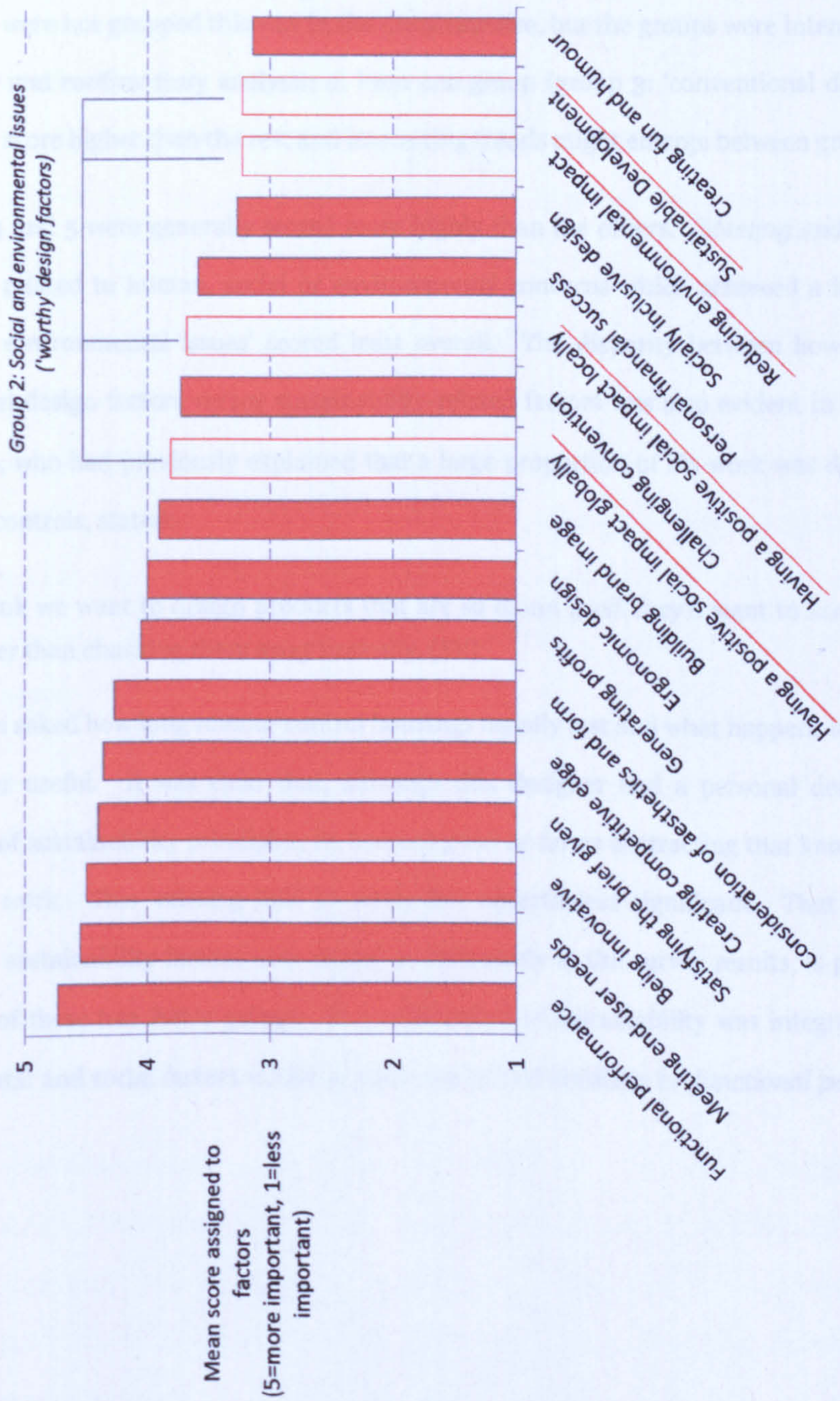


Figure 4.4.4: Factors which respondents considered most important to their work as designers

Design Factor Groups

The design factors selected for the survey were originally divided into six groups, each with an associated theme[59]:

1. Human factors
2. Social and environmental issues
3. Conventional design concerns
4. Client concerns
5. Reactionary attitude
6. Designer's other personal motivations

The factors were not grouped this way in the questionnaire, but the groups were intended to facilitate both exploratory and confirmatory analysis; at least one group (group 3: 'conventional design concerns') was expected to score higher than the rest and interesting trends might emerge between groups.

Groups 3, 4 and 5 were generally scored more highly than the others. *'Meeting end user needs'* was the only factor related to human, social or environmental concerns which achieved a high score. Group 2 'social and environmental issues' scored least overall. The disparity between how designers attend to conventional design factors versus sustainability-related factors was also evident in the interviews. One interviewee, who had previously explained that a large proportion of his work was designing the housing for remote controls, stated:

> I think we want to design products that are so damn good they'll want to keep using them rather than chucking them away basically. [SF]

He was then asked how long remote-control housings usually last and what happens to the material once it is no longer useful. It was clear that, although this designer had a personal design ethic and some knowledge of sustainability principles, he had not gone as far as abstracting that knowledge for use in his day-to-day work. This 'missing link' is subtle but nevertheless significant. That conventional design factors and sustainability factors were scored so differently in the survey results, is perhaps telling of the separation of these two factor groups. If consideration of sustainability was integral to design practice, environmental and social factors would probably be scored similarly to *'functional performance'* and *'end user needs'*.

[59] These can be viewed in the original context (as part of the rationale behind the survey questions) in Appendix A(iii).

Significant Differences between Profile Groups

Within the results there were some significant differences between groups with different profiles. Designers with an arts background valued *'aesthetics and form'* more highly than both those with non-arts backgrounds [stat 2], which is perhaps unsurprising as arts-based design education has traditionally focused on aesthetics.

Designers working in consultancies with 1-9 employees are more likely to value *'satisfying the brief given'* and *'consideration of aesthetics and form'* than in-house designers in companies with 10 or more employees [stats 3 & 4].

Significant relationships between design factors

There were also significant correlations between different design factors, showing some strong relationship groups. Designers who were motivated by *'personal financial success'* also scored other factors related to money and competition highly [stat 5]. Many of the variables had moderate correlations with lots of the other variables, whereas *'personal financial success'* was only linked to *'profits'*, *'competitive edge'*, and *'functional performance'* which strengthens this finding.

Factors found to be most commonly related to *'aesthetics and form'* [stat 6] included human and social factors as well as conventional design factors and could be seen to represent a balanced approach to design; the notable absence from this group are those factors relating to environmental sustainability. Moreover, design consultants with an arts background, working in a small company were more likely to score *'aesthetics and form'* highly (discussed earlier) which could indicate that this particular set of design factors may be more representative of a design consultant's attitude to design factors than a designer working in-house.

Designers who valued *'reducing environmental impacts'* were also more likely to value issues related to social impacts [stats 7 & 8], which is not surprising. However, there was no significant correlation between *'reducing environmental impact'* and *'sustainable development'*. One possible explanation is that, given two similar factors, designers were encouraged to make a distinction and therefore decide which of the two factors were more important. Indeed *'sustainable development'* correlated with more variables than *'reducing environmental impact'* [stat 9].

So, *'sustainable development'* appears to appeal as part of a more rounded approach to design alongside conventional design factors such as *'functional performance'*, *'competitive edge'* and *'satisfying the brief'* while still being linked to more worthy issues such as *'social impacts'*, *'end user needs'* and *'ergonomics'*, which perhaps indicates that these designers appreciate the 'bigger picture' associated with sustainable development as opposed to environmental concerns.

The link between *'brand image'*, *'competitive edge'* and 'worthier' factors [stat 10] could be related to the emerging business interest in social and sustainable issues.

Some particularly strong relationships between individual design factors were also found, indicating that designers who valued one were likely to also value the other(s):

- *'Functional performance'* and *'brand image'*
- *'Competitive edge'* and *'brand image'*
- *'Sustainable development'*, *'positive social impacts globally'* and *'ergonomics'*

Factors Reflected in Work

Q4	*Do you feel that these factors as you've rated them above are reflected in your work with manufacturing companies?* (Scale: 1=never 5=always)

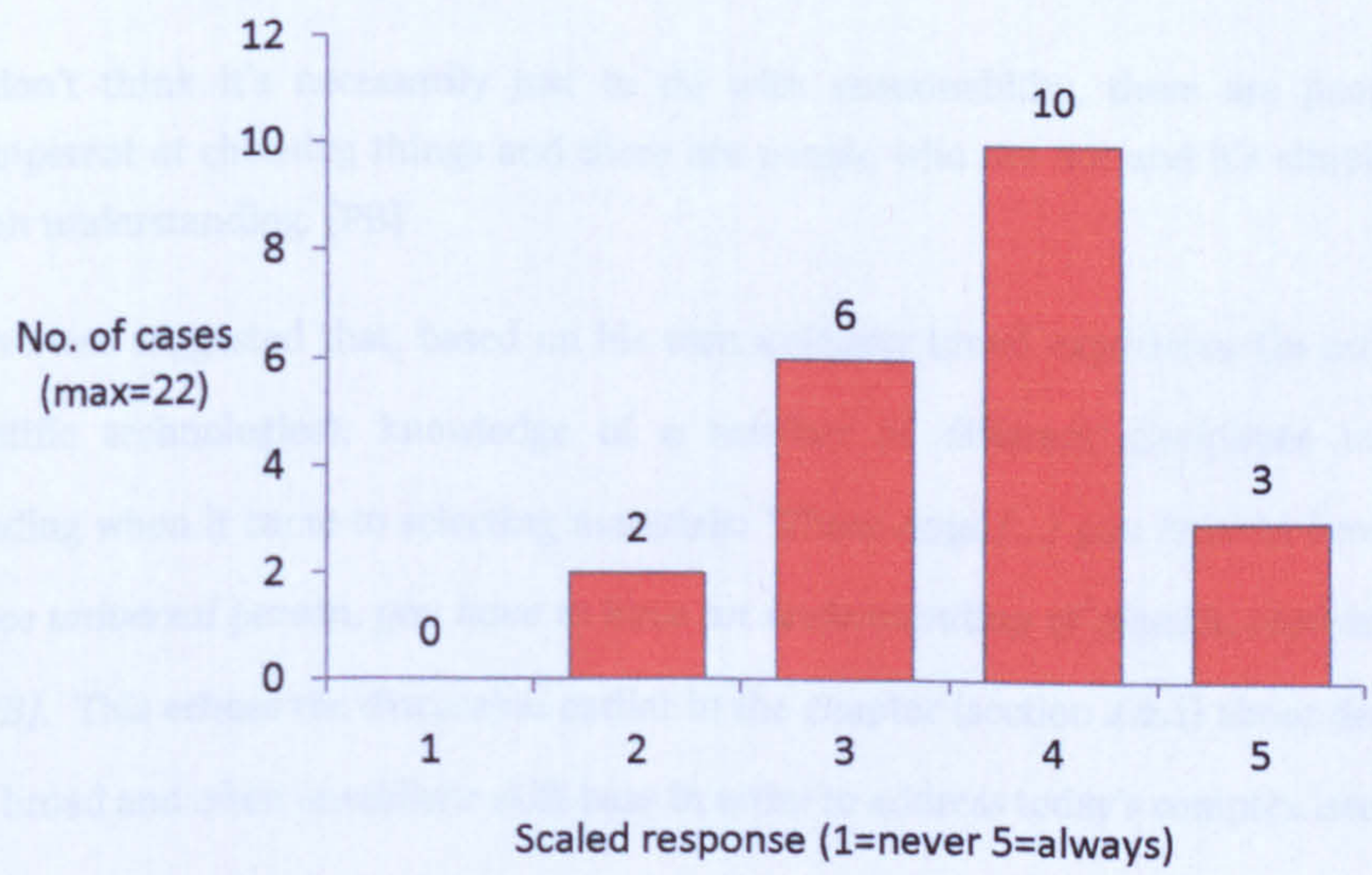
Respondents generally felt that their design values are reflected in their work with almost half scoring 4 (fig 4.4.5). Only three respondents scored 5 which indicates some cannot incorporate their design values in their work as much as they would like.

However, when looking at the design factors results in the earlier chart (fig. 4.4.4) it could be said that designers have chosen factors which are realistic and reflective of the current situation and purpose of commercial design. If designers had been more idealistic, then the scores in figure 4.4.5 would probably have been lower. Indeed, the negative correlations between '*the extent to which values are reflected in design work*' and 'worthy' design factors [stat 11] indicate that these factors, in particular, are difficult for designers to consider in their work for manufacturers. The correlations are not particularly strong but showed up in great contrast to the strong positive correlations visible between the various design factors explored earlier. What is more the interviewees supported this finding suggesting that, when they had wanted to consider sustainability, it had been difficult to implement in their work:

> I think it's simple because commerce drives you in a way where you cannot bring [sustainability considerations] to the fore. [...] The pressure that you get during work doesn't always allow you to put [different perspectives] into practice. [PB]

> Well [laminated plastics] are not very recyclable really, but then again that's what people want so... [SF]

Figure 4.4.5: The extent to which respondents feel that their priorities (design factors) are reflected in their work for manufacturing companies



Materials Training

Q5	*To what extent do you disagree or agree with the following statements?*
	(Scale 1=disagree 5=agree)
>	*My design training has involved guidance on how to select materials*
>	*I am confident that I can select the most appropriate materials for my design*
>	*My design training has involved guidance on the sustainable use of materials*
>	*I am confident that I know in what ways my materials choices are sustainable or unsustainable*

While the extent to which designers' '*training involved materials guidance*' varied, their '*confidence in selecting the most appropriate material*' for their design work was most commonly scored 4 (64%), which is relatively high (fig. 4.4.6).

Conversely, figure 4.4.7 shows that designers' training had involved very little guidance on the sustainable use of materials, with the majority of scores clustered around 2 and 3. Unlike the other three statements, designers' '*confidence in the sustainability of their materials choices*' triggered a non-uniform response. This could be described as a divide between those who are confident that they know in what ways their materials choices are sustainable (scored 4 or 5: 45%), and those who are clearly not confident (scored 1 or 2: 36%).

The survey interviewees were not surprised by these findings; two of the four designers interviewed had strong views about the inadequacy of material engagement and experimentation in design training and suggested that a lack of understanding of materials, in general, meant that many designers – particularly recent graduates – were ill-equipped for making appropriate choices or for engaging with material sustainability:

> A lot of recent graduates we've found quite ignorant of [material quality and behaviour], and also the tendency to do everything in CAD [Computer Aided Design] also means you're kind of in a virtual world. [SF]

> I don't think it's necessarily just to do with sustainability, there are people who are competent at choosing things and there are people who are not and it's simply to do with their understanding. [PB]

One interviewee suggested that, based on his own uniquely broad experience (in architecture, interiors, and scientific technologies), knowledge of a number of different disciplines might enable better understanding when it came to selecting materials: *"These days [...] you have to become almost like the renaissance universal person, you have to have an understanding of physics, chemistry and all of those things" [PB].* This echoes the discussion earlier in the chapter (section 4.2.1) about designers increasingly needing a broad and often unrealistic skill-base in order to address today's complex issues in their work.

Figure 4.4.6: Guidance received by respondents on how to select materials, and their confidence in selecting appropriate materials

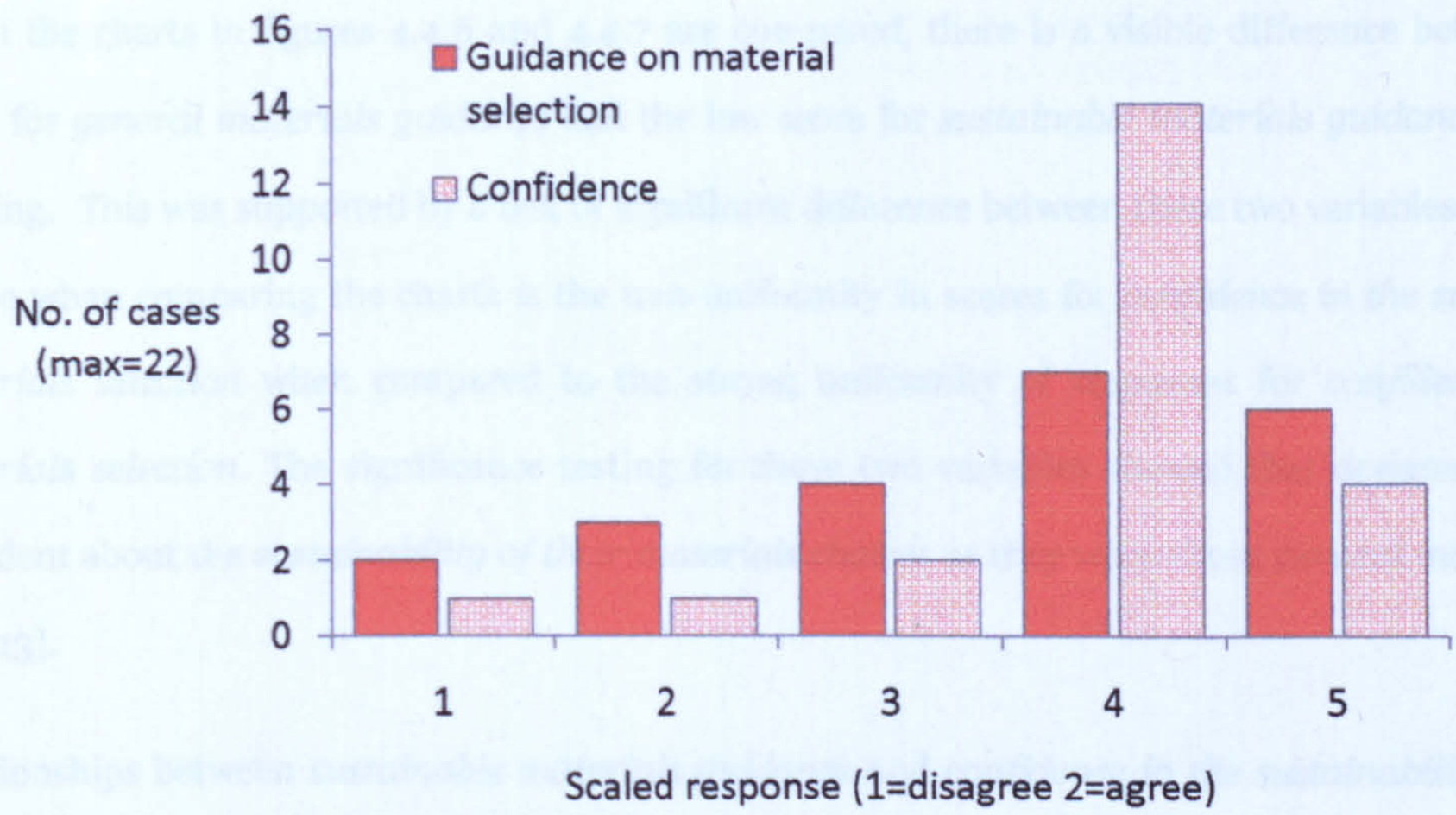
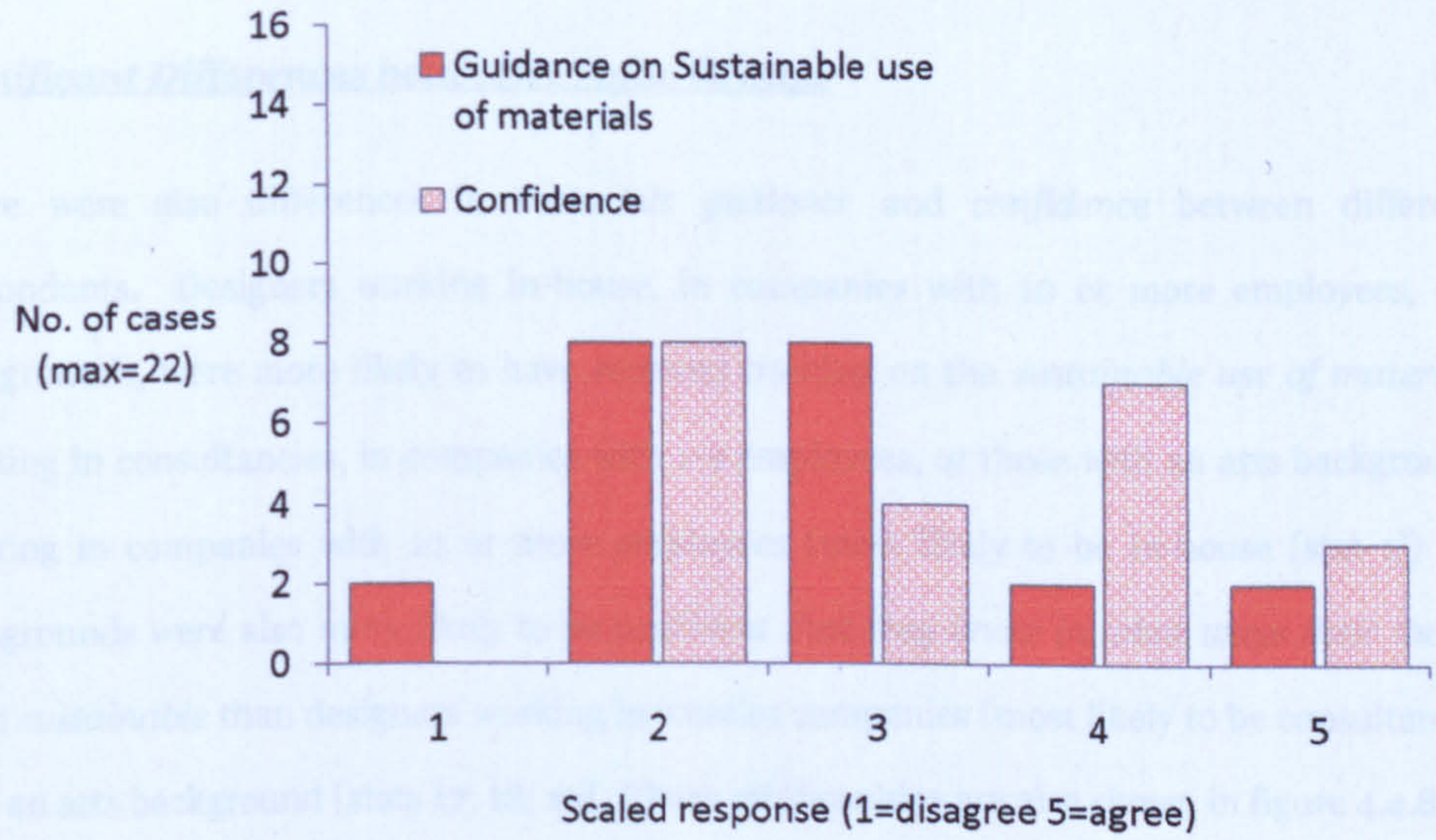


Figure 4.4.7: Guidance received by respondents on the sustainable use of materials, and their confidence in knowing in what ways their materials selections are sustainable



Although all four interviewees could contribute to the discussion about the meaning of material sustainability, they also admitted that their own knowledge is limited, using phases such as *"there're things I know a lot about and there are others that I don't know much about at all" [BG]*, and *"I don't know enough about the true cost of a lifecycle" [PB]*.

Significant Relationships between Materials Guidance and Confidence

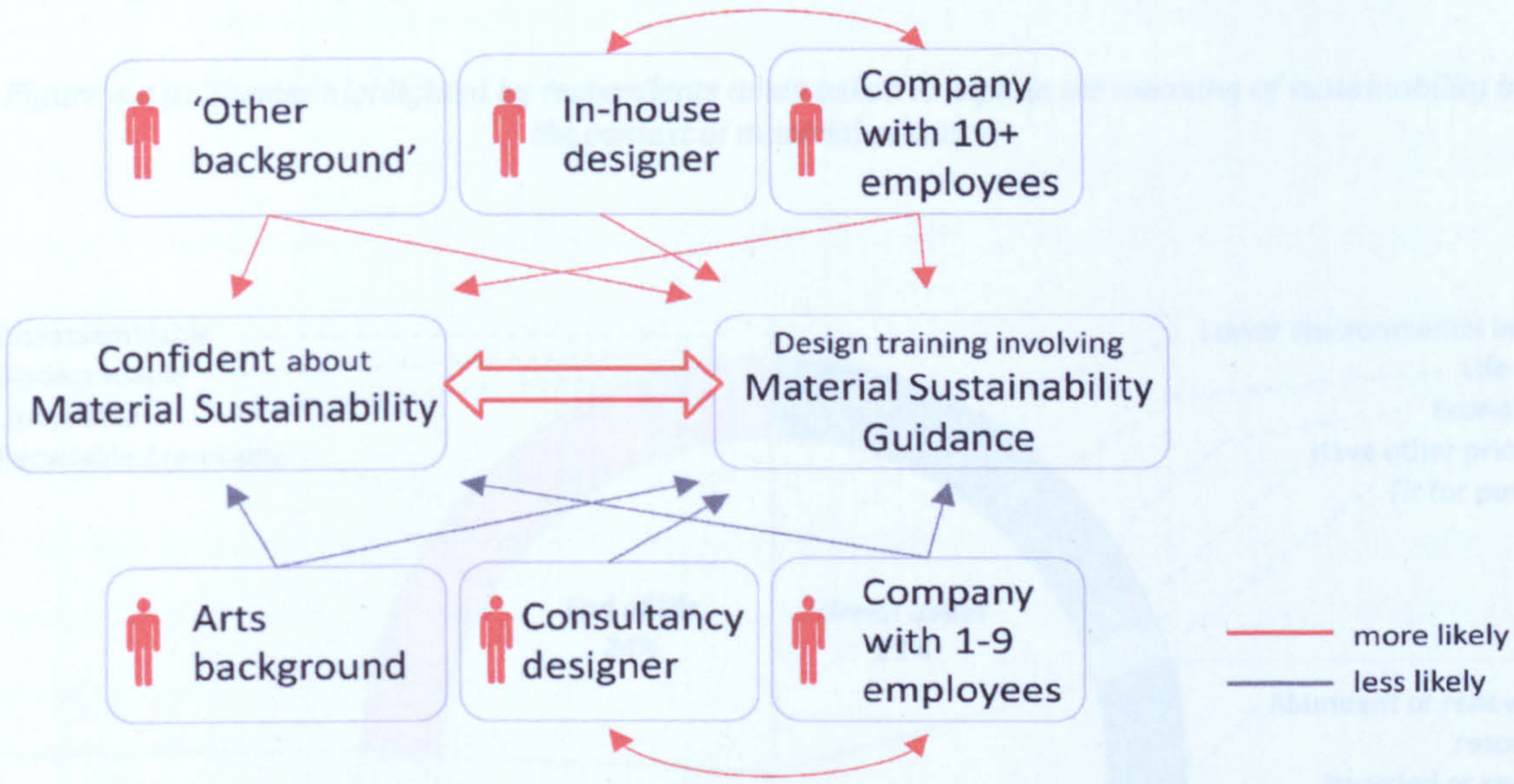
When the charts in figures 4.4.6 and 4.4.7 are compared, there is a visible difference between the high score for *general materials guidance* and the low score for *sustainable materials guidance* in designers' training. This was supported by a test of significant difference between these two variables [stat 12]. Also visible when comparing the charts is the non-uniformity in scores for *confidence in the sustainability of materials selection* when compared to the strong uniformity of responses for *confidence in general materials selection*. The significance testing for these two variables showed that designers were not as confident about the *sustainability of their materials choices* as they were about *general materials choices* [stat 13].

Relationships between *sustainable materials guidance* and *confidence in the sustainability of materials selection* (shown in fig 4.4.8) were also found to be statistically significant [stats 14; 15; 16], suggesting that preparing designers for sustainable material selection through appropriate guidance during design training is linked to a greater confidence in their own ability to select appropriate and sustainable materials in professional practice. This is in contrast to the relationship between *general materials guidance* and *confidence in general materials selection* where no correlation was found; designers tended to be fairly confident about materials selection while the level of guidance they had received in their training varied.

Significant Differences between Profile Groups

There were also differences in *materials guidance* and *confidence* between different groups of respondents. Designers working in-house, in companies with 10 or more employees, or with 'other' backgrounds, were more likely to have received training on the *sustainable use of materials* than those working in consultancies, in companies with 1-9 employees, or those with an arts background. Designers working in companies with 10 or more employees (most likely to be in-house [stat 1]) or with 'other' backgrounds were also more likely to be *confident that they know in what ways their materials choices were sustainable* than designers working in smaller companies (most likely to be consultancies [stat 1]) or with an arts background [stats 17; 18; 19]. These relationships are also shown in figure 4.4.8.

Figure 4.4.8: The relationship between sustainable materials guidance in respondents' design training, confidence in the sustainability of their material decisions and their design scenario.



These findings would seem to suggest that designers with some backgrounds have a greater advantage than others when it comes to the sustainable selection of materials.

Middleweight designers were more *confident about sustainable materials choices* than senior designers [stat 20]. A possible explanation is that sustainability issues have only come to the fore in recent years and less experienced designers, who are likely to have trained more recently, may have been exposed to knowledge and information about sustainable materials use. However, this is only a marginally significant finding.

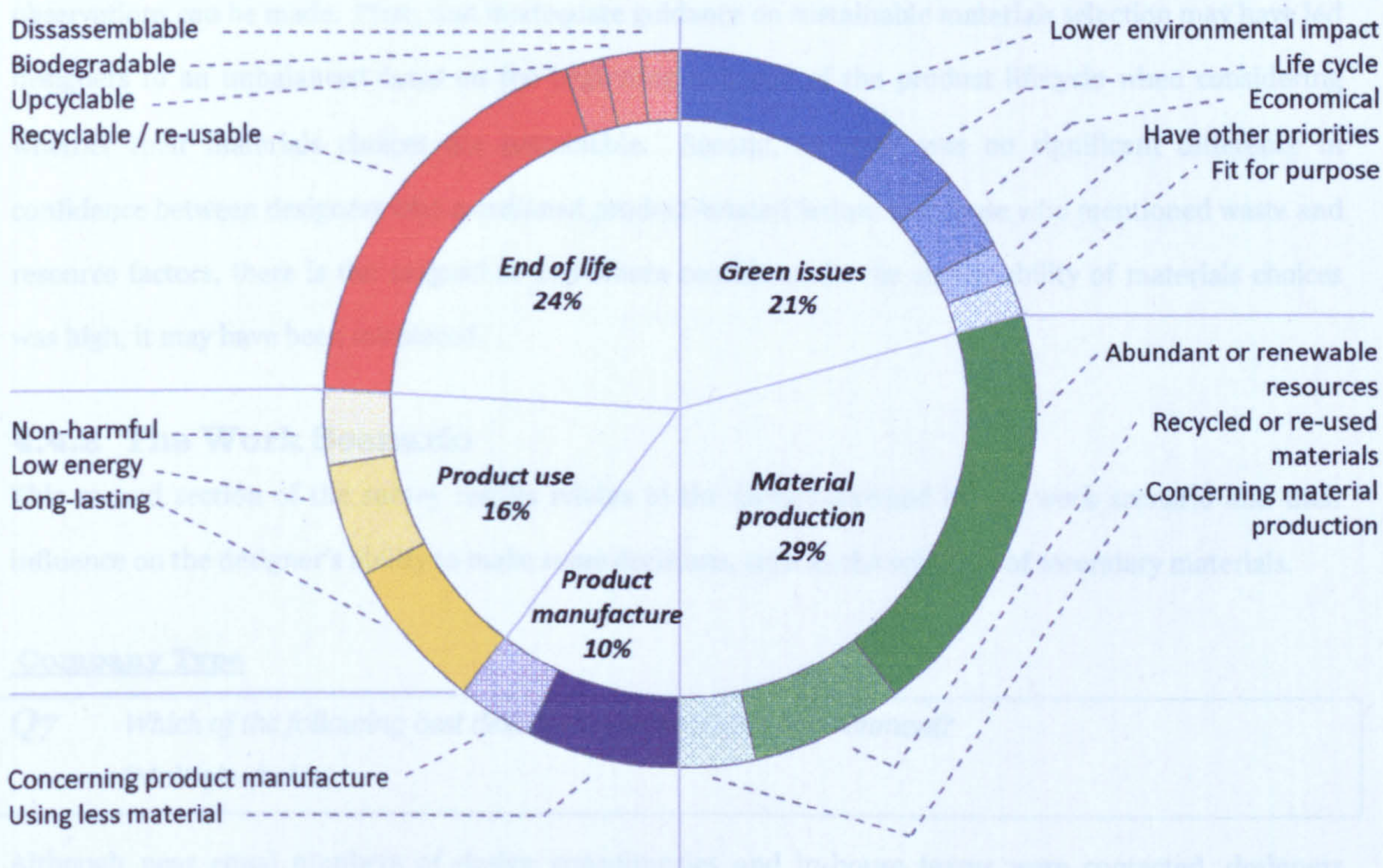
Q6	*What does 'sustainable' mean to you in this context?* (Open response)

Themes from the responses to this open-ended question were coded and then grouped by the product life-cycle phase they refer to. The frequency that each theme was mentioned by respondents is presented in figure 4.4.9.

The results show that, when attempting to define the term 'sustainable' in relation to material selection, respondents most frequently mentioned issues to do with *material production* or *end of life treatment*, with *use of abundant or renewable* and *recyclable or reusable* materials the most popular themes. Respondents did not mention the *product manufacture* and *use* phases as frequently. This indicates that they do not generally consider their choice of materials to impact the sustainability of the artefact during these phases. Very few designers mentioned the *use of recycled materials* and therefore failed to acknowledge how they might close the product lifecycle 'loop'. Argument, Lettice & Bhamra (1998) also

observed this emphasis on waste and resources concerns when they interviewed industry representatives, describing this view as "pragmatic" (Argument, Lettice & Bhamra 1998:76).

Figure 4.4.9: Themes highlighted by respondents when asked to explain the meaning of sustainability in the context of material selection



When the survey interviewees talked about sustainability they presented a much more comprehensive understanding of the issues than the survey questionnaire findings suggest, using phrases such as *"sustainability is about closing the loop [...] it's not a finite resource or process" (JB], "cheaper in the whole socio-economic context, I mean what [material/something] costs to the world" [SF]* and *"the issue is about us, the way we use [materials]" [BG].* This demonstrates a level of awareness not only about sustainable materials, but about the sustainable use of materials. The disparity between responses in the survey questionnaire and the interviews is perhaps due to the discursive nature of interviews and the involvement of the interviewer in prompting reflection. A further implication is that the deeper and more complex issues of sustainability do not come automatically to mind for designers, especially when they are not predisposed to think about them[60]. This higher level of thinking about sustainability issues was lacking when the interviewees talked about their work; this interviewee, who earlier had stated "sustainability is about closing the loop", then commented:

[60] Respondents hadn't been forewarned about the sustainability theme of the research when answering the survey questionnaire. By the time of the interviews they were inevitably much more aware of this focus.

> It would be interesting to sort of find out about the secondary materials, what you're saying about that 'cos that was the thing which stuck in my mind... made me kind of think, yeah I really don't think about secondary materials, I only think about, you know, just premium virgin materials. [JB]

When these trends are considered alongside responses to the previous questions, about guidance on the sustainable use of materials and designers' confidence in the sustainability of their materials choices, some observations can be made. First, that inadequate guidance on sustainable materials selection may have led designers to an unbalanced focus on the beginning and end of the product lifecycle when considering whether their materials choices are sustainable. Second, as there was no significant difference in confidence between designers who mentioned product-related factors and those who mentioned waste and resource factors, there is the suggestion that where confidence in the sustainability of materials choices was high, it may have been misplaced.

4.4.2 The Work Scenario

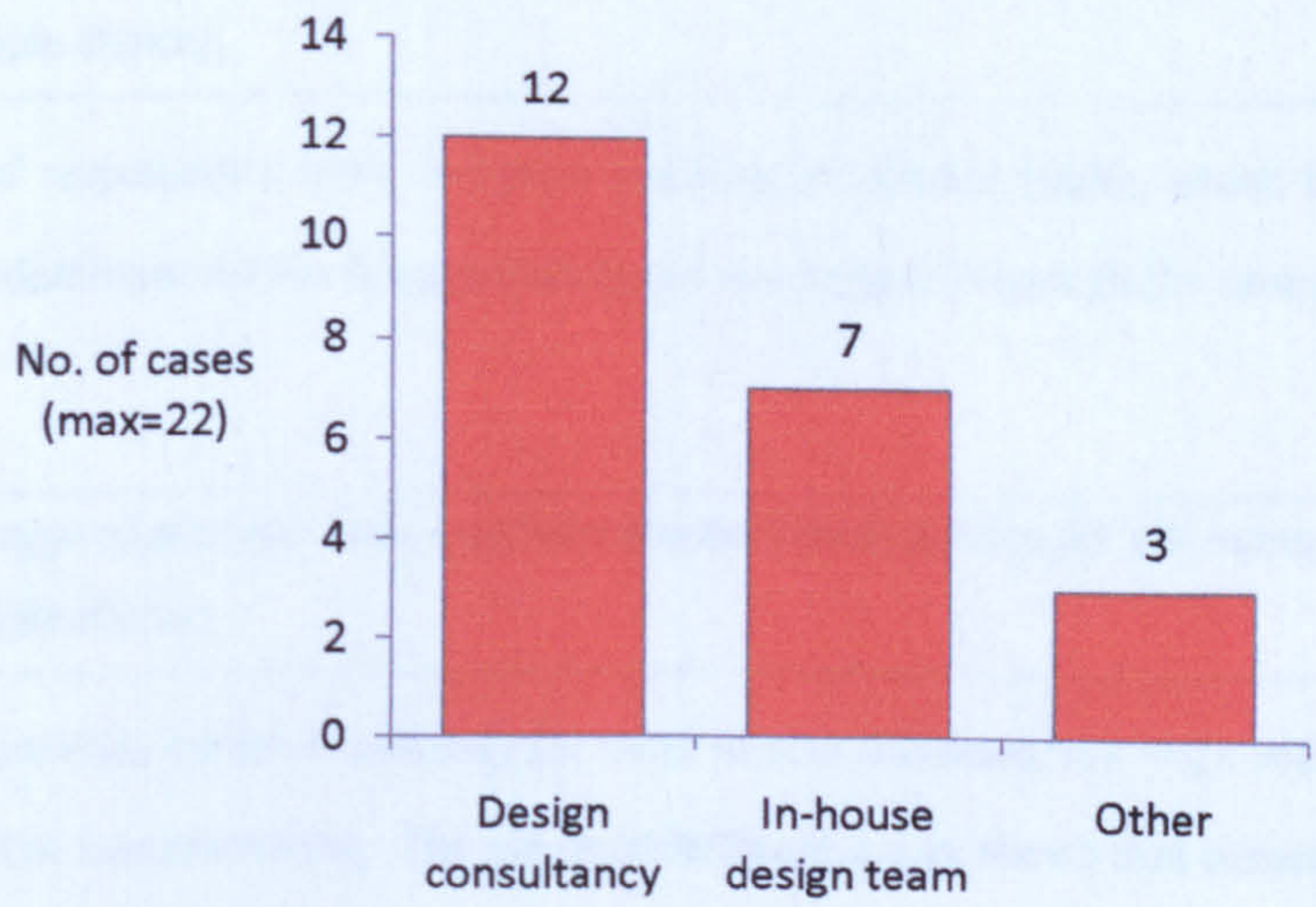
This second section of the survey results relates to the factors dictated by the work scenario and their influence on the designer's ability to make some decisions, such as the selection of secondary materials.

Company Type

Q7	*Which of the following best describes your working environment?* (Multiple choice)

Although near equal numbers of design consultancies and in-house teams were contacted, designers working in consultancies made up the majority of the sample (fig. 4.4.10). No freelance designers returned the survey, which was not surprising as they were not intentionally included in the sampling frame.[61]

Figure 4.4.10: Type of company that respondents work for



[61] Although freelance designers' responses would undoubtedly been valuable, they are near impossible to access using a consistent sampling method and it would have been too time-consuming given the constraints of the project.

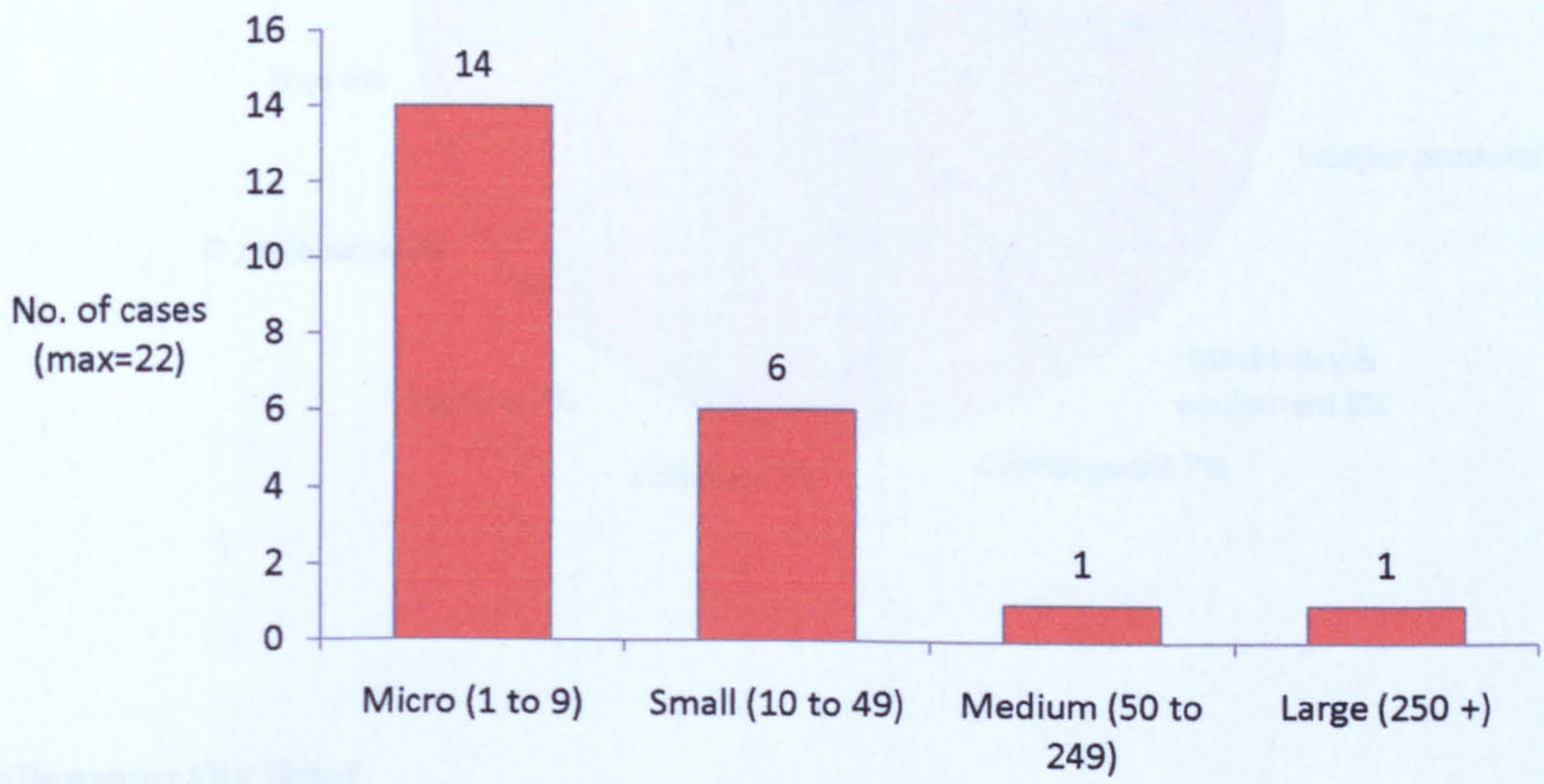
Company Size

Q8	*How many people do the company you work for employ?* (Multiple choice)

The majority of respondents were from companies with 1 to 9 employees (fig. 4.4.11). Design consultancies are most commonly small enterprises with 1-9 employees and the sample frame for manufacturing companies was also biased towards small and medium sized enterprises[62], which explains the small number of respondents from large companies.

There were only two respondents who fell outside of the two dominant groups, so the second group '10 to 49 employees' was extended to '10 or more employees' to include the two larger organisations.

Figure 4.4.11: Size of company that respondents work for



Company Location

Q9	*Where is the company located?* (Multiple choice)

The majority of respondents were designers working in London (59%), which is not surprising as this location is also dominant within the population and was targeted through the sampling frame.

Sectors

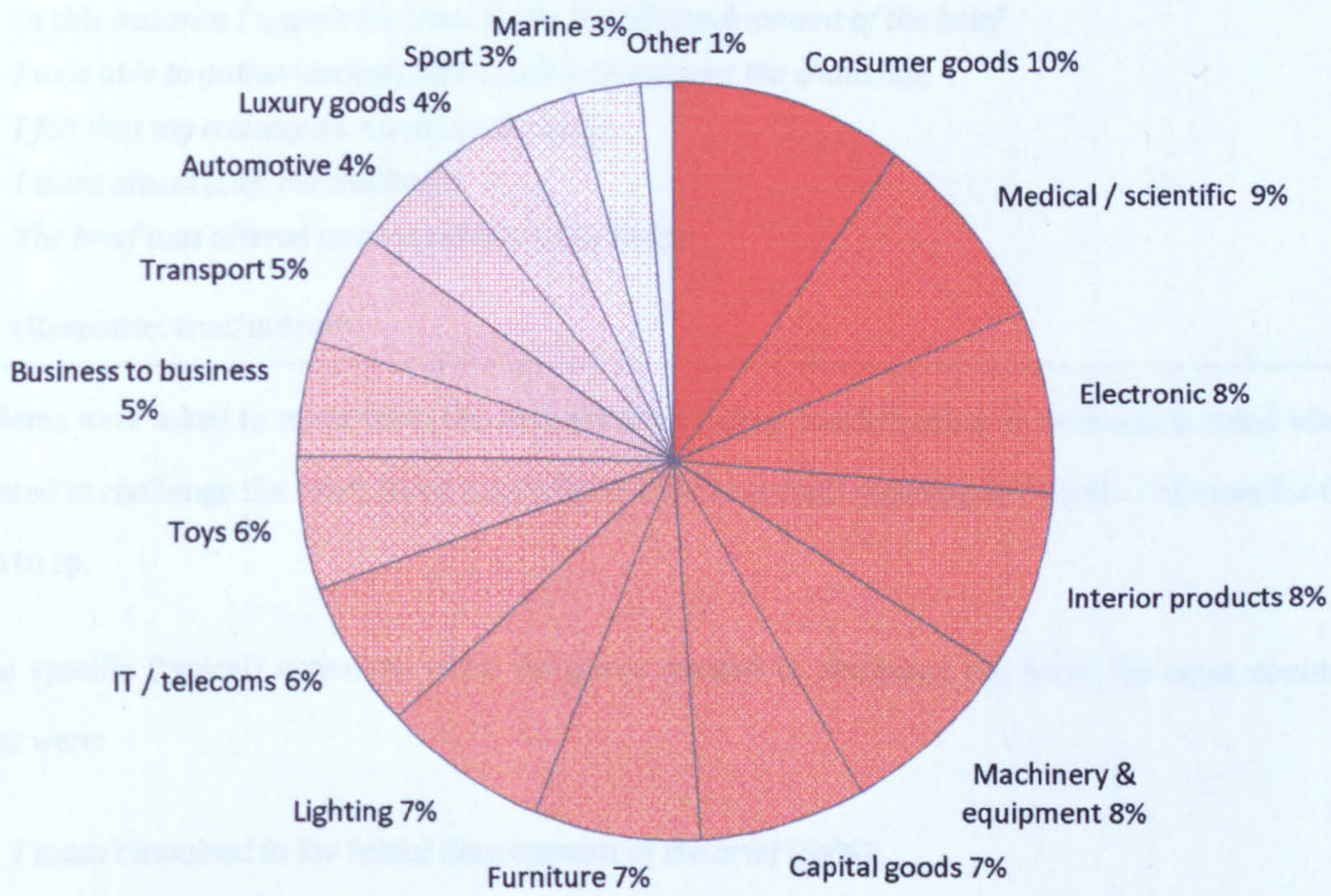
Q10	*What type of products have you been involved in designing for UK manufacturers?* (Multiple choice)

This question provides evidence not only for what sectors the designers work within, but also the sectors represented in UK manufacturing. The pie chart in figure 4.4.12 shows that consumer products categories are well-represented within the sample. Two respondents selected the 'other' category: one identified their sector as 'fashion accessories' but also selected other non-textile areas such as lighting, furniture, toys and

[62] This was dictated by the sample frame, see section 4.3.2

interior products which fit with the target group. The other respondent mentioned 'entertainment' and was in the business of manufacturing products for the film and television industry. There was statistical evidence that design consultancies work with more sectors than in-house design teams [stat 21].

Figure 4.4.12: Sectors that respondents work within



Challenging the Brief

Q11	*How often do the following events occur? (Scale: 1 = never, 5 = always)*
>	*I am involved in the initial development of the design brief*
>	*I want to challenge the design brief given to me*

The responses to this question reveal that designers were *often involved in the development of design briefs,* with the most frequent score being '4' (12 of 22 cases). This implies that designers can influence the project direction early on in the design process. However, designers also *often wanted to challenge the design brief,* with the most frequent score being '5' (7 of 22 cases).

In addition *designers who were often involved in the development of the design brief* also *often wanted to challenge the brief* (12 of 22 respondents scored '4' or '5' for both questions), which suggests that being involved in the development of the brief does not necessarily result in the designer being satisfied with the brief throughout the design process.

Designers with an arts background *wanted to challenge the brief* more often than designers with 'other' backgrounds [stat 22]. This could be explained by the likelihood that designers with an arts background

work in consultancies which, the literature suggested, may be geographically and culturally distanced from the client (manufacturing) company. The design consultant's role as external expert may result in greater differences of opinion and, therefore, more frequent challenges to the brief.

Q12	*Try to think of a typical project where you wanted to challenge the brief and consider this in relation to the following statements:*
>	*In this instance I wasn't involved in the initial development of the brief*
>	*I was able to gather enough information to support the challenge*
>	*I felt that my colleagues would back me up*
>	*I went ahead with the challenge*
>	*The brief was altered as a result of my challenge*
	(Response: true/untrue)

Respondents were asked to move on to the next question if they couldn't bring an occasion to mind where they wanted to challenge the brief; three respondents didn't respond reducing the number of cases for this question to 19.

On these specific (typical) occasions when designers wanted to challenge the brief, the most common responses were:

- *I wasn't involved in the initial development of the brief* (63%);
- *I was able to gather enough information* (79%);
- *I felt my colleagues would back me up* (84%);
- *I went ahead with the challenge* (74%);
- *The brief was altered as a result of my challenge* (79%).

The table in figure 4.4.13 outlines the frequency that a particular sequence of answers in an individual case occurred. In the two sequences that were most common, the designer was *able to gather enough information, felt that their colleagues would back them up, went ahead with the challenge on the brief, which was changed as a result of that challenge* (13 of 19 respondents: 68%). Of those 13 respondents, 7 stated that this occurred when they *were not involved in development of the brief*, while 6 respondents said they *were involved in the development of the brief*. This suggests that the majority of designers feel that they have enough information and support to challenge a brief, whether or not they were initially involved in its development.

These findings are perhaps not surprising given the designers' priorities, which were found to be fairly conventional for product and industrial design, favouring *'functional performance'*, *'end-user needs'* and *'being innovative'*. These factors are also likely to be in the interest of the client and therefore it may be fairly straightforward for the designer to communicate the benefits of changing the brief in these types of direction. An alternative explanation is that designers are 'choosing their battles' and know when clients

are unlikely to be interested. It is encouraging, however, that challenging the brief appears to be commonplace for designers as this will be necessary if they are to begin to address the sustainability of artefacts or select secondary materials.

Whether or not the particular occasion, reflected on by designers while answering this question, was typical of their experiences, the results can be seen as an indication of their general feeling or attitude towards challenging the brief.

Figure 4.4.13: Respondents' typical experience of challenging briefs given to them; frequency that a particular sequence of answers in an individual case occurred

Involved	*Informed*	*Supported*	*Challenged*	*Brief changed*	*Frequency*
X	✓	✓	✓	✓	7
✓	✓	✓	✓	✓	6
X	x	x	x	x	2
X	✓	✓	x	x	2
✓	x	✓	✓	✓	1
X	x	x	x	✓	1

Significant Differences between Profile Groups

The statistical difference tests indicate that designers with an arts background were generally more negative about their experiences when challenging the brief [stats 23; 24]. When this is coupled with the finding that designers with an arts background wanted to challenge the brief more frequently than designers with other backgrounds [stat 22], the results appear to indicate that designers with an arts background (who are more likely to work in consultancies) have a different experience of the brief development process than those with 'other' backgrounds.

The survey interviews seem to support this finding, revealing that it was frequently up to the client how involved the consultancy designer could be and to what extent designers' suggestions were taken on board; phrases such as *"[materials] are not even one of the choices" [SF], "[the decision] would be up to the customer" [JB]* and *"[clients] don't allow you the leeway"* were often used by interviewees to describe the client's leading role in design decisions.

However, the interview findings also suggested that the designers' involvement in the early stages of a project when the brief is being developed varies, which implies that there may be some projects where designers have more of an opportunity to introduce secondary or more sustainable materials:

> Sometimes you're involved a long way down the line, and [other times] you're involved on a continuous basis with your customer because they treat you as a knowledgeable resource [...] it varies hugely according to the relationship that you have. [PB]

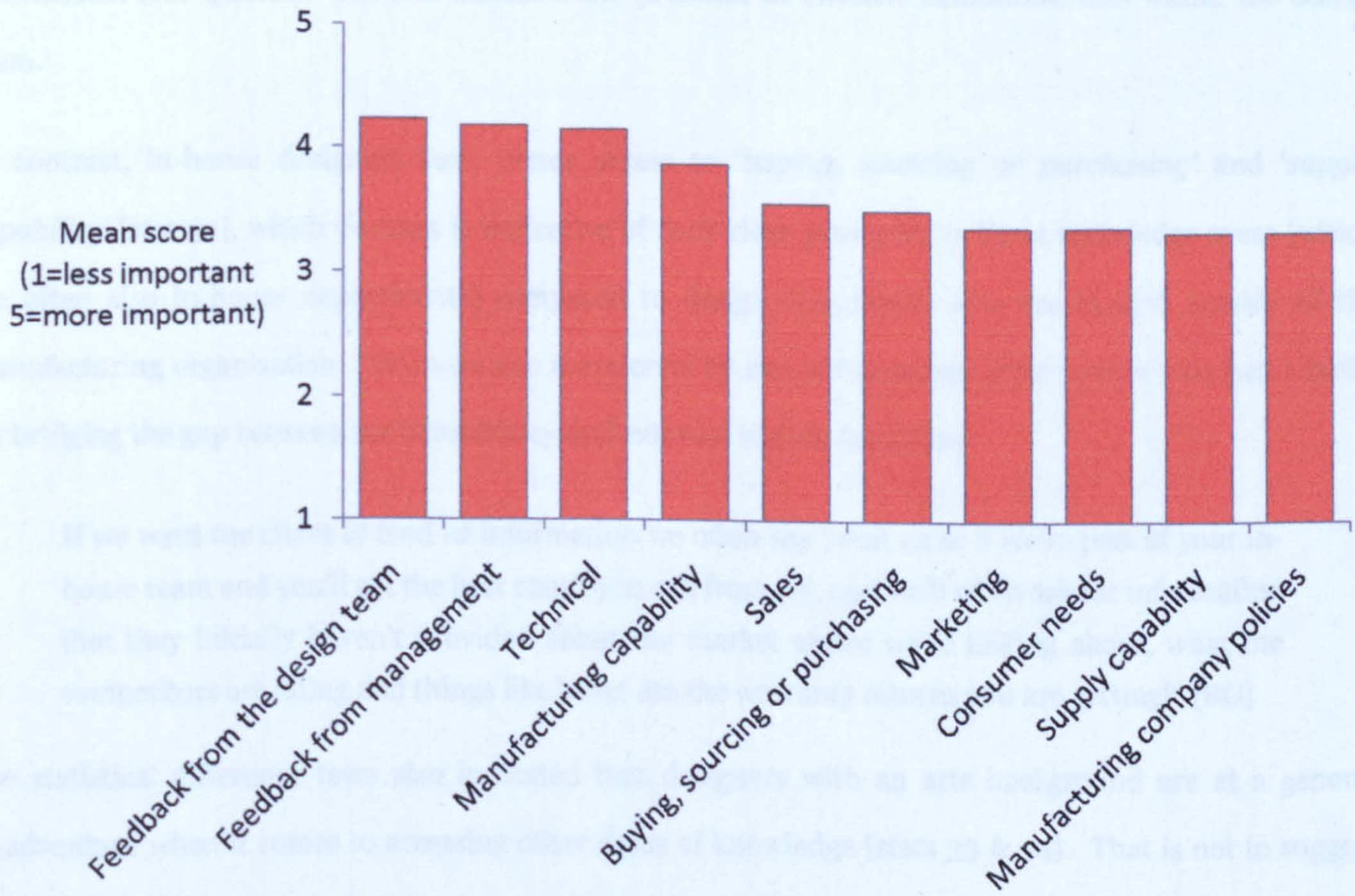
Access to Knowledge

Q13	*Do you feel your access to the following areas of knowledge is adequate?* (Scale: 1=adequate 5=inadequate)

This question was included to understand if designers have access to the types of knowledge they may need to influence design decisions, particularly with regards to sustainability. Figure 4.4.14 shows that access to *'feedback and advice from the design team'* and *'feedback from management and board of directors'* was scored higher on average than access to external areas of knowledge such as *'supply capability'*, *'marketing'* and *'sales'*. Access to *'technical'* knowledge also scored highly, perhaps because this is traditionally a knowledge area associated with design for manufacture.

All areas of knowledge achieved a mean score above the midpoint '3' which indicates that designers generally feel positive about their access to all areas of knowledge included in the questionnaire.

Figure 4.4.14: Respondents' access to other knowledge areas within product development



Significant Relationships between Knowledge Areas

Correlations between access to the different areas of knowledge showed some interesting, although perhaps not surprising, trends [stats: 25; 26; 27]. The tests also found that designers are more likely to have access to *'manufacturing capability'* knowledge if they have access to *'supply capability'* knowledge [stat 28] which could indicate one of two possible scenarios; either that *'supply capability'* knowledge resides with the manufacturer and therefore if the designer has good access to the manufacturer they also have good access to *'supply capability'* knowledge; or that a designer who is adept at accessing and communicating with manufacturers is also better at finding out about supply issues.

Having good access to *'feedback from management'* was linked to having good access to all other areas of knowledge within the product development process apart from *'consumer needs'* knowledge [stat 29], which is also the only area of knowledge not to have a formal representative in the conventional product development process. This is an indication that designers who have an effective communication network with the manufacturing organisation are more likely to have good access to non-design knowledge areas.

Significant Differences between Profile Groups

Designers working in consultancies were more likely to have access to *'consumer needs'* knowledge [stat 30] which, along with *'technical'* knowledge, was also linked to *'feedback from the design team'* [stat 31]. This is interesting given that *'colleagues'* were considered one of the most useful sources of material information (see Question 20) and indicates the presence of effective communication within the design team.

In contrast, in-house designers have better access to *'buying, sourcing or purchasing'* and *'supply capability'* [stat 32], which perhaps is indicative of their close proximity to these knowledge areas (which are often also in-house departments) compared to design consultants who are located outside of the manufacturing organisation. This was also mentioned by one of the survey interviewees who had a tactic for bridging the gap between the consultancy and external knowledge areas:

> If we want the client to feed us information we often say 'treat us as if we're part of your in-house team and you'll get the best result you can from us', and we'll often ask for information that they initially haven't provided about the market sector we're talking about, what the competitors are doing and things like 'what are the warranty returns you are getting?' [BG]

The statistical difference tests also indicated that designers with an arts background are at a general disadvantage when it comes to accessing other areas of knowledge [stats 33 & 34]. That is not to suggest that arts-based education in itself is the causal factor but, when considered in tandem with the differences between in-house and consultancy designers, it suggests that designers with an arts background and working in a consultancy are likely to have reduced access to other areas of knowledge. Although, as mentioned above, design consultancies may have tactics for reducing this effect, it was apparent in the

survey interviews that accessing and coordinating external knowledge areas was a challenge for these designers. For example one interviewee stated:

> We've always had this [problem] with plastics: do you go to a plastic moulder, he commissions the tooling, or do you go straight to the toolmaker? If you go straight to the toolmaker and you get a tool made, well then you get into the difficulties of whether it's actually suitable for the presses, and who's going to guarantee that it works and so on. [SF]

Time-related Factors

Q14	*Consider the time and information resources you require to source materials effectively. Do you mostly disagree (1) or agree (5) with these statements?*
>	*I spend very little time investigating materials*
>	*The time I spend investigating materials is adequate*
>	*When I investigate materials it is mostly in my own time*
>	*I have sufficient access to information sources to investigate materials.*
	(Scaled response)

Respondents tended to disagree that they *spend very little time investigating materials,* although it was not a strong disagreement, with the majority of responses clustered around '2' or '3' (9 and 7 of 22 cases). There was a stronger disagreement among respondents that they *investigate materials mostly in their own time* with the majority of respondents selecting '1' or '2' (7 and 9 of 22 cases).

The *adequacy of the time spent investigating materials* most frequently scored '3' (13 of 22 cases) which could indicate that designers are not sure whether the time they spend investigating materials is adequate, or that they don't feel strongly either way. Another explanation is that the consideration of materials is not normally a separate area of focus in the design process and as such the time spent in this area is difficult to identify, as this survey interviewee comments:

> You're not actually looking at materials seriously for each project, except for a very limited point in its development, and ok you'll consider materials probably when you're doing conceptual work, you're sketching things out and thinking 'well it could be this or it could be that' and you'll talk about them vaguely but you won't do anything specific unless you want to introduce something. [PB]

Respondents didn't feel strongly about the *sufficiency of their access to information sources* with responses evenly distributed between '2', '3' and '4' (6, 7 and 6 of 22 cases).

Significant Relationships between Time-related Factors

There were some significant findings which help to describe the relationship between the statements included in this question. If the respondent thought his/her *time spent investigating materials is adequate* they were less likely to say they *investigate materials in their own time* [stat 35] which suggests that time pressures are not a problem or that those designers do not see sourcing materials as a task which warrants investigation in their own time.

Respondents who disagreed that *they spend very little time investigating materials* were also more likely to feel that that *have sufficient access to information sources* [stat 36]. This supports the idea that time is an important factor in accessing information sources.

Further significant correlations link these time-related factors to materials training and confidence (discussed in Question 5), suggesting that *materials training* is linked to designers *using fewer information sources* and having *adequate time* to do so. While increased *confidence in materials selection* may be linked to a designer *spending more time* investigating materials and finding that their *access to information sources is sufficient* [stats 37; 38]. These relationships are expressed in figure 4.4.15.

Significant Differences between Profile Groups

Designers in companies with more than 10 employees (likely to be in-house [stat 1]) were more likely to feel that the *time they spend investigating materials is adequate* and more likely to use *fewer material information sources* (discussed later in relation to Question 20) than designers working in smaller companies (likely to be consultancies [stat 1]) [stats 39 & 45]. When added to the earlier finding that in-house designers and those working in larger companies were also more likely to have received *guidance* and be *confident about sustainable materials selection* (discussed earlier in relation to Question 5 and shown in fig. 4.4.15), there is the suggestion that designers who are better prepared for materials selection limit their searches to the most effective information sources. An alternative explanation might be that in-house designers are likely to be dealing with a narrower range of materials than design consultants and their material information needs are therefore less demanding (Pedgley 1999).

From this data it would appear that design consultants are less prepared for materials selection, they search more widely for materials information and find that the time available to do this is insufficient. This particular section of the survey has shown that there are interesting relationships between materials training, confidence in materials selection, time-related factors and access to information sources. However these relationships and the possible implications would benefit from more detailed exploration to verify and add clarity to the situation.

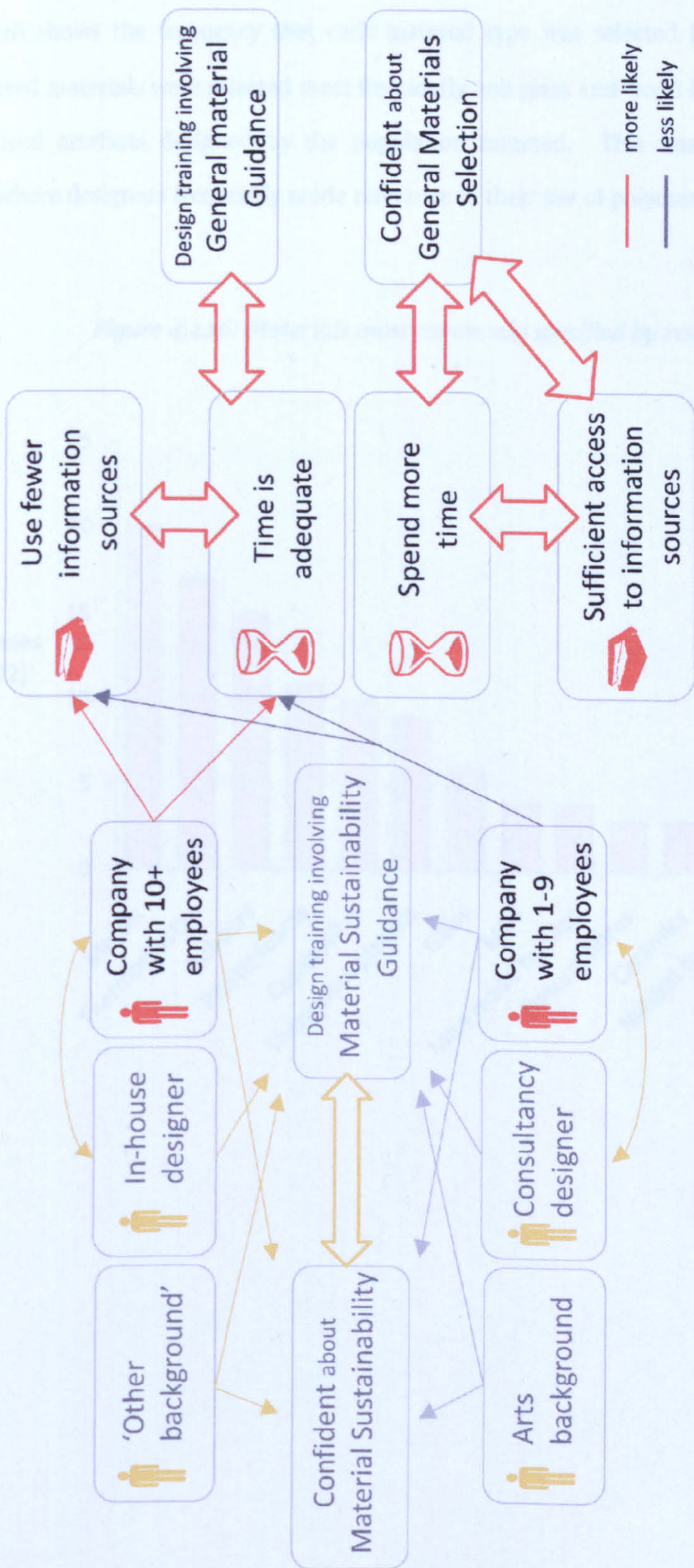


Figure 4.4.15: Diagram expressing the relationships between materials training, use of time and resources within the design scenario. Continued from fig. 4.4.8 (grey section) presented earlier in relation to Question 5.

4.4.3 Material Sourcing Behaviour

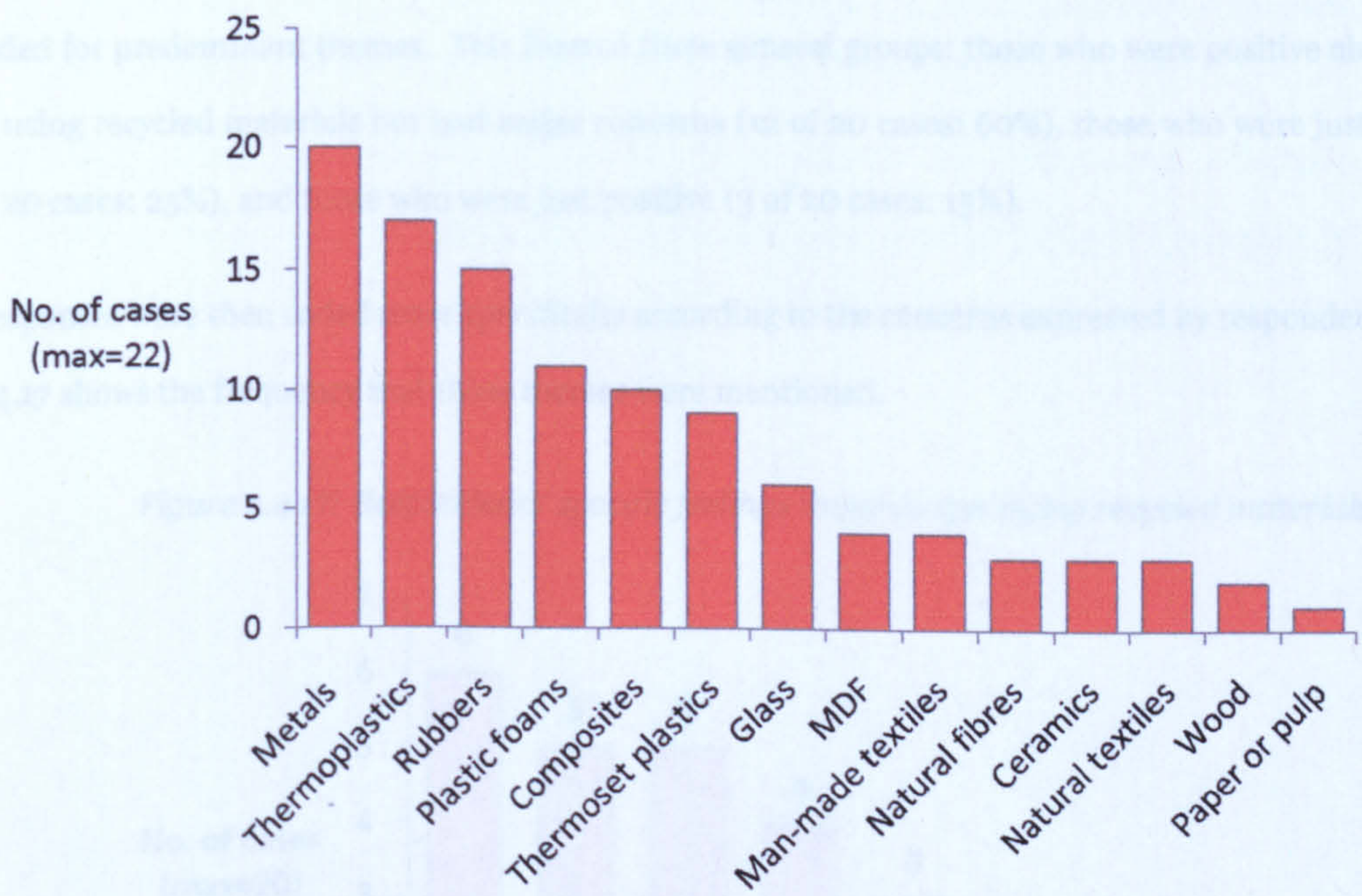
This third and final section of the results relates specifically to attitudes and methods of sourcing materials and can be seen to combine elements from the individual designer's situation and the work scenario.

Materials Use

Q15	*What types of materials do you most commonly specify?* (Multiple choice)

Figure 4.4.16 shows the frequency that each material type was selected by respondents. Metals and polymer-based materials were selected most frequently and glass and wood least frequently, reflecting the mass-produced artefacts designed by the population targeted. This was also evident in the survey interviews where designers frequently made reference to their use of polymeric materials to illustrate their points.

Figure 4.4.16: Materials most commonly specified by respondents



Recycled Material Use

Q16	*Have you ever specified recycled materials?* (Response: yes/no/not sure) *What was the source of the waste material?* (Multiple choice / other)

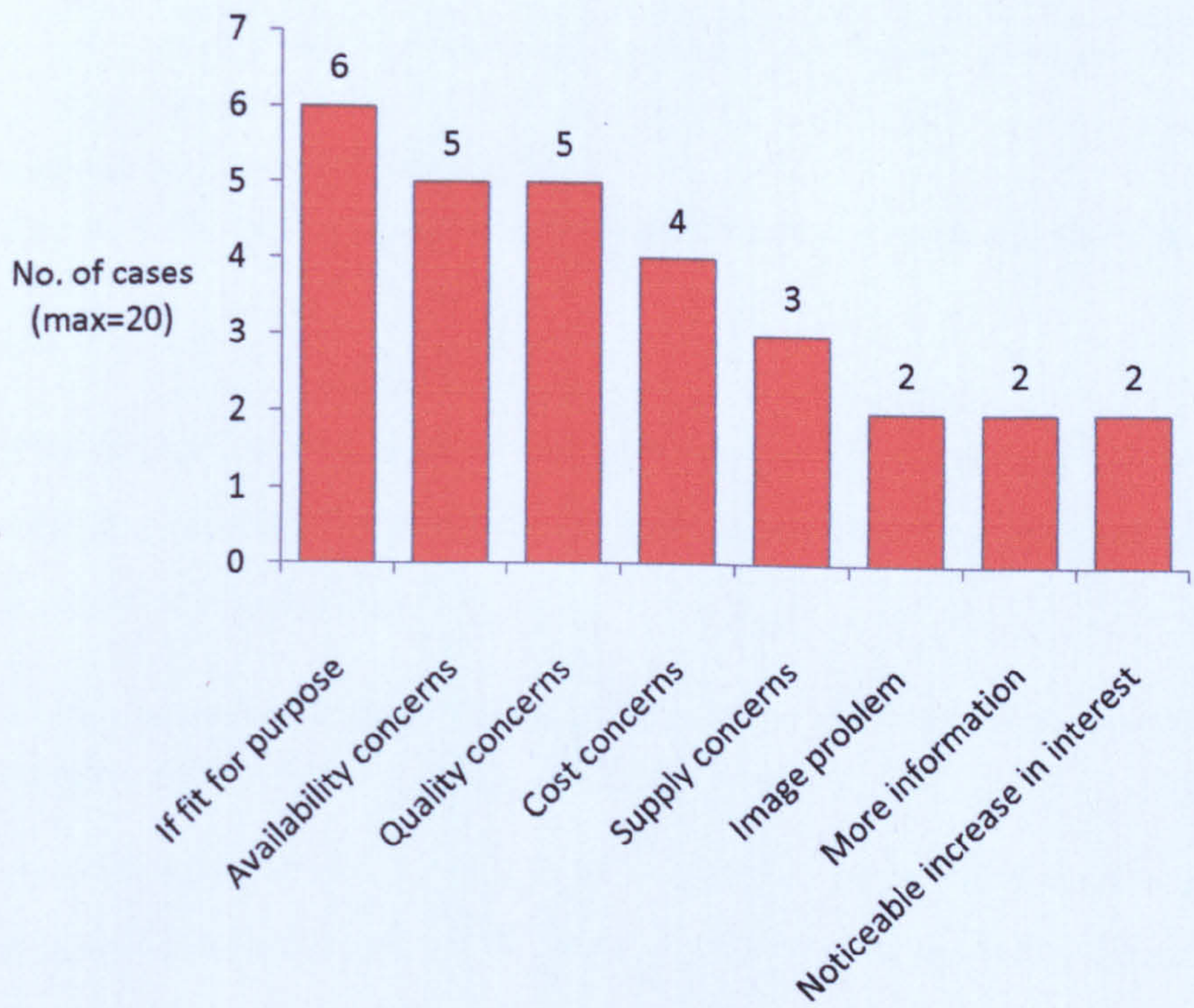
Surprisingly there were an equal number of respondents who had and who hadn't specified 'recycled' material before (10:10 cases of 22). The survey interviewees also represented this 50:50 split with two having specified recycled materials before. This is encouraging as it shows that it is possible for product and industrial designers to source and use secondary materials. The source of the material identified by those surveyed varied but was most commonly from a reprocessor (5 of 13 cases: 38%) or from manufacturers (3 of 13 cases: 23%).

Q17	*What is your opinion of recycled materials?* (Open response)

Two respondents did not answer this question resulting in 20 cases for analysis. Responses were first coded for predominant themes. This formed three general groups: those who were positive about the idea of using recycled materials but had major concerns (12 of 20 cases: 60%), those who were just negative (5 of 20 cases: 25%), and those who were just positive (3 of 20 cases: 15%).

Responses were then coded more specifically according to the concerns expressed by respondents. Figure 4.4.17 shows the frequency that these themes were mentioned.

Figure 4.4.17: Respondents' specific feelings towards specifying recycled materials



The four greatest concerns were *availability, quality, cost* and *supply* which had also been highlighted by the industry expert interviewees[63] and were confirmed by the survey interviewees, who commented:

> It's the uncertainty really of having a material that is of variable quality [SF]
>
> I've tried to specify [recycled materials] before and historically it's been difficult. [BG]
>
> You're not sure if it's going to be repeatable quality, the last thing you want as a designer is to design something which falls apart. You know one batch is stiff, the next is bendy. *[Interviewer] What are those ideas based on, have you had any encounters with recycled materials and what have those encounters been?* I think it's just my inherent prejudice! [JB]

Interviewees were also sceptical of the actual recycling system. However, echoing the findings of the survey questionnaire, the interviewees were also positive about using secondary materials if they are *fit for purpose*:

> It would be interesting to sort of find out about the secondary materials [JB}
>
> In areas where the performance of the material doesn't go to extremes there's no reason why you shouldn't use [recycled material], as long as it's available relatively easily. [PB]

There were virtually equal numbers between those with an arts background and those with 'other' backgrounds when it came to opinions on recycled materials, specifying recycled materials, and awareness of legislation (discussed shortly), which suggests that these findings are applicable across profile groups.

[63] This is discussed further in Chapter Five

Obligation

Q18	*To what extent are your materials decisions affected by a contractual obligation to a particular material or material supplier?* (Scale: 1=none 5=all)

Few respondents felt that their materials decisions were contractually bound, with the majority of responses being clustered around '1' and '2' (14 of 22 cases: 64%) which indicates that this doesn't greatly limit material choice.

The material choices of designers with an arts background are more contractually bound than designers with other backgrounds [stat 40]. As a high proportion of designers with an arts background are likely to work in consultancies, they are perhaps more likely to work on tight briefs presented by clients which limits the designer's materials choices. This finding was strengthened by the survey interviews, where the designers frequently mentioned the constraints on their materials selection resulting from the client's existing practices, manufacturers' contracts with suppliers, and because of the location of manufacturer, where specified materials are often substituted with cheaper more accessible ones:

> You still have a lot of clients who know exactly what they need to make it out of, there are no options. [BG]

> With a lot of cases [the material] is probably pretty given from the start, you know, if it's an electronic housing it's probably going to be ABS. [SF]

> We specify a supplier or a material and then [the design] goes to China and then they use the Chinese, and we've got no control of that. [JB]

Legislation

Q19	*Are you aware of any legislation or regulation that affects yours or the manufacturer's materials choices?* (Response: yes / no / not confident) *Please state the item of legislation or regulation which is most significant to your materials choices.* (Open response)

Over half of the respondents were aware of legislation affecting their materials choices (13 of 22 cases: 59%). The other respondents either weren't aware (2 of 22 cases: 9%) or weren't confident (7 of 22 cases: 32%), as this survey interviewee comments:

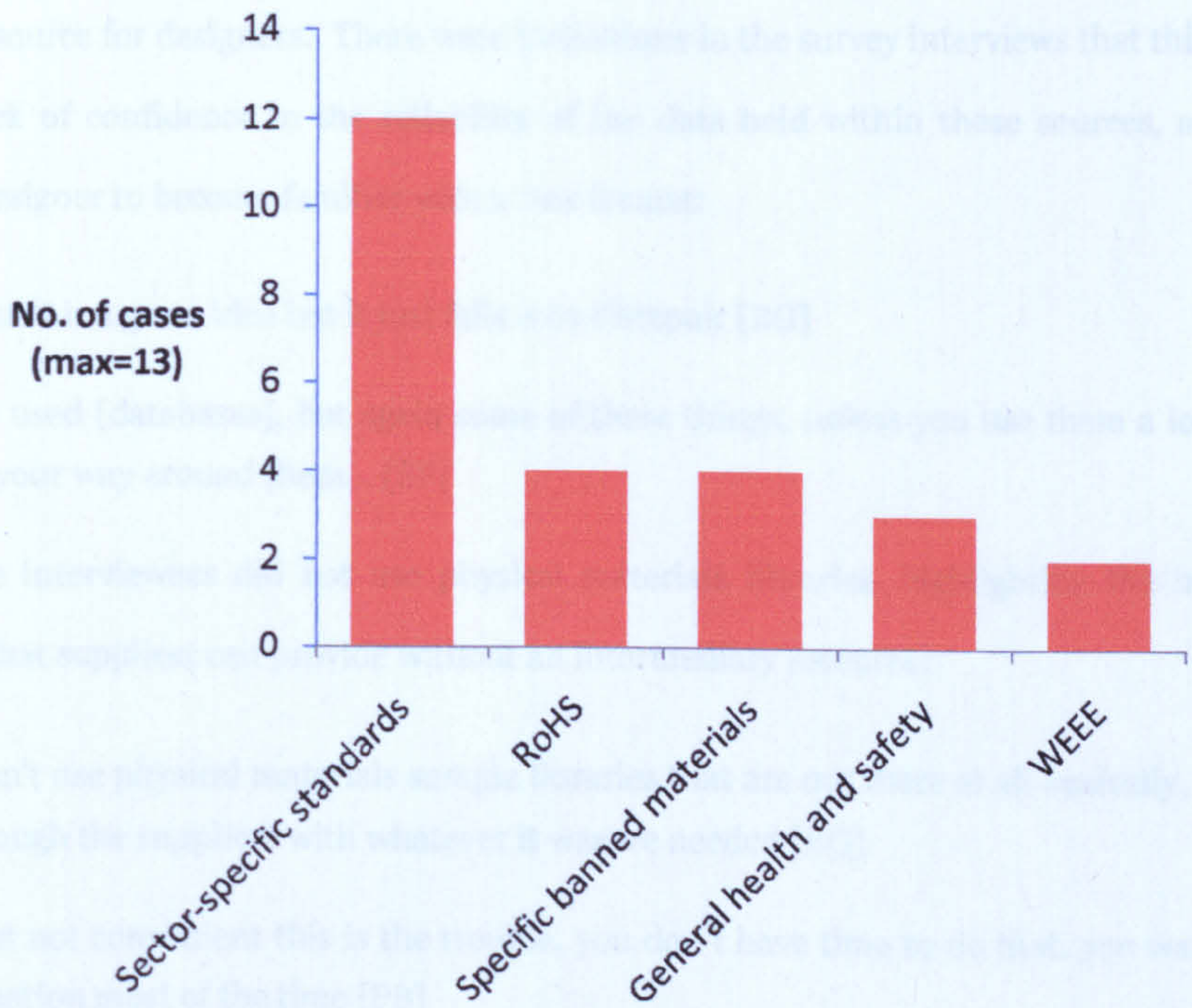
> [Legislation] is always changing and it's a question of, very often it's delayed and it's difficult sometimes to identify what is desirable and what is mandatory [SF]

Only 13 respondents answered the second part of the question. Figure 4.4.18 shows that *sector-specific standards* were most commonly mentioned by respondents, with *RoHS* and *WEEE*[64] mentioned very little.

[64] Restriction of Hazardous Substances and Waste Electrical and Electronic Equipment directives (DEFRA 2009)

The overall sense is that designers are only responding to legislation and regulations enforced in the sectors they work in, such as health and safety in the transport sector, and rarely to do with sustainability issues. Senior designers were marginally more aware of legislation than middleweight designers [stat 41], which is perhaps not surprising as knowledge of legislation is likely to come with experience.

Figure 4.4.18: Materials-related legislation that respondents could name without prompting



Materials Information Sources

Q20	*Tick the sources that are most useful for initially looking for materials.* *Tick the sources that are most useful for finding materials that are used in the final specification.* (Multiple choice: all that apply)

Figure 4.4.19 presents both the resources respondents' find useful during the first stage of a materials search, when they are looking for materials that might be suitable, and the resources respondents' find useful during the second stage of materials selection, when they are looking for materials that are actually used in the product.

First Stage

The findings suggest that designers find their '*own experience*' (used it before) most useful for finding out about materials in the early stages of the project. The internet is the next most popular resource, either by looking directly at a '*supplier's website*' or using an '*internet search engine*'. These findings were supported by the survey interviewees who stated:

> There was a time when [material] information was good for twenty years, now you've got to keep abreast of it, and the internet allows you to do that [PB]

> The internet is incredible and I suppose one tends to default to Googling it these days [SF]

Respondents also find their *'colleagues'* experiences and product examples *('saw it used in another product')* useful, whereas *'materials databases'* and *'product literature in the company library'* were selected less frequently. This is perhaps surprising considering that these are the richest sources, with information on a wide range of materials, and that Pedgley (1999) had suggested that the company library was a useful source for designers. There were indications in the survey interviews that this could be due to designers' lack of confidence in the reliability of the data held within these sources, and because they require the designer to become familiar with a new format:

> Campus[65] is a great idea but it just falls into disrepair [BG]

> I have used [databases], but again some of these things, unless you use them a lot and you know your way around them... [SF]

Similarly, the interviewees did not use physical materials libraries, highlighting the immediacy of the information that suppliers can provide without an intermediary resource:

> We don't use physical materials sample libraries that are out there at all basically, we would go through the suppliers with whatever it was we needed [BG]

> It's just not convenient this is the trouble, you don't have time to do that, you want instant information most of the time [PB]

Returning to the findings of the survey questionnaire; *'trade press'* and *'books'* were not popular choices, perhaps because of the time involved in reading them. The survey interviewees commented that they infrequently had time to read these types of information, visit seminars or material collections, despite their apparent usefulness:

> I get enormous amounts of trade magazines and things come through and there are times when, you know, I can afford the time to go through them and look at them and tear out things, or follow up leads, and there are other times when you just don't have time even to look at them, and they have to go in the recycling bin [PB]

> If it was within an hour's travel I'd consider it but I'm not going to take up an entire day for a half-day seminar [BG]

'External experts' were also scored lowly, which may be due to the cost and the perceived inappropriateness of this type of resource during the early phases of a materials search.

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[65] Campus is an online database of polymeric materials

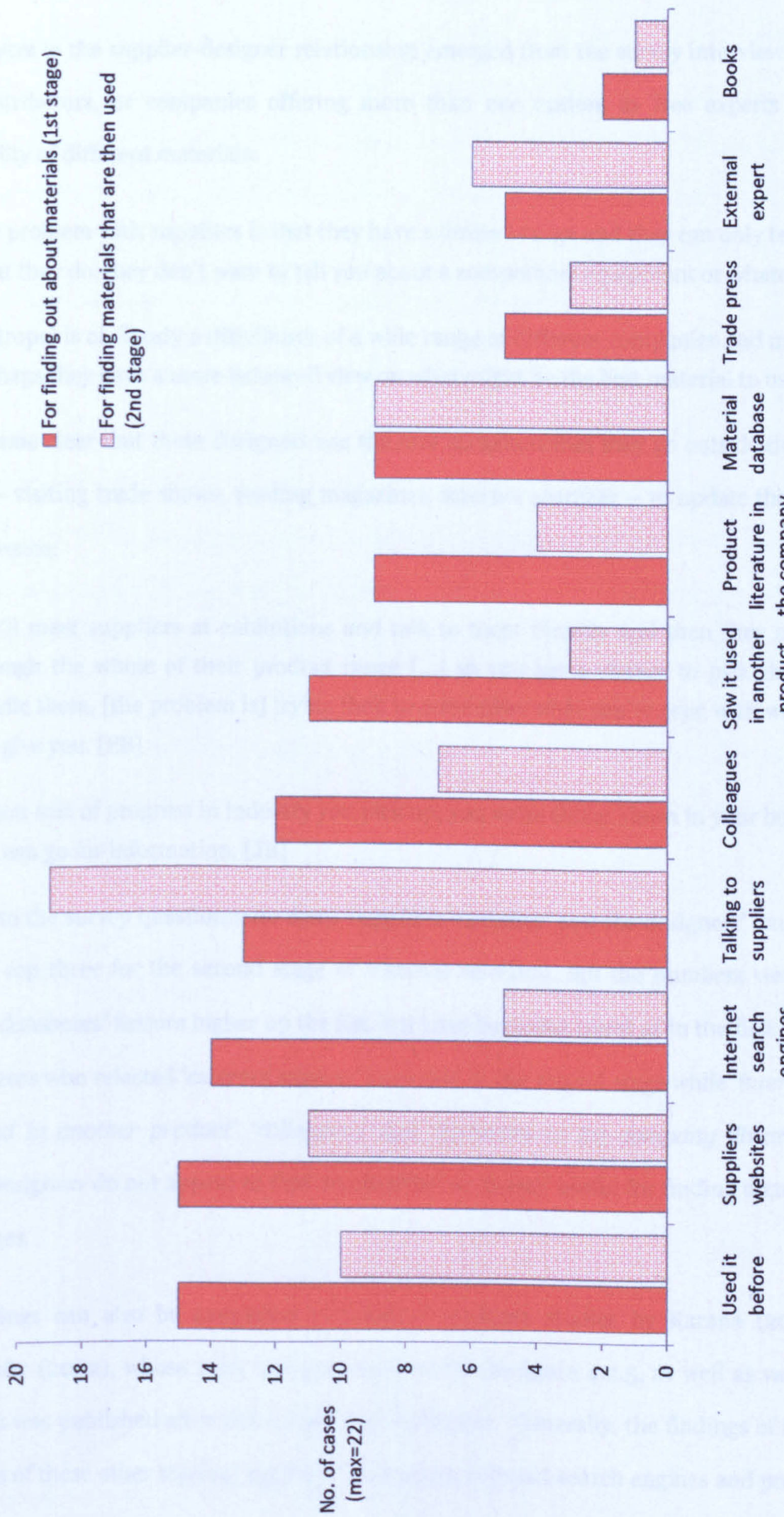

Figure 4.4.19: Information sources found most useful by respondents for finding out about materials (first phase)

Second stage

The most preferable sources in the second stage were different to the first (see fig. 4.4.19); '*talking to suppliers*' was considered by far the most useful source, and the survey interviewees strongly agreed with this finding:

> I think [supplier information] is generally the most up to date [BG]
>
> I think I realised pretty quickly that suppliers, exhibitions and the trade press in particular, which is generally free, were probably the best sources for information [PB]

Further layers to the supplier-designer relationship emerged from the survey interviews. For example the role of distributors, or companies offering more than one option, as free experts to consult on the comparability of different materials:

> The problem with suppliers is that they have a limited range and they can only tell you about what they do, they don't want to tell you about a competitors equipment or whatever [PB]
>
> Distropol is obviously a distributor of a wide range of different companies and materials and perhaps they have a more balanced view on what might be the best material to use. [SF]

It also became clear that these designers use the rare occasions that they go outside their usual sphere of reference – visiting trade shows, reading magazines, internet searches – to update their supplier lists for future reference:

> You'll meet suppliers at exhibitions and talk to them directly and then they can take you through the whole of their product range [...] so you get a chance to pick things up and handle them, [the problem is] trying then to remember what you've seen with whatever they can give you. [PB]
>
> As you sort of progress in industry you pick up, you write things down in your book of places you can go for information. [JB]

Returning to the survey questionnaire data; '*suppliers' websites*' and the designers' '*own experience*' were still in the top three for the second stage of material selection, but the numbers were greatly reduced. '*Materials databases*' feature higher up the list, but have the same count as in the first stage. The number of respondents who selected '*external experts*' increased in the second stage while '*internet search engine*', '*saw it used in another product*', '*colleagues*' and '*literature in the company library*' were much less popular. Designers do not appear to find '*trade press*' or '*books*' useful for finding materials in the first or second stages.

These findings can also be compared to those of previous studies by Karana (2004) and Chick & Micklethwaite (2002), whose work was presented earlier in figure 4.2.5, as well as van Kesteren (2008) whose work was published after this survey was conducted. Generally, the findings of this survey support the findings of these other studies; suppliers, colleagues, internet search engines and product examples are

particularly useful to designers, while material databases, books and company literature is less useful. Van Kesteren (2008) found that time pressures prevented designers from visiting exhibitions or using commercial sample collections, which was also a finding of this study. Van Kesteren's study also suggested that designers in larger companies made use of established collections and databases located in-house, which smaller companies did not have the resources to provide for their designers.

Significant Differences

There were some statistically significant differences between the number of times some information sources were selected for the first stage of material sourcing when compared to the second stage [stat 42]. Most notably, *'talking to suppliers'* is preferred in the second phase [stat 43]. These trends reflect the different requirements of material information during the earlier and later stages, highlighted by Ashby and Johnson (2002)[66], with a general search during the early phases and a more focused approach in the later phases when designers are looking for specific information. Designers find more sources useful in the first stage of material sourcing than in the second stage [stat 44].

During the first stage of finding out about materials 75% of respondents found less than half of the information sources included in the survey useful, which is surprising considering that this is the time during a design project when a designer's search is broadest and freest. These results were explored to see if there were any significant differences between those designers who formed the majority group (found less than six sources useful), and those in the minority group (found six or more sources useful). Designers working in companies with 10 or more employees (likely to be in-house designers [stat 1]) found fewer information sources useful than designers in smaller companies (likely to be consultancies [stat 1]) [stat 45]. It is not surprising that these designers also found that they had adequate time to use them [stat 46], but it also implies that designers who wanted to use more information sources found that they did not have adequate time to investigate materials to the extent desired.

[66] This is discussed in more depth in Chapter Six

4.5 Addressing the Research Questions for Enquiry 1

The previous section presented the results of the survey questionnaire and interviews undertaken in Enquiry 1. The survey findings are now considered in relation to the three research questions for Objective 1 which were proposed in section 4.3, based on the theoretical framework.

4.5.1 Designers' Individual Situations

Are designers' individual situations conducive to considering material sustainability, and the use of secondary materials?

- The findings suggest that materials guidance in designers' training affects their confidence when selecting materials, particularly with regards to the sustainability of their choices; designers had received very little guidance on the sustainable use of materials and designers with an arts background, most likely to be working in consultancies, were at a particular disadvantage.
- In addition, survey respondents' understanding of 'sustainability' in relation to materials was limited to material production and end-of-life treatment, missing out the production and use phases of the lifecycle, and failing to *close the loop* by mentioning the use of secondary materials. The interviewees were able to talk about complex sustainability issues abstractly, but appeared not to apply this thinking to their design work.
- Designers were also little aware of legislation relating to sustainable use of materials and appeared to respond only to legislation that is enforced in the sectors they are working for and as an inherent part of the brief. This means they are not able to use legislative drivers to support sustainable material decisions.
- Having used a material previously was the *most useful source for finding out about materials* to use in design work, which strengthens the idea that past experience of material selection has a substantial impact on design decisions. The implication is that this experience may limit the designers' consideration of unfamiliar materials such as secondary or more sustainable alternatives.
- The survey revealed that social and environmental sustainability are considered by respondents to be the least important factors in their capacity as designers, which implies that these are unlikely to be considered unless they are implicit or explicit in the brief. Designers who did value these 'worthy' factors were less likely to able to incorporate them into their work for manufacturers. However the study also showed that factors relating to personal financial success were scored relatively lowly indicating that designers are not generally motivated in this way.

Summary

Overall, designers' are ill-equipped for considering material sustainability, and the use of secondary materials. This appears to result from inadequate training and experience, and more important design priorities.

4.5.2 Designers' Work Scenarios

Are designers' work scenarios conducive to considering material sustainability, and the use of secondary materials?

- The data suggests that designers' experiences of challenging the brief are generally positive, although less so for designers with an arts background, who also had less access to other knowledge areas than designers with other backgrounds. Based on the high number of designers with an arts background working in consultancies, this could be indicative of being further removed from the project stakeholders. In-house designers had better access to supply knowledge, whereas consultants were more in-touch with consumer needs and enjoyed better access to feedback from the design team.
- Designers generally didn't tend to spend their own time sourcing materials and felt that the amount of time they spent was adequate. However, the results also suggested that designers who have received materials training may limit their searches to the most effective information sources and feel that the time they need to do this is adequate. While those who are more confident in their materials choices spend more time searching for materials and then find they have sufficient access to information sources. These relationships were interesting but complex – further research is needed to clarify the situation.
- Designers in smaller companies, who were also more likely to be working in consultancies, were at a general disadvantage; they used more information sources and were less satisfied with the time they had available to source materials. The survey interviewees also mentioned the limited time available to use a wider range of information sources. This could be indicative of the difference in work scenarios between consultancies – who are likely to encounter a wider range of material requirements – and in-house teams – whose material requirements may be more limited.
- As mentioned above, designers who scored the importance of 'worthy' design factors highly were less likely to feel that these factors were reflected in their work, which indicates that work scenario does have a limiting effect on designers being able to practice sustainable design.
- When it came to contractual obligation of materials choices designers with an arts-background (likely to be in consultancies) were again more constrained than other designers. This was also a

strong finding in the survey interviews which revealed that there are few projects where suggesting an alternative material would be acceptable to clients.

- However, half of the respondents have specified secondary materials before which suggests that this is possible for industrial and product designers, if only in particular situations.

Summary

Design consultants work in more constraining scenarios than in-house designers which prevents them from considering alternative materials, such as those that are more sustainable. This could be partly due the consultancy's geographic and cultural distance from other project stakeholders.

4.5.3 Opportunities in the Product and Industrial Design Scenario

Does the product and industrial design scenario offer any opportunities for improving the likelihood of designers considering and selecting secondary materials for high-value mass-produced artefacts?

- Improving guidance on the sustainable use of materials in design training (particularly arts-based) would positively affect designers' confidence when selecting the most appropriate and sustainable material, and could redress the balance in the importance placed on social and environmental sustainability in design practice. In addition, improved knowledge of sustainability issues and their relation to design practice is essential if designers are to consider sustainability in the natural course of their design thinking, and to consider whole lifecycle implications of material selection rather than just the popular view of beginning and end-of-life concerns.
- Methods to bridge the gap between consultancies and other project stakeholders would be beneficial. These could also be incorporated into design training; for example, advice on how to communicate more effectively with other stakeholders[67]. In addition, improving sustainability guidance and information for material selection, so that it is more usable and useful to designers in constrained work scenarios, would be beneficial for dealing with the immediate situation[68].
- With regards to specifying secondary material, the findings suggest that firstly it needs to be fit-for-purpose which, in turn, must be effectively communicated to the designer, including how to choose the right projects for pursuing the use of secondary materials. Secondly, specifying secondary material needs to be as easy as having used it before, which again implies that designers' knowledge and awareness of these materials needs to be greatly improved. Finally the benefits of using secondary material need to be aligned to the factors that designers believe are

[67] As discussed earlier in relation to Cooper & Press (2003), Rieple, Haberberg & Gander (2005) and Hakatie & Ryynanen (2007).
[68] The survey highlighted many ways in which material information could be improved, and these are explored more thoroughly in Chapters Six and Seven.

most important, not just the environmental benefits which do not appear to be a primary motive for designers.

- From this survey it has become clear that, although there are opportunities for product and industrial designers to select secondary materials, they are few; therefore, a final implication of this study is that this knowledge could be used to identify design scenarios that might be more conducive to selecting secondary materials.[69]

4.6 Successes and Weakness of Enquiry 1

The aim of Objective 1 was to generate new knowledge about *the design scenario* that would inform the development of *new models for utilising surplus and waste resources in design practice.* Designers of high-value mass-produced artefacts were targeted to enable a higher volume of secondary materials to be incorporated back into new products, and also to maintain value and material properties through multiple cycles. This survey has established that these (product and industrial) designers' *individual situations* combined with their *work scenarios* are not generally conducive to proactively considering material sustainability or the use of secondary materials. The study has enabled factors that contribute to this scenario to be identified, suggesting opportunities for change.

The survey findings also support the theoretical framework presented in section 4.3. In particular, the combined effect of the designers' *individual situation* and their *work scenario* on their ability to make design decisions. For example designers who thought 'worthy' factors were important also often felt these factors were not reflected in their work for manufacturers. There were also several findings linking design training and background to elements of the work scenario such as time and the use of material information sources. Exploring the two areas of *the design scenario* and the corresponding *factors of influence,* indentified in 4.2.3, would appear to be an effective way of identifying opportunities for change based on the successes of this enquiry.

However, some weaknesses should also be acknowledged. First, a fuller picture and greater comparisons would have been possible if in-house designers had been interviewed as well as design consultants. This would also have allowed for the possibility of developing the research with in-house designers as well as design consultants, although this would not have been feasible within the limits of this project. Second, the survey covered a broad range of phenomena and so some areas which are quite complex, such as how time is spent when sourcing materials, could have benefitted from closer study. However, this approach was taken intentionally to examine relationships between disparate aspects of the design scenario, which haven't been explored before, and some detail was inevitably sacrificed. These findings could, therefore, be used as a starting point for close investigation of one particular aspect of *the design scenario,* perhaps involving qualitative methods such as observation or design diaries.

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[69] This is explored in Chapter Five.

4.7 Chapter Four Summary

This chapter has presented the focused literature review, research strategy (including a theoretical framework), and results for Enquiry 1.

The aim was to better understand industrial and product design practice in order to highlight areas for change or improved support which may enable the use of secondary materials in high-value mass-produced artefacts. The findings revealed that the design scenario of product and industrial designers is not generally conducive to the proactive consideration and use of secondary materials, but also identified a number of potential opportunities for improving the situation.

The next chapter will present Enquiry 2 which was undertaken to address Objective 2. This will consider secondary plastic in London; how it is treated, what materials are available and their potential uses in design practice. Enquiry 3, presented in Chapter Six, will then review existing methods of supporting designers, and together the three enquiries will inform the development of a 'new model' in Part III of the thesis.

CHAPTER FIVE Enquiry 2: Secondary Materials, Focus on Plastic in London (Objective 2)

This chapter presents the focused literature review, research questions and methods for addressing Objective 2. It reports the findings of the investigation into secondary material, focusing on the 'story' of plastic in London. The purpose was to understand the processes and specific issues involved with material recovery and possible approaches to use, to inform the development of a new model for supporting designers in the utilisation of secondary materials.

5.1 Introduction

Objective 2 was originally included in the project proposal by the collaborative partner London Remade to ensure that the research was relevant to their own remit, and stated:

> Identify key potential product and design sector applications for secondary materials within London.

This was seen by the author as an opportunity to become familiar with the issues involved in recovering and using secondary material, from collection through to the design and production of new artefacts, but within a manageable geographic focus (London). It was also decided that the study would be further narrowed to a particular material type, to identify material-specific issues whilst also highlighting themes applicable to secondary materials in general. Plastic was chosen because:

- It is the most commonly specified material in the design of high-value mass-produced artefacts;[70]
- It is particularly problematic to recycle;
- It has an interesting history of shifting cultural perceptions which has affected the way plastic artefacts are used, valued and disposed of.

The aim of this enquiry was to explore these issues first through a focused literature review, drawing on the survey findings as well as insights from nine interviews with industry experts (introduced in Chapter Four); second through field visits to material recovery facilities (MRFs), material reprocessors, and design studios, and by attending conferences. A list is included in Appendix B(i).

[70] According to the survey findings, see section 4.4.3.

5.2 Focused Literature Review: Secondary Material

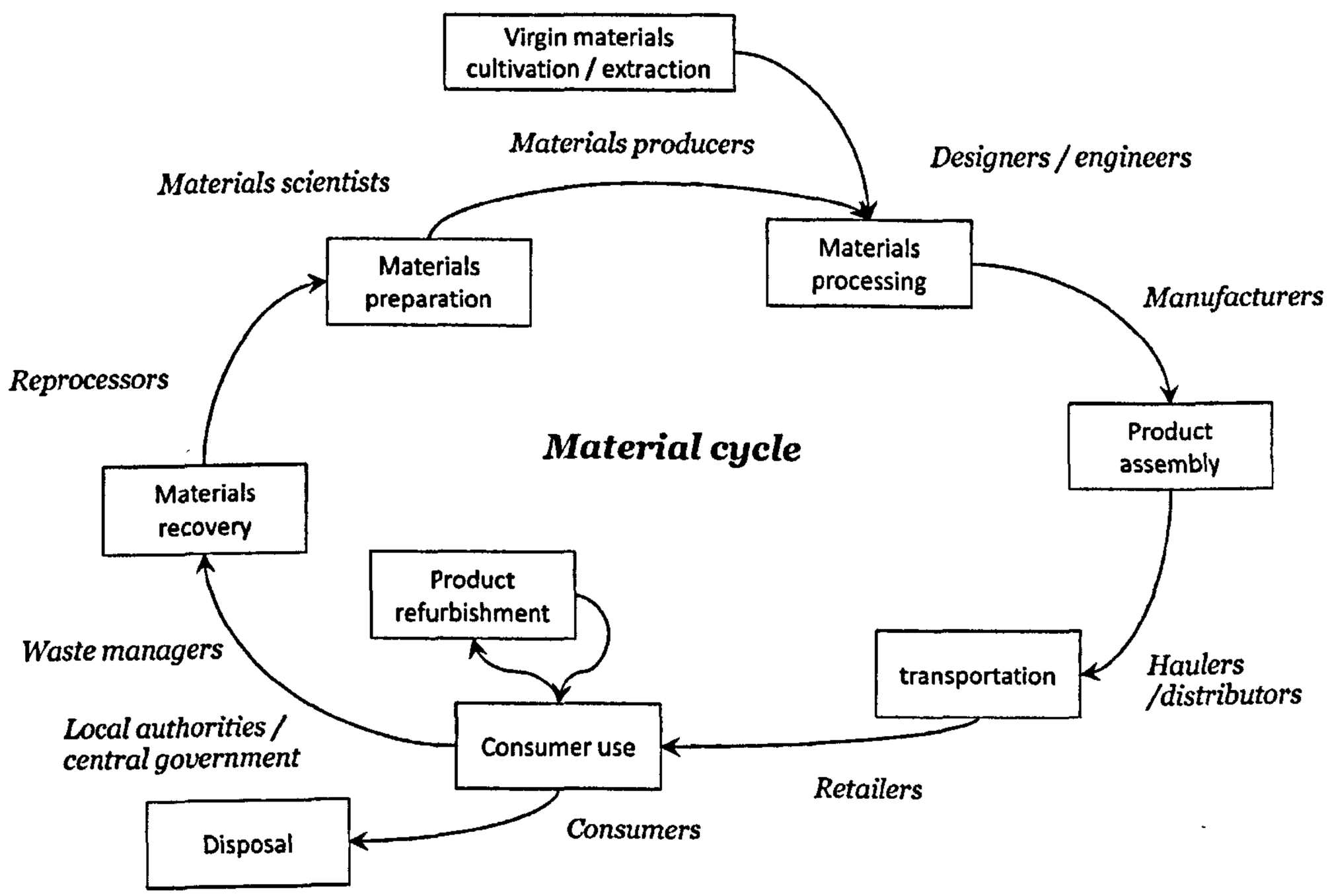
The London and UK context for policy and design interest relating to secondary material was introduced in Chapter One, and some of the general debates around recycling were presented in the Initial Literature Review (section 2.2). The following discussion builds on these areas by exploring the specific issues relating to secondary plastic and its use in design, based on current industry and academic literature, and the insights of expert interviewees.[71]

5.2.1 Dealing in Waste

Waste producers

Currently in the UK and the western world there exists a self-sustaining and largely unnecessary industry of waste production and 'management'. Figure 5.2.1 shows how this system can be seen as a cycle with many participants, none of whom can be held wholly accountable, but each equally responsible for their part in keeping the cycle moving (Geiser 2001). This is a conveyer belt on a downward spiral, continuously moving material from a raw virgin state, often decreasing in versatility and usefulness (down-cycling) as it goes through the process for the second, third or fourth time (Cooper 1994). The waste management industry is the main participant in recovering and delivering material for reintroduction into manufacture and it is worth noting that this is an industry which can only survive as long as humans are wasteful.

Figure 5.2.1: Actors in the Material Cycle; adapted from Fletcher, Dewberry & Goggin (2001)



[71] See section 4.1 for further details of the industry expert interviews.

It is also important to keep in mind that recycling is not the first strategy for dealing with wastefulness, as discussed earlier in relation to the Waste Hierarchy (Chapter Two). Secondary materials must be considered within the broader context of material cycles and sustainability concerns, which prioritise waste prevention and reduced material throughput. However, this is an approach that is unlikely to be supported in any meaningful way by an industry that currently profits from the perpetuation of the waste system.

Material Markets

Currently in the developed world a material becomes available to buy because a material supplier has responded to an identified demand from producers, retailers or consumers. Producing this material will undoubtedly have involved investment, particularly if substantial Research and Development (R&D) was undertaken, but if the supplier has 'read the market' correctly, the risk is minimal and they can be confident that they will be able to sell their product. However, this is perhaps an unsustainable way of making materials available for industry; if there is sufficient demand for a material and it is economically viable to extract or grow, it will continue to be sourced regardless of its scarcity. O'Neill (1998) explains:

> [In market economies] decisions are not constrained directly by social custom and ethical goals, but rather respond to a system that proceeds independently of these. The economies are amoral. In contrast, in non-market economies, economic decisions are constrained directly by social custom and needs, and operate directly in terms of the nature of the goods involved.[72]
>
> (O'Neill 1998:5)

The 'supply and demand' nature of free-markets, therefore, does not currently protect the long-term sustainability of resources; over-subscribed materials will inevitably dwindle (Petras & Veltmeyer 2003), or natural resources may be monopolised by industry rather than being used by other species or communities (Kingsbury 2007). A more satisfactory model, from a sustainability perspective, might be to only use abundant materials. Karlsson and Luttropp present an interesting example of Swedish wood production:

> Sweden is one of the many places where hardwood is a diversified high quality renewable raw material resource. Simultaneously the trees also contribute to a better biodiversity, improved quality of air and water and more attractive recreational values. The long-term supply capacity and environmental qualities are dependent on maintenance of a productive, sustainable forestry. The design of attractive hardwood products could catalyse higher customer interest and motivate investments in hardwood related businesses. Such customer interests and business capabilities would increase the value of hardwood trees and make them more interesting to grow for the land-owners. In this way, a higher market value for hardwood could lead to a higher future content of hardwood trees in the forests. Such market-based mechanisms can give a better base for biodiversity and sustainable forestry

[72] O'Neill explains that one argument for the prominence of the free-market economy is the limits of individual or group knowledge that would be necessary for centralised 'planned' economies: "the market overcomes the problems of human ignorance" and "is presented as a self-regulating homeostat, providing the informational feedback between economic actors necessary for the mutual adjustment of their activities." (O'Neill 1998:129)

> than the limited conservation approach to protect the scarce species. The conservation approach tends to result in economic scepticism against hardwood amongst land-owners because if allowed to grow, these trees may become interesting conservation objects. To avoid this, farmers' stick to the mainstream coniferous forestry, by eliminating young hardwood trees. EcoDesign could improve the linkage between attractive hardwood products and land-owner interests to nurture more hardwood plants and trees.
>
> (Karlsson & Luttropp 2006:1296)

Here Karlsson & Luttropp (2006) present a complex chain of issues to do with market forces, the sustainable provision of materials and the important role of material selection in design. In this case developing a market for a material which has, in the past, been portrayed as 'unsustainable' is seen instead as a positive step towards greater biodiversity. This perhaps highlights the need for an active engagement in the types of resources which, if cultivated, would benefit wider sustainability issues. This new approach would undoubtedly involve knowing what materials are abundant, in what quantities and the implications of production, extraction or growth for the locality. A conscious decision needs to be made to manage resource supplies with greater reference to the sustainable supply of that material rather than commercial forces.

In *Capitalism as if the World Matters,* Porritt (2007) advocates the use of markets to support the sustainable use of resources:

> There seems no reason to suppose that properly regulated markets, operating within a genuinely sustainable macro-economic framework, will not continue to be the most effective (and sustainable) mechanism for the allocation of resources.
>
> (Porritt 2007:90)

Importantly Porritt emphasises the need for new 'frameworks' or, indeed, new ways of thinking about resource abundance, information management and market stimulation. This is the challenge being faced with secondary materials; they are abundant but demand is relatively low so confidence must be raised, material flows must be 'known' and markets must be 'found', if the energy and resources invested are to be recovered and valuable virgin materials saved.

Secondary Material Escalator

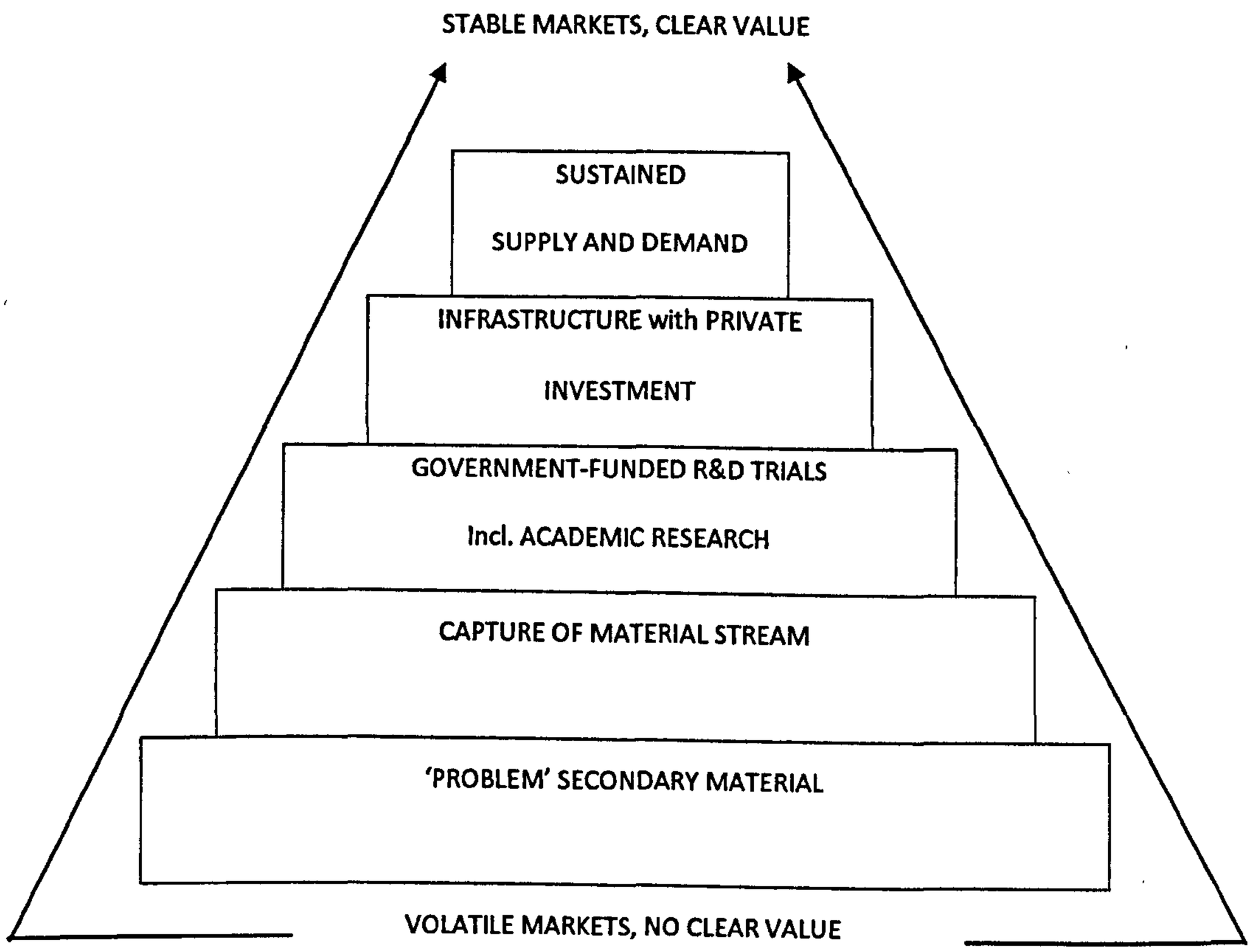
Historically the motivation to utilise secondary material comes from environmental and political drivers (legislation) rather than market demand.[73] Creating demand for an existing material is much more challenging and complex than developing a material to meet a demand that already exists. Under normal circumstances R&D would be funded by material suppliers or other private partners, whereas with secondary materials it must instead be heavily subsidised by the UK government.[74] To utilise waste

[73] One notable exception is in markets for secondary metals which, due to their weight, value and property recovery relative to virgin metal, have sustained an effective material cycle throughout their history. For example see the British Metals Recycling Association (2005).

[74] For example WRAP provides funding for many areas of recycling technology development (WRAP 2008) and the Technology Strategy Board has also funded recycling technology projects (Technology Strategy Board 2008).

resources technologies must be developed which can produce a material that is wanted, at a cost which is acceptable, in existing or new markets. This process of preparing a waste material for introduction into commercial markets can be represented by an 'escalator' (fig. 5.2.2); as R&D around a 'problem' waste stream increases, improvements are made and its market value may gradually increase. Greater production volumes and improved supply could eventually make a secondary material self-sustaining in commercial markets, with no further need for government subsidies.[75] The availability and market price of virgin material, as well as economic and political activities can also impact on the demand for secondary material.

Figure 5.2.2: Secondary Material Escalator; the transition from problem material to stable markets



The *material escalator* is a theoretical model that will be discussed further in the Results & Discussion section of this chapter.

[75] An example is closed-loop Recycled Polyethylene Terephthalate (R-PET) which is discussed later in this chapter.

5.2.2 The Nature of Plastic

The specific focus of this enquiry on plastic[76] is due to its common use in product and industrial design, the problems associated with recycling it and the popular perceptions of its use. These issues were explored by the author in an earlier paper entitled *Utilising Waste Plastic in Design Practice* (Hornbuckle 2008)[77]. In this paper the author describes the "paradox of plastic use" (Hornbuckle 2008:163), identifying five characteristics which on the one hand mean plastic offers designers and manufacturers great versatility, but also makes plastic more challenging to deal with in the end-of-life (EOL) scenario:

Visibility:

Plastic is often used because it is bright and colourful but this also means it is a highly 'visible' pollutant in the environment;

Lightness:

Plastic is light in transportation but this also means it floats in waterways and is easily blown by the wind. This also makes plastic uneconomical to collect and transport as 'waste' because it attracts a lower price as scrap and Local Authority targets are measured in 'tonnage';

Variety:

Plastic comes in a great variety of colours and types which is beneficial during the design phase but problematic when it comes to collection and sorting during EOL. This leads to contamination which means that versatility is often reduced during reprocessing;

Abundant and Cheap:

The use of plastic to replace more expensive materials and processes has enabled access to affordable artefacts, but has also brought about the proliferation of cheap and poorly-made goods on a massive scale. Despite the development of new high-performance plastics[78], the popular perception is still of a cheap disposable material which is at odds with sustainable attitudes and behaviours[79].

Durability and Degradation:

Plastic is durable in the short-term (it will never break down and be absorbed into nature) but can fade and crack with weathering and use. Artefacts made from plastic therefore have a specific design-life; plastic is almost 'too durable' for a disposable pen, but a plastic chair may not last long enough before discolouring or breaking.

(Hornbuckle 2008:164-165 paraphrased and abridged)

Plastic therefore presents unique challenges for recycling systems, but also for designers who seek to use secondary plastic or who strive to be considerate of plastic material cycles when making design decisions.

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[76] Plastic in this context refers to polymeric materials derived from crude oil, rather than the term's broader meaning or polymers derived from plant matter which are discussed in the Results & Discussion section of this chapter.

[77] This paper is included in Appendix B(ii) to demonstrate the author's knowledge of the contextual issues associated with secondary plastic and its use in design.

[78] The Science Museum's *Plasticity* exhibition (May 2007 to Jan 2009), for example, attempted to show the technological future of plastic as well as the importance of its ongoing historical emergence.

[79] *Proud Plastics*, initiated by the Eternally Yours Foundation, attempted to challenge perceptions of plastic as a cheap and disposable material, by exploring user experience of plastic artefacts (Eternally Yours Foundation 2004).

5.2.3 Challenges to Designers Selecting Secondary Plastic

Recovering value and properties from secondary plastic is a significant challenge for economic, systemic and cultural reasons; these are passed onto the designers and manufacturers who set out to use secondary plastic in the manufacture of new high-value artefacts. The expert interviewees and the survey findings highlighted some of these challenges, which are briefly discussed here.

Availability, Quality, Supply and Cost

The materials and manufacturing expert interviewee from WRAP identified the main problems faced in the preparation of recovered materials for use in manufacture as:

> Quality of feedstock (risk of contamination)
> Price (customers' expectation is that it's cheaper – they won't pay more)
> Security of supply (is there a reliable supply of feedstock?)
>
> [Rec Mat Man]

This interviewee also explained that the biggest cost is in cleaning contaminated materials, which can be reduced if the contaminant is known. Similar issues were revealed in the survey where designers' main concerns about recycled materials were:

> Availability (what is available?)
> Quality (what are the material properties?)
> Supply (what are the supply capabilities and is the supply secure?)
> Cost (Are the materials competitive on price)

The parity of the survey findings with those from the expert interviewees is even more striking given that they were responding to an open question rather than predefined choices. So, it is clear that these four issues are of concern both to designers and more broadly in industry; they are real concerns and not just perceived by designers.

Encouragingly, 68% of survey respondents were generally positive about using recycled materials but most of those also expressed the concerns highlighted above. The general feeling was that these materials need to be *fit for purpose*. However, the survey suggested that supporting product and industrial designers in the use of secondary material could be challenging beyond these issues.

Information

The survey suggested that the information sources found useful by designers for looking for materials are limited, and they mostly prefer materials they have used before, or to use internet search engines or suppliers websites. This suggests that designers need to be actively looking for secondary material in order to encounter it, unless they had used it before and been satisfied with the experience. Chick and Micklethwaite (2004) also found that information was the most common obstacle to specifying recycled materials amongst architects and designers, and call for validation of secondary materials to provide quantifiable data (echoed by the Sust Eng expert interviewee). Industry has responded to this need, with

the British Standard Institute (BSI) and Granta Design (the company behind Cambridge Engineering Selector) both involved in projects to improve data for 'sustainable materials'.[80] This is still in the early stages of development, but it is quite possible that the concerns highlighted above could be alleviated with sufficient and appropriate information about secondary materials.

Design Priorities

Surveyed designers considered *'environmental impacts'* and *'sustainable development'* to be the least important factors in design, indicating that they are unlikely to be motivated by these issues when selecting materials. This suggests that if designers are to consider and use secondary material there need to be other benefits, such as *'functional performance'*, *'meeting end user needs'* and *'being innovative'*, which were the top three design factors in the survey. These priorities when designing were also reported by Sherwin (2000) who stated that, when working on an eco-design brief, designers frequently returned to the consideration of the end-user to guide the direction of design work and decision-making:

> There were strongly held feelings that the best way to motivate industrial designers was through 'innovation' (the potential to innovate and design new 'things'), rather than through more traditional environmental motivations - such as ethics or equity, efficiency or business profitability. This is striking contrast to many commonly held beliefs, that the primary design motivations will be factors such as economic efficiency or cost savings
>
> (Sherwin 2000:136)

This suggests additional challenges for considering secondary materials in the design of mass-produced artefacts: what opportunities for innovation do they offer the designer? Secondary material is by definition retrospective, often with negative connotations,[81] rather than being new, exciting and hinting at the future. One of the expert interviewees suggested:

> If you turn the problem around from being about recycled materials [...] the unsexiest and unattractive materials, if that becomes your problem [...] "I've got this you know, really heavy unattractive laminated chipboard, what the hell can I do with it to make it really, really appealing" that is an interesting problem.
>
> Des Sust expert

In contrast to Sherwin's findings, the survey interviewees saw cost savings as the greatest motivation for selecting secondary materials, as these could be easily communicated to the client (echoed by Dehn 2008).

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[80] Both Granta and BSI spoke on this subject at the Materials KTN Standards for Sustainable Materials workshop (27/05/09). Granta Design are also part of a new Environmental Materials Information Technology consortium (see http://www.grantadesign.com/emit/ accessed 17/07/09)

[81] Secondary materials often become available again some time after they were first produced; they can be either 'aesthetically retrospective', meaning their appearance is no longer 'in fashion', or they can be 'compositionally retrospective', meaning that their content or make-up is out-dated. The latter means that they may contain banned substances, that they cannot so easily be mixed in with newer materials during reprocessing, or that the infrastructure is no available to deal with them.

Location of Manufacture

Another important aspect in the ability of designers to influence material decisions is the location of production for the artefact they are designing. The survey interviewees reported that the majority of their designs are manufactured in the Far East,[82] making it almost impossible for them to identify specific materials or to choose UK or European suppliers.[83] In addition, the social, environmental and economic benefits of using secondary material recovered locally to manufacture artefacts are sizable, meaning that UK-based manufacturing projects – although apparently rare – offer UK-based designers the best opportunity for incorporating secondary material into new high-value, mass-produced artefacts.

5.2.4 Design's Potential Contribution

It is important to note that design's potential contribution to the material cycle stretches beyond the specification of secondary plastic, an idea introduced in the Initial Literature Review (section 2.3). To explore this further the author created a 'mindmap' which is included in Appendix B(iv). For example, the application of design thinking in a variety of disciplines, beyond product and industrial design, could help to develop markets for secondary plastic: through graphic communication, to improve public perceptions; engineering design, to find new systems for processing recyclables or new manufacturing techniques to handle reprocessed plastic more effectively; architectural design, to make it easier for people to collect recyclables in their homes, where space is limited; or even at policy level, to find creative solutions to systemic issues. This relates to the *design and sustainability strata* construct (discussed in Chapter Two) which, it was argued, *represents the potential for design to visit the various strata of sustainability in order to address a complex array of problems.*

Within the field of product and industrial design numerous approaches focusing on prevention, reduction, design for recyclability, and end-of-life scenarios, as well as different methods of using recycled materials, were highlighted.[84] This broader potential of design was also mentioned by the expert interviewees:

> I think if you talk about recycled materials [...] what is the stuff we're really throwing away and what can we do to implement systems [...] we can start using design to solve that specific problem, and it may be quite an unattractive problem.
>
> [Des Sust expert]

Moving on from the various potential applications of design thinking, Dehn (2008) has studied *the creative and economic potential of materials made from waste* and the benefits to communities. She reported that many of the case studies in her investigation, involving design-led collaborations where

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[82] Although two designers also reported a noticeable return to UK and EU manufacture, because of the difficulties of communication and proximity during product development.

[83] There is the potential for secondary material suppliers to be found in non-EU countries, as had been the experience of one expert interviewee [Pr Des]. However, additional barriers were reported such as cultural differences, making it difficult to trace the source of the material or to get regulatory reassurance.

[84] Designers' consideration of material use in the design phase can also impact non-material sustainability concerns as was highlighted in the Initial Literature Review (section 2.2), but for the purposes of maintaining a manageable focus for the study, these are not explored further here.

secondary materials were used in the mass-production of artefacts, had a positive impact on communities through job creation, local regeneration and the opportunity to educate through the demonstration of socially- environmentally- and economically-sustainable practices.

5.2.5 Summary

The focused literature review highlighted the following points that contributed to the development of research questions for Enquiry 2:

- The use of secondary plastic must be considered in reference to the material cycle and the broader sustainability agenda;
- Secondary materials are abundant with no ready market and therefore go through several stages to reach market-readiness and commercial self-sufficiency (represented by 'the material escalator');
- The successful recovery of value and properties from secondary plastic is subject to various cultural, systemic and economic challenges, many of which are related to the material's unique properties;
- Designers have a number of concerns around the use of secondary materials, which could be alleviated by the provision of appropriate information to demystify the *availability, quality, supply and cost* of secondary plastic;
- Designers may be best motivated by innovation possibilities of secondary plastic, and how they can help meet end-users' needs;
- Design's potential contribution to the material cycle goes beyond the <u>use</u> of secondary material;
- Existing uses of secondary material by designers have contributed to economic and social development as well as the development of markets.

5.3 Research Strategy for Enquiry 2

With the benefit of the background research discussed in the focused literature review, it was then possible to reposition Objective 2 as follows:

> Investigate the 'story' of secondary plastic in London in order to identify the materials available for use by designers, and to understand the system that produces them.

Enquiry 1 established that the *design scenarios* of industrial and product designers are not generally conducive to considering material sustainability or using secondary materials. It was therefore decided that attention to the design scenarios of designers who had used secondary material would also be beneficial to this enquiry:

> Identify existing approaches taken by designers when utilising secondary plastic, and note any common characteristics of their design scenarios.

5.3.1 Research Questions for Enquiry 2

Objective 2 translated into the following research questions:

> How is secondary plastic derived from London currently recovered, treated and processed, and what are the trends for future development in this area?
>
> In what forms are these materials then available for use in the manufacture of new artefacts in London or the UK?
>
> What approaches have been taken by designers for utilising secondary plastic in the production of new artefacts?
>
> Are there any common characteristics of the designers' scenarios that could have contributed to their ability to utilise secondary plastic?

5.3.2 Research Methods for Enquiry 2

The nature of this enquiry was *exploratory,* as it sought to "find out what was happening" in a "little-understood area", and the research progressed in a *flexible* manner (Robson 2002:59).

The methods selected were principally aimed at fact-finding; this was one of the two smaller enquiries in the research project and therefore time- and labour- intensive methods were not feasible. In addition to desk research, a strategy similar to *snowball sampling* (Robson 2002) was used for gathering opportunities to visit material recovery and reprocessing facilities, design studios, conferences and workshops;[85] London Remade was frequently the gatekeeper to these opportunities.

The adhoc nature of these encounters and the frequently audio-unfriendly surroundings meant that the conversations could not be recorded; this was not ideal but did not hinder the enquiry greatly as much of the information was also available in the public domain via company literature and websites. The author

[85] Details are included in Appendix B(i)

made detailed notes[86] immediately after each meeting or field visit and, where authorised, took photographs. Therefore, the data is sufficient to provide the insights necessary for theory-building and to inform the remaining research.

5.4 Results & Discussion

The results are divided into two main sections: first, a presentation of the practical factors involved in recovering plastic in London and the materials that result from that process; second, a discussion around the existing approaches taken by designers to utilise secondary plastic in their work drawing on specific examples 'gathered' during the enquiry.

5.4.1 The Collection, Movement, Treatment and Reprocessing of Plastic in London

This part of the enquiry involved the investigation of secondary plastic material flows in London. Some of this information, particularly relating to Local Authority operations, is publicly available but was found to be patchy and often out of date. Once the material has left the public realm it is much more difficult to track, inevitably involving commercially sensitive information relating to sales figures and customer locations, particularly in the waste management sector. This lack of transparency was discussed in section 2.2 in relation to the Mass Balance Research Programme (Biffaward 2006) which stressed the importance of material flow information in the management and ultimate improvement of materials cycles. The findings presented here are therefore a representation of the best available information gathered from informants, through conversations and the author's observations, recorded during the enquiry. The range of information sources used and perspectives gathered, as well as the involvement of London Remade, adds to the validity of the findings.

The London Context

The regulatory and policy framework for recycling in London was introduced in section 1.1. Further evidence of the general use and movement of secondary plastic in London is provided in the *City Limits* report, published by the Chartered Institute of Waste Management Environmental Body (2002). The report estimated that in 2000 Londoners 'consumed'[87] 691,000 tonnes of plastic products (this includes all plastic products, not only high-value artefacts that are the focus of this study). Also important to this enquiry is the manufacturing capacity of London as it was established that local manufacture offers the best opportunity for designers to select specific materials and is arguably more desirable from a sustainability perspective.[88]

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[86] An example of meeting notes is included in Appendix B(iii)
[87] This was calculated by adding production and imports of plastic products then subtracting exports. 'Consumption' therefore includes material that is either in use or in the waste management system.
[88] The most preferable options for sustainability are the subject of much debate (discussed in Chapter Two).

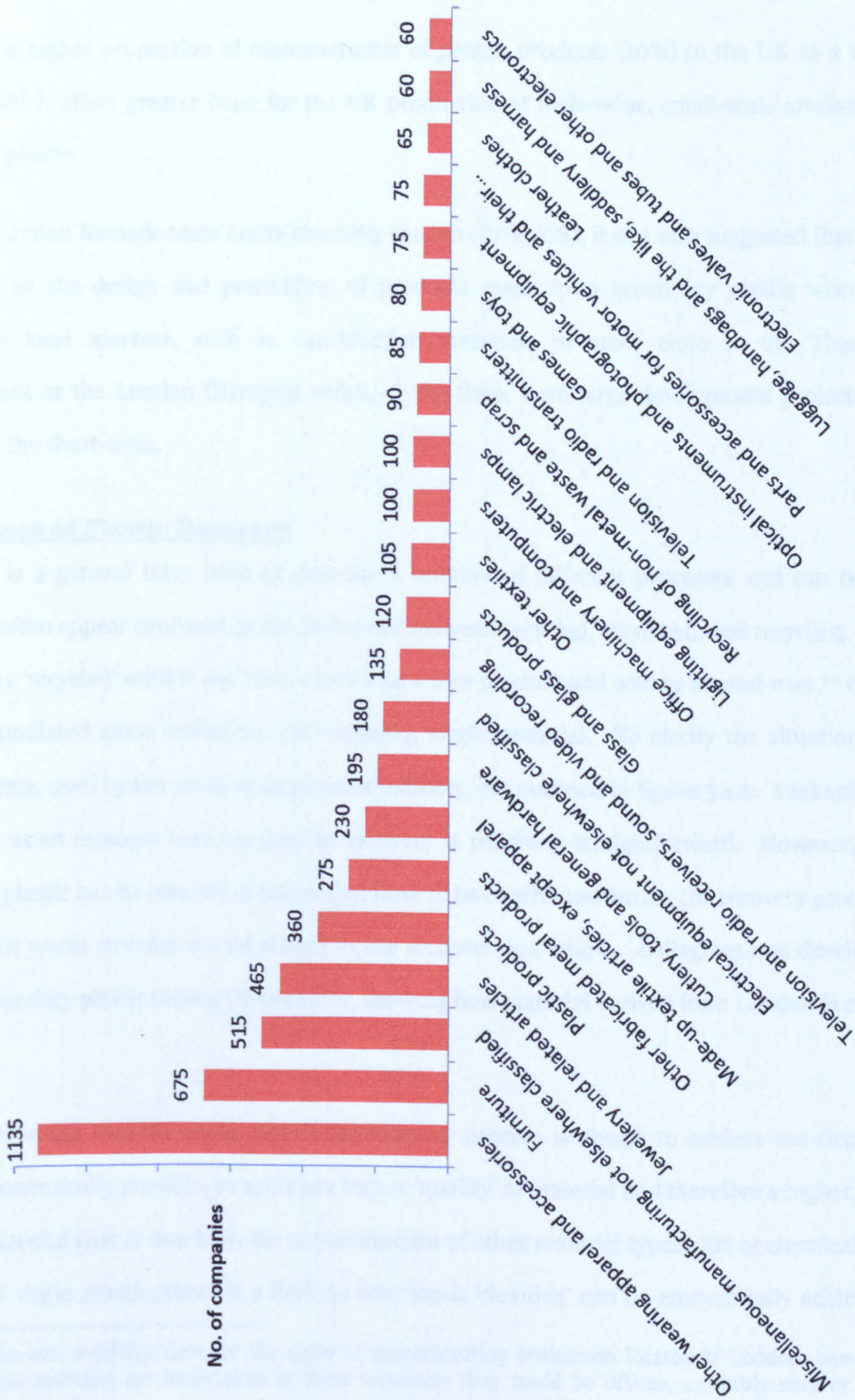


Figure 5.4.1: Number of London-based VAT-registered manufacturing enterprises by type of production: filtered to include only the categories related to the production of high-value small-scale artefacts. Office of National Statistics UK Business: Activity, Size and Location Data Series (2006)

The Office of National Statistics *UK Business: Activity, Size and Location Data Series* (2006) describes the VAT-registered manufacturing enterprises in London[89], showing that:

- A substantial proportion of London's production is *publishing, printing and the reproduction of recorded media* (41%);
- Of the production of high-value small-scale artefacts, *wearing apparel and accessories* (18%) is the most common type of production, with *furniture* (11%), *jewellery* (8%) and *plastic products* (6%) the next most common types (see fig. 5.4.1).

There are a higher proportion of manufacturers of *plastic products* (10%) in the UK as a whole than in London, which offers greater hope for the UK production of high-value, small-scale artefacts made from secondary plastic.

During a London Remade team brain-storming session (8/04/08), it was also suggested that a focus could be placed on the design and production of products made from secondary plastic where there were substantial local markets, such as construction materials in areas close to the Thames Gateway Development or the London Olympics which, at the time, were large development projects planned for London in the short-term.

The Process of Plastic Recovery

Recycling is a general term used to describe a number of different processes and can be misleading; laypeople often appear confused by the difference between recycled, recyclable and recycling. A material is not actually 'recycled' until it has been made into a new product and sold to an end-user,[90] recovering the value accumulated since collection and replacing virgin material. To clarify the situation, some more specific terms, used by the waste management industry, are outlined in figure 5.4.2. Packaging plastic has been used as an example here because its recovery is relatively straightforward. However, each type of secondary plastic has its own set of issues that have to be confronted during the recovery process; the three main plastic waste streams are presented in the sections that follow. A diagram was developed for each type of secondary plastic during this enquiry, showing how material derived from London is currently dealt with.

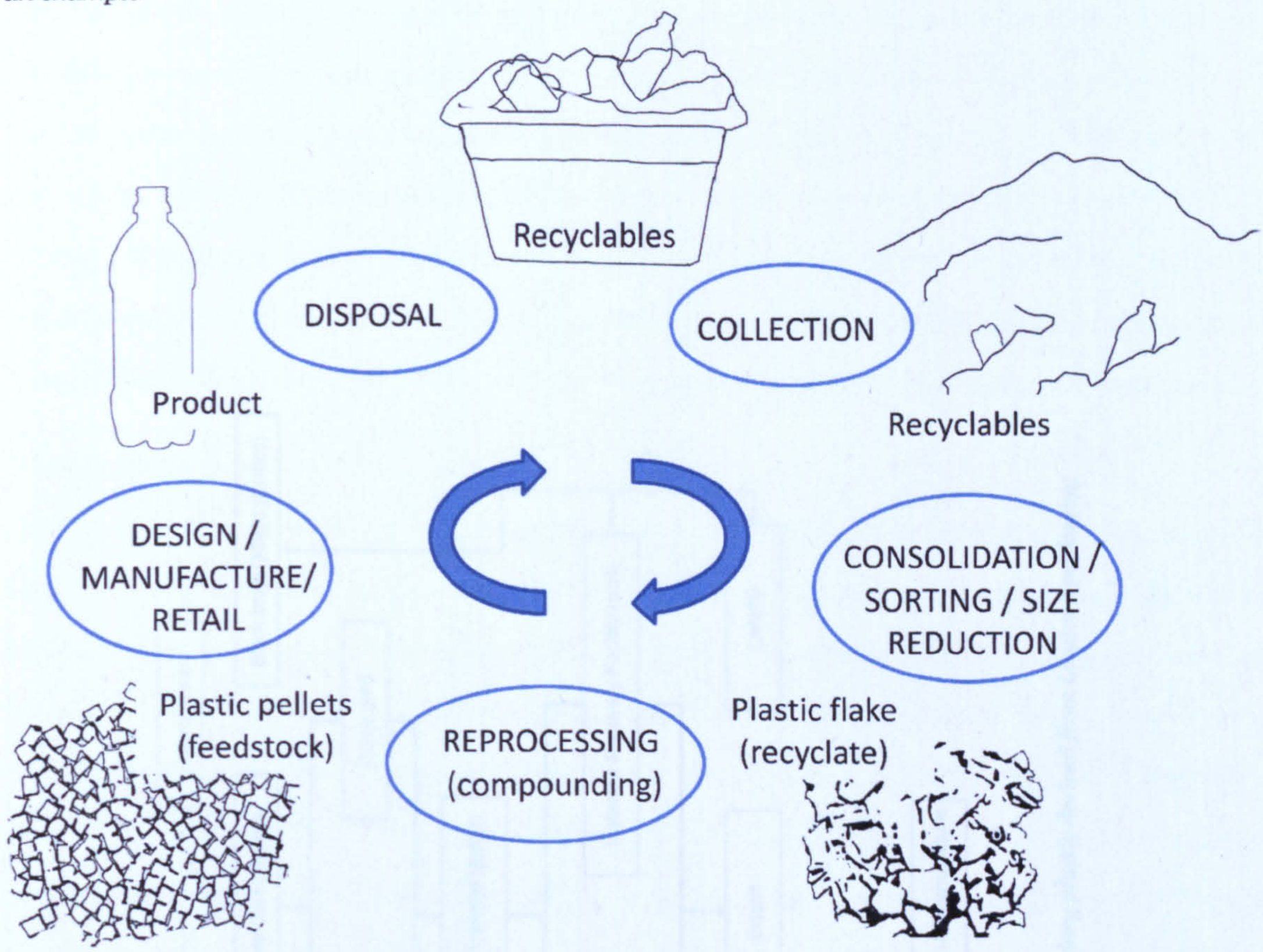
It is worth noting that the main aim of the recovery process is always to achieve the cleanest material streams economically possible, to achieve a higher 'quality' of material and therefore a higher price. 'Clean' refers to material that is free from the contamination of other material types, dirt or chemicals. Due to the low cost of virgin plastic, there is a limit to how much 'cleaning' can be economically achieved [Rec Mat

[89] This is the best available data for the types of manufacturing businesses located in London, however it doesn't describe what activities are undertaken at these locations; they could be offices, assembly sites or manufacturing facilities.

[90] This was mentioned by one of the expert interviewees [mat eng], Colin Williamson from Smile Plastics, and was also frequently mentioned by those working in the waste management industry who were met by the author during the enquiry.

Man expert]. There is increasingly a need to be able to validate the properties of the recovered material to reduce risk and understand the material's potential use (Chick & Micklethwaite 2004b; [Sust Eng expert]).

Figure 5.4.2: Specific terms used to describe the different stages of 'recycling', using packaging plastic as an example



Plastic Packaging

Plastic packaging may not be the most prolific domestic waste by weight, but by volume it has a substantial presence, meaning that it is the most visible material in kitchen bins and takes up a lot of space (WRAP 2008a). Figure 5.4.3 shows the general movement of plastic packaging according to the findings of this investigation.

Collection

Although there are strong arguments for source-separated packaging recycling systems[91] because of the single polymer streams that can be achieved, the trend in London is towards co-mingled recyclables that are then sorted at a Material Recovery Facility (MRF)[92]. This is due to the limited space available for separate bins in such a densely populated urban environment, making 'one bin for all' more feasible, and also because simple systems are likely to encourage participation particularly amongst less affluent or second-language communities. However, collection systems differ between authorities which confuses people leading to a call for the standardisation of collection systems (Sage 2008).

[91] See for example The Campaign for Real Recycling http://www.realrecycling.org.uk/ (accessed 10/06/09)

[92] The evidence for this trend is anecdotal, based on observations and opinions of people working in the waste management industry. However, the majority of London Boroughs (22 of 33) now operate co-mingled as opposed to 'kerb-side sort' recycling collections (Capital Waste Facts 2009)

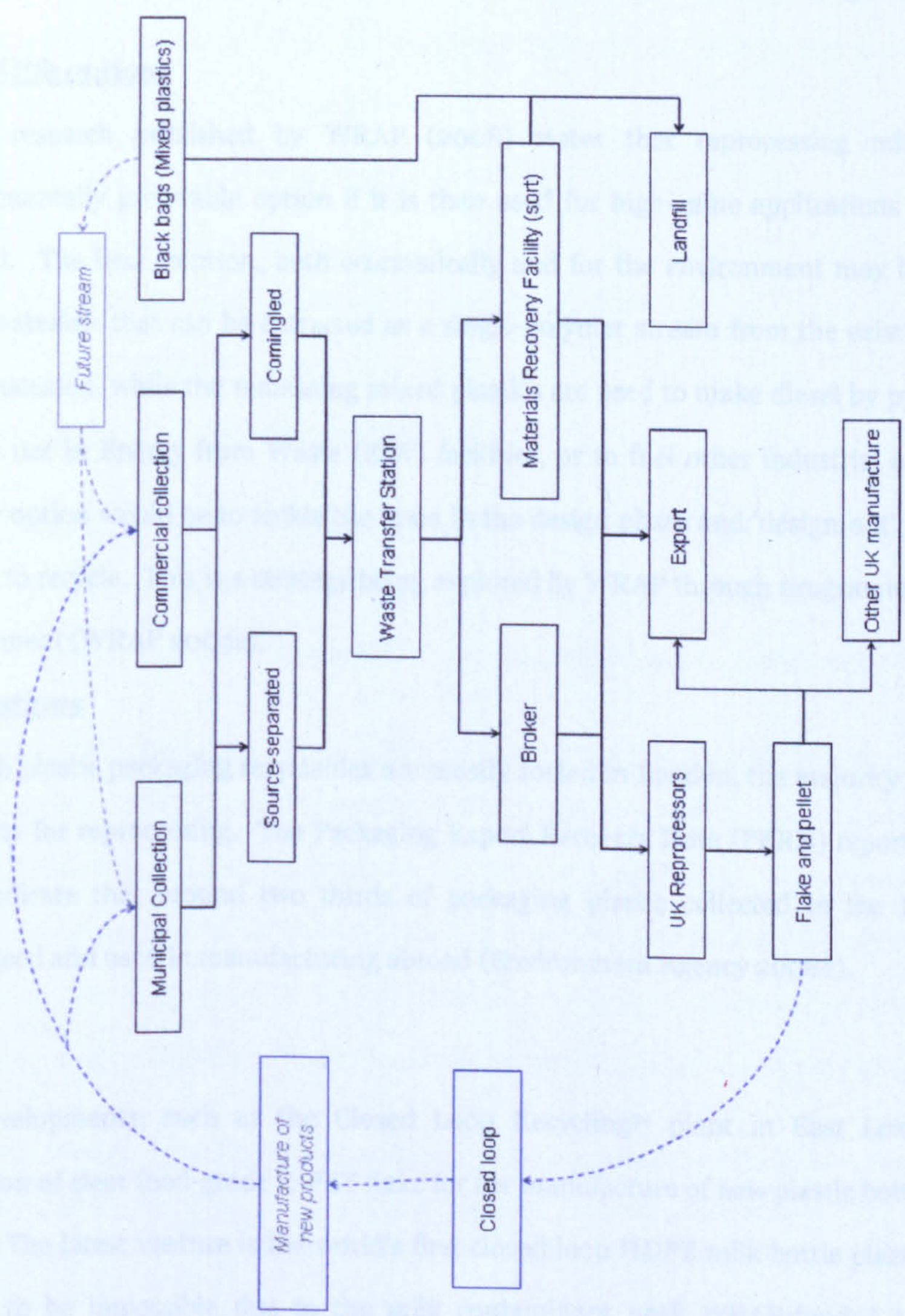


Figure 5.4.3: Movement, treatment and destinations of secondary plastic derived from London's packaging

Sorting

Although most MRFs claim to recover up to 95% of input materials the actual figure is likely to be much lower and the contamination in recovered material may be higher than necessary.[93]

PET bottles currently form the most stable fraction of the secondary packaging plastic stream. The variety of 'other' plastics used in packaging and the difficulty in separating them economically and effectively has lead to a mixed plastic waste stream that is of little market value (Sage 2008). As such most Local Authorities currently only collect bottles and most mixed plastic waste continues to go to landfill (WRAP 2008a). With increased public and government pressure this issue is now being addressed through the development of improved separation technologies and will apparently lead to the capture of mixed plastic packaging recyclables across the UK (Sage 2008), which is expressed in the figure 5.4.3 as 'future stream'.

End-of-life options

Recent research published by WRAP (2008) states that reprocessing mixed plastic is only an environmentally preferable option if it is then used for high-value applications where virgin material is replaced. The best solution, both economically and for the environment may be an integrated strategy where materials that can be extracted as a single-polymer stream from the existing mixed plastic stream are reprocessed, while the remaining mixed plastics are used to make diesel by pyrolysis, Solid Recovered Fuel for use in Energy from Waste (EfW) facilities, or to fuel other industrial activities (WRAP 2008a). Another option would be to tackle the issue in the design phase and 'design-out' grades of plastic that are difficult to recycle. This is a strategy being explored by WRAP through programmes such as the Courtauld Commitment (WRAP 2009a).

Destinations

Although plastic packaging recyclables are mostly sorted in London, the majority are then transported out of the city for reprocessing. The Packaging Export Recovery Note (PERN) reports for the first quarter of 2008 indicate that around two thirds of packaging plastic collected in the UK was exported to be reprocessed and used in manufacturing abroad (Environment Agency 2008a).

Trends

New developments, such as the Closed Loop Recycling[94] plant in East London, have enabled the production of clear food-grade R-PET flake for the manufacture of new plastic bottles in the UK since June 2008.[95] The latest venture is the world's first closed loop HDPE milk bottle plant,[96] a concept which was thought to be impossible due to the milk contaminant until WRAP-funded technology trials proved

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[93] This was observed by the author when visiting MRFs where sorted material had obvious signs of contamination, For example, plastic bottles in a bale of aluminium cans. Frequently the pace and volume of material being sorted resulted in ineffective sorting or recyclable material being discarded. People at the facilities talked about 'sending loads back' because the material didn't meet the specification standards for the plant.

[94] See www.closedlooprecycling.co.uk (accessed 10/06/09)

[95] Currently up to 50% content in new packaging (WRAP 2006c)

[96] Currently 30% content in a new milk bottle (WRAP 2007)

otherwise (WRAP 2008b). Both closed-loop projects were managed by Nextek, a technology company founded by two entrepreneurs from Australia. Knowledge transfer from Australia's recycling industry has been instrumental in UK developments; the model for London Remade's Mayors Green Procurement Code - a sign-up scheme for businesses to increase the procurement of products made from recycled materials – was imported from Victoria. A further development for mixed plastics is Powder Impression Moulding (PIM) a technology development, part funded by the Technology Strategy Board (TSB), which compresses mixed plastic into construction hoarding boards. This is an interesting development because the plastic waste does not need to be sorted or cleaned and, reportedly, can be recycled into the same product many times[97].

Secondary plastic materials commonly available from packaging waste

During the study it was observed that the following materials were available as a result of reprocessing waste packaging plastic collected in London:

- Food grade Polyethylene Terephthalate (PET) pellets and flakes
- PET pellets and flakes
- High Density Polyethylene (HDPE) pellets and flakes
- Polypropylene (PP) pellets and flakes
- Low Density Polyethylene (LDPE) Pellets

Types of plastic that are not currently a common output from packaging reprocessing include Polyvinyl Chloride (PVC), which is difficult to separate from other plastics and is being phased out by the packaging industry[98], and Polystyrene (PS) which is not commonly collected (Capital Waste Facts 2009).

Waste Electrical and Electronic Equipment (WEEE) and other rigid plastic

The processing of WEEE and consequential plastic recovery is still at an early stage of development with significant barriers to using the resulting materials in manufacture. The presence of additives, such as brominated flame retardants (BFRs), conflicts with the Restriction of Hazardous Substances (RoHS) directive for electronic products (WRAP 2006a). WRAP, in collaboration with Axion Recycling, have conducted a study to develop and test a process for removing these additives but warn:

> The BFR polymer treatment processes that were developed in the course of this study are still likely to require 2-4 years of further development before they can be deployed commercially at large scale. Until commercially viable treatment processes are available, the

[97] Environmental Recycling Technologies (ERT) has the technology license, see www.ertplc.com/pimprocess.htm (accessed 14/03/09)

[98] For example Marks and Spencer phased out all PVC from its packaging by 1st January 2000 (Marks & Spencers 2008)

> options available for disposal of BFR-containing WEEE polymers will be export for recycling outside the EU,[99] landfill or incineration with energy recovery.
>
> (WRAP 2006a:4)

The report also highlights that there are two types of WEEE separation facility; small sites are manually operated and can recover fairly clean single polymer streams while the larger facilities produce large quantities of shredded mixed polymers which are limited in terms of their use in new products. However, in June 2009 WRAP, Axion Recycling and Indesit announced the successful completion of the first WEEE closed loop project in the UK, where secondary plastic derived from old fridges was used to manufacture a new washing machine part.

Secondary rigid plastic is also recovered from vehicles, garden furniture, toys, pallets, wheelie bins and other non-WEEE products that are sorted and treated in London at the Express Recycling Park in Rainham, Kent. This facility produces ABS, PP/PE mix and LDPE flake, 70% of which is reputed to remain in the UK for the manufacture of black outdoor and construction products. Express Recycling also operate some closed-loop services for wheelie bins and non-load-bearing car parts.

Figure 5.4.4 shows the general movement of WEEE and rigid plastic according to the findings of this investigation.

Secondary plastic materials currently available from WEEE and other rigid waste

During the study it was observed that the following materials were available as a result of reprocessing WEEE and rigid plastic collected in London:

- Low-density polyethylene (LPDE) pellets
- Polystyrene (PS) / High Impact Polystyrene (HIPS) pellets (black and off-white)
- Black Acrylonitrile Butadiene Styrene (ABS) or Polypropylene (PP) pellets
- Black PP/Polyethylene (PE)mixed pellets or coloured PP/PE flakes
- Components and parts for reclamation and reuse
- Preformed materials such as black outdoor and construction products

This plastic stream holds great potential for use in new high-value mass-produced artefacts as it could lead to large quantities of single-type, rigid, non-packaging secondary plastic and the opportunity for 'single-sourcing' (discussed in section 5.4.2), as long as RoHS regulations can be adhered to.

[99] RoHS is an EU directive and therefore not applicable in non-EU states which means that material that can't be reprocessed in the EU may be sold further afield.

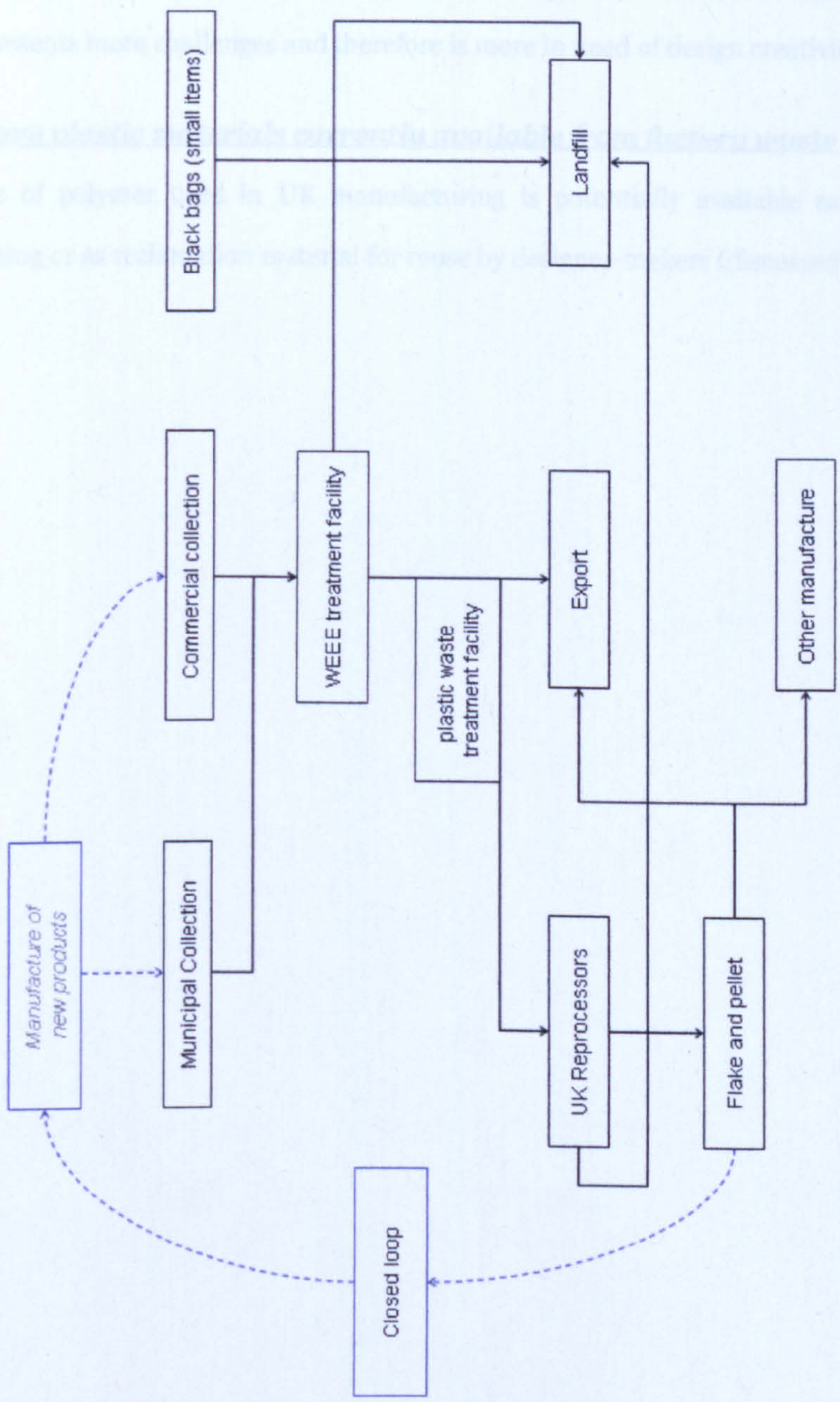


Figure 5.4.4: Movement, treatment and destinations of secondary plastic derived from Waste Electrical and Electronic Equipment (WEEE) ('commercial' includes producer service centres)

Secondary Plastic from Factories

UK plastic reprocessors source much of their input material from factories, where the secondary material is extremely clean compared with post-consumer sources which may contain unknown contaminants. Figure 5.4.5 shows the general movement of secondary plastic derived from factories according to the findings of this investigation.

It is difficult to quantify the availability of secondary plastic from factories; where plastic products are manufactured there is likely to be a secondary material stream, enabling *single-sourcing* (discussed in section 5.4.2). Many manufacturers feed their waste directly back into production but this is not always possible without an additional reprocessing step in between. This type of secondary plastic perhaps offers the best opportunity for use in consumer products as it presents less risk to manufacturers. Post-consumer plastic presents more challenges and therefore is more in need of design creativity.

Secondary plastic materials currently available from factory waste

Any type of polymer used in UK manufacturing is potentially available as factory waste, either for reprocessing or as reclamation material for reuse by designer-makers (discussed in section 5.4.2).

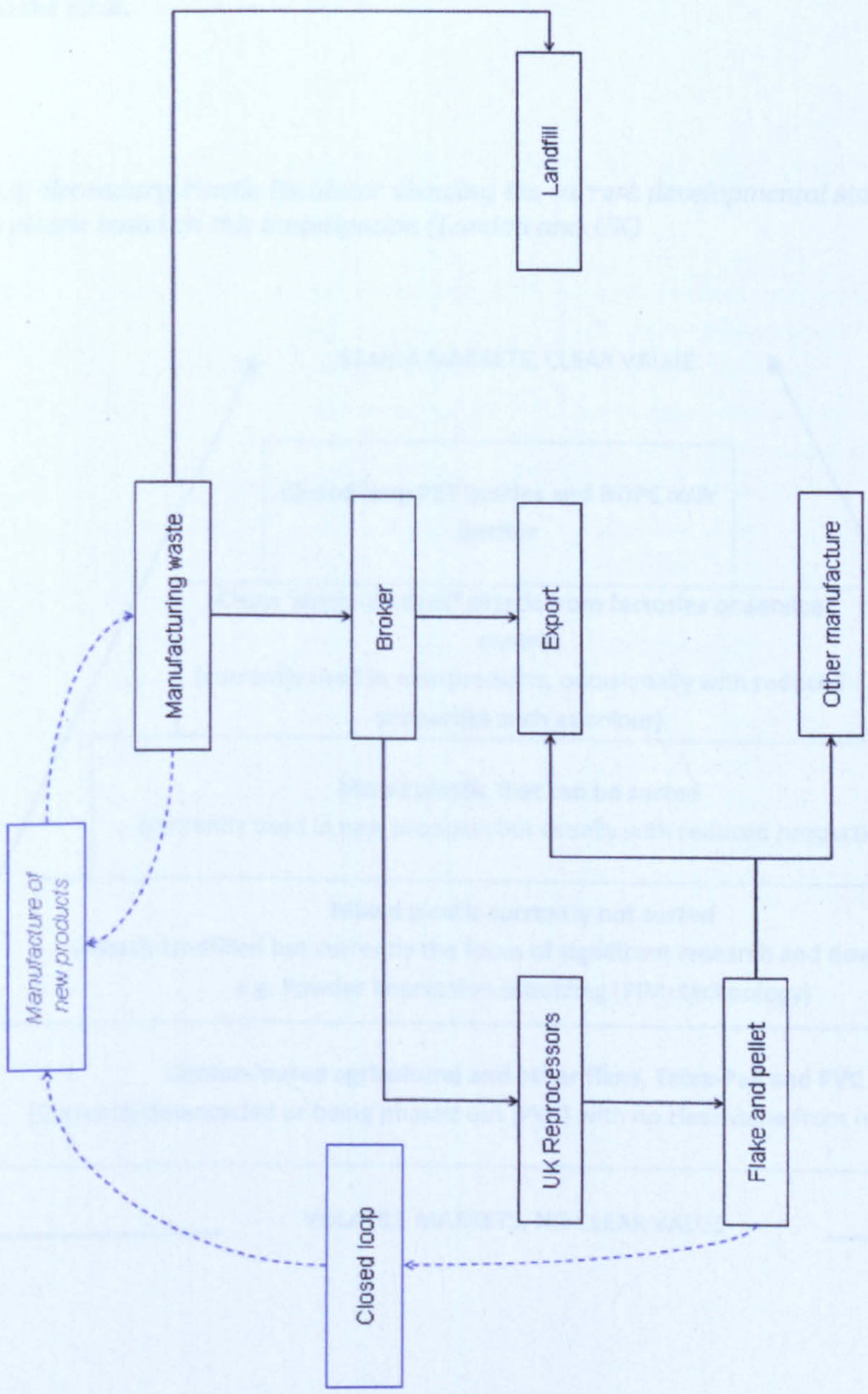


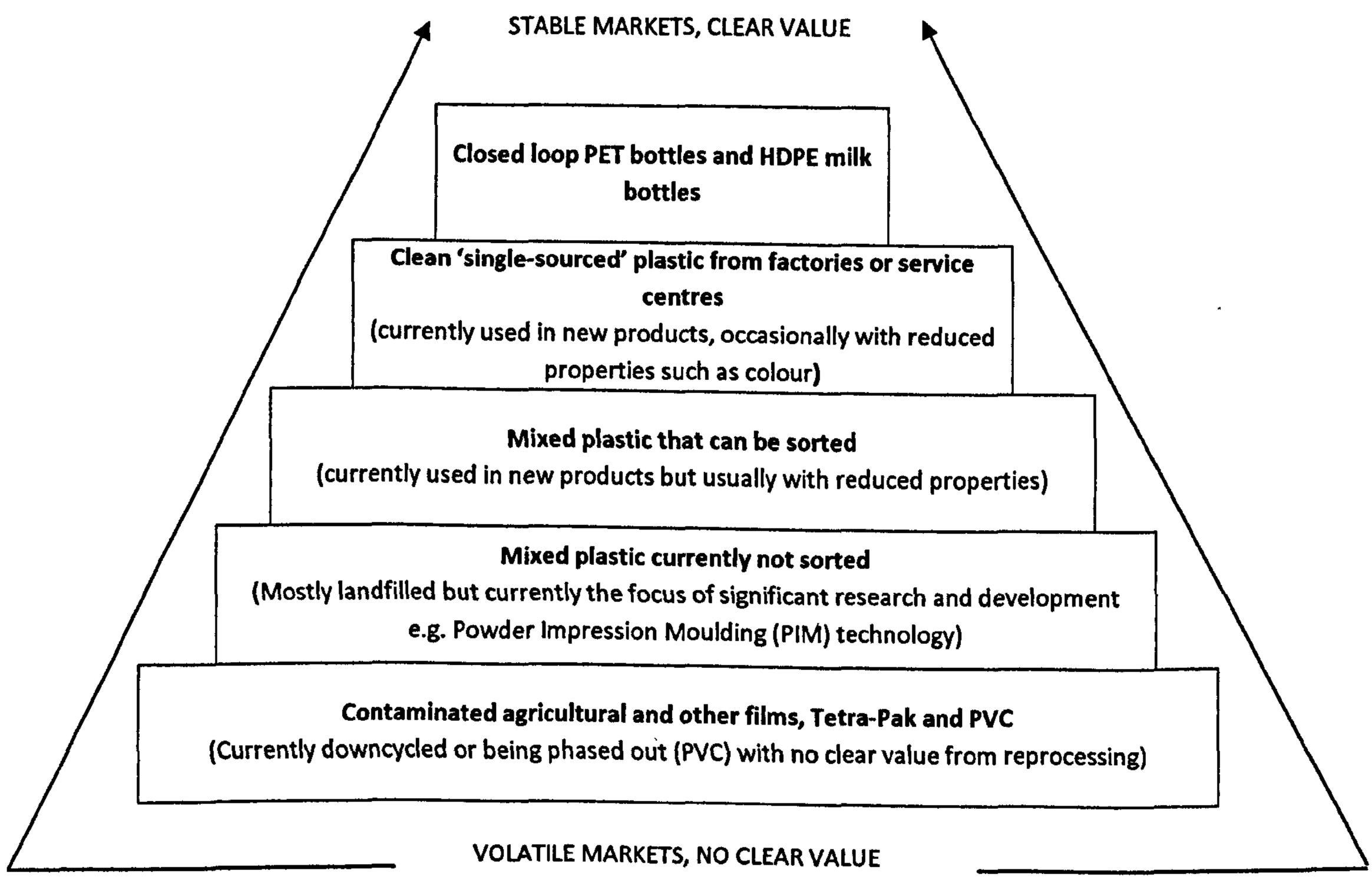
Figure 5.4.5: Movement, treatment and destinations of secondary plastic derived from factories

Secondary Plastic Escalator

The findings of the investigation into the collection, movement, treatment and reprocessing of plastic in London, presented above, can be mapped onto the *Secondary Material Escalator* introduced in section 5.2.1.

The *Secondary Plastic Escalator* (figure 5.4.6) captures the current developmental stages of different types of secondary plastic in London and the UK, according to the findings of this investigation. As with the general secondary material escalator, the most problematic secondary plastic stream is situated at the bottom, and the plastic with the most stable market is positioned at the top. This situation is, of course, in flux and there are intricacies involved that are not represented in this simplified diagram. However, the aim is to acknowledge the current situation and to understand the process of moving from the current situation to the ideal.

Figure 5.4.6: Secondary Plastic Escalator showing the current developmental stages of different types of secondary plastic based on this investigation (London and UK)



Preferable EOL Options

Based on this investigation it is also possible to propose the most preferable end-of-life (EOL) options for general artefact types (fig. 5.4.7). These are based on the current system and technologies available; as systems and cultures change, so will the best ways to achieve effective material cycles.

Optimum Design-life and Supply(column 3 in fig. 5.4.7) may benefit from further explanation. The *design-life* given here is approximate and based on observations of the current situation. The consideration of whether a type of product is likely to produce a *consistent supply* of homogenous material is also important to effective material cycles, which appears to be more likely with packaging and disposables where the design-life is fairly predictable and the throughput of similar material grades is high. The design-life of the artefact may also determine whether the resulting secondary materials are *'retrospective'* and are therefore more difficult to use or reprocess[100].

Figure 5.4.7: Most desirable and feasible end-of-life approaches for different artefact types, according to the findings of this investigation

Artefact Type	*Example*	*Optimum Design-life and Supply*	*Most Desirable and Feasible EOL Approach (in order of preference)*
Packaging	Food packs etc.	1 – 12 months Consistent supply	Closed loop (external) Secondary material consolidated single polymer Biopolymer (if managed effectively)
Disposables	Toothbrushes, razors, CDs etc.	1 – 12 months Fairly consistent supply	Closed loop (external) Secondary material for consolidated single polymer Biopolymer (if managed effectively)
Technology (superseded by updated versions)	Phones, audio equipment, cars etc.	2 – 5 years Fairly consistent supply Fairly retrospective	Repair, upgrade or remanufacture Closed loop (internal) Secondary material for single-sourcing Secondary material for consolidated single polymer
Durables	Furniture, crockery, houses, bicycles etc.	25 – 50 years Inconsistent supply Retrospective	Repair or remanufacture Closed loop (internal) Secondary material for single sourcing Secondary material for consolidated single polymer

[100] For example the constant changes in fashion for types of materials used (white laminated chipboard bedroom furniture may have been fashionable in the 1980s whereas the current trend may be oak laminate) and new regulations (the materials used to make televisions in the 1980s contained Brominated Flame Retardants which are now banned, meaning that new technologies are needed to remove these substances from secondary material (WRAP 2006a)) may make the material (or artefact) less easy to reincorporate into current material cycles.

Current Trends and Possible Future Scenarios for Secondary Plastic

Over the course of this research (2006 – 2009) substantial economic and political changes have taken place, which have undoubtedly affected material use. Oil prices rose to the unprecedented level of $137 a barrel in august 2008.[101] Shortly after, a prolonged period of economic stability and growth in many countries came to an abrupt end in October 2008. The sudden downturn devastated global markets for both virgin and secondary material; figure 5.4.8 shows how prices for virgin metals, secondary metals and plastics all peaked in summer 2008, then took a dramatic fall in October. Prices for secondary materials stabilised in early 2009 and the implication is that summer 2008 prices were economically unsustainable. Recovering material properties is the key to creating stable secondary material markets that can survive fluctuating economic conditions, as WRAP's director of market development Marcus Gover states: "There will always be a spectrum [of secondary material quality] but those that can produce the higher quality materials are going to be more resilient to changes in the economy - they are going to have the most valuable materials." (Height 2009:no pg. no.).

Economic changes could perhaps assist in creating more effective materials cycles by rendering the production of secondary materials with reduced properties uneconomical.

The cost of removing unknown contaminants in recovered materials is a significant barrier to recovering high-value materials from a waste stream; the problems therefore with recovering and reprocessing materials are not technological but economic and systemic. In the right circumstances it could be possible to process recovered plastics to as high a specification as virgin polymers, for example if oil supply was severely limited and renewable energy was abundant. These types of hypothetical future scenarios are discussed briefly here to reflect upon the potential for dealing with secondary materials in more effective ways.

Building tomorrow's plastic mines

If plastic becomes scarce and its value rises, it may become economically viable to retrieve it from wherever it resides, even if that means excavating landfill sites.[102] This makes little sense in terms of effective waste management; if unvalued plastics are mixed in with organic and mineral material it will make future retrieval from the burial site much more difficult and resource-intensive. An alternative might be to keep individual waste streams separate in depositories, made secure so that pollutants can't be released. The clear obstacle is the long-term investment that would be required to store it separately and safely.

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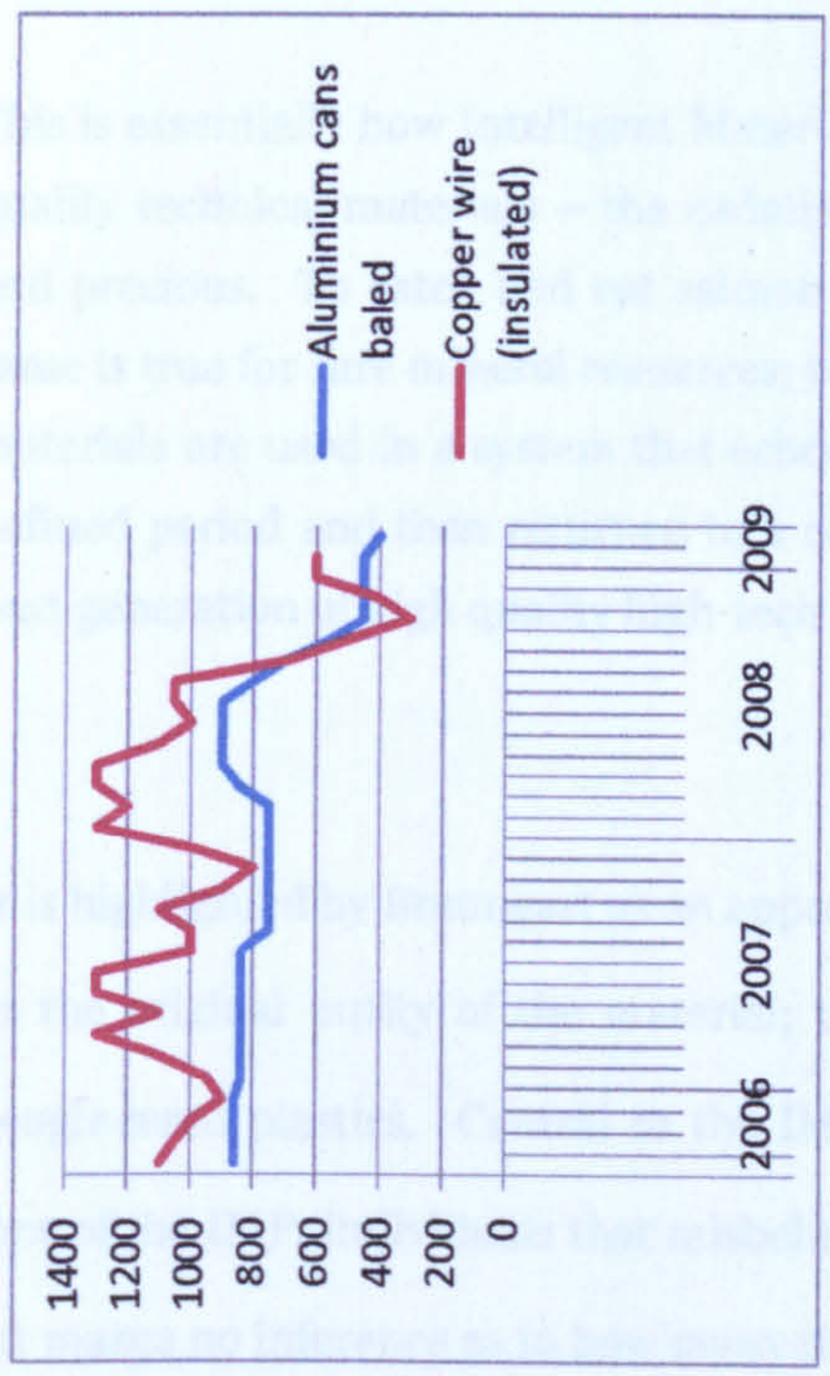
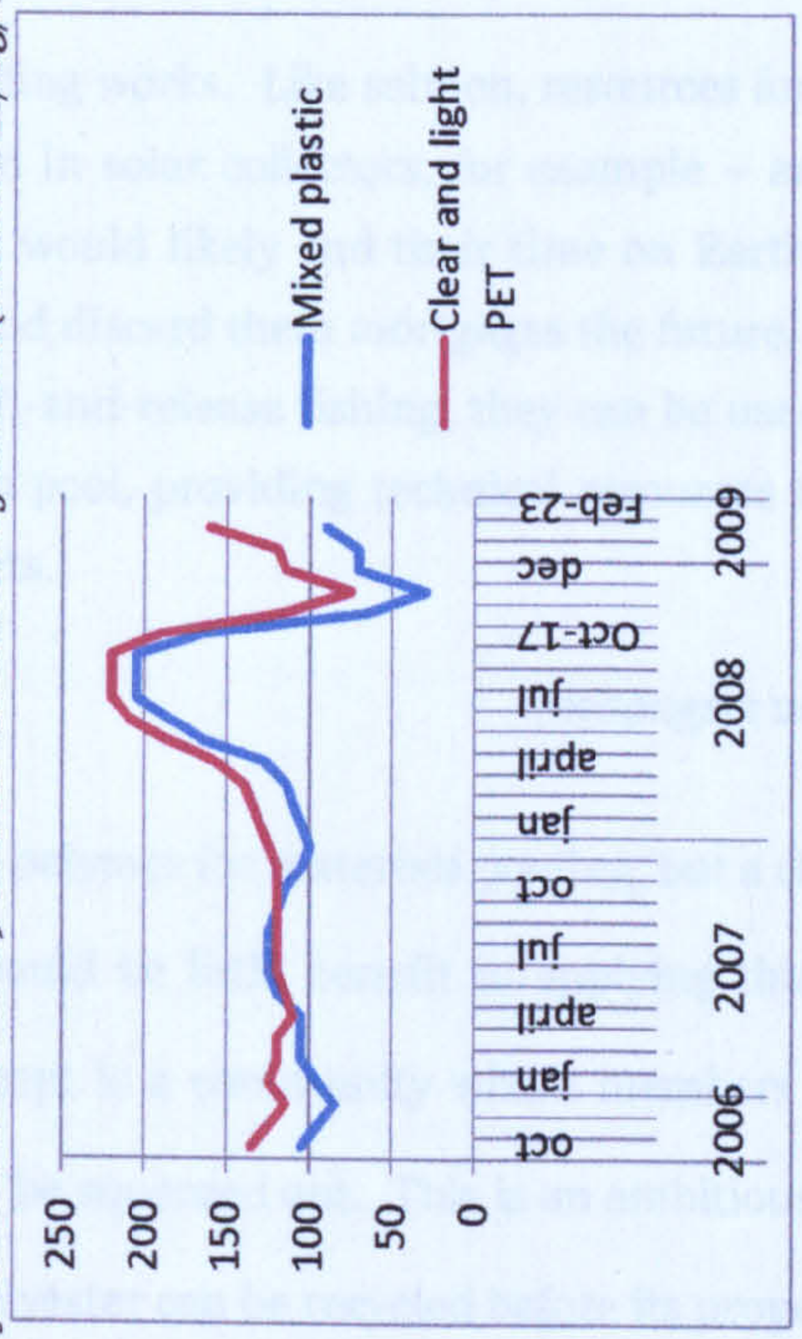
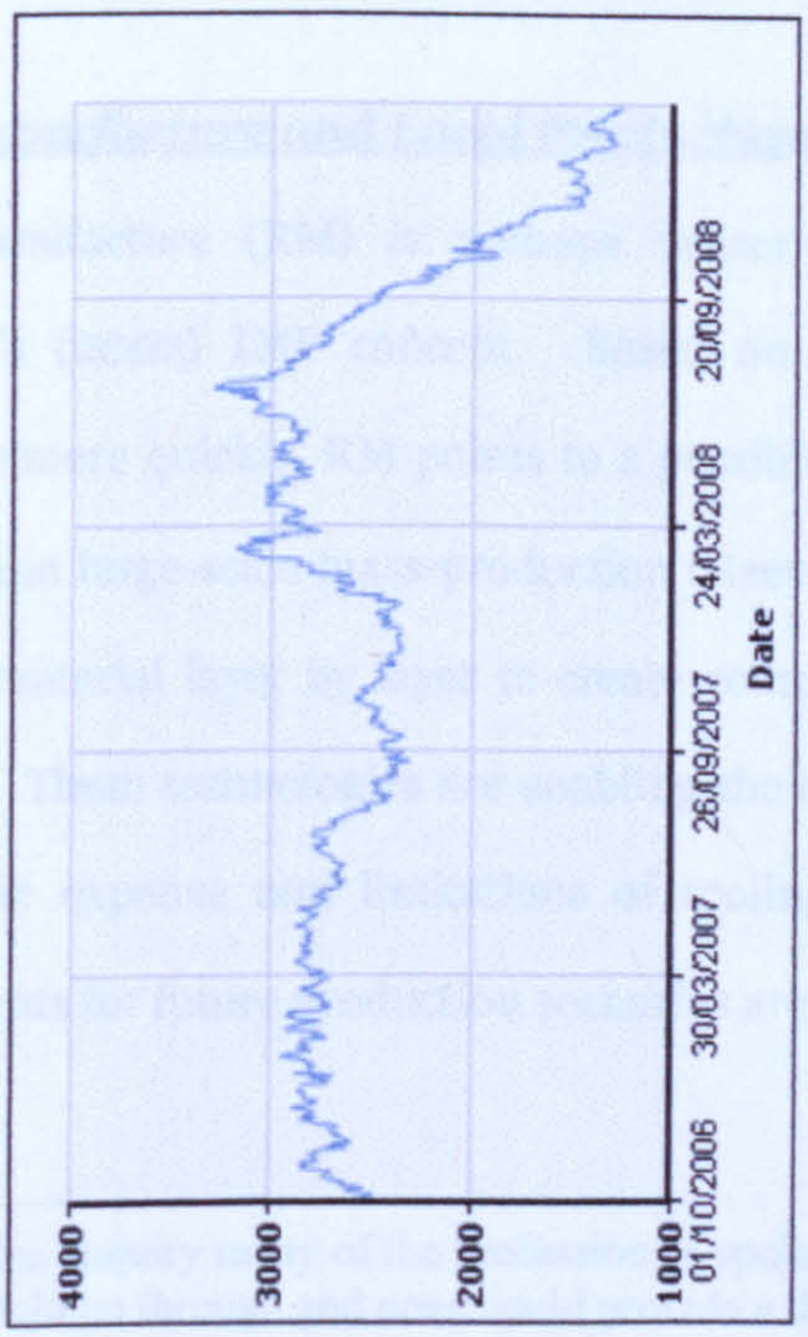
[101] According to Bloomberg.com on 09/08/08 (see also Forbes Oil Prices 1861-today http://www.forbes.com/2008/05/13/oil-prices-1861-today-real-vs-nominal_flash2.html accessed 10/06/09)

[102] For example this is reportedly being considered for rarer metals such as gold in waste circuit boards (Gray 2008)



Price curve of secondary metals (above) and secondary plastics (below) from Oct 06 to Feb 09 Source: www.letsrecycle.co.uk (Accessed 21/05/09)





Price curve of virgin aluminium (above) and copper (below) from 1/10/06 to 24/02/09 Source: London Metal Exchange http://www.lme.co.uk (Accessed 21/05/09)

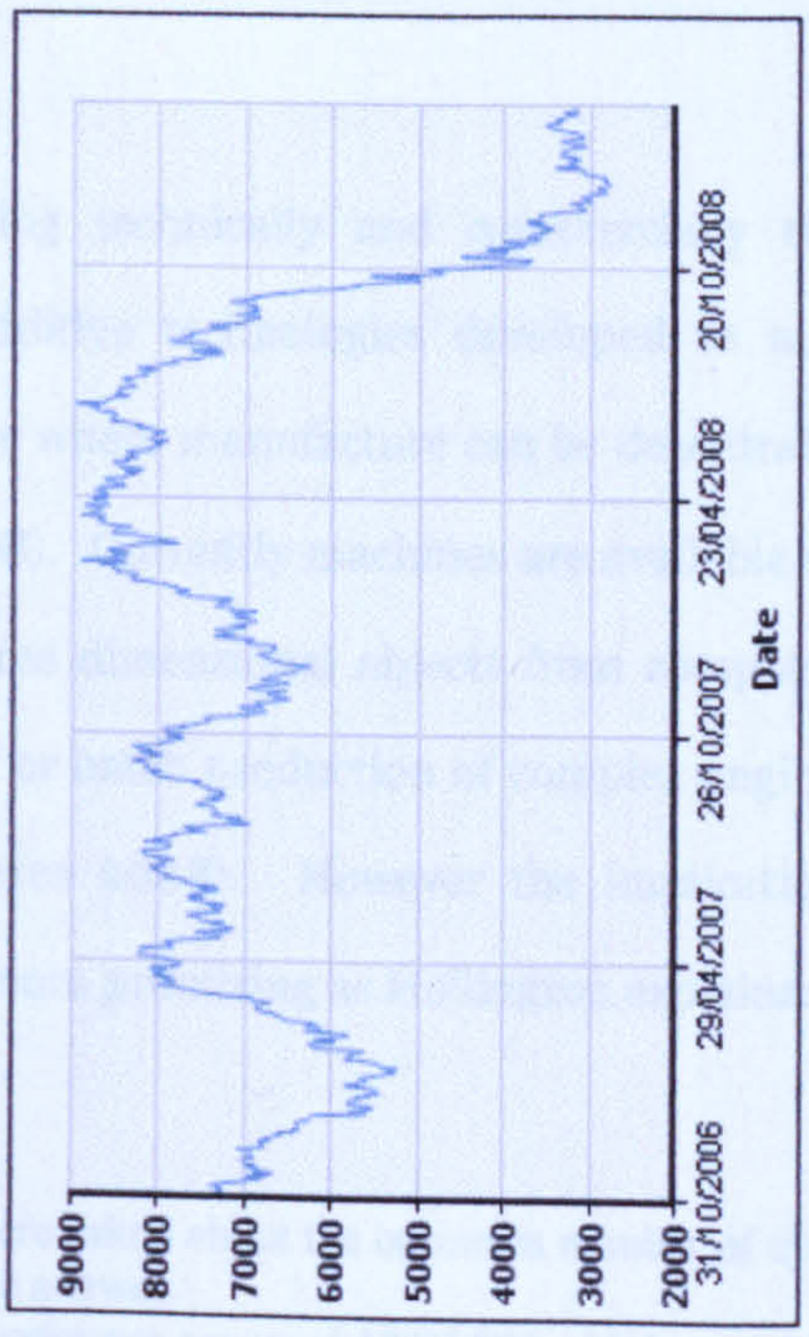


Figure 5.4.8: Material price charts, showing how prices for virgin and secondary materials peaked in summer 2008 and fell dramatically the following October. This illustration is intended to show a comparison of market volatility rather than material price; materials follow a similar market pattern regardless of source.

Intelligent Materials Pooling

McDonough & Braungart's Cradle to Cradle protocol, introduced in 2002, developed industrial ecology principles and brought them to a larger audience, capturing the imagination of some product and industrial designers. Intelligent Materials Pooling or IMP (Braungart 2002) is a future-forward development of McDonough & Braungart's belief that 'technical nutrients' or man-made materials can be managed effectively if kept within a closed cycle completely separate from the biosphere (nature). IMP is based on a simple fishing metaphor, drawn from Braungart's own experiences, as he explains:

> This is essentially how Intelligent Materials Pooling works. Like salmon, resources for high-quality technical materials – the cadmium used in solar collectors, for example – are rare and precious. To catch and eat salmon at will would likely end their time on Earth. The same is true for rare mineral resources; to use and discard them mortgages the future. But if materials are used in a system that echoes catch-and-release fishing, they can be used for a defined period and then returned to a common pool, providing technical resources for the next generation of high quality high-tech products.
>
> (Braungart 2002:1)

Polyester is highlighted by Braungart as an appropriate polymer for materials pooling, but a clear emphasis is put on the original purity of the material; there would be little benefit in applying this principle to cheaply engineered plastics. Central to the IMP concept is a community where members agree on the governance of the IMP; individuals that misbehave can be squeezed out. This is an ambitious concept and Braungart makes no inference as to how many times polyester can be recycled before its properties change, indeed this appears unknown.[103] In theory it is technically feasible to return plastic to its virgin properties but again this may be more dependent on economic rather than technical feasibility, and the ability to manage contaminants to an exacting standard.

Rapid Manufacture and Local Production

Rapid Manufacture (RM) is perhaps nearer to being technically and commercially realised than Braungart's (2002) IMP concept. Based on the additive technologies developed to make product prototypes more quickly, RM points to a possible future where manufacture can be decentralised and de-coupled from large-scale mass-production (Reeves 2008). Currently machines are available which 'build' or 'print' material layer by layer to create complex three dimensional objects from computer-generated models.[104] These technologies are enabling the one-off or batch production of complex engineering parts without the expense and limitations of tooling (Reeves 2008). However the implications of these developments for future production scenarios are even more promising as Hollington explains:

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[103] During this enquiry many of the professionals spoken to were asked about the optimum number of cycles that polymers could go through and none could provide a definitive answer.

[104] See for example Metropolitan Works (www.metropolitanworks.org accessed 10/06/09) which explains in layman's terms the main features of different RM technologies.

For two and a half million years design and manufacture have been substantially constrained by the physical limitations of manufacturing processes. RM removes this constraint in a clean break with all of history [...] it is very possible that the arrival of rapid manufacturing creates the hinge point for a second industrial revolution.

(Hollington 2007:24-26)

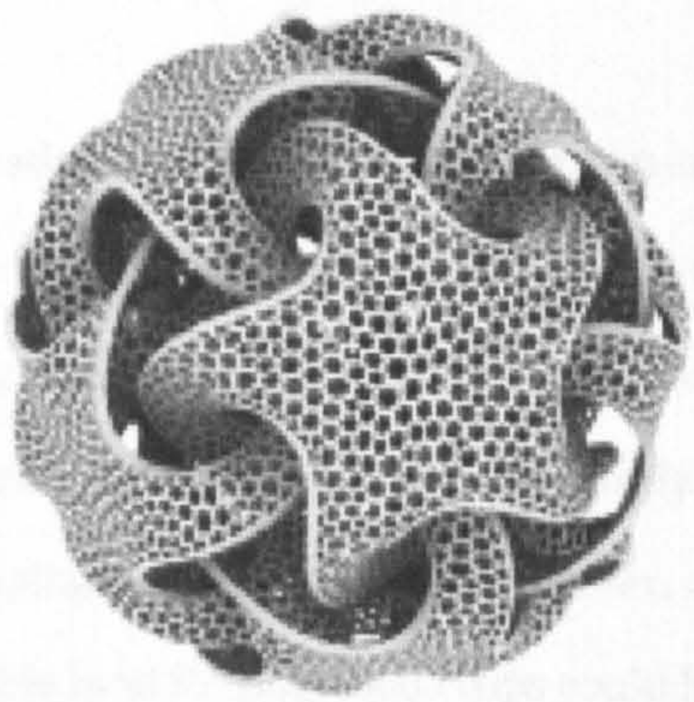

Figure 5.4.9: Quin.MGX pendent light. Designed by Bathsheba Grossman and produced by .MGX using Selective Laser Sintering (SLS) using PA (nylon)

Alongside these technological advances are the more humble activities of designer Richard Liddle, whose work is discussed in section 5.5.2. Liddle's RD4 chair[105], made using his patented URE (Uncooled Recycled Extrude) process, bears little resemblance to the intricate organic forms being produced by the materialise.MGX studios (fig 5.4.9), but in terms of the concept there are similarities. Liddle's method puts reprocessed plastic into the hands of the designer-maker and allows him/her to form a one-off artefact 'on location' without tooling or mass-production, demonstrated in the *U.R.E Live* exhibit at the Design of The Time (DOTT) festival in 2007. This approach has also been taken with other secondary materials, for example the *Fast Glass* exhibit at *Design Show Liverpool 08,* where designer Nick Munro produced new vases using the glass beer bottles from the previous night's launch party. The vases were then sold in a department store the following day (Liverpool Daily Post 2008).

Considered side by side these developments hint at a possible future scenario where secondary plastic could become feedstock for locally produced artefacts, allowing local communities to deal with the by-products of their lifestyles rather than exporting their waste. The benefits of managing secondary resources locally and on a smaller scale could include 'cleaner' material streams than can currently be achieved from large-scale sorting plants. Local community involvement could build awareness of resource value and provide jobs for local people (Dehn 2008).

[105] See fig. 5.4.16 in following section

It is perhaps difficult to see how the high specification of the polymer powder used in Rapid Manufacture (RM), could be achieved with secondary plastics, however, surplus polymer powder can be reused in the RM process (Zarringhalam *et al* 2006). Richard Hague notes, "Materials research is a key factor in RM development. RM will become increasingly effective as the properties of the materials it is able to make use of improve, year on year." (Hague 2007:12)

Post-oil materials

Biopolymers are one possible alternative to plastic derived from non-renewable sources. Made from plant-based starches, they can vary in their composition and rate of degradation (European Bio-plastics Organisation 2008). Arguments for and against biodegradable polymers have developed over the last few years (for example Gerngross & Slater 2000). If managed effectively they could be a useful alternative to non-compostable plastics for packaging and disposables. However, as the rapid demand for bio-fuels in the US has demonstrated, using arable land for non-food crops could have a negative impact on global food availability (Kingsbury 2007). Additional concerns over biopolymers have been raised such as genetically-modified (GM) content, green-house gas emissions if they are landfilled, and the difficulty of distinguishing biopolymers from oil-derived polymers, which presents a significant contamination risk during recycling (Dvorak & Kosier 2008). A further criticism is the use of valuable resources to produce a material which is only useful for weeks. The real benefit of polymers derived from plant material is likely to be the ability to control their durability, from a material which lasts only weeks in one application to one which is durable and recyclable in the same way that existing plastics are, giving future generations the ability to *grow* plastic[106].

The introduction of new materials highlights the tension between innovation and stability in the material cycle; where does the consideration of material recovery come into these exciting material advances? Benjamin comments:

> The mixing and combining of materials, both of traditional and new ones, which can also lead to new properties, is of growing importance. This will certainly have its impact on the processing and manufacturing of materials. It will however also influence the possibilities for material reuse, the nature and efficiency of waste treatment, occupational exposure and the associated environmental pollution problems.
>
> (Benjamin, Edirisinghe, & Zwetsloot 1994:13)

This is not to suggest that materials research should be halted or hindered but, at some point in the design and production of new materials, the lifecycle and the ability to recover the immense value embodied in that material must be considered (Geiser 2001). The pressure to consider these issues will inevitably increase in the course of deciding which materials best suit future resource challenges.

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[106] This idea developed as a result of a conversation with Colin Williamson at a conference: *Plastics: Looking to the Future and Learning from the Past,* May 2007.

5.4.2 Existing Approaches to Utilising Secondary Plastic in Design

Having identified some of the current trends in the recovery of plastic materials in London, this section will explore what designers have already done to exploit the secondary plastic made available by this system. In particular this part of the enquiry sought to understand the approaches designers have used and the scenarios that enabled these approaches to be taken.

The author had some prior knowledge of secondary plastic use in design (Hornbuckle 2008) and during the enquiry additional examples were encountered. The ten examples discussed here (figs. 5.4.10-19) were chosen to represent the variety of approaches encountered by the author during the enquiry. The frequency that each approach is observed in the chosen examples is not meant to be representative of the popularity of that approach in the wider population. In some cases the author met with the designer, developer or reprocessor who was involved in the project (see Appendix B(i)). In other cases the artefact itself and its production method (confirmed by the designer via email or from other sources) were the primary source of information. Figure 5.4.20 outlines the main characteristics of these designs in line with the research questions.

Some common themes are then explored, in reference to these examples, to build on the theory developed in Enquiry 1 about how the design scenario may affect the ability of the designer to consider and use secondary materials. The 'types' of designers referred to here were discussed in section 4.2.1.

How is Innovation Achieved Through the Use of Secondary Plastic?

The survey findings (Enquiry 1) revealed that designers consider innovation to be one of the most important factors in design. This is in concurrence with Sherwin's (2000) finding that designers are most commonly motivated by the opportunities for innovation offered by eco-design, rather than just environmental concerns. Sympathies towards sustainability issues were apparent, to differing degrees, in all examples of secondary plastic use explored in this enquiry which may have led to the consideration of alternative materials. However, in these examples other factors such as aesthetics and usability are equally, if not more, important to the success of the design.

New Methods of Production

Several of the designers have explored new methods of production to overcome the difficulties of utilising secondary plastic. Australian designer Damien Melotte has developed the mottled 'jazz' material, popularised in the UK by Smile Plastics, by teaming up with Wharington International[107] to thermo-press mixed Acrylonitrile Butadiene Styrene (ABS) resin chips (from Telstra telephones and Holden car parts) into a three-dimensional mould. The resulting *Kiljuhanhi swivel chair* (fig. 5.4.11) gives a full three-dimensional form to a material aesthetic previously only seen in sheet form. This approach also enables

[107] Wharington International: www.wharington.com.au

the artefact to be manufactured directly from chips to chair, removing the need for a middle reprocessing phase.

The challenge of removing the number of production phases between secondary plastic and end-product was one of the innovations demonstrated by Richard Liddle's *RD4 chair* (fig. 5.4.15). A unique extrusion tool named URE (Uncooled Recycled Extrude) was developed, providing the designer with a hands-on technique for using the fluid plastic to create a new artefact. This concept challenges the conventional method of production for new plastic artefacts by potentially allowing them to be made in the same location as the source of the secondary material. For example, in the future this system could be used to create new school furniture from a pile of plastic bottles left over from lunch break, rather than being transported for reprocessing further afield.

Clothing producer Patagonia was one of the first to use recycled plastic bottles to make fleece fabric for its outdoor clothing range in 1993. In this process the material recovered from recycled PET (polyester) bottles is used to make a high-value item of clothing, but to do this the properties of the plastic are changed, making it less versatile than the PET originally used to make the bottle. In 2005 Patagonia was able to go one stage further with *Capilene* (fig 5.4.14), a polyester clothing product developed in collaboration with manufacturer Teijin[108], which is recovered from end-users and reprocessed into an identical item of clothing.

The innovation offered by secondary plastic in all three of these examples is therefore in the production method.

Business Leadership

There are three clear examples where the impetus for using secondary plastic has come from innovation in the business model, in favour of sustainable practices. Sustainability is a central feature of both Patagonia's and Herman Miller's corporate identity and PLI Design has also led the field in championing sustainable furniture production in SMEs. The benefits to the companies involved are brand differentiation and, in the case of Herman Miller, Cradle to Cradle Accreditation. The benefit to the designers is that sustainability is inherent in the brief, diminishing many of the obstacles identified during Enquiry 1.

[108] Teijin: www.teijin.co.jp/english/ (accessed 21/15/09)

Figure 5.4.10: Cycloc bicycle storage and security device, made from 100% (post-industrial) secondary plastic. Design and image: Andrew Lang

Figure 5.4.11: Kiljuhanhi Chair, made from ABS chips derived from phone and car parts. Design and image: Damien Melotte

Figure 5.4.12: Deluxe Bench for the Ordinary Furniture range, made from plastic wood containing 100% secondary plastic. Design and image: Ineke Hans Studio

Figure 5.4.13: Multisheer Panel, made from reclaimed PET sheet. Design and image: Kate Goldsworthy

Figure 5.4.14: Capilene Baselayer, made from 64% closed-loop polymer fibre.
Design and image: Patagonia

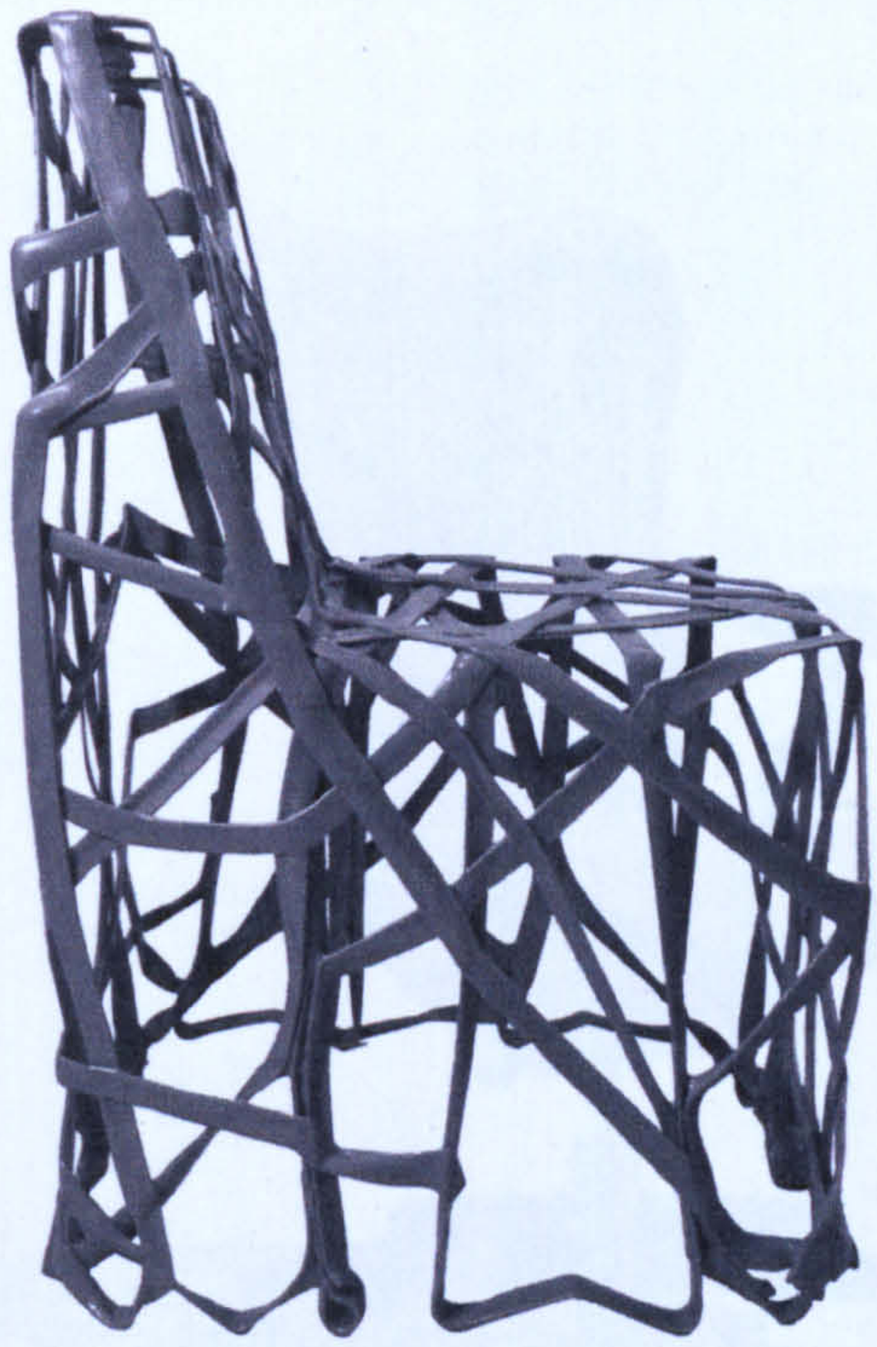

Figure 5.4.15: RD4 chair, made from secondary polymer using the URE process.
Design and image: Cohda Design

Figure 5.4.16: Mobile Phone plastic sheet, made from removable cases from mobile phones.
Design and image: Smile Plastics

Figure 5.4.17: REEE chair, made from reprocessed secondary plastic derived from Sony Playstations.
Design: Sprout Design and PLI Design. Image: PLI Design

Figure 5.4.18: Fret Speaker, prototype made from plastic sheet containing secondary plastic.
Design and image: Studiomold

Figure 5.4.19: Mirra office chair, containing 42% secondary materials, including plastic.
Design: Studio 7.5 for Herman Miller. Image: Herman Miller

Aesthetics

There is a clear division in the examples between those which 'look' like they are made from secondary plastic and those where the inclusion of secondary plastic is 'invisible'. Smile Plastics were perhaps the first in the UK to innovate on the basis of a 'recycled aesthetic' (fig 5.4.16), while Damien Melotte's design uses a similar aesthetic but is less obvious in its visual reference to 'waste' (fig 5.4.11). The form and colour of Richard Liddle's chair (fig 5.4.15) is directly linked to the use of secondary plastic as a result of the production process, allowing him to create an innovative aesthetic. Being made from plastic wood, Ineke Hans' *Ordinary Furniture* (fig 5.4.12) presents the user with an unfamiliar sensory experience (looking like wood but feeling like plastic) and its chunky design differs from the usual use of this material for cheap outdoor furniture. These are all examples of the 'visible' aesthetic of secondary materials. Herman Miller's *Mirra Chair* (fig 5.4.19), PLI's *REEE Chair* (fig 5.4.17) and Andrew Lang's *Cycloc* (fig 5.4.10), however, demonstrate the ability for secondary plastic to be 'invisible' which can also be seen as an innovation, given the challenges of using secondary plastic discussed earlier.

A Unique Story

PLI Design's *REEE Chair* (fig 5.4.17) demonstrates how the 'story' of recycling can be a design innovation and a useful marketing message; a chair designed for a school made from *Sony Playstations*. There is also

a simplicity in the message '100% post-consumer plastic, made in the UK' that producer Chris Pett believes is essential to the success of the design. Richard Liddle's *RD4* chair (fig 5.4.15) tells the intriguing story of turning an old plastic artefact into a new one 'on location', and thereby exposing the manufacturing process which ordinarily remains hidden in factories.

What Type of Scenario are these Designers Working Within?

It was established in Enquiry 1 that product and industrial designers' work scenarios are not generally conducive to the consideration and selection of secondary material, identifying a combination of factors. These cases could provide additional evidence of the characteristics of a design scenario where secondary plastic can be successfully utilised.

Self-initiated

All but three of the designers considered here work in a 'designer-maker' scenario, where they are their own clients, initiating their own projects and managing the design process. Rees (1997) described the designer-makers as working "at the end of the design spectrum closest to craft" (Rees 1997:130) commenting:

> It is rare for a designer, unlike a craftsperson, to combine the roles of inventor and entrepreneur. The resulting product has much more in common with the craft object. It was not a response to a commercial brief, and a single creative personality guided the process from beginning to end.
>
> (Rees 1997:129-30)

The designer-maker scenario now appears to be much more common than Rees found in 1997 but it isn't an *easier* scenario for a designer, involving the negotiation of the entire design process leading to distribution and retail. However it may be a more conducive scenario for considering the use of secondary material; the designer as "single creative personality" must choose the materials and is therefore perhaps more focused on that issue than designers in commercial scenarios. Studiomold, for example, is predominantly a commercial design consultancy but the Fret Speaker (fig 5.4.18) was a self-initiated project.

Sustainability Leadership

Three of the examples are organisations rather than individual designers; Patagonia, Herman Miller and PLI Design. These businesses operate with 'sustainability leadership', meaning that the designers working with or for them are already in a scenario where sustainability is considered an important factor, regardless of their personal motivations.

Networking and Collaboration

Direct involvement with the various stakeholders involved in a project is arguably an inherent characteristic of the designer-maker scenario. Designer-makers have to manage the whole design process

leading to market, involving production, distribution, sales and marketing, and negotiate with all of the parties involved in that process. However, these may also be characteristics essential for the utilisation of secondary plastic regardless of the designer's scenario. This is because the actors who know how to work with secondary material, and those that want to, are likely to be fewer than those who only operate with virgin plastic and who are not sympathetic towards this type of project. Networking was an essential during the development of PLI Design's *REEE Chair* (fig 5.4.17) in particular, which enabled the identification of a specific end-user (schools) and a single-source secondary material (from Sony Playstations). The director of PLI, Chris Pett, also stressed the importance of the manufacturer-designer collaboration which made the project possible. This example supports the theoretical framework presented in Enquiry 1, that the designer's ability to communicate well with other project stakeholders is central to a scenario conducive to the selection of secondary material.

Academic Practice-based Research

Two of the designers presented here developed their use of secondary plastic during academic practice-based research. The research for Richard Liddle's URE process took place during an MPhil degree, and Kate Goldsworthy decided to undertake a practice-based PhD to fully explore the theoretical and practical context of her use of secondary plastic in textile design (fig 5.4.13). The implication is that neither of these designers would have had the time or space to develop the processes that led to these artefacts, had they not enrolled on a research degree.

Financial Support

As discussed in relation to the *Plastic Material Escalator*, subsidisation of Research & Development appears to be an essential part of raising secondary plastic from low-value to commercial self-sufficiency in the open market. Dehn (2008) identified that government subsidies had enabled some manufacturing sites, for artefacts made from secondary plastic, to be built in areas of deprivation. Of the example presented here, PLI Design and Andrew Lang received funding and business support through London Remade[109] to enable secondary plastic to be used in the manufacture of their designs.

[109] Funding provided by the London Development Agency (LDA) and the European Regional Development Fund through London Remade

How is Material Sourced?

These cases provide further evidence of the types of secondary plastic material available for designers to use, and the approaches used to source them. These are presented in order of the amount of processing the material has undergone when the designer sources it, starting with reclaimed plastic where no treatment or processing has taken place.

Reclaimed Plastic

Kate Goldsworthy's approach to the use of secondary plastic (fig 5.4.13) is typical of designer-makers, craftspeople and artists, as demonstrated by the [re]design 06 exhibition catalogue.[110] The accessibility and inexpensive nature of secondary materials that are reclaimed personally by the designer make them ideal for one-off and batch-produced artefacts. While this approach does not have great impact on the volume of secondary material used, it does raise awareness of waste issues and allows the individual designer to reduce the impact of their practices on resource use.

Single Sourcing for Manufacture

This method is similar to the principal of industrial symbiosis,[111] developed to address the problem of reduced material properties when plastic materials from different sources are mixed. Instead, the designer or business first identifies a source of material of the type that they want to use in the manufacture of a new object. The material stream can then be processed into pellets or flakes to create feedstock that has consistent and repeatable properties, close to the original virgin material. The main risk with this method is that the duration of the supply is uncertain, but in the event of a diminishing supply, a similar source may be found.[112] The potential benefit of a limited supply is that the artefacts are essentially 'limited editions' which could raise their value and longevity. For example, single sourcing is a method used by Smile Plastics to find interesting new sources of waste materials for their decorative panels; the example in figure 5.4.16 was made using the removable cases of mobile phones which were first introduced in 1998 by Nokia[113] and became very popular, resulting in an abundant material stream which has dwindled in recent years, preventing Smile from manufacturing any more of these panels. PLI Design is in a similar situation, when the manufacture of Sony Playstations ceases the current version of the *REEE chair* (fig 5.4.17) will essentially have been on a limited production run. The next generation of computer console may provide a suitable replacement material and the process will begin again.

Single-sourcing also enables the use of flaked or chipped secondary plastic before it has been reprocessed, allowing the original colour of the material in a mixed-colour source to be visible even though it will not be

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[110] See www.redesigndesign.org (accessed 30/04/09)
[111] Where a business with spare resources is partnered with another who can utilise that resource. See for example the National Industrial Symbiosis Programme (www.nisp.org.uk accessed 10/06/09). The danger is that this creates an obligation to produce a surplus which may not be in the interest of broader sustainability concerns
[112] It is important to note that finding suitable sources is time-consuming, Colin Williamson of Smile Plastics estimated that half his time is spent looking for new clean sources.
[113] http://www.nokia.com/A41360001?newsid=778571

achievable in subsequent cycles. This technique is demonstrated in both Smile Plastics' and Damien Melotte's designs (figs 5.4.16 and 5.4.11). The removal of a processing step also reduces the resource embodiment of the material which is more desirable from a sustainability perspective.

Reprocessed Plastic Feedstock

Reprocessing prepares secondary plastic for introduction into conventional manufacturing machinery, although some parameters may need adjustment as they would with any new grade of material. The other purpose of reprocessing is to consolidate similar material types from different sources, which addresses the problem of maintaining consistent supply at the quantities required by manufacturers. Typically this method allows the consistent supply of generic grades of plastic, often described as 'commodity' rather than 'engineering' grades, and in a reduced colour palette. Andrew Lang used this approach for the Cycloc (fig 5.4.10), and this may also have been the used for the Mirra Chair[114] (fig 5.4.19). Some WEEE waste streams have allowed for large quantities of one colour, for example off-white PS.[115]

Preformed Materials made from Secondary Plastic

Ineke Hans Studio and Studiomold have both used 'preformed materials' in their designs (figs 5.4.12 and 5.4.18); these are often sheet or profile materials manufactured using secondary plastic pellets or flakes. The benefit of this approach is that the material is consistently available as long as the manufacturer stays in business, reducing the risk of using secondary plastic. This is best suited to designer-makers and interior designers who deal mainly with preformed materials, as opposed to manufacturing feedstock.

Closed Loop

'Closed Loop' refers to the manufacture of new artefacts using secondary material derived from the same type of old artefact and, crucially, demonstrating the same properties. For example, Closed Loop Recycling (introduced in section 5.4.1) produce PET derived from old clear plastic drinks bottles ready for use in the manufacture of new clear plastic drinks bottles. This can be described as external closed-loop 'pooling' because the material is consolidated from many sources and not necessarily returned to the original producer. Patagonia have adopted a similar approach, with textile fibres for clothing (fig 5.4.14), but instead of consolidating or 'pooling' the material with other sources, they 'internalise' the closed loop. This is an intensive process involving global transportation and an additional step of breaking the polymer "down to the molecular level" (Patagonia 2009) which involves additional resources. However, Patagonia claims that this creates a more favourable footprint for the resulting garment than other available methods. Importantly, the material properties are maintained through multiple cycles; the material from a discarded garment is used to make an identical new garment.

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[114] The precise secondary plastic content and source is not identified in the Mirra product literature (Environmental Product Summary: Mirra Chair, Herman Miller, http://www4.hermanmiller.com/MarketFacingTech/hmc/products/Mirra_Chairs/EPS_MIR.pdf

[115] AxPoly: material produced by Axion Recycling www.axionrecycling.com (accessed 10/06/09)

Figure 5.4.20: Ten examples of existing approaches to utilising secondary plastic in the design of artefacts; outlining the characteristics of each approach

Designer and artefact	*Type of secondary plastic used*	*Design scenario*	*Production method*	*Design innovation*	*Consideration of material cycle*	*Consideration of other sustainability concerns*	*Primary source of information*
Andrew Lang Cycloc (fig. 5.4.10)	100% Post-industrial plastic feedstock, (UK)	Designer-maker, supported by London Remade, now in small-scale commercial production	Two parts, rotation moulded from secondary plastic feedstock	Bicycle security and storage device, innovative for its function not its material, but this appeals to the target user (cyclist)	Disassemblable, recyclable, but continued down-cycling likely	Making cycling more convenient, UK production	London Remade www.cycloc.com (accessed 10/06/09) personal email communication (march 07)
Damien Melotte Kiljuhanhi chair (fig. 5.4.11)	100% Post-consumer ABS feedstock from telephones and car parts (AU)	Self-initiated collaboration with material source and manufacturer	New production method (protected) moulding 3D shape from plastic flake	Bespoke swivel chair, innovation for the process and aesthetics which are quirky but not too obviously recycled	Dissasemblable and recyclable, but continued down-cycling likely	Proceeds donated to species conservation charity	Personal email correspondence (march 07)
Ineke Hans Ordinary Furniture (fig. 5.4.12)	Preformed plastic wood made from post-consumer PE film (NL)	Designer-maker Batch produced furniture	Cut and assembly of preformed materials	Bespoke outdoor furniture range, innovative for its aesthetics as well as the materials	Disassemblable and recyclable, but continued down-cycling likely	None claimed, but durable, bespoke design unlikely to lose value over time leading to longevity	www.inekehans.com www.lankhorst.co.uk (accessed 10/06/09)
Kate Goldsworthy Multi-sheer panels (fig. 5.4.13)	100% reclaimed PET plastic film (UK)	Academic practice-based research, designer-maker	Laser-cut and printed PET film, assembled	Decorative interior feature, innovative for aesthetics, process and use of secondary material	Disassemblable, recyclable	Bespoke design unlikely to lose value	www.kategoldsworthy.co.uk (accessed 10/06/09)
Patagonia Capilene Baselayers (fig. 5.4.14)	64% Closed loop textiles (International)	Environmentally-driven manufacturer	Material is chemically reprocessed to create new textile fibres	Basic clothing; the innovation is in the process and the sustainable business leadership	Closed-loop system	Carbon savings despite global transport, various sustainability initiatives of business, not directly linked to this artefact	www.patagonia.com (accessed 10/06/09)
Richard Liddle RD4 chair *(fig 5.4.15)*	100% Post-consumer plastic feedstock (UK)	Academic practice-based research to develop process, now designer-maker	New URE production method (protected) applying extruded plastic freely to create form	Bespoke chair, innovation for the process, the material, and the resulting aesthetics, promoted on the merits of secondary material use	Single material type, recyclable, but continued down-cycling likely	Education through demonstration, production from local materials	www.cohda.com (accessed 3/4/07)
Smile Plastics Interior panels (fig. 5.4.16)	Single sourced post-industrial and post-consumer plastic feedstock (UK)	Self-initiated	Pressure moulded sheets from plastic flake / reclaimed artefacts	Innovation is in the material aesthetic which is obviously recycled	Single material type, recyclable but down-cycling likely	UK production	www.smile-plastics.co.uk (accessed 10/06/09) Site visit 11/04/08
Sprout Design for PLI Design REEE chair (fig. 5.4.17)	100% single source post-consumer plastic feedstock from Sony Playstations (UK)	Environmentally-driven manufacturer; collaboration between designer, material source, end-user (school), reprocessor and manufacturer	Material is reprocessed and used to injection-mould one part, several of which are assembled to chair frame	Fairly inexpensive general purpose chair, innovative for the use of secondary material without compromising aesthetics, the story of the material source, and design for manufacture with secondary material.	Closed-loop system	UK production, inexpensive for schools, easy to replace parts	www.plidesign.co.uk (accessed 10/06/09) Site visit 20/03/08
Studio 7.5 for Herman Miller Mirra office chair (fig. 5.4.18)	31% post-consumer and 11% post-industrial feedstock (international)	Environmentally-driven manufacturer	Unknown	Office chair, innovative for its ergonomic design and holistic approach to sustainable design, characterising the sustainable business leadership	Disassemblable, 92% recyclable	Ergonomics (comfort at work), phasing out of hazardous chemicals (cradle to cradle certification)	www.hermanmiller.com (accessed 10/06/09) Presentation given by Studio 7.5 and Michael Braungart at Cradle to Cradle workshop 8/11/06
Studiomold Fret Speaker (fig. 5.4.19)	Preformed plastic sheet made from post-consumer PE film (UK)	Self-initiated project within a predominantly commercial consultancy	Cut and assembly of pre-formed materials	Prototype, innovative for its function and form rather than the material	Disassemblable and recyclable but continued down-cycling likely	None claimed	www.studiomold.co.uk (accessed 03/03/07) Personal email correspondence 17/01/07

5.5 Addressing the Research Questions for Enquiry 2

The findings of this investigation can now be considered in relation to the research questions for Enquiry 2, presented earlier.

5.5.1 The Story of Plastic in London

How is secondary plastic derived from London currently recovered, treated and processed, and what are the trends for future developments?

- The current system involves three main secondary plastic streams – packaging, WEEE (and other rigids) and factory by-products – that are collected from domestic, commercial and industrial sources.
- Within these streams there are different types of secondary plastic that are more stable in terms of collection and end-markets and others which are down-cycled or go to landfill.
- There are consolidated materials from various sources (in relation to closed-loops, this was termed 'external' or 'pooling'), and materials from single-sources (in relation to closed-loop this was termed 'internal'). The latter has more potential for recovering material properties in subsequent applications, including colour.
- These streams were mapped onto a *Secondary Plastic Escalator* which shows the different developmental stages relative to the ideal of 'closed-loop recycling'
- Different end-of-life options appear to be better suited to different types of artefact.
- Systemic, economic and cultural challenges can damage markets for secondary plastic; materials which retain more of their original properties are more likely to survive these changes.
- The implication is that a range of approaches to end-of-life treatment of plastic may be the best option depending on the materials' potential for moving up the escalator. However, these must be considered in reference to other, more preferable, options in the design phase such as reduction and waste prevention.
- Hypothetical future scenarios were considered, including decentralised artefact production using secondary plastic sourced locally, and the evolution of biopolymers into an effectively managed, renewable and recyclable plastic, where different time-scales of durability can be designed into the material.

5.5.2 Materials Available to Designers

In what forms are these materials then available for use in the manufacture of new artefacts in London or the UK?

- The current system results in a variety of plastic materials available to designers, differing in terms of their form, the limitations of their physical and aesthetic properties, and the processes they are suited to.
- Forms include: reclaimed artefacts, flakes, pellets, and pre-formed materials made from secondary plastics.
- Readily available feedstock types include: food-grade PET and HDPE, black or natural PET and HDPE, black LDPE, PE/PP mix, PP, ABS, PS, HIPS, natural and coloured PS and HIPS. There may be other types which were not encountered during this investigation.
- The factory- and single-sourcing methods imply that any type of polymer, that is currently used or manufactured in the UK, may be available if a suitable source can be located and secured.

5.5.3 Existing Approaches to Utilising Secondary Plastic in Design

What approaches have been taken by designers for utilising secondary plastic in the production of new artefacts?

- Within the chosen examples sympathies towards sustainability were apparent, which may have led to greater consideration of material use.
- However, these examples also prioritise other design factors highly such as function and aesthetics.
- There are also clear innovation gains achieved through the use of secondary material, such as new methods of production, business leadership, aesthetics and a unique story.
- Materials were sourced from different stages in the material cycle. Methods included reclaiming, single-sourcing, feedstock sourced from reprocessors, using pre-formed material made from secondary plastic, and internal closed-loop (within the organisation).

5.5.4 Common Characteristics of Designers' Scenarios

Are there any common characteristics of the designers' scenarios that could have contributed to their ability to utilise secondary plastic?

- The scenarios of the designers could not be investigated as thoroughly at those in Enquiry 1, however some observations were made.
- Many of the designers managed the production of the artefacts (designer-maker scenario); projects were initiated by the designer themselves rather than an external client. This indicates that they have more control over the design decisions and the material selection.
- Where a manufacturer initiated the project and consulted the designers, either in-house or from consultancies, there was clear sustainability leadership within the organisation.

- Networking and collaboration appeared to be an important characteristic, as did financial support which may have reduced the risk and encouraged entrepreneurial attitudes to secondary plastic use.
- Two of the examples had been developed during academic practice-based research which perhaps had allowed the designers some necessary space and time not available in commercial practice.

5.5.5 Implications beyond Secondary Plastic

Many of the issues encountered here are specific to plastics. However, there are also some general findings that may be applicable more broadly. In particular the *Secondary Material Escalator,* which represents the development of a material from *volatile markets, no clear value* to *stable markets, clear value*, or more importantly – from the perspective of sustainability and building an effective material cycle – the development of a material so that its properties can be recovered through multiple cycles. Although this model has been demonstrated here in reference to secondary plastic, the concept was first proposed following the focused literature review (section 5.2.1), which considered issues relating to secondary materials in general. It would be interesting to explore the potential of this model for mapping the development of other types of material in future research.

The future scenario of *secondary plastic as a local resource for decentralised production of artefacts* was illustrated by Richard Liddle's *U.R.E Live* Exhibit, but there is also potential for other materials in this scenario, demonstrated by the *Fast Glass* exhibit. Furthermore, Rapid Manufacture currently utilises many different types of material and is an area of considerable R&D (Reeves 2008).

Some aspects of the *existing approaches used by designers* could be applicable to the use of secondary materials in general. For example, the importance of design factors such as *function, aesthetics* and *innovation* which can be pursued by designers through the use of secondary materials, and the visible sympathies towards sustainability which may lead to the greater prioritisation of material consideration in the design process.

The characteristics of the design scenarios demonstrated here could also be applicable more generally; they relate to how the designer has found the space, time and control over the project to consider the use of an alternative material. Indeed, these observations could have implications for the use of materials other than those that are secondary, or for the consideration of other sustainability criteria. This relates back to the strength of *The Design Scenario* model, presented in Chapter Four (fig. 4.3.1), for understanding how a designers' priorities (resulting from their background) and their work situation combine to create a scenario more or less conducive to the consideration and application of something, which in this case is secondary material and designing for the material cycle.

5.6 Chapter Five Summary

This chapter has presented the focused literature review, research strategy, and results for the research enquiry undertaken to address Objective 2. The aim was to better understand the factors affecting the movement and use of secondary material, particularly plastic in London.

The enquiry produced some useful practical knowledge to inform the development of a new model for supporting designers. This knowledge related to the types of secondary plastic made available by the current system of production and consumption. In addition some current design approaches to using secondary plastic were revealed, which also provided an insight into the kinds of design scenario characteristics that may be more conducive to the consideration and use of secondary materials.

The next chapter will present Enquiry 3, which involved a critical reassessment of existing methods of supporting designers. Added to the findings of Enquiries 1 & 2, the aim of Enquiry 3 was to provide useful knowledge about how designers are best supported to inform the development of a new model, presented in Part III.

CHAPTER SIX Enquiry 3: Tools and Models to Support Designers (Objectives 3 & 4)

This chapter presents the focused literature review, research questions and methods for addressing Objectives 3 & 4. It reports the findings of an investigation into tools and models for supporting designers generally, and in the use of secondary materials. A categorisation method was used to understand the nature of different design tools and to extract attributes that are more appropriate for supporting designers.

6.1 Introduction

The overarching aim of the research project, of *creating new models to support designers...*, necessitates that the nature, successes and limitations of existing methods of support be carefully considered. This was the purpose of Objectives 3 and 4:

> Investigate current processes and tools by which designers are enabled and supported in creating high-value applications for secondary materials;
>
> Critically reassess these processes and tools to support design practice.

It is implied that 'tools and processes' are the operational devices which support and enable designers to act within and in accordance with 'new models'.

Design tools relating to the three areas of the research project – design, materials and sustainability – were explored; first through a focused literature review, and second through desk research, site visits and informal meetings.

6.2 Focused Literature Review: Design Tools

Design tools are perhaps best known as the physical and virtual equipment a designer uses to do design work. However there are much broader implications to the term, as well as deeper contextual issues relating to how tools are used and how they affect design practice. This section will explore these themes in relation to the literature; first the general nature of design tools and then the specific characteristics considered desirable in design tools relating to materials, design and sustainability. Much of the theory encountered was within the research fields of eco-design and material selection.

6.2.1 Defining 'Design Tool'

The word 'tool' can be used in almost any context to describe some 'thing' that is "used for a particular task or in a particular job" (Crozier 2006:878). In academia the use of tools in design practice has been the subject of critical debate. Dormer, for example, has examined how tools – and in particular technology – have enabled the diffusion of craft knowledge: "the craft of a process is diffused into the tools and processes of manufacture" (Dormer 1997:102). This frames the design tool as an 'aid' to designers who are

increasingly separated from material, production, and new knowledge about design. Dormer also suggests that, without pre-existing knowledge or "personal know-how" relating to the task, the tool can limit or prescribe the outcome. Comparing a parish newsletter editor with a graphic designer, Dormer remarks "the critical ingredient is the possession of knowledge that supplements or overrides that which you have bought as a package" (Dormer 1997a:139). The implication is that the tool's ability to distribute knowledge and enable desirable outcomes is limited if the person using the tool has little knowledge of the task to begin with. That is not to say that the tool will not enable an outcome, more that the outcome is unlikely to be as successful without prior knowledge of the situation. This has immediate implications for tools developed to support designers in areas where they have little or no tacit knowledge or understanding, such as sustainability or material cycles.

A 'design tool' therefore can be described as *some 'thing' that aids the distribution of design knowledge to those designers who do not possess it*[116] (Dormer (ed.) 1997) and, ideally, in a situation where knowledge and learning of the task is pre-existing or can be developed alongside. The term 'thing' is used here deliberately to include any format – physical, virtual or otherwise – and keep the enquiry 'open' to opportunities.

A Useful Metaphor: Designer as Workman

Tools date back to man's earliest existence; when our ancestors began making tools they set in motion the development of the modern world (Diamond 1997). As times have changed so has the nature of tasks and tools have been adapted to accommodate. Yet what remains unchanged is the basis for the development of tools, aptly described by Dormer (1997), and the relationship between the particular person, his/her tasks and his/her tools. This provides an instinctive understanding of how tools 'work' and can be used as the basis for a metaphor.

The use of metaphor as a powerful reference model in understanding design practice is advocated by other researchers. In his 1999 paper, *Design as Bricolage,* Louridas builds a strong metaphor to facilitate discussion around the design process; in introducing his method he explains:

> Metaphors are powerful tools. Stemming from the biological, bodily aspect of the human existence, they underwrite most human thought. Metaphors are tools for meaning, representation, understanding, science, and education. Their potential has not gone unnoticed by researchers in design. It has been advocated that metaphors should be used as guiding principles in the design process. We go a step further: we advocate the use of metaphors as guiding principles in understanding the design process.
>
> (Louridas 1999: 517)

[116] The inability for an individual to acquire all of the knowledge and skills now expected of designers was discussed in Chapter Four.

In this enquiry the *Designer as Workman* metaphor, described in figure 6.2.1, was developed and used as a foundation and quick reference model for understanding the potential successes or limitations of design tools.

The use of tools in design practice appears a perfect fit; a designer seeks to find a solution to a problem and uses the tools at his/her disposal to help solve it. In this way the designer is a workman, s/he too limits the tools in his/her 'inventory' (Louridas 1999) to those that the designer knows are versatile and work well. Not all of the designer's tools - in fact hardly any of them - are recognisable as 'tools' in the traditional sense (drawing board, drafting pens, a computer etc.) and, taking the broader definition explored earlier, it is clear that 'design tools' describes a wide range of physical, virtual and intangible things.

From this metaphor a number of important considerations in the success of design tools can be drawn, starting with the point at which the designer encounters the tool and leading through the necessary stages towards successful adoption. Developing an effective and widely adopted design tool is both a real challenge and largely dependent on a number of unpredictable factors. Not only are there many different purposes for tools and types of tool but, as more and more are introduced, it becomes difficult for designers to find the right tool. A designer's toolkit is now an overflowing carpet bag of things competing for attention; the temptation for designers to say 'this one works so it stays, I don't have time to find out if these other ones work better' is inevitable.

Types of Design Tools

A systematic method can also be used to describe design tools, such as the typology of design tools presented in figure 6.2.2. These tool types were developed intuitively as well as from the literature review. Tischner (2000) and Vessoli & Sciama (2006), for example, have defined different types of eco-design tools in their work, which were used to validate this model.

One notable function (intentional or not) of many design tools is 'inspiration' yet it was decided that, as designers can draw inspiration from almost anything, this type of tool could indeed be everything. Therefore it is possible to say that all design tools have the potential to inspire but must also have another primary function which would enable them to be categorised according to the typology proposed in figure 6.2.2. Figure 6.2.3 shows how the designer may draw on design tools including the design development function ↻ of his or her own mind. Designers can also utilise the design development abilities ↻ of colleagues who may contribute to the development of the design or offer tools from their own inventory. The design process model ⇄, itself a type of tool, maps design activities and is not usually used by designers but by those operating outside design activities, such as design managers or researchers, so that they can understand and better support the design process (for example Cooper & Press 2003, Smith & Morrow 1999, Ulrich & Eppinger 2008).

Designer as Workman

A toolbox contains all manner of useful and versatile things. When s/he is confronted by the problem to be solved, a workman reaches into the depths of the container with the confidence that something in there can be used to help fix it. Space in the box is limited: the tools that lie beneath the bolted lid have competed for their position. They are versatile and work well. The workman's knowledge of their mechanism allows them to be used on their own or in combination for a multitude of tasks. In the physical world even the box has its use; as a step to stand on or to sit and eat sandwiches.

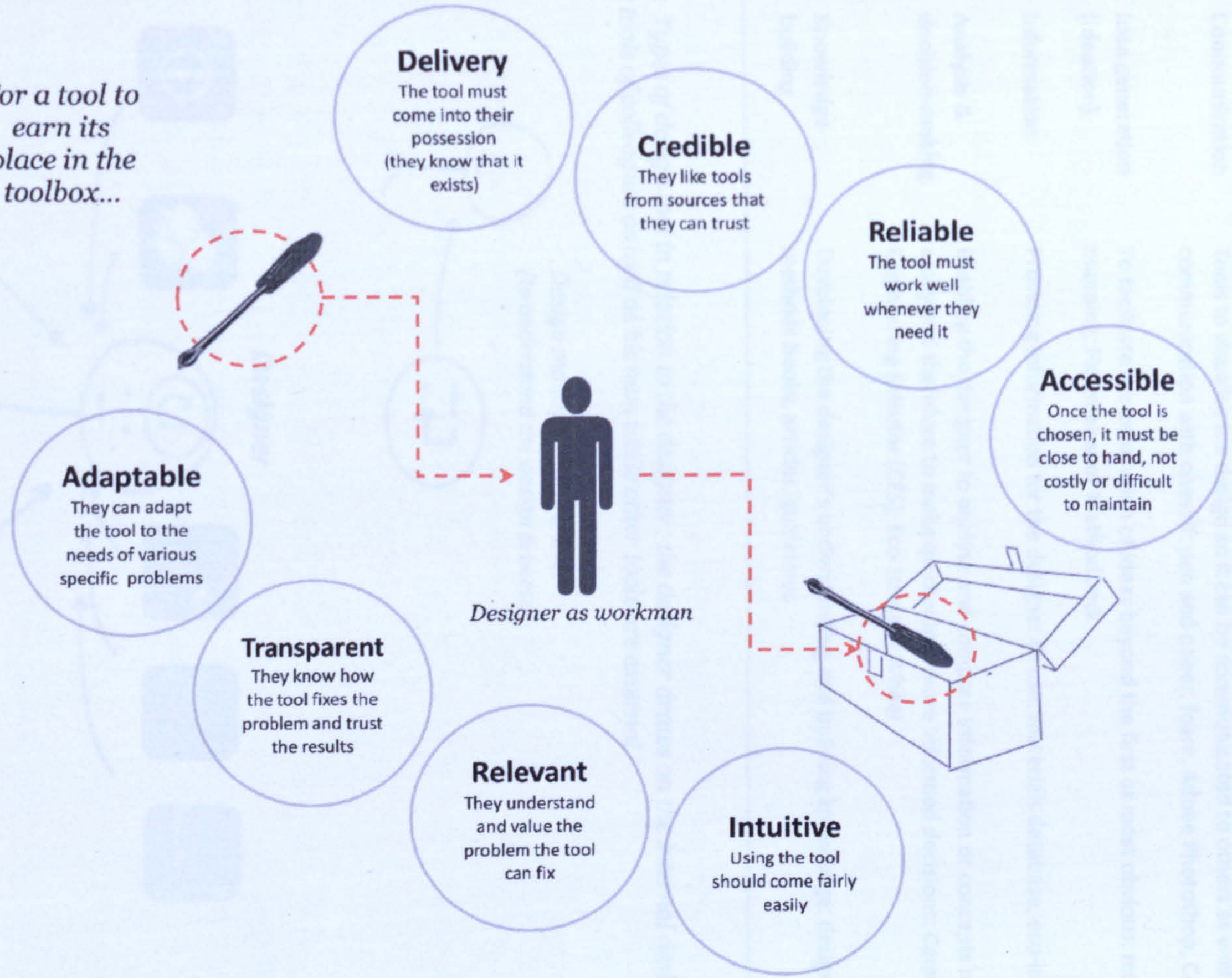
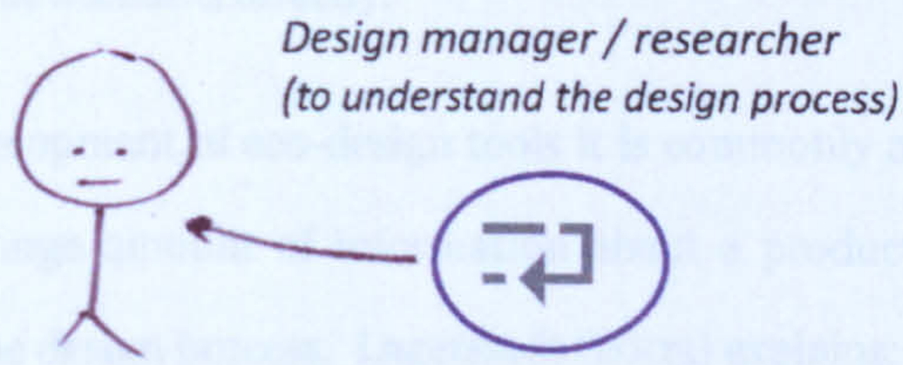


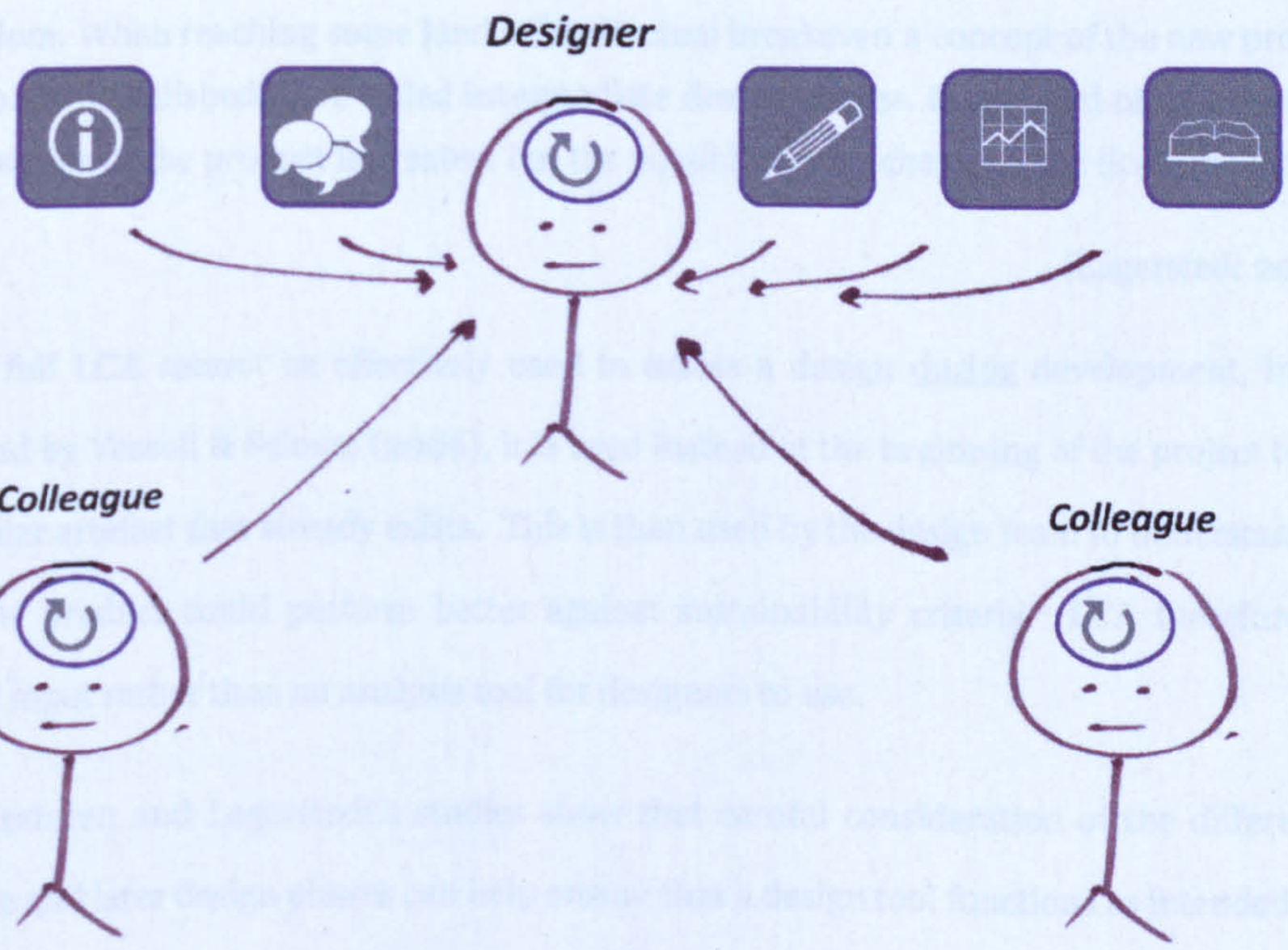
Figure 6.2.1: 'Designer as Workman'; a metaphor for understanding the relationship between tool-user and tool, and hence the likely route towards successful adoption of a design tool.

Figure 6.2.2: Typology of design tools

Pictograph	*General design tool categories*	*Description*
	Design process	Understanding or explaining the design process through a model
	Design development	Aiding the development of the design: the creative mind of the designer
	Communication	Tools to visualise the design so it can be communicated to others as well as communication with oneself: pen and paper, foam, Adobe Photoshop, CAD etc
	Idea generation (Ideation)	To facilitate the generation of ideas beyond the first or most obvious: mind-mapping, Flowmaker or MethodDeck
	Information	Providing information for the designer to use: materials database, eco-indicators
	Analysis & decision-making	Enabling the designer to analyse and compare information or concepts more easily and therefore to make quicker and more informed decisions: Cambridge Engineering Selector (CES), Eco Strategy Wheel
	Knowledge-building	Developing the designer's understanding and building knowledge: design methods books, articles, guidelines

Figure 6.2.3: Types of design tool in relation to the designer; the designer draws on the internal design development tools of colleagues as well as his own while other tools are external





Each of the methods of defining design tools, presented in this section, was developed alongside the literature review that follows shortly. These ways of thinking about design tools assisted in the process of considering how a tool might work, when exploring the literature for specific characteristics, and during the review of existing design tools.

6.2.2 Design Tool Content

The first design tool characteristics to consider relate to what the tool does and how it functions; here this is termed design tool *content.*

Suitability to Design Phase

The design phase in which the tool will be used is seen in the literature as being important to its usefulness. Product development has been described as a three stage process (Ulrich & Eppinger 2008) which implies that there may be different tasks and therefore different tool requirements at these different stages. For example, drawing on Ashby & Johnson's (2002) terminology, van Kesteren (2008) states that material information is more likely to be used for 'inspiration' in the early phases of the design process and for 'analysis' in the later phases. This has implications for a material information tool which, van Kesteren proposes, should accommodate these changes in use by providing *multiple detail levels,* involving general and visual information for 'inspiration', which can be accessed abstractly, and more detailed data for 'analysis', which can be accessed directly.

Similarly, in the development of eco-design tools it is commonly accepted now that as Life Cycle Analysis (LCA)[117] requires a large amount of information about a product or service it can only be used in full towards the end of the design process. Lagerstedt (2003) explains:

> Information about the product increases as the product develops, but at the cost of design freedom. When reaching some kind of intellectual breakeven a concept of the new product is normally established, here called intermediate design phases. By the end of the process the knowledge of the product is greatest but the possibilities for changing the design are small.
>
> (Lagerstedt 2003:27)

Although a full LCA cannot be effectively used to assess a design during development, in an approach demonstrated by Vessoli & Sciama (2006), it is used instead at the beginning of the project to provide data about a similar artefact that already exists. This is then used by the design team to understand and identify how the new product could perform better against sustainability criteria. LCA therefore becomes an information input rather than an analysis tool for designers to use.

Both Van Kesteren and Lagerstedt's studies show that careful consideration of the differences between early, middle and later design phases can help ensure that a design tool functions as intended.

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[117] Life Cycle Analysis (LCA) is the dominant tool used in sustainability decisions and therefore much of the eco-design literature is aimed at examining or adapting LCA to design practice.

Complexity and Simplification

There are other controversies associated with Life Cycle Analysis (LCA) tools; they require complex and time-consuming calculations, and expertise beyond the resources or skills of most designers. Intensity of resources and rigour in LCAs is absolutely crucial to their reliability and credibility. In one survey of peer-reviewed LCAs only 55 out of 272 studied were considered of sufficient quality for consideration (WRAP 2006b). In an attempt to try to utilise the apparent accuracy of LCA data in a quicker and easier tool, 'streamlined' versions have been introduced such as Eco-indicator 99 which provides "numbers that express the total environmental load of a product or process" (Ministry of Housing, Spatial Planning and the Environment Communication Directorate 2000:6) and Material Intensity per Service Unit (MIPS) which calculates "how much use can be obtained from a certain amount of nature" (Ritthoff *et al* 2002:9). These provide the user with predefined scores derived from LCAs for each item in the product lifecycle. For example, a particular material will have a score which is then added to the score for a specific process and so on; to find the most preferable combination of design choices the scores for different options are compared. However, in isolating the numeric data from the LCA methodology important understanding about the assumptions and limitations of the analysis is taken away; the person who uses those scores is removed from the system that generated them. This can be seen as the 'diffusion of knowledge' that Dormer (1997) speaks of in relation to tools. In the Eco-indicator *manual for designers* it is asserted that "although the application of these standard values is basically very simple it is very important to understand some of the backgrounds, the features and the limitations." (Ministry of Housing, Spatial Planning and the Environment Communication Directorate 2000:6). Yet the manual is 49 pages long, which in itself requires investment of time and reasonable knowledge.

Using data of this type to measure the sustainable performance of a product can, therefore, be seen as problematic. A measurement is something apparently exact and indisputable which is inconsistent with issues relating to sustainability and design. This unease is reflected in the literature by a general consensus that the output of an analysis tool should reflect the difficult decisions and 'messy' path that has been taken in its calculation. In their proposal for the *Ten Golden Rules* Luttropp & Lagerstedt (2006) explain that contradictions within the rules are inevitable and that these must be explored by the designer in order to understand for him/herself where the priorities lie, which vary from project to project. Luttropp & Lagerstedt's tool requires the designer to engage with the decision-making process which enables knowledge-building, promotes confidence in the process and allows the designer to relate the general tool to his or her specific work. Tools which rely solely on predefined scores remove this engagement and, with it, take away the opportunity for designers to understand and believe in decisions that are made about the artefact, and build knowledge in the process.

Other approaches include the *Sustainability Cycle* (James 1997) which uses a traffic light coding system to present conclusive, inconclusive, contradictory, positive and negative information. This diagrammatic

system allows elements which are difficult to measure, such as social & ethical considerations, to be viewed alongside measurable impacts, such as energy use, in turn enabling the designer to communicate ideas more easily with team members and stakeholders. Benjamin's (1994) *EDEN Eco Profiler* also aims to represent the complexity of information sourced for making sustainability-related decisions about materials and artefacts. Instead of traffic lights Benjamin suggests marking information as either 'qualitative', 'quantitative' or 'inference'; this is discussed further in section 6.4.

Prioritising

Sustainability is one of many concerns in design practice (Luttropp & Lagerstedt 2006).[118] Moreover, designers may know very little about sustainability, while reliable information is dispersed and therefore difficult to find. During design education students have the time, space and guidance to explore new ideas and information, but the findings from Enquiry 1 suggested that, in a professional context, that liberty diminishes and designers are increasingly forced to ignore new information and resort to their previous experience and trusted resources. In eco-design research the emphasis placed on simple comparison and prioritisation tools is symptomatic of this problem; for example Tischner suggests:

> It is rare that all environmental problems can be considered simultaneously. The establishment of priorities determines which environmental impacts are greatest in importance and should be dealt with first. In addition, an important question is, what improvement possibilities lie within the sphere of influence of the company.
>
> (Tischner 2000:67)

Importantly Tischner acknowledges that in order to implement eco-design companies (or individuals) must have targets that are attainable. Van Hemel (1997) also endorses this method of giving companies priorities suggesting that, by highlighting 'quick-wins', companies who have previously had no experience of, or inclination to adopt, eco-design principles can be introduced to these methods. 'Quick-wins' were also mentioned by Lofhouse (2006) who reported that in her study designers had "asked for a simple, explicit hierarchy of approaches, so that they knew what to tackle first for an 'easy win'." (Lofthouse 2006:1390)[119].

There is clearly an impetus to make difficult decisions relating to sustainability quick and easy for time-poor designers. Without tacit knowledge, trusted information sources or a means of measuring and prioritising, the issues involved seem insurmountable and unquantifiable, which can make decision-making, and the qualification and communication of those decisions difficult. One approach taken by Earley and Fletcher (2003), at the Textile Environment and Design (TED) research group at Chelsea School of Art, was to present "five interconnected approaches to fashion textile design" (Earley & Fletcher

[118] The survey (Enquiry 1) revealed that designers prioritise 'functional performance' 'end-user needs' and 'innovation', whereas Ashby & Johnson (2003) suggest that designers are mostly concerned with how the material can contribute to "product physiology and psychology" (Ashby & Johnson 2003:27)
[119] The use of secondary materials as a 'quick win' was discussed in Chapter Two in relation to van Hemel (1997).

2003) which can be taken by designers to explore sustainability. The benefit of this approach is that it is practical and relates directly to design practice which eases designers into the consideration of intimidating issues. This is also an example of a kind of pluralist attitude to the consideration of sustainability in design practice (discussed in Chapter Two).

Accessing Information for Tool Content

The inability to measure indirect consequences, such as feelings of well-being, high morale or social impacts, has led some design researchers (for example van Hemel 1997) away from LCAs towards simpler tools which require the designer to use his/her own 'common sense' to weigh up the information available and make an informed and often personal decision. Yet this approach is largely reliant on easily accessible information, which is not only an issue in eco-design but a broader problem faced by designers. The problem of information provision has been exacerbated in recent years by the speed and volume with which it can now be conveyed. Daljit Singh of digital design agency *Digit* comments:

> I think the word which is really relevant for me is blur, this idea of blur. I mean there's so much noise out there at the moment, you know, it makes my head hurt every morning, [...] For me, one of the most important design tools which is out there and something which we have to all collectively be aware of is the internet. It's changing everything fundamentally. It's changing the way that design's happening.
>
> (Macdonald *et al* 2007)

Benjamin's diagram portraying information overload (fig.6.2.4) aptly demonstrates the problem for designers and, with the rapid expansion of the internet, is even more poignant now than when it was first presented in 1994.

With the proliferation of internet use new methods have been developed for helping users to stay abreast of the 'information blur'. For example, digital hubs have been developed where resources can be centralised and personalised allowing users to keep up-to-date with favourite blogs and resources from one location.[120] The internet has also brought about new methods and attitudes to searching, typified by 'search engines', which has changed peoples' expectations of information availability.

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[120] See for example the IPhone 'Home Screen' where 'apps' can be located to access various resources http://www.apple.com/uk/iphone/iphone-3gs/home-screen.html (accessed 09/07/09) or IGoogle's homepage where 'gadgets' can be located to summarise the content of external sites http://www.google.com/ig (accessed 20/11/08) or Addict-o-matic which creates a homepage for search criteria with content from a variety of websites http://addictomatic.com/topic/eco+textile+design (accessed 22/06/09)

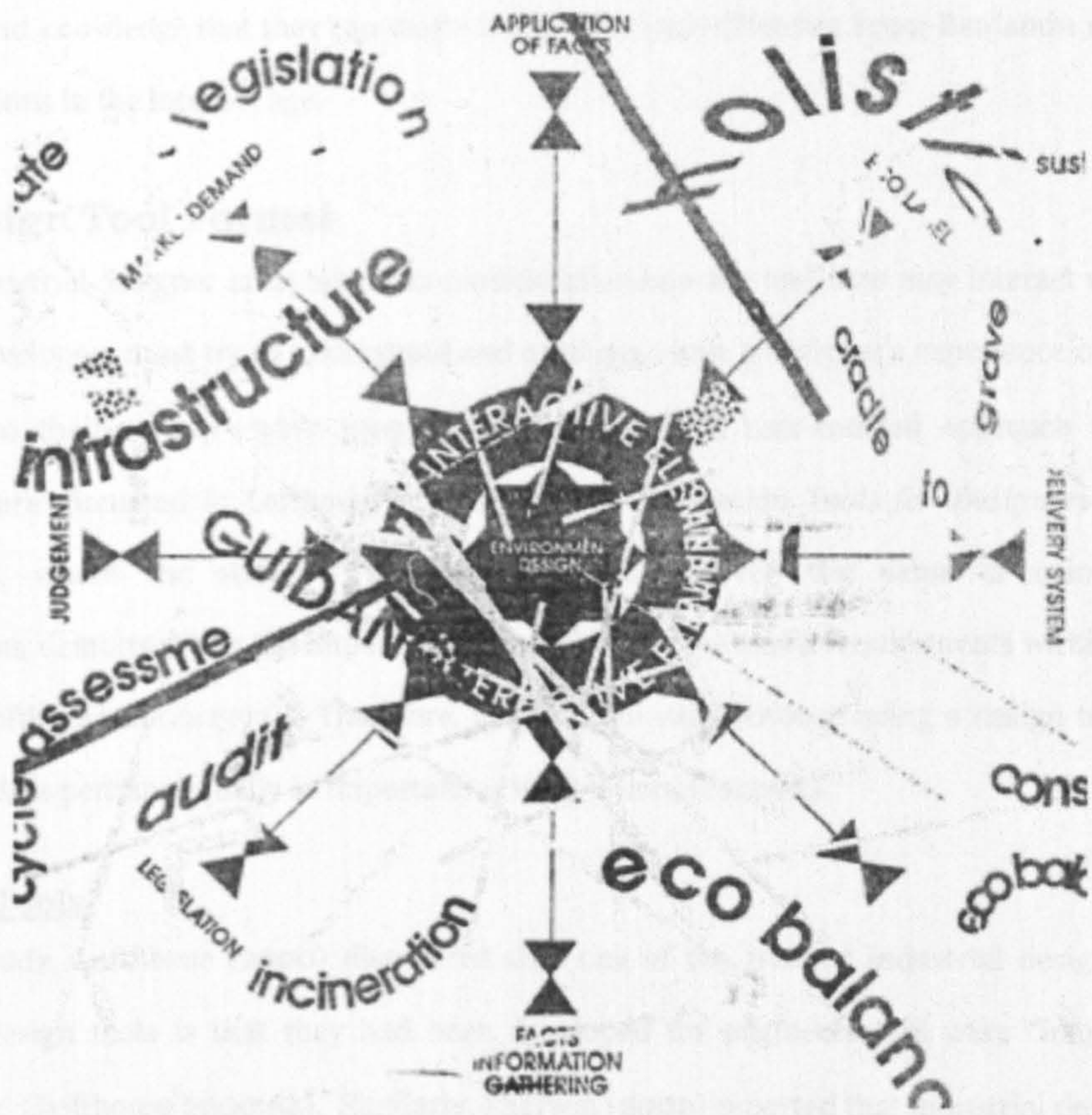

Figure 6.2.4: The confusion faced by designers searching for reliable environmental information, (Benjamin 1994:162)[121]

A report by Trendwatching.com has proposed a checklist of "changed consumer behaviour now taking place online" (Trendwatching.com 2008:7) which, it is claimed, is affecting peoples' behaviours and expectations 'off-line'; these include:

> Sharing; Constant, 24/7 always on; Cheap, fast and easy; Free; Ongoing feedback; Transparency; Customisation, personalisation, creation; Searchability; Easy befriending & connecting; Instant gratification; and Total control (or at least the illusion of it)
>
> (Trendwatching.com 2008:7).

These virtual trends and behaviour patterns, the report suggests, can be utilised in the physical world.

In the field of design and sustainability this 'off-on' connection has already been used to good effect to raise designers' awareness of digital tools. In the 'soft' department at *City Eco Lab* (organised by Thackara's Doors of Perception) digital and online tools were placed in various tins and arranged on shelves in the exhibit. The aim was to "make visitors aware of the existence of such 'soft' tools and present a selection so that they would not be overwhelmed by what's out there" (Thackara 2008). One of the biggest challenges in supporting designers to incorporate unfamiliar concerns into their work is to deliver reliable, useful

[121] This image was copied from microfilm which accounts for the poor quality. Subsequent attempts to obtain a higher quality image from an original proved unsuccessful as the British Library copy was missing. The image has been included because it remains useful to the discussion.

information and knowledge that they can locate amidst the 'blur' (Fletcher 1999; Benjamin 1994), and that meet expectations in the internet age.

6.2.3 Design Tool Format

Just as an industrial designer must take into consideration how the end-user may interact with a product, design tool developers must try to understand and anticipate how a designer's experience of that tool may be different to their own (Pedgley 1999). The benefits of a user-centred approach to design tool development are discussed in Lofthouse's (2006) paper, *Eco-design Tools for Designers: Defining the Requirements*, where she states: "The findings clearly proved the value of using appropriate communication, demonstrating the importance of considering the user's requirements within the design of anything." (Lofthouse 2006:1392). Therefore, aligning the experience of using a design tool (format) to design methods is perhaps equally as important as what it does (content).

Text-based Tools

During her study, Lofthouse (2000) discovered that one of the reasons industrial designers don't use existing eco-design tools is that they had been developed for engineers and were "inappropriate and difficult to use" (Lofthouse 2000:64). Similarly, Sherwin (2000) reported that industrial designers showed "little interest in numerically intensive or quantitative data, or in information not represented in a stimulating manner" (Sherwin 2000:119). The implication is that industrial designers are unable to 'read' or relate to the specific technical language and expertise typical of engineering and it therefore needs translating into design language. In relation to materials information, Ashby & Johnson (2002) suggest that this is because of a distinct difference in design methods: "while technical design utilises well-established methods and sophisticated computer-based tools, industrial design cannot so easily be made systematic or quantitative" (Ashby & Johnson 2002:27).

Simple steps such as using text in small 'nuggets' (Lofthouse 2006: 1388) and not making language over-wordy, as demonstrated in Luttropp and Lagerstedt's (2006) Ten Golden Rules, can be taken. Both are keen to stress that language must be appropriate for designers who may not have knowledge of specific terminology, while some writing styles may be more effective at holding designers' attention and interest in what is being said. In addition, Lofthouse (2006) refers to the need to acknowledge designers' visual awareness and communication by suggesting that a 'consistent graphical theme' (Lofthouse 2006:1389) or effective communication design was an important factor in making her Information Inspiration website[122] easily navigable and engaging for designers.

Tingstrom & Karlsson (2006), Lofthouse (2006) and Luttrop & Lagerstedt (2006) all report that checklists are already used by designers and therefore could be an appropriate format for incorporating eco-design. Indeed, checklists appear to be an eco-design tool 'staple' with many organisations offering their own

[122] www.informationinspiration.org.uk (accessed 24/04/07)

versions (see for example Centre for Sustainable Design 2009; Crul & Diehl 2005). Although informative and quick to use, checklists and guidelines can be dry, difficult to absorb and not particularly memorable, making the information difficult to recall. Memory aids could assist the absorption of guidelines or checklists; for example, Luttropp & Lagerstedt (2006) recognised the potential benefit of visual cues, stating that 'the guidelines should be easy to remember and come back to. The pictures should help people remember the leaflet." (Luttropp & Lagerstedt 2006:1405).

Visual Representations

Visuals may make text-based information more memorable and they are also a more natural medium for designers than words and numbers (Sherwin 2000). This was the attitude taken by Lofthouse (2006), who developed a *holistic framework for industrial design focused ecodesign tools* during the development of the *Information Inspiration* tool. Within her framework Lofthouse identifies the key characteristics required to align tools to industrial design methods and approaches; containing both information and guidance, using appropriate language and visual information. Indeed, Lofthouse was able to gain insight into the specific purpose of images in the context of a design tool from which some interesting conclusions were then drawn:

> The usefulness of the images went beyond attracting the designer's attention, raising awareness and motivation as Sherwin suggests. Images also have the potential to play a much more practical role, as a mechanism through which designers can learn how the product works, how the product was manufactured, how it was used and what it was made from.
>
> (Lofthouse 2006:1392)

Not only are images and drawings a more 'designerly' medium than prose, they are also capable of conveying a huge amount of information in a short space of time, an attribute which is also increasingly acknowledged in relation to materials information as Ashby & Johnson (2002) explain:

> [Visual representations] become tools not only for communication, but also for reasoning. [...] The power of the visual image lies in the ease with which it can be manipulated by the mind and its ability to trigger creative thought.
>
> (Ashby & Johnson 2002:31)

Tufte (1990) – an advocate of excellence in the visual presentation of information – provides some useful guidelines to enable "escapes from flatland", the dominant mediums of paper and computer screen used for information displays:

> To envision information [...] is to work at the intersection of image, word, number, art. The instruments are those of writing and typography, of managing large data sets and statistical analysis of line and layout and colour. And the standards of quality are those derived from visual principles that tell us how to put the right mark in the right place.
>
> (Tufte 1990:9)

The results are design strategies for "enhancing the dimensionality and density of portrayals of information" (Tufte 1990:9). Tufte's enduring advice is to present complex data which is understandable in the macro and in the micro reading using colour, tone and mark-making to separate layers of information and avoiding over-simplification, which results in meaningless graphics.

Three Dimensions

Images are often communicated digitally and are therefore also part of the 'blur' discussed earlier; designers may see thousands of images daily which undoubtedly dilutes their influence. Luttropp & Lagerstedt (2006) suggest that in seeking to make eco-design information memorable the physical medium as well as the use of images may provide solutions: "Another idea was to establish a version that could be kept as a poster on the wall, rather than keeping an electronic version, which may be lost amongst other information." (Luttropp & Lagerstedt 2006:1405).

So, the effective communication of information to designers may be increased if images are used and are positioned where they can be easily seen. However, the impact of a poster is also due to the requirement of physical interaction; the decision is made to put it up and grappling with drawing pins or blue-tack makes its presence felt by the design team, they know it is there in their physical environment. In a world which is increasingly viewed in two-dimensions, three-dimensional things 'speak volumes' especially to industrial designers whose job is to generate (predominantly) three-dimensional solutions. This was evident in the materials selection literature. Van Kesteren's (2008) study of designers' use of an in-house material collection[123] suggested that some information could not be obtained without physical interaction with the material itself:

> Product designers use [material] collections to store and recall former design projects, interesting parts 'from the street' or from tradeshows. Samples provide information about sensorial aspects of materials such as visual and tactile features.
>
> (van Kesteren 2008:136: Table 2)

There is a further dimension to material samples hinted at here; they include hoarded abstract pieces picked up here or there, or from 'on holiday', and product examples from previous projects. What emerges is an illustration of how designers may surround themselves with all manner of objects to deduce abstract as well as technical and sensorial information, to understand what is possible in the physical world and to synthesise these ideas into new possibilities and new products.

This method has been recognised in the field of material information exchange resulting in the formation of sample libraries. Too few libraries, however, have been able (whether through ignorance or more likely lack of resources) to show the application of those materials in product examples. One of van Kesteren's

[123] This facility was available to designers in van Kesteren's study because they worked in a large consultancy that had the resources to maintain it. This is in contrast to the smaller consultancies in the survey that better represent the broader population of design consultancies (Design Council 2005).

(2008) key findings suggests that being able to see how materials could be processed and how they would behave during product use was one of the areas both most desired and most frequently absent from materials information resources.

Both Lofthouse (2000) and Sherwin (2000) highlighted the usefulness of product examples in their studies. Lofthouse found that designers wanted product examples, and even working-drawings, to learn how eco-design principles have been applied. This approach was taken by Chick and Micklethwaite (2004a) in the InspireRecycle.org website which gives case studies of products made from secondary material, the business models used and key considerations in using secondary material. Using product examples to raise awareness of the uses for secondary materials was also a tactic used by Jakki Dehn in the Creative Resource exhibition,[124] demonstrating the use and quality of material to designers much more fully than images or sample chips.[125]

So, just as Ashby & Johnson (2002) noted that the value of the image is not only in the communication of information but also as a 'trigger for creative thought', the three-dimensional world offers even more multi-sensorial stimulation, providing further opportunities for lateral and inductive, as opposed to deductive, reasoning (Ashby & Johnson, 2002). It is quite probable that – particularly in the 'inspiration' or early phases of a project (which is likely to be ongoing in a designer's day-to-day activities as projects overlap) – a designer will pick up objects for a great many reasons other than the one intended by the provider; a pencil because it has an interesting texture, or a doll because it reflects a previous experience which may be of use to a future project. Material samples too may be subject to this approach, not only to show the designer the properties of the material but also to inspire abstract thoughts which may, in the end, not lead to the selection of that material. In other words, it may be difficult to predict and therefore influence what information or knowledge a designer takes from an object or resource.

Facilitating Dialogue

The survey findings in Enquiry 1 highlighted that the sources designers find most useful for sourcing materials are those that are accessed through a 'conversation' either with their own previous experiences, or with colleagues or suppliers. It seems that dialogue is a preferred way for designers to gather information and knowledge. This was also advocated in the literature; for example, Benjamin (1998) strongly supports the use of networks as a tool for providing information and guidance about sustainable development which are inherently reliant on dialogue between trusted peers. D'anjou (2007) also suggests that dialogue with students in the design studio may facilitate reflection on their work and help to locate ethics within their practice. Dialogue with someone who has specific or different expertise may enable designers to abstract, synthesise and understand information more quickly, whilst also allowing them to

[124] The Creative Resource exhibition opened at Barnsley Design Centre in April 2007.
[125] Sample chips are usually squares made from a material to show the colour, texture and finish, but not how it performs with different processes or forms.

gauge the trustworthiness and reliability of the information more easily than if it is static or removed from the original source, as it would be in a database, book or magazine.

Flexibility of Structure and Navigation

Some authors have recognised the need to make design tools flexible to use. For example, Van Kesteren's (2008) "multiple detail levels" (2008:137) are best accessed using different methods depending on the requirements of the material information; a simple word search based on material characteristics or properties is suggested, and a facility which enables direct comparison of materials. Ashby & Johnson (2002) are in agreement and summarise the need for tools of this kind to be flexible:

> This [material selection] tool should (a) capture and store material, process and product information, organising it in a way that allows rapid retrieval, (b) present the same information in a creative format, and (c) allow browsing, retrieval, and combination of, 'bits' of information about materials, processes and the products they create.
>
> (Ashby & Johnson 2002:117)

Van Kesteren studied the use of material sample collections in large design organisations and observed that designers recorded their experiences of using the different materials in the collection by adding notes to the database. They also bought in their own material and product examples for use in addition to the samples in the collection. This shows that enabling designers to extract, add to, and use the information, resulting from or included in tools, could mean that their function is improved.

A similar approach to enabling designers to access and use information in flexible ways is demonstrated in Lofthouse's study. Here she explains the idea behind the dual function of the website: "It was seen that the designers used the tool either in the capacity of a magazine, or as a database. The approach that they chose reflected the nature of the information they were looking for" (Lofthouse 2006:1391). This tool enables designers to go to the 'Information' section if they are looking for specific details and to the 'Inspiration' section if they are looking for ideas and want to browse. Once in either section, designers are able to follow links to further detailed information or to related themes, which is reminiscent of the path they would naturally take and therefore more accessible than conventional linear navigation methods.

Lofthouse (2006) also noted that designers wanted to go one step further by extracting the images and information and using them in their own representations; one designer "wanted to be able to group and collate the examples he found interesting, so they could be printed out and referred back to." (Lofthouse 2006:1390). This feature would also allow designers to use the information to support and communicate their ideas to other stakeholders which was highlighted as being of particular importance in Chapter Four.

Durling, Cross & Johnson (1996) studied designers' learning styles and compared them to non-designers. Their findings summarise Lofthouse's (2006) observations. Broadly, designers prefer teaching which:

- begins with the big picture, with concepts, and then explains details;
- is focused toward future possibilities and gives alternative viewpoints;
- has lightweight structure, allowing for guided exploration;
- mostly shows objective data, is logical and analytical, and is based on exemplars showing things. (However, about a third of designers will be happier with more subjectivity, a person-centred approach, and the utilisation of value judgments).

(Durling, Cross & Johnson 1996:5)

Resource Limitations in the Design Scenario

The complexity of eco-design tools, and the impact that has on the amount of time taken to use them, was discussed earlier. Tischner's handbook *How to do Ecodesign?* addresses this issue by providing a graph which maps eco-design tools against 'complexity' and 'time requirements' (Tischner 2000:65). Time constraints are also likely to restrict the use of geographically-distant tools such as libraries or seminars, an issue highlighted by the designers interviewed in the survey (Enquiry 1). The internet has provided what would appear to be a perfect solution to these problems; a tool can be downloaded for desktop access whenever the designer requires it and there are usually few direct costs. However, if the website's function is to provide information that must be updated regularly, it may be expensive to maintain and a subscription fee may be charged. This could prevent designers from using some tools, but this issue is rarely considered in the literature. In addition, the internet is not appropriate for certain aspects of some tools; as discussed earlier, in relation to van Kesteren's study, some material information can only be obtained through interaction with the material itself. When considering the best medium for a design tool, the internet promises much in terms of accessibility, but it also has its limitations and other means must be sought to address those shortcomings.

6.2.4 Design Tool Delivery

The predisposition within design academia to develop design tools has resulted in a rich depository of information about the desirable characteristics, yet how the designer comes to adopt and use the tool is rarely considered. Argument, Lettice & Bhamra (1998), for example, found that a lot of the academics in their study had developed eco-design tools whereas the industry representatives stated that they didn't know about many eco-design tools.

Maximising Adoption

It is evident in the literature that design researchers are addressing the issue of adoption within the group of designers involved in the particular study. The most common method for achieving this is close collaboration; the tool is explained, support is given and developments made that suit the particular

scenario of the group. This face-to-face explanation and discussion can build designers' confidence in a particular tool or method. Vessoli & Schiama (2006) reported that, in the development and implementation of their eco-design checklists, workshops with the design team and user feedback played a significant role in successful adoption:

> At this stage [final draft of the checklists] a workshop was organised in order to remove the remaining doubts, to deepen the open technical and critical aspects, and especially to share the results and get a commitment with the whole team.
>
> (Vesssoli & Sciama 2006:1323)

The successful adoption of the eco-design tool by the designers in Vessoli & Sciama's study appears to have been directly linked to their involvement during its development and the credibility that was gained through that process, a tactic which was also employed in the implementation of eco-design methods during the IC EcoDesign project in the Netherlands (van Hemel 1997). In addition van Hemel briefly alludes to longer-term adoption through 'recommendations'. The feedback from the companies who took part in the IC EcoDesign project suggested that there was potential for eco-design to spread by word of mouth, with 90% of companies saying that they would recommend the approach to others. This is promising, not only because other companies may be made aware of the project, but also because a peer organisation spreads the word rather than academics, thus increasing the credibility and reputation of effective eco-design principles.

Some researchers have used other methods of delivering the face-to-face explanation and training apparently essential to adoption by a wider audience. Charter's Smart ecoDesign™ checklists (Centre for Sustainable Design 2009), for example, are disseminated through workshops while awareness of ReDesign's Flowmaker cards is gained through university workshops and ReDesign events.[126] However, the reach of this approach is limited, being resource-intensive for the designers as well as those delivering the service.

Another solution used by researchers is to make tools available online accompanied by explanatory text, but how are designers to find these tools and, if they do, are they likely to spend their time reading lengthy guidelines? Lofthouse developed the *Information Inspiration* tool so that designers only need to be made aware of the web address; the website itself is designed to be self-explanatory and intuitive without over-wordy guidelines or instructions.

The majority of these tools are only suitable for designers who already have a strong personal or commercial drive to do eco-design or to look for new materials, and therefore elements that may persuade or seduce the designer to use tools are not covered in the literature. If the intention is for eco-design - or

[126] Kingston University seminar attended 06/11/07; ReDesign at London Design Festival, September 2007

indeed any area which is considered to be overlooked in design practice – to become common practice, the wider delivery and awareness of these tools needs to be considered more carefully.

Tool Success

It is not surprising that researchers' primary concern is with the identification of a need for a tool and the consequent research and development work. Bringing the tool into general use is the final but crucial hurdle in influencing mainstream practice. Luttropp & Lagerstedt comment:

> There is a lot of interest in sustainable product development, and many tools and guidelines have been suggested. It is unclear if those tools are being used and if they have any real effect on product system developments.
>
> (Luttropp & Lagerstedt 2006:1396-7)

Academic researchers will often use or test the tool with students and in doing so are preparing future generations of designers, but this is not a quick enough response to rapidly changing social, economic, and environmental situations. Yet there is no established route for introducing new methods into design practice; engagement in job-related training is lower among designers that in any other occupational group except for artists (Design Council 2005).

Tingstrom & Karlsson (2006:1412) consider design tool adoption as a measure of success in the introduction to their analysis of qualitative and quantitative environmental assessment tools, with reference to *'logical verification'* (academic rigour which allows a tool to be accepted by the academic community) and *'verification by acceptance'* (successful take-up in industry). Smith & Morrow (1999:241) also consider the relationship between these two elements in their study of design process models. Although the focus is tools for design managers rather than tools for designers, the situation reported is comparable to that of any design tool developer and is therefore useful for this discussion. Smith & Morrow (1999) refer to the social science concept of type 1 and type 2 errors. 'Type 1 error' stems from the absence of academic rigour (logical verification) resulting in a model which is 'wrong' but is used by industry, with undesirable consequences. While 'Type 2 error' occurs as a result of striving for academic rigour but not taking into account the appropriateness to real-world practice, which Smith & Morrow observed has often resulted in a model not being accepted in industry.

Monitoring methodological rigour is an established part of academic research and is often undertaken on the completion of the project or through peer-reviewed journals, whereas monitoring and reporting 'verification by acceptance' is not an integral part of the design research system. Many approaches to the development of design tools have included collaboration with industrial partners, allowing real-world study, testing and feedback. These measures help to ensure that the resulting tool is relevant to the potential user and functions as desired, but there is rarely any open consideration of how to achieve this success beyond the initial group involved in the study or how to roll the tool out across the design industry.

If tools are successfully adopted it would be beneficial to researchers and developers of design tools for this to be reported. The absence of such reporting means that currently the best indicator is anecdotal evidence of use in the field. Interestingly the tools which are known to be used by designers are also often those that have performed commercially. For example, the material selection database Cambridge Engineering Selector and its green companion Eco-selector were developed initially at Cambridge University and now operate on a subscription-basis.

There are important differences between tools that are developed and maintained commercially and those that exist wholly in academia. Commercial tools can only exist if there is sufficient demand and must respond to the needs of the clients if they are to have sustained success. The developers have substantial resources and over time this scenario allows the tools to evolve into something much more sophisticated and fit-for-purpose than tools developed in the academic sphere. Software developer Adobe is one example; programmes such as Photoshop and Illustrator have become a staple in design studios worldwide and the developers now have the resources and the momentum to react to user needs, improving features to remain competitive.

This method of tool development suits designers; they get tools which are fit-for-purpose and as their methods evolve the developers keep pace, providing a constantly improving and increasingly indispensable design tool.

This suggests that the commercial situation enables design tools to flourish:

- Revenue is needed to maintain design tools, to update and keep them relevant;
- Commercial viability confirms the tool need and success;
- Investment in a tool will command respect and is more likely to be used in order to justify its cost.[127]

Yet a tool which aims to support designers in ways that they are not yet entirely open to (such as sustainable practices or the consideration of unfamiliar materials) is unlikely to perform in a commercial market, indicating that subtler strategies might need to be adopted. Rather than offering a design tool as a standalone product, delivery might involve offering it as part of a service or suite of products that appeal to designers or that they use already. Full commercialisation could be a long-term aim for tool developers situated in academia; as with secondary materials, subsidies or alternative funds must be found in order to develop the tool and the market.

[127] There is an opposing argument, based on general criticisms of commercialisation (Whiteley 1994), that developers are encouraged to design 'desire' into their tools and are duping designers into thinking they need the latest version; that these are 'wants' rather than 'needs', and that the resulting tools can limit rather than enrich the design process and outcome (Dormer (ed.) 1997).

6.2.5 Summary

This focused literature review has highlighted a number of considerations that contributed to the development of research questions, and the methods employed to *critically reassess existing design tools and methods*, which was the aim of Objective 4.

While there are clearly many factors to consider when developing a tool for design, the overriding message is that designers have their own methods which are not easily imposed upon. If effective and successfully adopted design tools are to be developed, then the nature of design processes, methods, and attitudes need to be understood, respected and accommodated. Figure 6.2.5 summarises the key characteristics identified in the literature.

Figure 6.2.5: Summary of the key points taken from the literature about design tool development

Content	***Format***	***Delivery***
For appropriate design phase	Aligned to designers' preferences and practice, or company culture and procedure	Lack of evidence that design tools are successful
For appropriate type of work	Using designers' existing information formats and sources	Evaluating success through logical verification or verification by acceptance
Not over-complex or over-simplified	Use of visuals: images, drawings, charts, and consistent graphics	Ensuring adoption may require extensive consultation or collaboration
Reflecting qualitative as well as quantitative aspects	3D examples: samples and products	Steps can be taken to gain designers' confidence
Can be used to communicate ideas to others	Design language and wording, but generally avoiding text	Use of trusted sources, experts and peers
Allows for degrees of certainty (grey areas)	Facilitates dialogue	Delivered as part of already successful design tools
Facilitates easier prioritisation	Synthesis and dialogue rather than numbers and structure	'Designer as Workman'
Involves general as well as specific detail layers	Aligned to conventional design factors: competitiveness, cost, user needs and functional considerations	
Allows transparency to enable understanding	Not resource-intensive	
Stimulates and accommodates learning: both the user and the tool itself	Designers have their own methods	
Includes 'quick wins'	Allows lateral connections to be pursued	
	Involves abstract as well as direct access / search options	
	Extractable, addable, usable, adaptable and editable information or outcomes	
	Enables comparisons to be made	
	Evidence of regular information updating	

6.3 Research Strategy for Enquiry 3

The focused literature review revealed some useful theory about the probable characteristics of an effective design tool. Crucially, this involves making the tool content, format and delivery appropriate to the methods of designers and respectful of the relationship between a designer and his tools.

6.3.1 Research Questions for Enquiry 3

Objectives 3 & 4 can therefore be translated into research questions for Enquiry 3 as follows:

> What tools are available to support designers in the consideration and use of secondary materials, and within the broader context of the material cycle, sustainability and design practice?
>
> What are the characteristics (content, format, delivery) and in what ways are they aligned to design methods?

6.3.2 Research Methods for Enquiry 3

Similarly to Enquiry 2, the nature of this enquiry was *exploratory* as it sought to "find out what was happening" in a "little-understood area", and the research progressed in a *flexible* manner (Robson 2002:59).

The methods selected were principally aimed at fact-finding; this was one of the two smaller enquiries in the research project and therefore time- and labour- intensive methods were not feasible. Examples of design tools were gathered in the manner of *snowball sampling* (Robson 2002) and, where appropriate, site visits were undertaken (outlined in Appendix C(i)). Some professionals were also consulted through informal meetings and at events. However, the majority of information was retrieved from the relevant literature authored by tool developers and researchers online, in journals or books. Design tool searches were largely restricted to the fields of design, sustainability and materials because these were the main focus of the research project, and also to tools available to UK designers (although many are international and some are based in other European countries or the USA).

The adhoc nature of encounters with potential data sources and the frequently audio-unfriendly surroundings meant that it was not feasible to record conversations; this was not ideal, but did not hinder the enquiry greatly as much of the information was also available in the literature and online. In addition, the author made detailed notes immediately after each meeting or field visit and took photographs when authorised. Therefore, the data is sufficient to provide the insights necessary for theory-building, and to inform the development of a new model for design support.

To identify and document the tools a 'characterisation table' was developed, incorporating many of the issues encountered in the focused literature review. The term 'characteristic', defined as "a distinguishing feature or quality; typical or representative of someone or something" (Crozier *et al* 2006), was seen by the

author as the most appropriate term for this process; the items listed in the table were chosen not to exclusively *categorise* or *classify* the tools, but instead to describe the 'distinguishing features' of a large number of tools using a uniform set of descriptors. The purpose of identifying design tool characteristics was first to describe design tools, but also to understand their appropriateness to design methods and practice, which greatly aided the discussion and the author's ability to address the research questions.

The characteristics identified and used in this enquiry are described in figure 6.3.1, divided into seven groups, four relating to 'content' and three to 'format'. The mode of delivery for each tool was difficult to determine and characterise beyond general methods such as search engines, mailing lists, or through events and word of mouth, therefore 'delivery' was represented in the characterisation table by the existence of a website only. The literature highlighted academia appears less likely to actively pursue delivery methods for the tools it develops than commercial or government-funded tool developers. The characterisation table is included in Appendix C(ii) containing a selection of the tools considered during the enquiry that are most relevant to the discussion.

Figure 6.3.1: Tool characteristics identified and explored during the investigation

	Characteristics	*Pictograph*		*Description*
CONTENT	**Primary focus**	D	Design	Focuses on design issues related to materials or sustainability
		M	Material	Focuses on materials and design
		S	Sustainability	Focuses on sustainability and design
	Type	ⓘ	Information	Provides information without guidance
			Knowledge	Guidance which provides or encourages knowledge development
			Analysis	Facilitates analysis
			Idea generation	Assists idea generation
			Communication	Enables communication of ideas, through visualisation, by comparison or description
	Scope	<—>	General	Broader and more general such as an organisation
		>|<	Specific	Has a very narrow focus such as a checklist
	Project Phase	1	Early phase	Typified by 'inspiration', less detail, development of the brief and creative freedom
		2	Middle phase	Typified by 'synthesis', more detail, and 'intellectual break-even'
		3	Late phase	Typified by 'analysis', great detail, specification and very little room for change
FORMAT	**Language**		Images	Wide use of images, graphics or illustrations
		Aa	Text	Predominantly prose-based
		3D	Physical	Objects that can be handled, for example products, samples or playing cards
		√	Data	Scientific language to describe information
			Charts or diagrams	Information displayed in charts or diagrams
		☑	Checklist	List of simple prompts to be checked off
	Manifestation	WWW	Online	Web-based indicating easy access
			Software	Using software rather than hardcopy
			Print	Includes books, journals or printed material
			Collection	Of materials, books, data etc.
			Network	Involves a network of like-minded individuals, peers or experts
			Event	Provides events such as seminars, workshops, exhibitions or conferences
	Use and Interaction		Add or extract content	Flexible and can be adapted to users' own methods or type of work
			Dynamic or abstract access	Abstract access or connections can be pursued, or incorporates playfulness
			Quick	Doesn't require great time investment
			Easy	Is not over-complex or beyond the expertise of designers
		£	Cheap	Free or low one-off payment without subscription
	Location			Region and country – if location specific
	Website			Web address or literature reference

6.4 Results & Discussion

The enquiry reviewed and characterised more than ninety tools which could aid design generally or in the consideration of materials or sustainability. The aim was not to be exhaustive, but to represent the resources available and identify best practice. There were four predominant tool groups within the sample:

- Innovative Formats
- General Design Support
- Eco-design Tools
- Material Selection Tools

As the investigation progressed it became apparent that some of the tools encountered were unrelated to the original search criteria but were useful to the enquiry because of their 'innovative' format. Each group had some defining characteristics and themes which are discussed in the subsequent sections using specific examples. Examples have been chosen here to illustrate the themes revealed through the enquiry, or to exemplify best practice.

Two different methods of presenting the tool characteristics have been used. First, the characterisation table (Appendix C(ii)) identifies the characteristics of each tool in a simple matrix which was mainly used as a method of reviewing and developing the characterisation during the enquiry.

Second, a 'tool characterisation bar' was developed for the main tools discussed using pictographs – previously identified in figure 6.3.1 – to identify the characteristics of that particular tool. Pictographs were used by the author to aid comparison and memory (an example is included in Appendix C(ii)).

6.4.1 Innovative Formats

Tools with 'innovative' formats were encountered during the enquiry and included in a separate group. They demonstrate tool characteristics that appear well-suited to design methods and practice, some of which may not relate directly to the focus of the study.

Familiar Software

Visualisation software such as *Adobe Photoshop* (fig 6.4.1) and *Computer Aided Design (CAD)*[128] are now a regular feature of the design toolkit because of their flexibility and roots in a method fundamental to any form of design (drawing and manipulation of image and form). The *Photoshop* and *CAD* 'environments' are analogies[129] of the traditional physical design studio, providing a blank background, a number of palettes and digital tools with which the designer can alter the virtual plane in a similar way to using pens, pencils, paper and material. Software developers continuously update features in response to evolving use and emerging requirements. Professional designers have become fluent in the language of these

[128] For example Rhino3D (http://www.rhino3D.com accessed 10/07/09)
[129] Analogies are used by software developers to ease users into the digital interface by using terms and references they are familiar with in the physical world (Sharp, Rogers & Preece 2007)

programmes and they exemplify the type of interaction and the level of flexibility designers have come to expect from their tools. Expectations of digital software are therefore an important consideration in developing design tools.

The digital drawing or modelling board increases design freedom in many ways, such as the ability to erase and edit repeatedly which is difficult in the physical world, but is also limiting in areas such as sensorial contact, materiality of the medium and the specificity with which the various brushes and filters operate. *Adobe Photoshop* has taken over twenty years to develop to the current standard (Computer Literacy 2008); trying to recreate a similar level of usability in new digital design tools would be near impossible and certainly beyond the resources of most academic research projects. One alternative might be to utilise existing software, familiar to designers, to make new tools that are instantly intuitive and usable. For example, 'hijacking' *Microsoft PowerPoint*[130] for use in interaction design is an existing method based on this principle;[131] each slide represents a screen in the interface and hyperlinks can be created to act as buttons navigating between screens, a process which is far simpler and quicker than developing a 'polished' interface prototype using specialist software. This approach to developing design tools involves working with the designer's existing understanding of how to use the software and benefits from being relatively inexpensive and risk-free to develop.

Another software tool which is ubiquitous in daily life, but was also one of the most useful tools for designers when looking for materials in the survey (Chapter Four), is the internet search engine. Perhaps one of the reasons designers find search engines so useful is the general and abstract access it can provide to a plethora of more specific information. This method of accessing information was identified in the literature as being particularly relevant to design methods, but also has pitfalls; it would appear to be a quick and easy starting point yet it can take much longer than expected to find the exact information required by the designer.

Making Data Memorable

Another digital tool which uses an inventive approach to interaction and digital information display is the *Royal Society for the Arts* (RSA) *Habbit* (fig 6.4.2), an online tool which transforms the user's answers about their behaviour into a three-dimensional representation of their carbon emissions. There are several tools available for this purpose but the *Habbit* is unique because it transforms the data into a human figure where the size of different parts of the body represents different carbon emissions. This makes the data more powerful, memorable and relevant to users. The playful and imaginative nature of this example also makes it stand out from other visual information.

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[130] PowerPoint is a software programme which uses the analogy of a slide projector but also allows dynamic links between slides, similar to the internet.

[131] An approach taught by an unknown Visiting Professor whist the author studied BA Hons Design at Leeds Metropolitan University from 2001-04

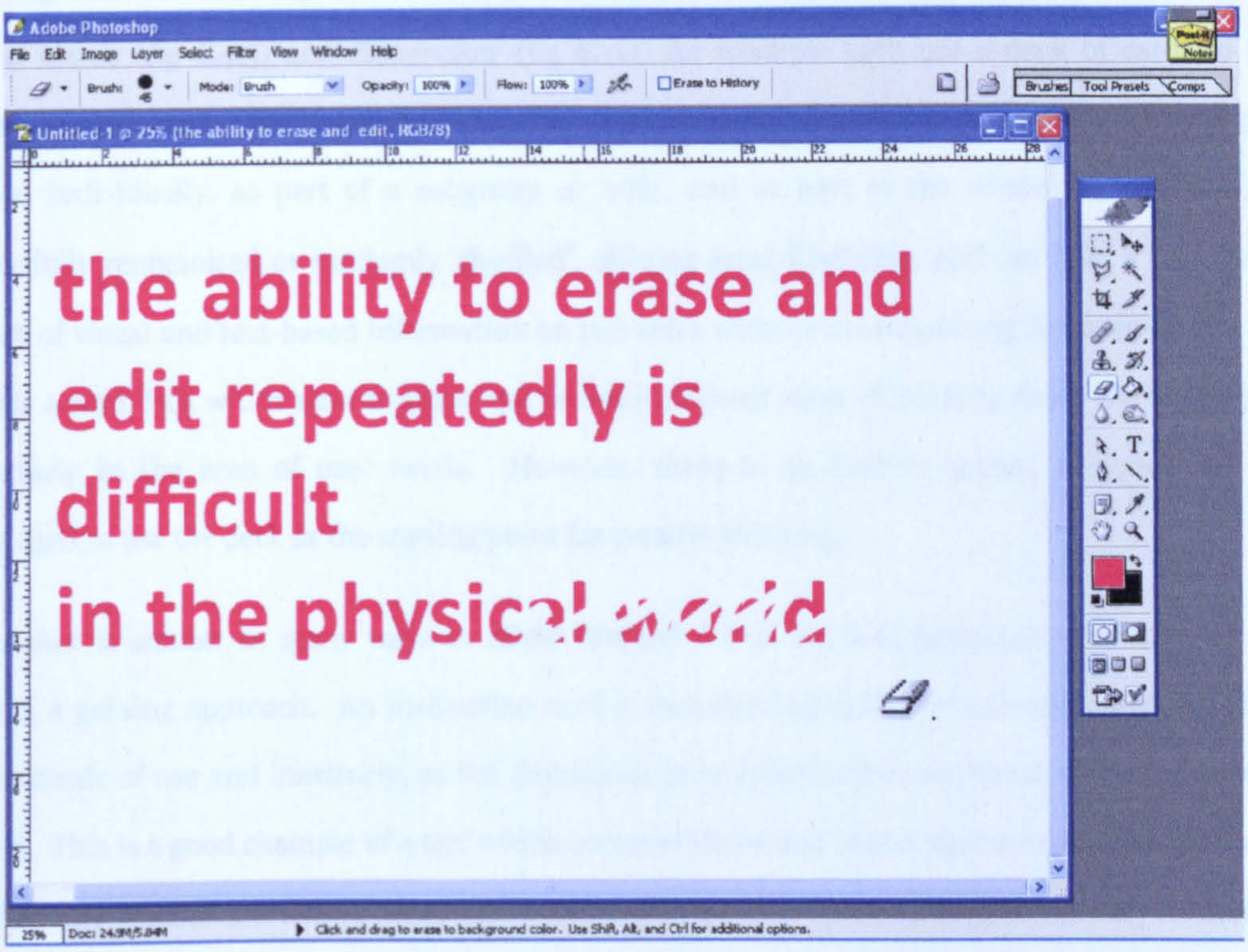

Figure 6.4.1: Adobe Photoshop screengrab showing the virtual drawing board and eraser

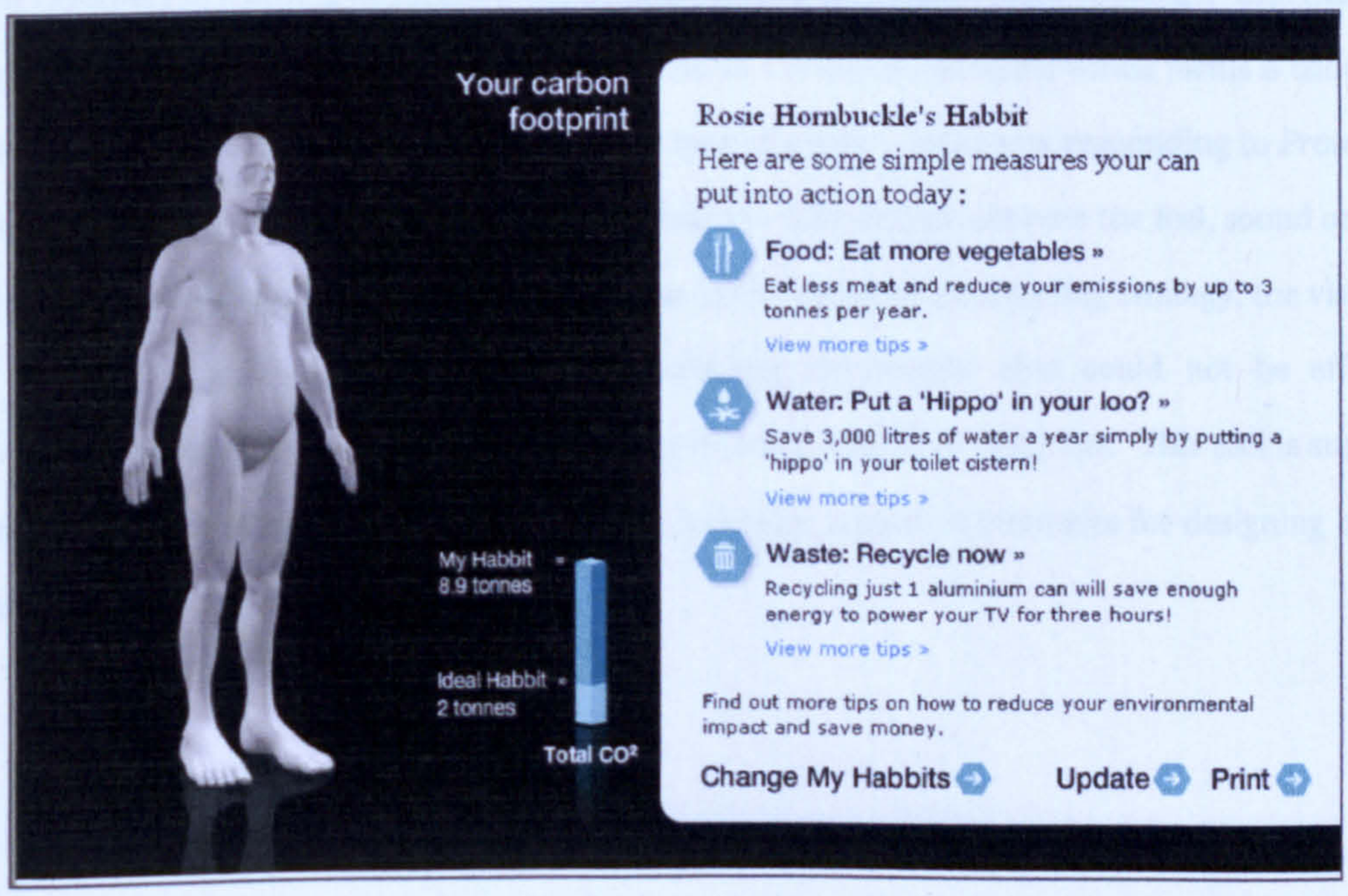

Figure 6.4.2: RSA Habbit screengrab showing the author's carbon footprint in the form of a human figure (http://rsachanginghabbits.org accessed 14/05/07)

Familiar Games

The recognisable form of a game as a means of investigative play are utilised in some design tools. *IDEO Method Cards* (fig 6.4.3) and *Flowmaker* (fig 6.4.4) for example both use a deck of cards to provide information and encourage idea generation. The value of a deck of cards is in its modularity; each card can be used individually, as part of a subgroup or 'suit', and as part of the whole pack. Cards can be purposefully reorganised or randomly 'shuffled', offering great flexibility, and can hold a relatively large amount of visual and text-based information on two sides without overwhelming the user. *IDEO Method Cards* is a card deck which aims to guide and provoke different ways of thinking about the design process, particularly in the area of user needs. However, there is no built-in 'game', designers are simply encouraged to use the deck as the starting point for creative thinking.

Flowmaker is similar in many ways to *IDEO Method Cards* but was designed with 'suits' or themes allowing a gaming approach. An instruction card is included but designers are encouraged to find their own methods of use and inevitably, as the developers have continued to use them, new approaches have evolved. This is a good example of a tool which accommodates and encourages a designerly approach; if it is sufficiently flexible and allows designers to adapt and use it in different ways a tool may fit more easily into their way of working and provoke, rather than restrict, desired activity.

Protomold, a company specialising in rapid prototyping, has come up with some inventive ways of engaging designers in learning about the processing properties of different types of plastic. One example is the *Resin Key Puzzle* (fig 6.4.5) (similar to those found in Christmas crackers) which forms a cube out of nine interlocking parts, each made out of a different type of plastic. Designers responding to *Protomold's* free offer receive this puzzle and while 'playing' may learn to differentiate between the feel, sound or weight of each piece. While this initiative surely has its roots in the company's marketing strategy, the visual and tactile object demonstrates a creative way of conveying information that could not be effectively communicated in text and images alone, and in a way that may appeal to designers. This tool is supported by *Protomold Design Tips* (for source see fig 6.4.5), a regular update of strategies for designing effective moulds, which is sent by email.

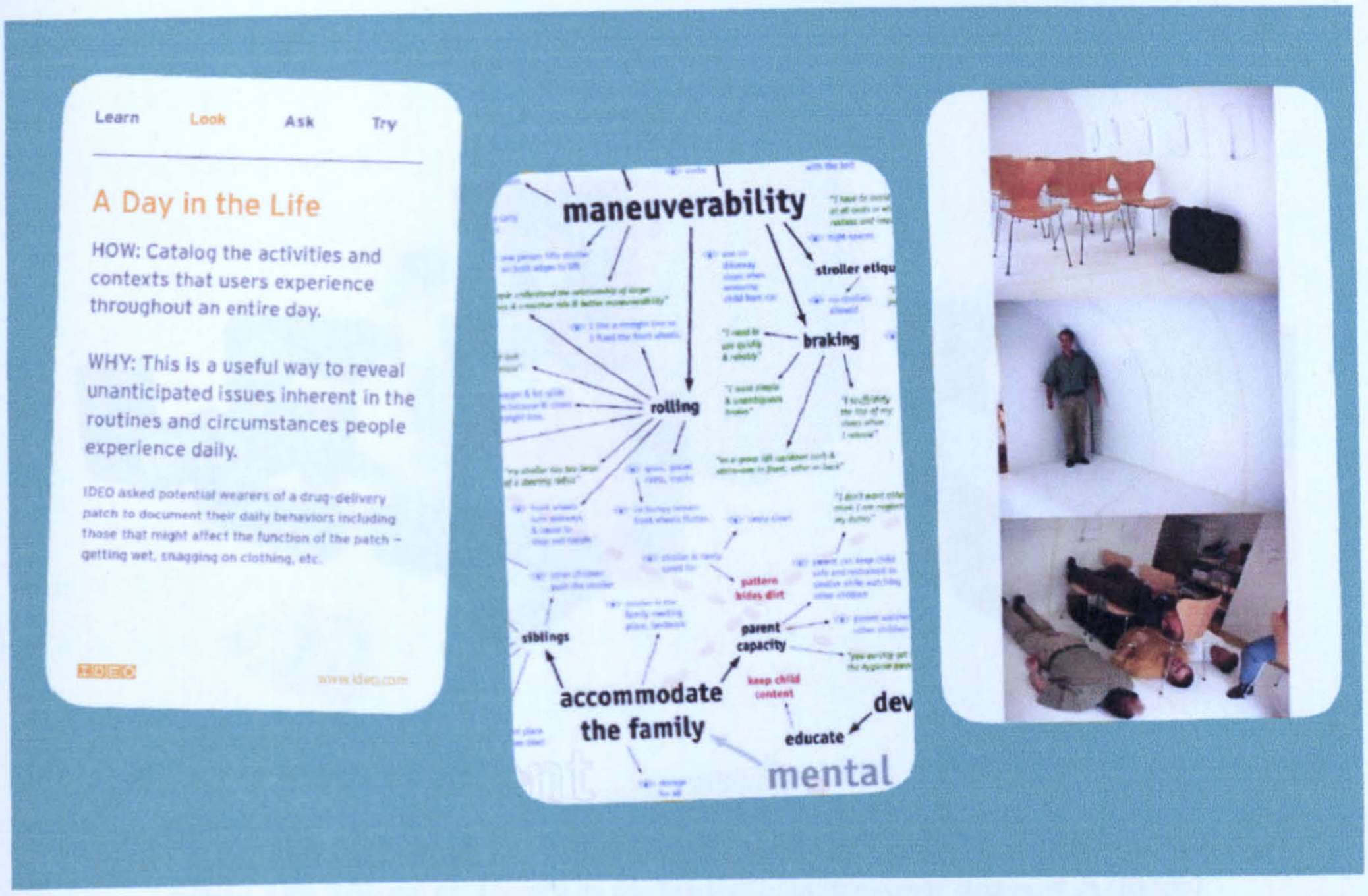

Figure 6.4.3: IDEO Method Cards
(http://www.ideo.com/publications/item/ideo-method-cards/ accessed 03/05/09)

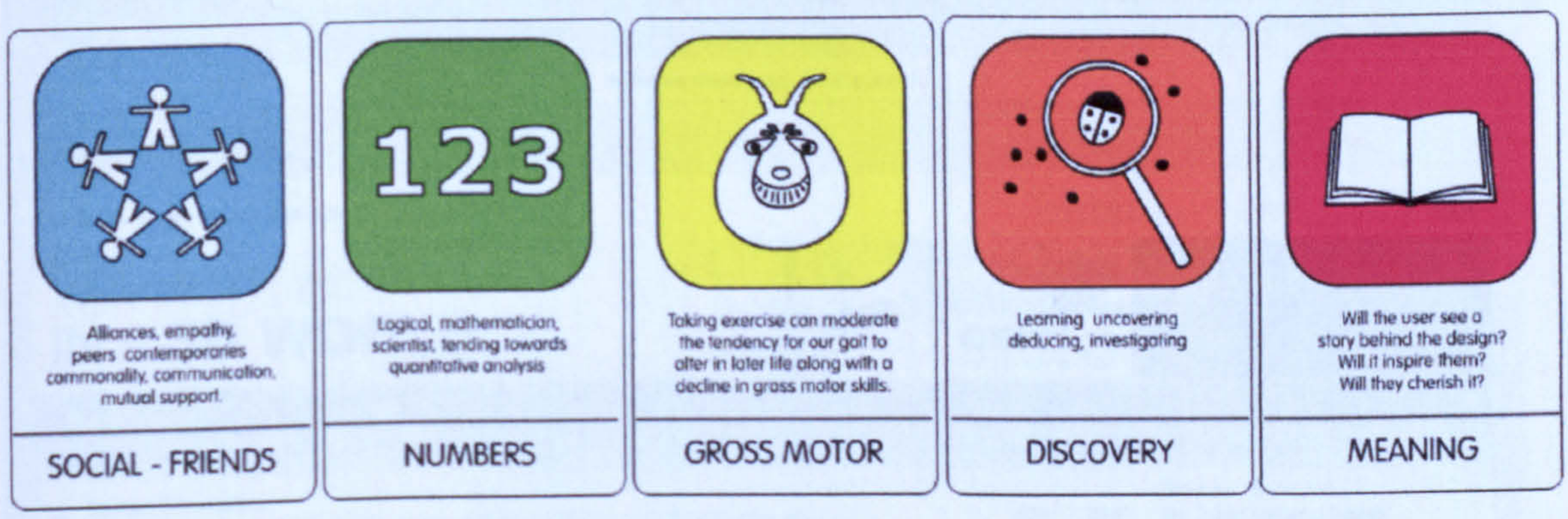

Figure 6.4.4: Flowmaker cards showing each of the five suits
(hardcopy and online http://www.wemake.co.uk accessed 23/07/09)

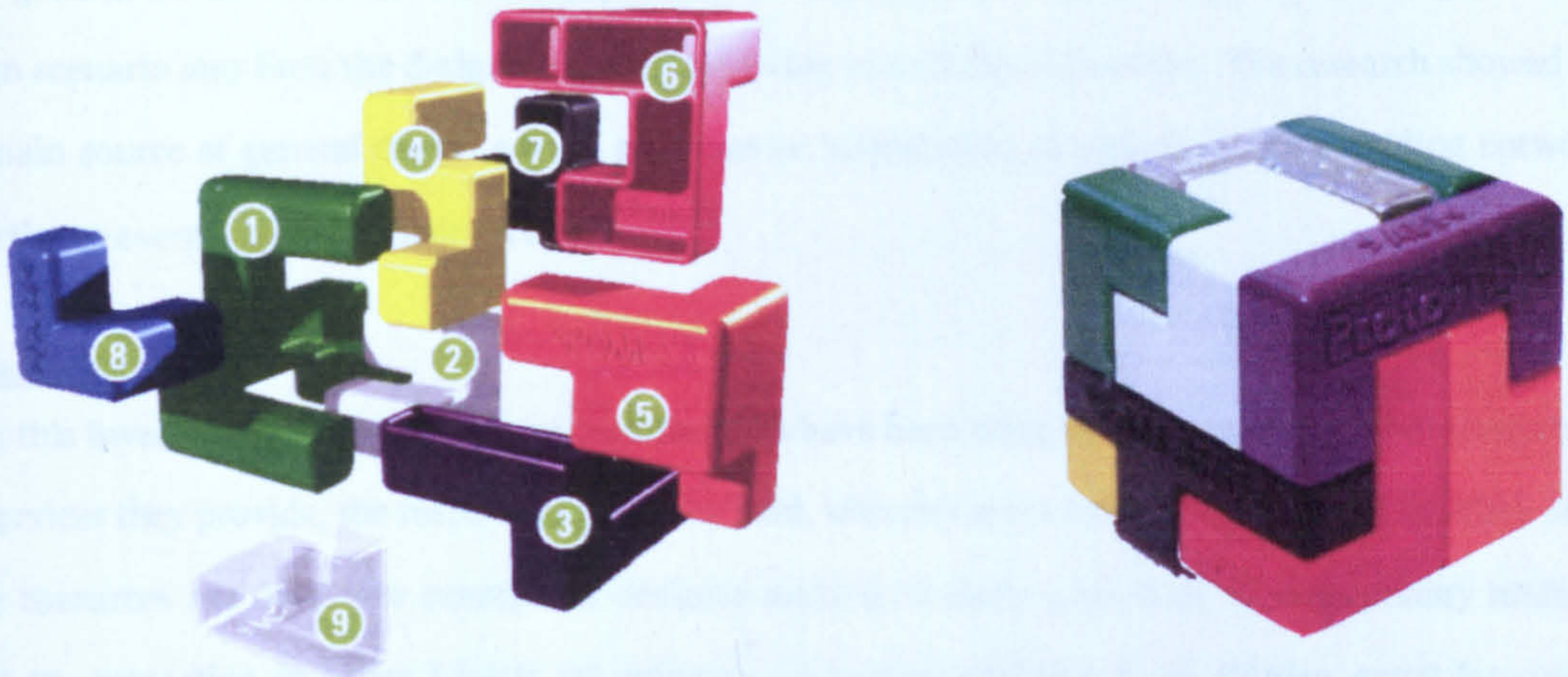

Figure 6.4.5: Protomold Resin Key Puzzle showing each part made from a different polymer (www. http://www.protomold.co.uk/DesignGuidelines.aspx accessed 21/10/07)

Figure 6.4.6: Product Design Forums screengrab (http://productdesignforums.com accessed 16/08/09)

6.4.2 Tools for General Design Support

The purpose of including tools for general design support was to understand where designers can go if they need general advice. This was following the acknowledgement in Enquiry 1 that various aspects of the design scenario may limit the designer when considering something unfamiliar. The research showed that the main source of general design advice, guidance or information, is organisations providing networks, expertise or events as part of their services.

Organisations

From this investigation alone numerous organisations have been discovered, each differing with regards to the services they provide, the responsibilities they hold, who can access their resources and whether or not those resources are free. For example, a designer looking to make a product from secondary materials might try contacting *Business Link*[132] for guidance on commercialising it, or *Hidden Art*[133] for support when trying to get exposure and sell it. But they could also go to the *Manufacturing Advisory Service (MAS)*[134] for advice about how to argue the case with manufacturers for producing the product from secondary materials. Whether or not that designer would know to go to these different organisations for these particular enquiries is uncertain.

Organisations can be contacted by phone for free which can save time if they are able to provide designers with useful information, but this may involve enquiries being passed on along a trail of unsuccessful contacts, which can be frustrating. Therefore, organisations may appear difficult to navigate to designers looking for information. The UK government is attempting to address this problem by introducing a *Business Support Simplification Programme* with the aim of reducing the portfolio of schemes from around 3000 to 100 by 2010 (DTI 2006a:4). *Innovation* and *Environment* form two of the nine focuses which will become the government's new business support programme, with reformation of *delivery* and *access channels* for support also highlighted. Therefore, this appears to be a serious issue for businesses generally.

Networks

Networks offer an important source of peer-support and guidance that organisations arguably lack; Benjamin provides a useful explanation in the *Design for Sustainable Development: Networks Directory* authored for the European Foundation for the Improvement of Living and Working Conditions (Eurofound):

> Networks are widely available to all, tend to be a reliable source of low cost information and access to experts in the subject area and are more likely to have a representation in more

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[132] A UK government-funded business support service (http://www.businesslink.gov.uk accessed 23/07/08)
[133] A London-based not-for-profit organization which help support and promote emerging design practice (http://www.hiddenart.com accessed 23/07/08)
[134] A UK government-funded manufacturing support service with regional centres (http://www.mas.berr.gov.uk accessed 01/08/09)

than one country. Organisations are only included if they offer the sorts of service associated with networks.

(Benjamin 1998:9)

Benjamin clearly favours networks as they provide a dialogue with peers and experts which can be an invaluable source of information and guidance. These can involve networking events or access to specialist contacts but most frequently their activities include virtual dialogue via a blog, internet forum or email feed. Examples include the online *Product Design Forum* (fig 6.4.6) where designers can post, or respond to, topics or questions on any aspect of design. There are also numerous networks focusing on eco-design, such as the *O2 Global Network*[135], which facilitates an email exchange between designers interested in eco-design from across the world. The particular benefit to designers is that the information comes from an impartial and varied source, giving it credence and instilling confidence. One notable downside is that it can be time-consuming to regularly read updates or attend events. Again, networks are numerous and it may be difficult for designers to discover them and to know which are most useful for a particular subject or enquiry.

What becomes apparent is that there is a plentiful supply of information, guidance and support 'out there' which isn't necessarily easy for designers to access or to trust; as one architect was heard saying (when opening a materials resource in London) *"There's a lot of information out there, but very little intelligence"*.[136]

6.4.3 Tools for Eco-Design

Eco-design is perhaps one of the most challenging areas for designers to practice in; the drivers are still largely non-commercial, the issues complex and the benefits hard to prove. For this reason different types of tools for aiding eco-design have been developed, many of which were discussed in the focused literature review for this enquiry. Rather than repeat the points discussed earlier, this section will focus on holistic eco-design tools which demonstrate some of the characteristics identified as desirable in the literature.

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[135] See http://www.o2.org (accessed 27/06/09)

[136] The opening of the new MaDE resource at the Institute of Materials, Minerals and Mining, Carlton Terrace, London 24/09/07

Holistic Eco-design Tools

One of the pioneers of the holistic approach to eco-design tools is Yorick Benjamin, who developed a proposal for the *EDEN Design Tool* as the main outcome of his PhD in 1994. In the early developments of the EDEN tool[137] Benjamin summarised its essential features:

- User control and independence of use - own data inputs
- Value judgement orientated and has to anticipate the future
- Flexible, quick to use
- Economically viable
- Work on a single issues or multi criteria
- Have a transparent information base
- User scopes the study – depth and width
- Expert groups formed to input 'core' data

(Benjamin 1994:160)

One of the most striking points about Benjamin's system is the emphasis on access to expert-approved reliable information, flexibility and adaptability, considerations which were emphasised in the literature.

To deliver these features Benjamin (1994) also developed an *Eco-Profiler* (fig. 6.4.7) to visualise different options, not dissimilar to the Eco-strategy or LiDS wheel developed later in the Netherlands (Hemel & Keldmann 1996). The *Eco-profiler* aims to represent the true availability of material and sustainability information by assigning data with *qualitative, quantitative* or *inference* markers and thus enabling the reader to make a more informed decision about the implications of that data for the project. Perhaps one criticism is the feasibility of organising and maintaining expert groups and the flow of information to develop and maintain the software to a high enough standard, keep it up-to-date and responsive to changing approaches.

More recent eco-design tools can take advantage of the flexibility of today's information technologies. For example, the *Information Inspiration* tool (fig. 6.4.8) developed by Lofthouse (2001) at Loughborough University has a number of features that other eco-design tools lack. A wide range of general eco-design information is collated in one location using designer-friendly text and images combined with product examples which are included to demonstrate the theory and provide 'inspiration'.

The real success of this tool is that it achieves a similar level of flexibility to the websites and interfaces that designers are used to, linking common themes and directing users to other more detailed information within the site and beyond, or to other tools which may be of use. Users are able to search the site abstractly using a key word, which is now an essential feature on most websites, demonstrating a real awareness of the needs of the audience.

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[137] To the author's knowledge the EDEN tool is still a prototype.

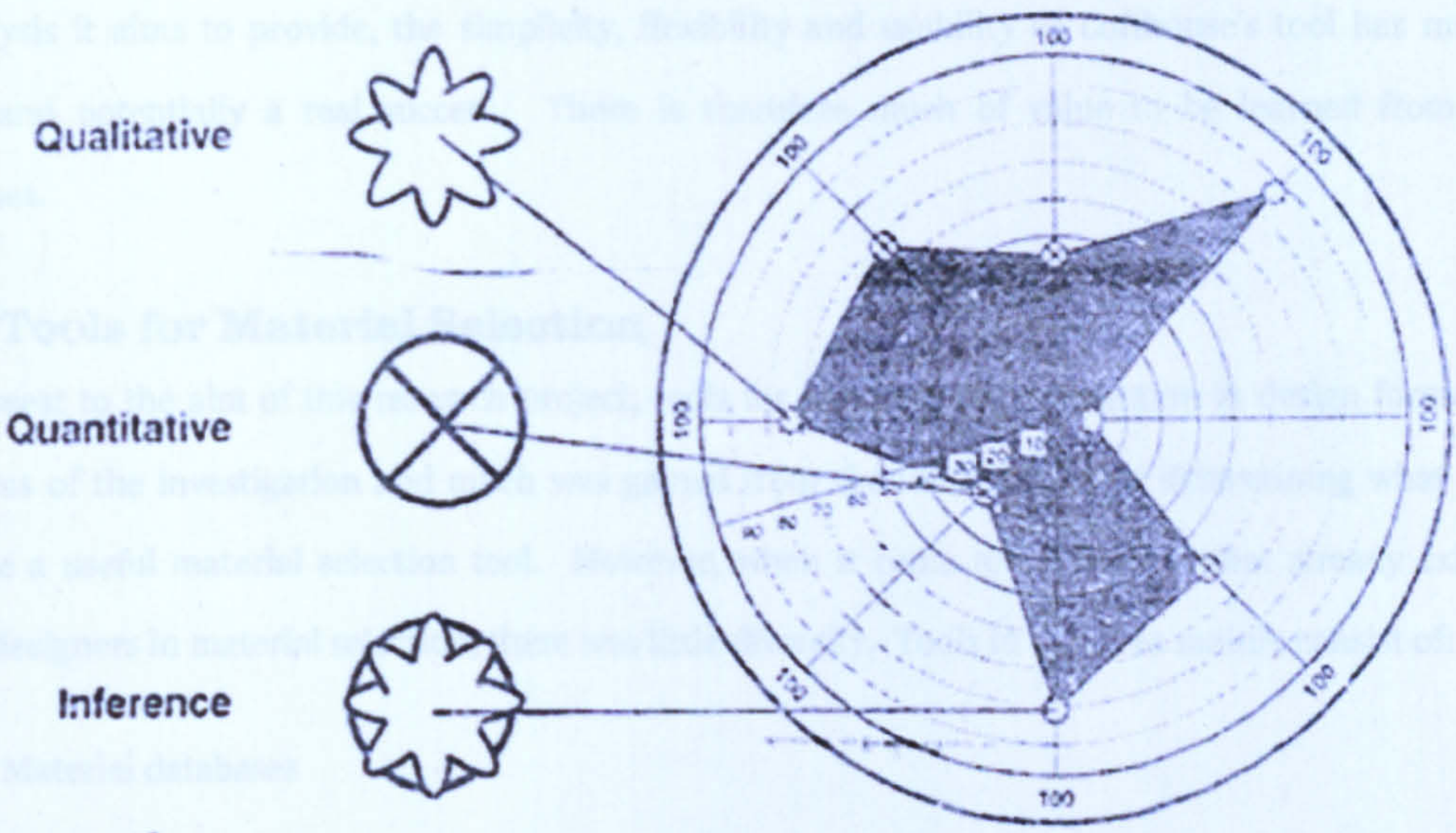

Figure 6.4.7: Eco-Profiler presented in the form of a wheel, capable of showing qualitative, quantitative and inferred information (Benjamin 1994:172)[138]

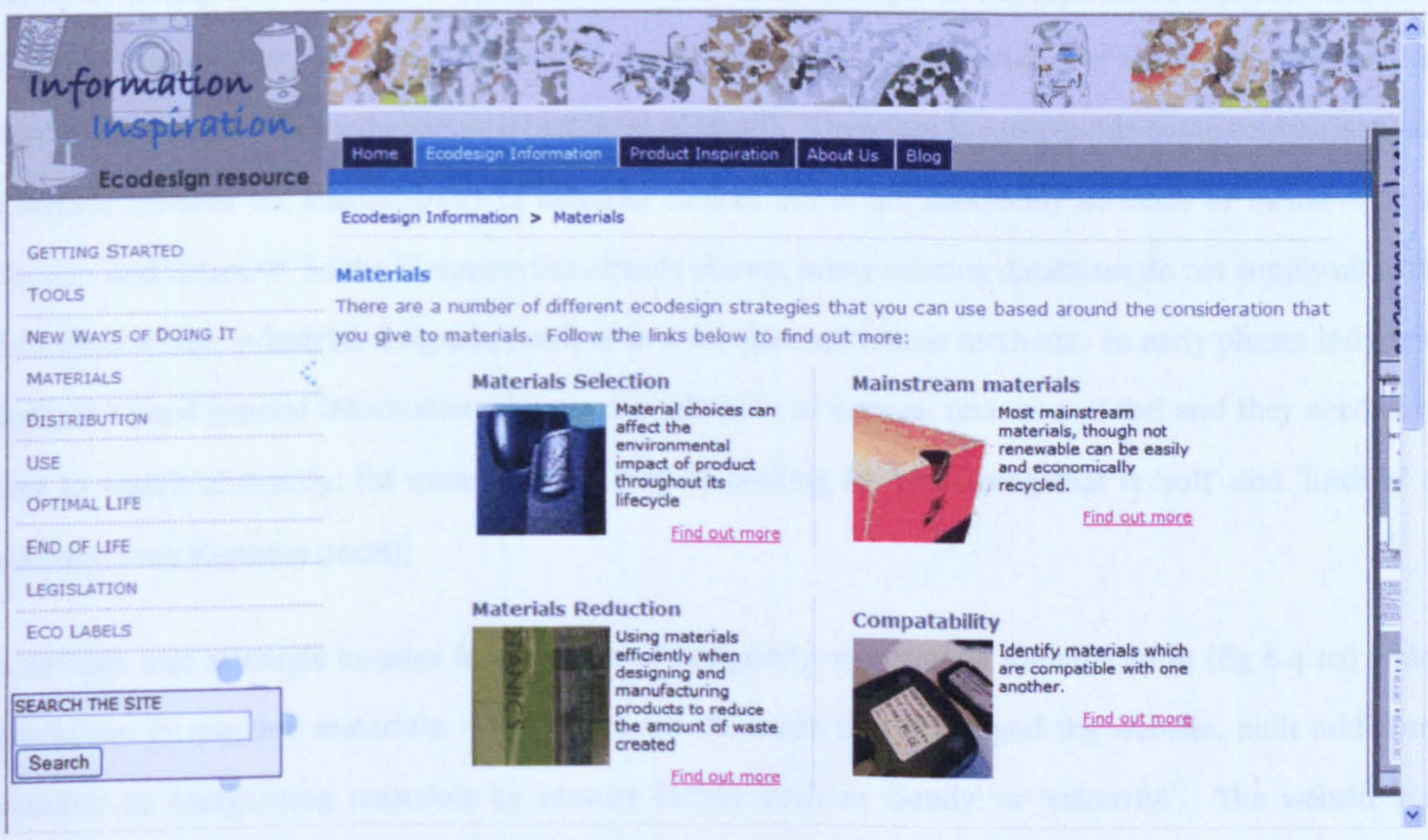

Figure 6.4.8: Information Inspiration screengrab (http://www.informationinspiration.org.uk accessed 01/08/09)

[138] This image was copied from microfilm which accounts for the poor quality. Subsequent attempts to obtain a higher quality image from an original proved unsuccessful as the British Library copy was missing. The image has been included because it remains useful to the discussion.

Whereas Benjamin's EDEN Design Tool is perhaps richer and more detailed in terms of the information and analysis it aims to provide, the simplicity, flexibility and usability of Lofthouse's tool has made it feasible and potentially a real success. There is therefore much of value to be learned from both approaches.

6.4.4 Tools for Material Selection

Being closest to the aim of this research project, tools for aiding material selection in design formed the main focus of the investigation and much was gained from the literature when determining what might constitute a useful material selection tool. However, when it came to looking at what already exists to support designers in material selection, there was little diversity. Tools in this area mainly consist of:

- Material databases
- Material libraries
- Material books and journals
- Supplier information

Material databases

Cambridge Engineering Selector (CES) and the greener equivalent *Eco-Selector* (fig 6.4.9) offer an excellent example of a database with good technical functionality. In the absence of test data and solid evidence *Eco-selector*, like other tools which aim to quantify the sustainability of materials, relies on best available data and informed estimates (Ashby *et al* 2005). Therefore it can provide some comparison and guidance towards the sustainability of material choices but is not absolutely accurate or inclusive of all impacts and issues.[139] As the literature has already shown, many existing databases do not supply all of the information that industrial designers need, or in a way that suits their methods. In early phases industrial designers need general information about materials such as images, texture and feel and they need to be able to search abstractly; for example, they may be looking for something that is 'soft' and 'flexible' or 'rubbery' (van Kesteren 2008).

A website that attempts to cater for this type of designerly approach is *Rematerialise* (fig 6.4.10) which specialises in recycled materials. Dehn, who led the team that developed the website, built additional usability by categorising materials by sensory factors such as 'bendy' or 'colourful'. The website also includes short films showing the material being handled, which overcomes some of the sensory deprivation of the virtual world.

[139] Granta Design, who manage CES, are seeking to improve information relating to the sustainability of materials (discussed in Chapter Five)

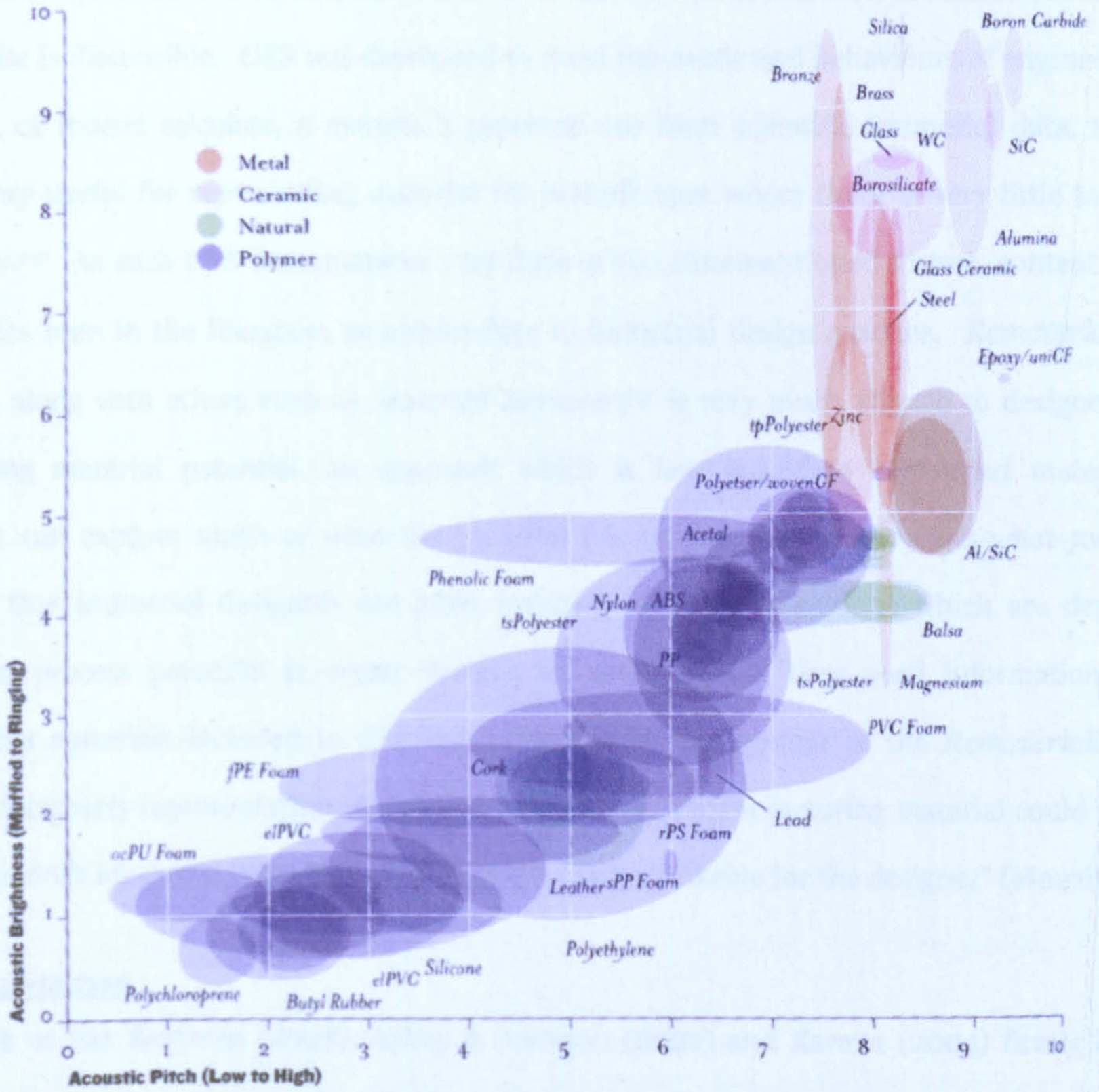

Figure 6.4.9: Material Property Map from Cambridge Engineering Selector material database (Ashby & Johnson 2002:72)

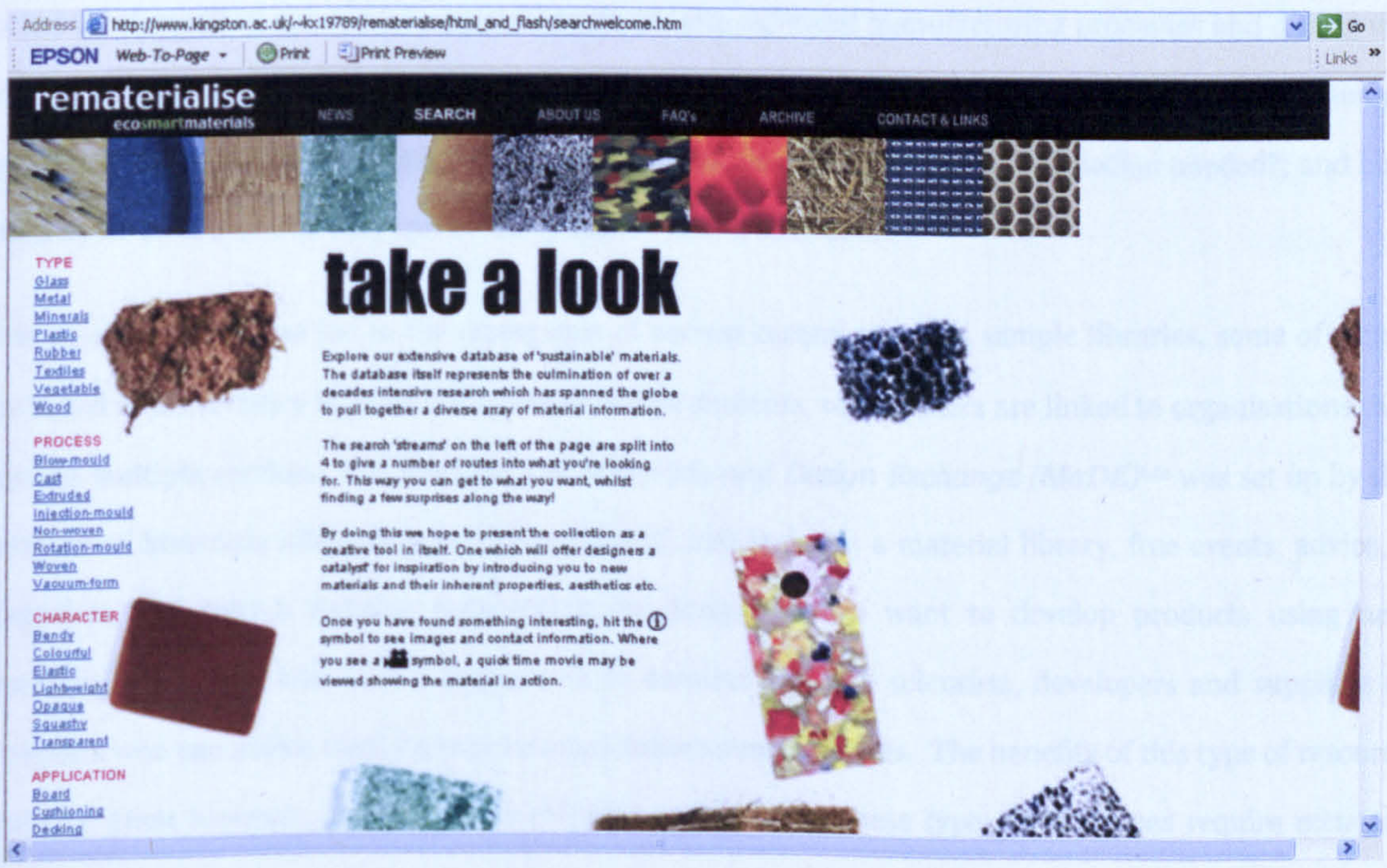

Figure 6.4.10: Rematerialise screengrab (http://www.rematerialise.org accessed 05/04/09)

The difference in presentation of material information between databases such as *CES* and those similar to *Rematerialise* is discernible. *CES* was developed to meet the needs and behaviours of engineers who can understand, or indeed calculate, a material's potential use from scientific (numeric) data, making this approach very useful for representing material for manufacture where there is very little to capture in photography.[140] As such *CES* demonstrates very little of the aforementioned format, content or delivery characteristics seen in the literature as appropriate to industrial design practice. *Rematerialise* on the other hand, along with others such as *Material Explorer*,[141] is very much aligned to designerly ways of understanding material potential, an approach which is best suited to preformed materials where photographs can capture much of what the material has to offer; what-you-see-is-what-you-get. The difficulty is that industrial designers are often involved in making decisions which are dependent on material and process potential to create designs for manufacture; they need information about the manufacturing materials included in *CES* but presented in the manner of the *Rematerialise* website. Marrying a designerly representation of material potential with manufacturing material could be useful in realising Manzini's ideal of making "the possible more easily thinkable for the designer" (Manzini 1986:17).

Material Libraries

Authors such as van Kesteren (2008), Ashby & Johnson (2002) and Karana (2004) firmly believe that designers need physical contact with materials in order to understand some properties that images, text and even video cannot convey, which was confirmed by the survey interviewees: "you need to sort of gauge how sort of bendy, stretchy and tactile something is. That's done quicker by actually holding it" [JB]. This includes information about how materials perform with different manufacturing processes and during use and is a particular challenge with materials information provision; supplying and delivering materials samples is expensive; even if designers receive samples, do they convey the information needed?; and how will they be stored so that they can be easily retrieved at a later date?

This perceived need has led to the emergence of several central material sample libraries, some of which are based in universities to serve the needs of design students, while others are linked to organisations that provide multiple services. For example *The Materials and Design Exchange (MaDE)*[142] was set up by the Institute of Materials Minerals and Mining (IOM3) and includes a material library, free events, advice, a magazine, and runs a funding competition for designers who want to develop products using new materials. The main aim of this initiative is to connect material scientists, developers and suppliers to designers who can utilise (and thereby commercialise) new materials. The benefits of this type of resource could be great however, in order to be effective and reliable, these types of resources require constant

[140] The developers of CES have pioneered an approach for mapping material characteristics which allows designers and engineers to understand the suitability of a material based on its measurable properties, however this visual method still excludes much of the information designers glean from seeing or touching the material. Van Kesteren (2008) found that designers using CES said they wanted more images of the materials.
[141] See http://www.materia.nl (accessed 30/03/08)
[142] See http://www.made.net (accessed 30/03/08)

maintenance and a dedicated team to research and source materials and keep the information updated. Although some of the survey interviewees were aware of this resource and saw the potential benefit of it, none of them had been to visit (a trend echoed by van Kesteren 2008); the most useful output of MaDE for the designers interviewed was the magazine which they occasionally had time to look at[143].

Designers are unlikely to go to material libraries regularly to get specific information but instead to find inspiration on rare occasions when they find the time, or when they visit design shows where materials libraries are exhibiting. It may be difficult to influence the everyday materials choices of designers through this type of design tool alone; designers are not exposed frequently enough to material libraries and the information they take away with them may not be about technical properties or supply, but inspiration to do with colour, texture or any number of other abstract associations.

The resource-intensive nature of material information management means that the most successful services are arguably those that have been commercialised and charge a subscription fee. Some of these offer basic services for free; for example, *Materia*[144] in the Netherlands includes an online materials database called *Material Explorer* which allows anyone to search materials online and includes an email newsletter which alerts users of newly sourced materials and other relevant news. If designers want to visit the 'Inspiration Centre', attend lectures or events, or talk to *Materia* experts they must then pay a fee.

The role of material collections, however, may go beyond direct contact with the designer. This investigation suggests that material information may be distributed from the central location of the library by the *material librarian,*[145] who often responds to remote enquiries, may act as a consultant to designers, be involved in trade shows, give talks and write articles for trade press. The librarian is the person most familiar with the material collection and is able not only to locate the desired information, but also to use a deep contextual understanding of the information to translate the requirements of the designer into materials that may be suitable. The survey (Enquiry 1) also highlighted the usefulness of talking to someone who knows about specific materials, such as suppliers or distributors, while one of the survey interviewees also imagined a material librarian as being useful: "if you've got somebody who said 'well why don't you try this material?'" [JB]. Material librarians, therefore, can be seen as the boundary-spanners (Rieple, Haberberg & Gander 2005) of the material and design worlds, translating and distributing the wealth of material information from the scientific community (suppliers) into the language of designers, through the most useful of mediums, dialogue.

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[143] One designer had also visited a MaDE event.
[144] See http://www.materia.nl (accessed 30/03/08)
[145] The author conducted informal meetings with two material librarians (see Appendix C(i)) Clare Qualmann who worked on the London Metropolitan University material library for seven years, and Chris Lefteri who, although not officially a librarian, had his own collection and curated the popular 100% Materials exhibit at the design trade show 100% Design. Margaret Pope, who founded the Royal College of Art's (RCA) material library which has since been amalgamated into other collections, was discussed in the meeting with Clare Qualmann (10/12/07) and by one of the survey interviewees [SF] who had studied while she was librarian at the RCA.

Material Books and Journals

Similarly to the material databases, there are two typical approaches to book-based material information for design: the first is aimed at engineers, such as the *Engineering Materials and Processes Desk Reference* (Ashby & Tooley 2009) which is written in the language of science and is data-intensive, the second is aimed more at industrial and product designers, such as *Materials and Design: The Art and Science of Material Selection in Product Design* (Ashby & Johnson 2002) which takes a much more general approach to terminology and uses plenty of images. Although books were not seen as a useful resource in the survey, the more general approach in Ashby & Johnson's text could be welcome in design education.

The most noteworthy journals and magazines are those produced for free by the materials and design community, such as the *MaDE* magazine which all four of the designers interviewed in Enquiry 1 were receiving and were generally positive about. Chris Lefteri also produces various publications about new materials, including the *Ingredients* series (Lefteri 2007). These magazines take a similar approach to the many glossy design magazines and the ever-popular *Design Week*[146] by using only short articles, summary or bullet-pointed text and spreads dominated by large images.

Suppliers' Information

The survey findings (Enquiry 1) revealed that product and industrial designers don't find central or 'hub' resources, such as those discussed above, useful for finding materials. Indeed the most useful source was their own experience, which emphases the constraints on their activities. The second most preferable sources were the internet and in particular suppliers' websites and talking to suppliers. The survey findings clearly point to suppliers as a key resource for designers, an area which appears to have been overlooked in previous studies of materials information provision, in favour of hub or centralised sources. There is apparently no infrastructure, protocol or training relating to strengthening this direct relationship, either for suppliers or designers.[147]

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[146] With a readership of 35,000 (http://www.designweek.co.uk/about-us accessed 12/03/09)

[147] This appears to be an area that Chris Lefteri – as boundary-spanner of materials and design worlds – is working on as a consultant. On supplier Dow Corning's website Lefteri is quoted: "Suppliers are beginning to realise the importance of the design community and that this community needs a different type of information than the more traditional engineering industry. Essentially a large part of this is about bridging the gap where actual physical samples are not available and giving information that fills that void." (http://www.dowcorning.com/content/about/aboutinnovate/Smart_Design_Innovation.aspx accessed 16/08/09)

6.5 Addressing the Research Questions for Enquiry 3

The new knowledge gained from this investigation can now be considered in relation to the research questions for Enquiry 3, presented earlier.

What tools are available to support designers in the consideration and use of secondary materials, and within the broader context of the material cycle, sustainability and design practice?

What are the characteristics (content, format, delivery) and in what ways are they aligned to design methods?

- Tools to specifically support the consideration and use of secondary material in design practice were few; these included exhibitions and a website that demonstrate the use of secondary material, and a material collection which mostly focuses on preformed materials made from secondary material.
- Tools for the broader areas of design, material and sustainability were discovered to generally fall into one of three groups: general design support, eco-design tools or material selection tools.
- An additional group was formed which exemplified tools with 'innovative formats' which appear well-aligned to design methods and practice.
- In relation to *innovative formats* it was considered that there may be some ways of engaging designers through the use of playful interaction, three-dimensional objects and inventive visual presentation of information.
- In relation to *general design tools,* it was discovered that, although there are organisations providing expertise, networks and events for designers, there are too many - each working in different areas and providing different services - for designers to keep abreast of the 'blur'.
- With regards to *eco-design tools* it was clear that a range of types of tools exist to support designers in this area but they are often limited in terms of their format. The delivery of information was discussed, acknowledging the vision of a holistic system which provides reliable information by forming 'expert groups' and also using simple representations for analysis. However, this was a particularly ambitious approach and a simpler, flexible tool was considered which demonstrated an appreciation of designers' methods and needs, providing a hub of general information in one location with links to more specific or detailed information resources.
- Finally, in relation to *material selection,* it was discovered that many tools exist for this purpose but that improvements are needed in terms of the type of information, how it is presented and accessed. Again the time constraints of designers were an issue here, but there is also the unique problem of providing three-dimensional samples. Centralised collections of materials samples are visited infrequently, if at all, which suggests that these alone may not be effective for influencing materials decisions. Suppliers appear to offer an opportunity for intervention as

designers see them as one of the most useful sources. A difference in approach to representing material information between engineering (scientific language) and industrial design (design language) was observed. Characteristics from both types of resource may need to be combined if industrial designers are to understand the potential of different manufacturing materials. In addition, it was observed that material librarians act as translators and distributors of material information for design, and could be called the 'boundary spanners' of the material and design domains.

- The various ways of defining effective design tools used in this enquiry, including the *typology of design tools*, the *designer as workman* metaphor and the *design tool characteristics table*, appear to provide a good theoretical foundation for developing and proposing speculative tools.
- Although the 'delivery' of design tools was difficult to explore in relation to specific examples, this is also a key consideration when developing tools that are accessible and useful.

6.6 Chapter Six Summary

This chapter has presented the focused literature review, research strategy and results for the enquiry undertaken to address Objectives 3 & 4. The aim was to critically reassess existing design tools in order to understand how designers might be better supported.

The enquiry provided invaluable insights into the kinds of characteristics that design tools should ideally demonstrate. A recurring theme related to how the proliferation of digital technology (software and internet use) has changed designers' expectations and behaviours around the handling and delivery of information, and that more needs to be done to consider design methods and dissemination (delivery) when developing new ways of supporting designers. A particular challenge exists in the presentation and provision of material and sustainability information which must also be addressed by any method of support for using secondary materials in design practice.

CHAPTER SEVEN Integrating and Interpreting the Empirical Findings (Objective 5)

This chapter synthesises the findings from all three empirical enquiries using two methods. First, the findings are ***discussed*** *to reveal themes that may contribute to answering the overarching research questions and meeting the project aim. Second, these themes are used to* ***explore possible tools or processes*** *to support designers in the consideration of secondary materials. The aim is to further process and understand the empirical findings whist also 'demonstrating' the practical application of the research.*

7.1 Introduction

The research reported in Part II of the thesis aimed to answer specific research questions and, in turn, generate new knowledge for addressing the project aim and objectives.

There were three distinct purposes of the empirical enquiries;

- **Enquiry 1** aimed to understand whether designers who are involved in the development of high-value mass-produced artefacts (identified as product and industrial designers working in-house or in consultancies) are in a position to consider and use secondary materials, and to identify opportunities for improving the situation.
- **Enquiry 2** aimed to understand the challenges of material cycles (secondary plastic in particular) and the context of secondary material use in design practice. Also to identify available materials, the challenges and existing approaches to using them.
- **Enquiry 3** aimed to reveal the strengths and limitations of existing forms of support (described as 'tools') in the areas of design, materials and sustainability to identify the desirable characteristics of a new tool or process.

This chapter presents two different approaches to integrating and interpreting the new knowledge obtained in Part II. The intention was to understand how the findings from each empirical enquiry relate to one another and to Objective 5 which seeks to find new ways of supporting designers in the consideration and use of secondary materials.

7.1.1 Research Strategy

The first approach was to use written discussion to explore common themes in the empirical findings. The second less conventional approach was to explore possible 'tools' to support designers in the consideration of secondary materials in response to the themes that emerged through the discussion. This served as a method of further processing the findings, 'demonstrating' the practical application of the research, developing 'specifications' for suitable tools and processes, and creating new models that could inform future work in this field by the author or other researchers.

These activities aim to address Objective 5 of the original project proposal:

> Develop innovative models to support designers in finding new applications for surplus and waste resources.

In Chapter Six it was proposed that *'tools and processes' are the operational devices which may support and enable designers to act within and in accordance to 'new models'*. Similarly, in relation to Objective 5, the author interpreted *'innovative models'* as the framework within which new tools and processes are developed. The research work reported in this chapter involved developing conjectural 'tools and processes' that would further the author's understanding about those innovative models.

7.1.2 Research Methods

This part of the project was *flexible* in nature, meaning that the research unfolded as new knowledge was gained. The exercise involved three phases:

- **Phase 1:** The **'discussion'** aimed to integrate the findings of the three empirical enquiries, to understand what they 'say' about how designers could be better supported in their consideration and use of secondary materials; involving:
    - An exploration of the findings of each of the three empirical enquiries;
    - Identification of common threads and themes within the findings;
    - Written discussion of how the findings relate to these themes and to Objective 5.
- **Phase 2:** **'Exploring new tools and processes'** sought to learn about, challenge and "demonstrate" (Durling and Niedderer 2007:11-12) the research findings through the use, reorganisation and real-world application of the knowledge gained, and to prepare the knowledge for use in future research, industry or education; involving:
    - The identification of exploration areas based on the themes from the discussion;
    - Identification of criteria or "specifications" (Durling and Niedderer 2007:11-12) for tools or processes in terms of content, format and delivery;
    - Development of conjectural tools or processes within each area through an iterative process enabling further understanding and clarification of the research findings and specifications;
    - Feedback from end-users where feasible (designers and suppliers) and data analysis;
    - Finalising specifications.
- **Phase 3:** A **'review'** was then conducted to reflect on these research activities and their contribution to achieving Objective 5; involving:
    - Posing and answering key questions about the purpose and success of the integration and interpretation exercise;
    - Drawing conclusions and addressing Objective 5.

The Methodology Overview (Chapter Three) locates these methods within the research strategy for the project and the context of design research.

7.2 Phase 1: Discussion

The following discussion is organised into four central themes which became apparent during the process of integrating the findings of the three empirical enquiries: design training and knowledge-building; material information provision; the relationship between the spectrum of design scenarios and secondary materials; materials and methods that are fit-for-purpose. The findings are discussed in relation to these themes and their relevance to supporting designers in the consideration and use of secondary materials.

7.2.1 Training and Knowledge-Building

The need to improve designers' knowledge generally, and about material cycles in particular, was highlighted throughout the research.

Enquiry 1 focused on the knowledge, attitudes and practices of professional designers, revealing that few had received guidance on the sustainable use of materials and those who had were more confident that they knew in what ways their material selections were sustainable. Many of the survey respondents shared a 'popular view' of sustainability in relation to materials use (waste and resource issues), rather than demonstrating a balanced and well-developed understanding (impact of material use across the whole cycle).

The majority of respondents received their training over ten years ago (64%), meaning that these results do not support a discussion of the inadequacies of current design pedagogy. However, they do suggest that guidance on the sustainability of materials is needed in design education. Moreover, it brings into question how designers who are already practicing can build knowledge and awareness; the likelihood of designers engaging in professional development is less than half that of other creative professions such as architects (Design Council 2005). Although new graduates can, to some extent, infiltrate current practice with new knowledge and awareness of sustainability, in a sustainable world designers will need to be able to respond to new knowledge and practices much more quickly than can be achieved by relying on the output of design schools. The *UK Design Skills Plan* has proposed a *Creative Skills Lab* to "secure the overall improvement in professional practice skills that will enable designers to meet future challenges" (Design Council & Creative and Cultural Skills 2007:50) which would be a helpful step forward in redressing the balance. This suggests that developing support tools to build knowledge in professional as well as student design scenarios could be valuable.

One of the main suggestions in the focused literature review for Enquiry 1 (section 4.2) was that the ability for designers to communicate effectively with other stakeholders is critical if they are to influence design decisions. This is even more crucial with decisions relating to sustainability where the commercial benefits may be difficult to quantify. Survey respondents' access to 'other knowledge areas' and their experiences of 'challenging the brief' were explored. The data suggested that designers generally felt that they have good

access to other knowledge areas and are able to challenge the brief. However this may be because designers' priorities (design factors) are well-aligned to those of clients and designers may 'choose their battles'. Designers who scored design factors relating to social and environmental impacts or sustainability highly were less likely to feel that these values were reflected in their work for UK manufacturers. There was additional evidence in the survey interviews; designers commented that they would be unable to pursue concerns about sustainability unless the client asked them to but they also had 'tactics' for creating a good relationship with clients and improving access to other knowledge areas. The findings, therefore, suggest that the ability of designers to create good relationships with clients, to define their roles and communicate effectively with other knowledge areas, need to be improved for projects where they want to pursue issues relating to sustainability. This is a general concern which is being explored by other design researchers (highlighted in Chapter Four). However, assisting designers in locating and communicating with other knowledge areas (clients, suppliers, manufacturers, support organisations) may be of use if they are to consider and use secondary materials. This was also identified as a desirable role for design tools in Enquiry 3.

Enquiry 3 revealed that models already exist for tools that build knowledge through the appropriate content, format and delivery of eco-design information (Lofthouse 2005) and a number of characteristics were identified that may assist in meeting that aim, such as enabling exploration through multiple detail layers, dynamic interaction through internal lateral links and links to external sources, use of images and examples. Durling, Cross & Johnson (1996) provided additional evidence of how designers' learning styles differ from other professionals.

Time-intensive knowledge-building tools are unlikely to be successful. Delivery and time-saving considerations were highlighted as being of great importance if professional designers are to use new support tools. This was also supported by the survey findings (Enquiry 1) and by the Design Council (2005) who found 'time' to be the most common barrier to designers engaging in professional development.

A further educational function for support tools could be in raising awareness. Lloyd (2009) suggests that "designers need to <u>know in advance</u> that undesired outcomes are possible" if design is to "be used to prevent bad situations occurring" (Lloyd 2009:162). Designers' attitudes to different design factors were explored in the survey and revealed that they do not prioritise sustainability during design work. This was also evident in the descriptions and discussions of sustainability in the interviews which revealed a 'gap' between designers' understanding of sustainability theory and their own practices. Enabling designers to relate what they are doing to the broader context of material cycles and sustainability is an area for further development. If designers don't value sustainability they are unlikely to prioritise alternative material use when making sense of and 'setting' the problem (Schön 1991) and consequently these issues may be absent

from the brief. Pearson (2008) makes a pertinent observation: "designers are only as good as the questions they are able to ask" (Pearson 2008:17).

7.2.2 Material Information Provision

Numerous authors have called for an improvement in the provision of material information to support the sustainable use of materials in design practice (for example Argument, Lettice, & Bhamra 1998; Benjamin 1994; Chick & Micklethwaite 2004b; Fletcher 1999; Pedgley 1999; Sherwin 2000). When asked about recycled materials the survey respondents' most common response related to their uncertainty over the availability and quality of secondary materials which is linked to the inadequacy of information.

In Enquiry 3 it was suggested that these shortfalls may result from issues relating to content, format and delivery of information. Preferences for particular types of language were suggested, for example, using imagery or multi-sensorial representations and 'nuggets' of text. There was an emphasis on layering information from general to specific and allowing dynamic access and navigation. The data-intensive language of manufacturing material databases was highlighted in contrast to catalogues which showcase preformed materials but use the types of design language preferred by industrial designers. The combination of these two disparate approaches presents a unique challenge for material information provision for designers of mass-produced artefacts who don't have technical knowledge of materials; this is an area that could benefit from further development. As mentioned in the previous section, a further role for material information should be to convey to clients the benefits of a particular material selection; a means of translating material information into benefits for designers and other non-technical stakeholders in the design process.

The survey investigated the material information sources designers find most useful revealing a tendency towards materials they had used before, talking to suppliers, using search engines and consulting supplier websites. Centralised resources, aimed specifically at improving material information provision, were not as useful to designers as these other 'direct' sources which may take less time, be more familiar, reliable and allow general access. These findings reaffirm those of similar studies such as Karana (2004) who found that supplier literature was the most useful material information source and van Kesteren (2008) who stated that very few of the interviewees used 'material selection software' and none used 'commercial sample collections' (material sample libraries). Yet both Karana and van Kesteren proposed to improve material information for design by creating new independent sources such as material libraries and databases. The current study, therefore, marks a departure in how the findings are interpreted. The view taken here is that designers' current use of material information sources, highlighted above, could directly inform improvements in material information provision. To this end, dialogue with suppliers appears to be the most important factor in material information exchange and translation. A centralised resource that

'ticks all the boxes' is not unimaginable (as van Kesteren (2008) and Ashby & Johnson (2002) have shown) but may be difficult to resource and manage to the standard required and expected by designers.

One final consideration for information provision is to be respectful of designers' value-systems, indicated in the survey findings, that sustainability concerns are likely to be considered secondary to functional performance, end-user needs and innovation. These priorities were echoed by Ashby & Johnson (2003) specifically with regards to designers' attention to materials. The importance of highlighting the innovation qualities of secondary materials was also observed in Enquiry 2, in relation to existing design approaches to utilising secondary plastic, and is a notion supported by other authors (for example Fletcher 1999; Sherwin 2000; Dehn 2008).

7.2.3 A Spectrum of Design Scenarios and Secondary Materials

Enquiry 1 explored the most difficult design scenarios for considering and using secondary materials to produce artefacts revealing a situation where time is limited and clients often dictate decisions. However, it also showed the inertia of commercial design and the narrow ways it defines itself. The prioritisation of conventional design factors such as functional performance, end-user needs and innovation was predictable; it was not surprising that the majority of designers felt that these factors were reflected in their work for manufacturers as this is the status quo in commercial industrial design scenarios. There also appeared to be a predominantly reactive attitude; legislation was considered to be the client's prerogative to include in the brief. For the most part the designers' sense of responsibility was for innovation, function, and safety directly related to product use.

However, there was also a notable difference between two distinct design scenarios;

i) Designers working in-house, with a non-arts background in large companies and;

ii) Designers working in small consultancies with an arts background.

The in-house group appeared to be in a better position to challenge the brief, having closer access to other knowledge areas, yet it was the consultancy group who were more likely to want to challenge briefs given to them. The in-house group appeared to have enjoyed better materials training, which had a positive benefit on their confidence when selecting materials, yet it is likely that in-house designers also use fewer materials (Pedgley 1999) which may demand less of their time, resources and general materials knowledge. The consultancy group were more likely to want more time to source materials and searched more widely than the in-house group. Finally the consultancy group scored design factors more highly than the in-house group indicating that they may have the 'higher interest' necessary for pursuing sustainability (Fletcher 1999) or indeed alternative materials.

There is a sense, therefore, that arts-educated design consultants do hold some potential for effecting change in this area; if they are better informed, with methods of support more appropriate to their

situation, they could make more sustainable material choices. Moreover, projects must be identified that are more appropriate for the consideration of secondary materials with regards to the relationship with the client, the needs of the product and the location and volume of manufacture. In-house designers also offer an opportunity for utilising secondary materials in the production of high-value mass-produced artefacts but their focus is likely to be specific to the types of materials and products used by the company they work for, meaning that although general guidance may be useful to them, specific advice may more be appropriate (Pedgley 1999).

The survey (Enquiry 1) explored the design scenarios discussed above but also provided a framework within which observations could be made about other design scenarios that appear more conducive to selecting secondary materials. These were explored in Enquiry 2 where existing approaches to sourcing secondary materials revealed several design scenarios where considering and using secondary material has been successful. Thus a spectrum of design scenarios has been observed during this research, some more conducive to the consideration of secondary materials than others. Similarly, Enquiry 2 revealed that secondary materials also exist on a spectrum between 'problematic' and 'stable markets', available at different points in the material cycle, and that a variety of approaches can be adopted to utilise them. The spectra of design scenarios and secondary materials, therefore, appear to offer the possibility of 'match-making' types of materials to types of scenarios thus demonstrating to designers that there are a range of approaches that could be taken, one of which might be appropriate to their particular design scenario. This represents a pluralistic approach to secondary material use in design practice (discussed in Chapters Two and Five).

7.2.4 Fit for Purpose

The phrase 'fit for purpose' occurred frequently during the research, most often from the designers involved in the survey. It seems to encapsulate the designers' attitude that whatever they consider or use has to work and make sense, not within some idealised notion of future 'sustainable design practice' but within their own (current) value-systems, methods and practice. This refers back to the idea presented in the initial literature review (Chapter Two) that a gradual pathway towards more sustainable practices may be the only way to lead designers, based in commercial scenarios, towards new ways of thinking about design and reframing their own activities.

Furthermore, 'fit for purpose' seems a suitable phrase to sum up the key considerations for exploring new tools and processes, and developing new models (Objective 5);

- Designers want to know that secondary material (or any material) is fit for purpose;
- Knowledge about material cycles, secondary materials or sustainability needs to fit design practice;
- Material information needs to be fit for design methods.

7.2.5 Summary

This discussion has considered the prevalent themes from the findings of the three empirical enquiries presented in Part II of the thesis. The aim was to reveal areas where an intervention might improve designers' ability to consider and select secondary materials, and identify possible areas for further exploration. These themes can be summarised as follows:

- Training and knowledge-building
    - Guidance on the sustainability of material use and engagement with materials generally: support tools to build knowledge in professional as well as student design scenarios;
    - Guidance on locating and effectively communicating with other knowledge areas (clients, suppliers, manufacturers, support organisations);
    - Enabling knowledge-building with tools that facilitate exploration through multiple detail layers, dynamic interaction through internal lateral links and links to external sources;
    - Enabling designers to relate what they are doing to the broader context of material cycles and sustainability.
- Material Information Provision
    - Information that deals with the availability and quality of secondary materials;
    - Content, format and delivery of information which is aligned to industrial design methods;
    - Utilising and strengthening the existing designer-supplier relationship to improve material information translation and delivery;
    - Highlighting the material's potential to meet the current priorities of designers: function, meeting end-user's needs and innovation.
- A spectrum of design scenarios and secondary materials
    - To provide approaches to sourcing the range of secondary materials available that recognises the spectrum of design scenarios, from industrial design consultants to designer-makers;
- Fit for purpose
    - Showing designers how secondary materials are fit for purpose;
    - Building knowledge that is fit for design practice;
    - Material information that is fit for design methods.

The next section will present Phase 2 of Integrating and Interpreting the empirical findings, involving the exploration of possible tools or processes for supporting designers and the development of specifications for future work in this area.

7.3 Phase 2: Exploring New Tools and Processes

7.3.1 Defining Exploration Areas

Synthesising the findings of the three empirical enquiries resulted in the identification of four prevalent themes: 'training and knowledge-building', 'material information provision', 'a spectrum of design scenarios and secondary materials' and 'fit for purpose'. It was decided that these themes could be combined into two main areas for exploring possible tools and processes:

1. Building knowledge and awareness of secondary material use and material cycles.
2. Improving material information provision for design, drawing inspiration from designers' current methods.

In addition to the findings of the empirical enquiries there were practical considerations which influenced the focus of the explorations, such as the time and resources available and the author's own expertise. For example it made sense to concentrate on professional practice rather than look at design pedagogy as this had been the focus of the research to date and contacts had already been established with designers in industry who could provide feedback within the timeframe. Time was also a consideration when deciding whether to explore workshops which may have been useful but would have been difficult to organise and conduct within the three months allocated for this phase of the research. Expertise was also a consideration; for example, the author's knowledge of the software programmes used to build virtual environments was limited and prevented these types of tools from being fully explored.

7.3.2 Initial Explorations

In essence, the findings of the three empirical enquiries assisted in defining the 'problem space' of *supporting designers in the consideration and use of secondary materials.* This 'problem space' is manifested in the content, format and delivery criteria, or 'specifications', for a possible intervention such as a new tool or process. The specifications for two interventions aimed at *building knowledge and awareness* and *improving material information* have been drawn from the findings of the three empirical enquiries. In response to these specifications the author undertook an exploratory process using sketches and prototypes (a selection of annotated development sketches are included in Appendix D(i) and D(ii)). The main outcomes of this exercise are described in the following sections.

Exploration 1: Building Knowledge and Awareness

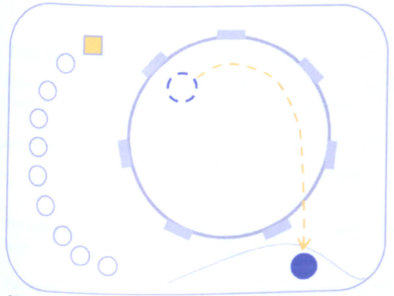
The empirical findings highlighted that although designers understand the concepts of design for recycling and specifying recycled materials, they do not bring the two together and 'close the loop' or readily see their own role within that concept. The main focus of this exploration therefore was to find a way of helping designers visualise how the material cycle relates to their own activities so that they might more instinctively bring it to mind when designing. Please refer to the annotated sketches in Appendix D(i).

The outcome of this exercise was the identification of locations in the material cycle where material typically 'ends up' and so can also be retrieved for secondary use. These locations link to the design phase of the material cycle via pathways representing different approaches to design for recycling (sending material) and design using recycled materials (getting material) forming a 'loop' or material cycle.

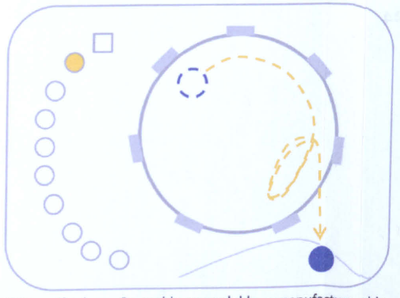
This concept of *The Material Cycle* (fig. 7.3.1) was proposed as an interactive web-based tool to help designers visualise the concept of closing the loop at the design phase, enabling them to explore the different approaches and discover the associated benefits or difficulties. The conjectural tool was not developed to the stage of fully working prototype so further feedback could not be sought at this stage. However, the additional understanding of how the empirical findings might be applied was important in developing a new model for supporting designers, which is discussed in Chapter Eight. This exploration also enabled the specifications for *building knowledge and awareness* to be expanded and clarified beyond those drawn from the empirical findings alone. The specifications are outlined in figure 7.3.2.

Figure 7.3.1: (following foldout page) Conjectural Tool for Building Knowledge and Awareness: The Material Cycle: Plan for an interactive interface for building knowledge and raising awareness of the role of the design phase within the material cycle.

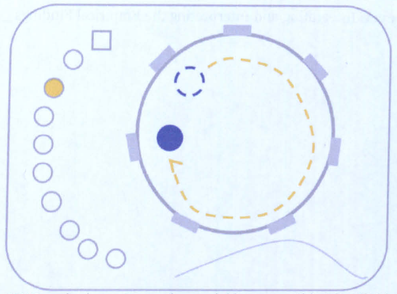
The Material Cycle



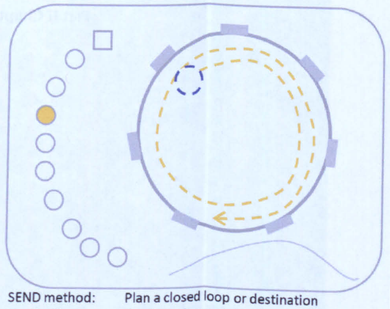
SEND method: No design for recycling methods used
Destination: Landfill



SEND method: Re-usable, upgradable, remanufacture-able
Destination: Multiple end-users, but eventually landfill



SEND method: Currently recyclable, compatible, identifiable separable materials
Destination: Reprocessed feedstock and preformed materials

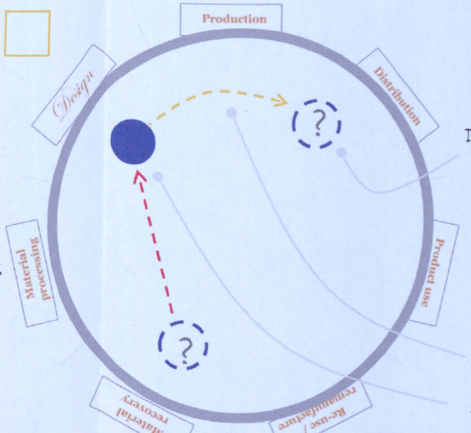


SEND method: Plan a closed loop or destination
Destination: Continued material cycling – no further intervention needed

B
4 methods of SENDING material

A
Buttons

C
6 methods of GETTING secondary material



E
Material Destinations/ locations

D
Pathways

Material

Landfill

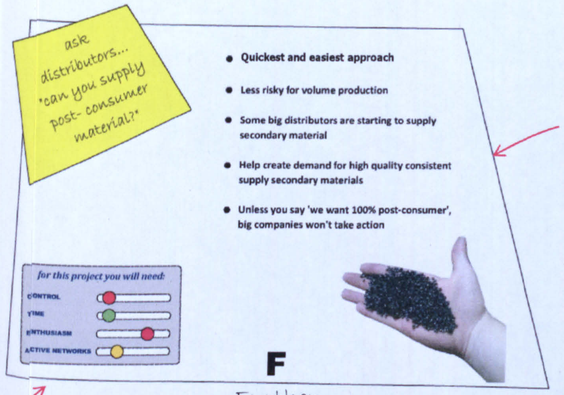
The Material Cycle (PLAN)

An interactive interface for building knowledge and raising awareness of the role of the design phase within the material cycle.

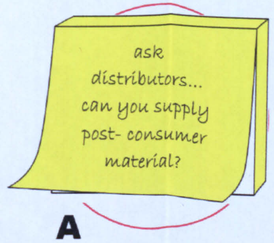
A series of 'buttons' are presented on the home screen (A), each representing a method for SENDING material (B) or a method for GETTING material (C). The two are inextricably linked by pathways intersecting at the design phase (D). Ideally the cycle remains intact, creating a continuous 'loop'.

If steps are not taken to GET and SEND material using appropriate methods at the design phase, then the cycle is broken and the material is wasted. The material can be retrieved from the various destinations (E). Each approach button on the home screen links to further information, including examples and external links (F).

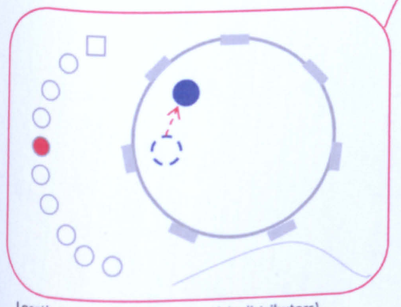
The Material Cycle



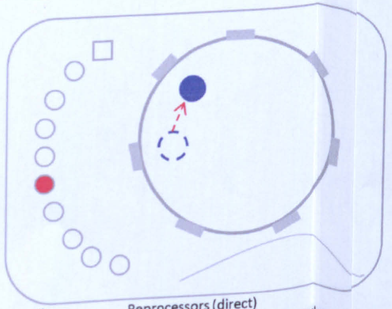
F
Further information



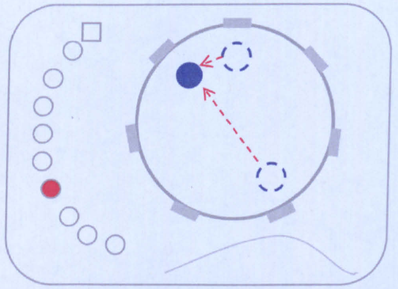
A
Button



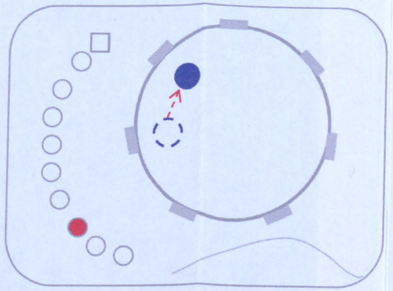
Location: Reprocessors (via distributors)
GET method: Ask your usual distributor if they could supply post-consumer secondary material



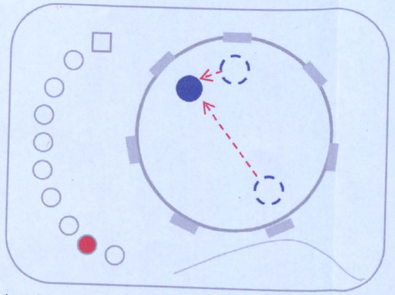
Location: Reprocessors (direct)
GET method: Contact reprocessors of secondary materials



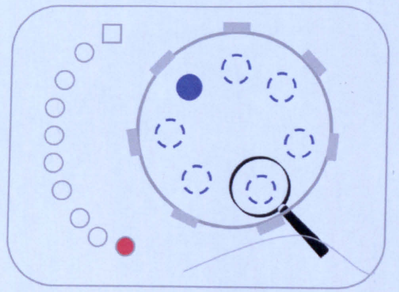
Location: Producers / service centres
GET method: Find a 'clean' source of secondary material



Location: Manufacturers of preformed materials
GET method: Use preformed materials made from secondary material



Location: Service centres, bring centres, producers, charity collections / unsellable items.
GET method: Re-decorate or remanufacture artefacts



Location: Operators at every stage of the material cycle
GET method: Investigate and experiment with 'problem' secondary materials

Exploration 2: Improving Material Information

The empirical findings indicated that designers need to know more about unfamiliar materials (such as secondary materials) if they are to use them and they need that information in a form that suits their own methods. The aim here was to explore the types of content, format and delivery of material information that might best suit designers and to 'test' the application of the relevant empirical findings.

The outcome of this exploration was the identification of material information that designers find most useful and a new layout which would allow them to view and understand the information more quickly than existing presentations. The main idea was that the new layout could help the designer see the 'story' of the material which would be more useful to them than technical data alone.

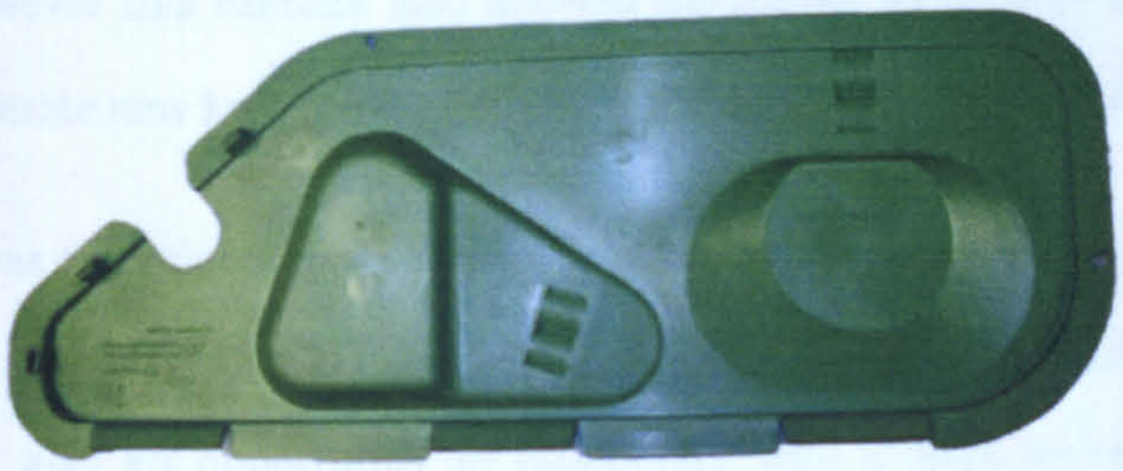
The *Material Story Card* (fig. 7.3.3) was proposed as a double-sided A5 card that could be digital or hardcopy and sent either by a supplier (on request from the designer) or as a tear-out reference card for a material featured in the MaDE magazine. If in hardcopy, these A5 cards could be kept in a dedicated file in a similar way to business cards. The front of the card included a short sentence explaining only the most important and unique benefits of the material along with three dominant images of the material in application. On the back of the card, separate from this general information, were four areas of more specific information:

- Price and availability
- Processes and applications
- Technical data
- Supplier contact

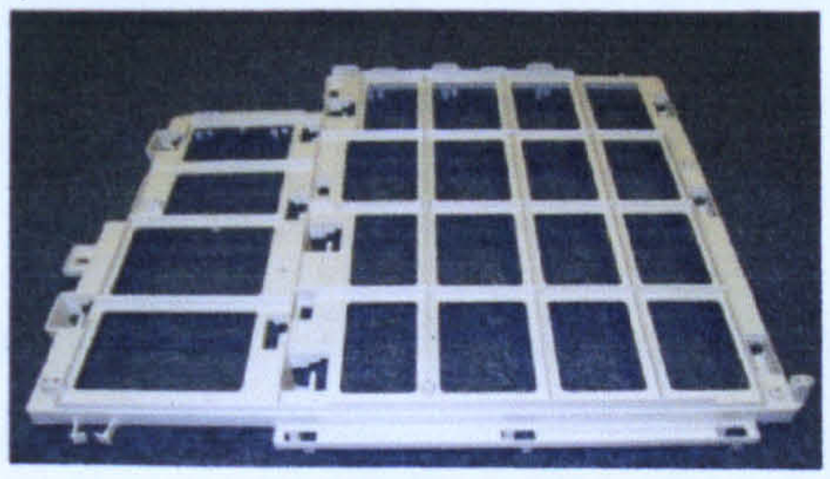
These areas used less text than the original information provided by the supplier (examples included in Appendix D(iii)) and were laid out in blocks to enable easy identification and browsing. A date was included on the back to inform designers of the reliability of the information as well as a reference number which was proposed as a way of linking all forms of information about that material to the supplier's records and to aid communication.

Figure 7.3.3: Conjectural Tool for Improving Material Information: The Material Story Card was developed with feedback from a secondary plastic supplier, Axion Polymers. The intention was for suppliers to complete these cards which could then be given to designers by themselves or third parties.

Axpoly 100% post-consumer polystyrene (PS/HIPS)



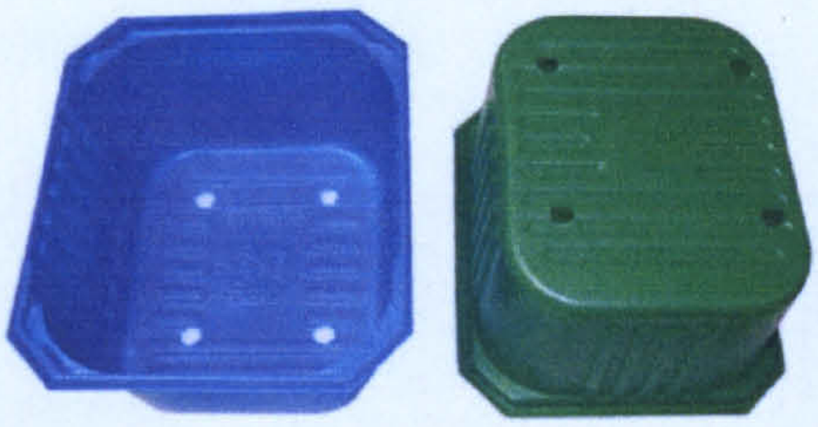
Washing machine part



TV part

material story

Axpoly is plastic that used to be someone's fridge.
It's a single-source, consistent quality and supply, 100% post-consumer polymer that has been used to replace virgin polymer in many applications.
Axpoly's production is truly '**green**', responsible for only 7% of the CO2 emissions of virgin plastic (based on Plastics Europe figures).
Axpoly can be tailor-made to your performance specifications, including higher impact resistance and colour-matching.



Fruit containers

Price and availability

Min. order: **1 tonne**
Max. capacity: **700 tonnes / month**
Standard versions are **available immediately**
£800 / tonne based on 20 tonne order, ex-works from Manchester - anticipated **20% less than virgin** polystyrene.
Prices may vary according to conditions of order and are correct at time of writing (Nov 08), please contact us for current pricing.

Processes and applications

Suitable for sheet **extrusion** and **injection moulding.**

Currently used for washing machines parts and coat hangers, but also suitable for other **complex injection moulded products** or parts.

Technical data (PS01 3000)

Melt flow index (5kg @ 200°C)	6g / 10mins
Density	1.05g / cm^3
Tensile Strength	21 MPa
Impact	8 kJ / m^2
Bulk Density	610 kg / m^3
Pellet size	3 mm
Colours	Off-white, (can be coloured to your spec) Black
Standards	**ISO 9001** **RoHS** compliant **REACH** ready

Supplier contact

Axion Polymers
Langley Road South
Salford
Manchester
M6 6HQ

Tel: **0161 737 6124**
Fax: 0161 925 9761

email: sales@axionpolymers.com

www.axionpolymers.com

Sales Director: Keith Freegard

Further Explorations with End-users

As the *Material Story Card* was a fairly simple proposal the author was able to gather feedback from designers who had taken part in the empirical enquiries. The initial aim was to further expand and clarify the specifications for 'material information provision' and enable the concept to be honed for future use. However this exercise also allowed the author to expand the exploration of the empirical findings and generate new knowledge about material information provision.

It was essential to find an appropriate material to use as an example in the *Material Story Card*; a fictional material would undoubtedly fail to illuminate the real-world issues that this study seeks to address. This was also an opportunity to collaborate with a supplier to ensure that the *Material Story Card* was appropriate to their needs as well as those of designers. A supplier of secondary plastic – Axion Polymers – who had been involved in Enquiry 2 agreed to take part in the development process.

Although this concept was intended to be applicable for all materials, it was necessary to use an example of secondary material during the feedback process to understand if the *Material Story Card* would be effective at delivering information about secondary materials to designers.

Semi-structured interviews were conducted with the four designers' who had been interviewed for Enquiry 1 as this was most feasible within the timeframe. The interviews took place in the designers' workplaces and were audio recorded. A format for the interview was developed which prompted the designers to respond to particular themes but also allowed the discussion to develop freely where appropriate. The structure of the interviews was:

- Recap of project background
- Introduction to the *Material Story Card*
- Designer's initial response
- Explanation of the key features
- Designer asked to comment on the proposed format, content and delivery

The interviews were transcribed and coded manually (interview schedule and results summary is located in Appendix D(iv)). The designers' responses to the *Material Story Card* are outlined below. Of particular interest were some unanticipated comments which revealed deeper prejudices about the use of secondary materials than had previously been uncovered.

Format

- All of the designers were generally positive about the format of the *Material Story Card*, the types of information included and the way they were presented. One designer commented: "I like the initial layout, I like the way the front is very graphical, straightaway you can see the example use, which I think is one of the strongest things, and then it goes onto the backside which is more of the nitty-gritty." [JB]

- However, three designers commented that bullet points, more graphical representation and even less text would be preferable which strengthens the idea that alternative visual communication methods must be found to replace lengthy text. In particular, the cost saving benefit, the date and reference number, and specifics about applications, processes and commercial information needed to be more easily identifiable. These are representative of factors which designers rated highly in the survey (Enquiry 1).
- Although the standard layout was considered a useful feature, making this information a different size to other supplier literature – which is typically A4 – might mean it gets lost in the filing system. Three of the designers clearly wanted information about new materials to fit seamlessly with their existing method of information storage and retrieval which strengthens the finding that design tools must be sympathetic to designers' existing methods.
- In Enquiry 1 the interviews revealed that designers use mixed methods for accessing information but prefer the internet as a reliable way of accessing up-to-date information, storing digital copies on their laptops or bookmarking websites. Similarly, three of the designers said they'd prefer the *Material Story Card* to be digital, either as a PDF or online, because it would be more reliable and could be searched or sent to clients to communicate material benefits.
- Two designers acknowledged that hardcopies might also be useful in some circumstances but they should be linked to an online record where updates could be checked.

Content

- Although images were preferred to text the designers interviewed couldn't easily understand what the images were showing; they weren't interesting enough and they didn't show applications that related directly to the type of products these designers would be working on. Rather than instilling trust in the material properties, as had been suggested in the survey interviews, these images of the material in application limited designers' understanding of what the material was suitable for.
- Other types of information were also insufficient: the list of applications was not long enough; the quantities stated suggested to one designer that the supply capabilities were inflexible; the standards included implied that others were not adhered to by the material. The implication is that in being explicit, which was seen as desirable in the survey interviews, the capabilities of the material became more limited in the designers' minds.
- Perhaps these designers, being submerged in day-to-day commercial design, are less likely to think imaginatively about a material than other aesthetically- or materially- driven designers. Another explanation is that the way the information was presented, as 'matter-of-fact', official, and with a standardised format, is less likely to prompt creative thought than other presentations.

- Designers observed that the *Material Story Card* does not allow them to compare materials any more easily than existing supplier information. Material comparison was identified in the literature and through the survey interviews as a desirable feature of material information, but was not pursued during the exploration as it would be difficult to facilitate without a central hub of information – a feature that the research has suggested is impractical.

Delivery

- Sending a hardcopy of the *Material Story Card* was suggested to designers with the hope that the additional information might convince designers of the material's potential. However, the designers' preference was for the *Material Story Card* to be delivered digitally as receiving and storing hardcopy information is not well-aligned to design methods. If the aim is to convince designers that these unfamiliar materials are usable then improving supplier's materials information can contribute but may not be effective alone.
- The consensus view was that the *Material Story Card* would be best delivered through suppliers, reinforcing the main survey finding that the designer-supplier relationship is of paramount importance in the distribution of materials information. One designer commented: "Having that data in a form that can go out when somebody makes that enquiry is just as important, you know it's more important because they need that information in a way which makes sense to them." [PB]
- Designers again stressed the use of large distributors who they could rely on to know the material products on their books, offer advice and ensure supply and quality control, particularly with regards to secondary or new materials because smaller producers might not be trusted to deliver large quantities over a long production run.

Perspectives on secondary material

Although this exercise was aimed at getting designers' feedback on the *Material Story Card* the secondary material used as an example also provoked interesting responses from the interviewees. This was beneficial for a number of reasons. First, the *Material Story Card* was probably scrutinised more than if a more acceptable material example had been used. Second, it revealed the designers' curiosity about secondary materials: "But they're not all the same grade are they, they're all going to be different grades and so how do they mix it all and get the right...? [...] Is there any strength or anything lost in the reprocessing?" [TL]

- Despite providing the information that designers wanted about the secondary material, they still had strong misgivings.
- One interviewee reemphasised the designer's priorities suggesting that other aspects of the design are too important to jeopardise: "There's quite enough risk at the beginning [of the project] unless

of course the whole concept is to use recycled material or it's essential for cost reasons that make it viable." [SF] This comment puts the responsibility firmly back with the client and also highlights the point that secondary materials have a far higher chance of being specified in materials- or sustainability- led projects.

- Two designers appreciated the aims of the project: "I think it would be a useful start, because I don't think at the moment, as for the recycled materials, you just tend to avoid them." [SF] "It's very valid all this because if we didn't know about [secondary material] at all then we'd never think about specifying it. But if a system like this comes along and we are educated a bit more then it's at least one of our options that's up there and we can explore." [JB]
- Although three of these designers had responded negatively when asked about their opinion of recycled materials in the survey questionnaire, by the end of the exercise they appeared to realise that secondary materials are an option. They were also in agreement that improved material information could assist them in being more aware of alternatives to the materials they are familiar with. This also supports a suggestion made during the design of the survey questionnaire, that the research activities themselves have an educational influence on participants.

General conclusions relating to the further development of this concept:

- Encountering information about unfamiliar materials in an appropriate form appears to stimulate designers' curiosity and prompt them to consider the material's suitability for use in their practice;
- However some fundamental concerns remain with how different types of material information promote or limit a designer's understanding of a material's potential;
- A digital system, which avoids the pitfalls of existing centralised hubs but allows comparison, should be considered;
- Suppliers and distributors should remain the main stakeholders and contributors in any such system;
- Any improvements to material information are only part of the solution towards convincing designers of the potential of an unfamiliar material, particularly with regards to secondary materials.

Based on this feedback some straightforward changes were made to the *Material Story Card* which are highlighted in figure 7.3.6. One alteration was to replace the 'story' paragraph with 'benefits' which are more in keeping with designers' existing methods and terminology. Consequently the *Material Story Card* was renamed *Material Information Card.* This exercise assisted in expanding and clarifying the specifications for '*improving materials information*' which are outlined in figure 7.3.4.

Tool specifications for Improving Materials Information

Figure 7.3.4: Tool specifications for 'improving materials information', drawn from the empirical findings and then expanded and refined during Exploration 2.

Content	*Format*	*Delivery*
Material name, ID, etc.	Images	Physical and digital
The benefits highlighted in bullet points: function, innovation, meeting end-user needs.	Consistent graphical theme	Supporting relationship with supplier
Examples of the material in application	Easy to browse and identify desired information	Avoid sending information cold
Potential material processes	Bullet points rather than lengthy text	Links from other materials and design organisations / press
Commercial information – price, availability, quantities	Multiples detail levels (from general to specific)	Internet
Test data and standards	Physical: tactile and memorable	
Supplier contact details	Digital: easily accessible	
Date (to ensure reliability)	To translate / communicate information to other stakeholders	

Developing Supplier Guidelines

The feedback from designers' reaffirmed the idea that *Material Information Cards* should be managed and distributed by the suppliers of the material represented, which opened up another opportunity for expanding the exploration. In order to understand how the concept would work from the supplier's perspective the *Material Information Card* had to be presented so that they can understand why it could be useful and how to use it.

First, this involved making sure that the *Material Information Card* could be produced by someone who had limited knowledge of graphics software. Microsoft Word was chosen as a platform for building a template because it was assumed that this would be the most widely available and universally understood software.

It was also decided that this could be an opportunity to explain to suppliers how designers are likely to behave when sourcing materials. Importantly, putting the theory into practice in this way forced the author to consider the position of the *Material Information Card* within the broader context of material information provision revealed through the empirical enquiries. Although the research suggests that designers are unlikely to use centralised resources to source materials, these currently offer the only opportunity for designers to encounter unfamiliar materials and so it was thought that these may be of use to suppliers. A diagram of design behaviour when sourcing materials was developed (fig. 7.3.5) illustrating the main finding of the survey questionnaire that designers first consult their own experience – here termed 'supplier list' – and that of their colleagues (1). The other sources are then presented in order of preference (2, 3, 4) with *supplier websites* and *talking to suppliers* consolidated into 'supplier list' and 'internet' while *saw it used in another product* is not represented because it doesn't offer suppliers a course of action. Also represented are 'trade shows' because the survey interviews highlighted that, although infrequently, designers do sometimes visit them and update their 'supplier list'. Finally, 'materials library' is also included because the findings of Enquiry 3 suggested that material librarians and consultants, who keep abreast of new materials, are often involved in material libraries and pass that knowledge on to designers through design workshops and seminars, at trade shows, or through columns in trade press. This implies that material libraries are also a useful place for suppliers to position their materials, if not directly to designers.

This diagram then led to six suggestions for how suppliers could position their material information to increase the chances of designers encountering them, also shown in figure 7.3.5. This information was combined to form the *Supplier Guidelines* as follows (Appendix D(v)):

1. *Suppliers: get designers interested in your products* (introductory paragraph and contents)
2. *How it works* (diagram and 6 action points)

3. *Materials information for designers: using the template* (diagram showing how to present material information for designers with reference to the *Material Information Card*)
4. *Resources* (list of trade press and shows; databases, libraries, curators and directories)

Feedback on Supplier Guidelines

The supplier who had provided the material example for the *Material Information Card* was able to provide feedback on the *Supplier Guidelines*. Initially a questionnaire was completed by the company Director who responded positively towards the content of the *Supplier Guidelines* and the ease with which the information was understood, commenting:

> Great to see somebody thinking about HOW the end-user designer gains access to recycled products. I will ask our marketing team to implement as much of this thinking as we can in the next few months.

As a result of the exercise the supplier began implementing the guidelines as follows:

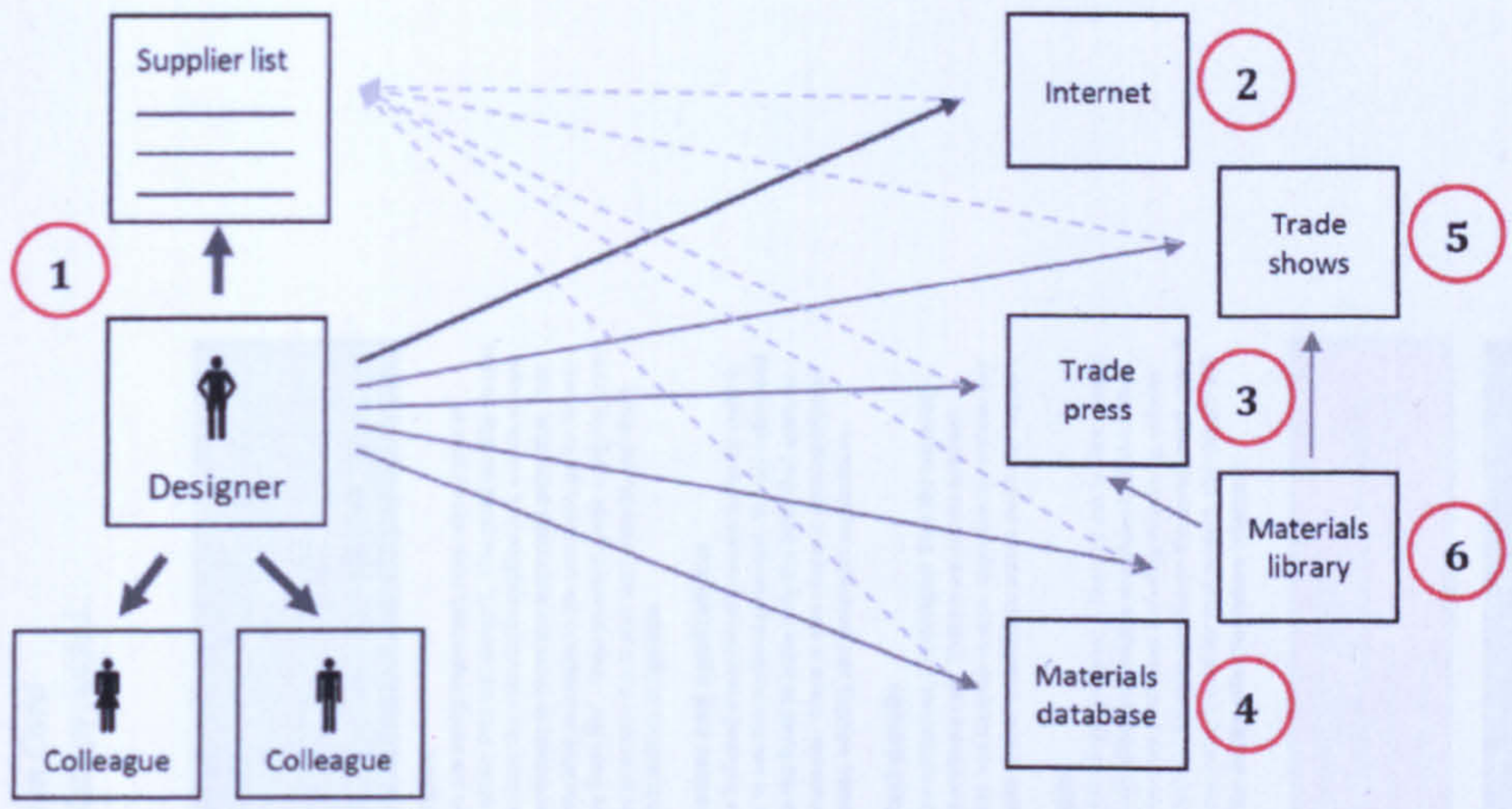
- They produced *Material Information Cards* for their materials, figure 7.3.7 shows an example;
- They sent their information to material libraries and databases and were able to provide feedback on their experience which is presented in figure 7.3.8;
- The supplier sought publicity in design trade press. An example of press coverage is included in Appendix D(vii).

Additional developments were made to the *Material Information Card* during the timeframe of the project such as consulting a graphic designer who produced a more 'professional' version (fig. 7.3.9), and it was also adapted by the author for a consultancy project led by Jakki Dehn in the 'rematerialise' library of recycled and renewable materials at Kingston University (fig. 7.3.10). The author hopes to continue to adapt the graphical presentation of the *Material Information Card* for different projects and user groups. Suggestions for further developments of this conjectural tool are discussed in Chapter Ten as part of the Recommendations for Further Research.

Figure 7.3.5: Supplier Guidelines page 2; explanation of designers' use of material information sources and suggestions for suppliers about how they could position their materials so that designers might encounter them.

1 How it works

Our research has helped us to understand how designers behave when it comes to sourcing materials... the diagram below shows what we've discovered.



1. **Get on the supplier list**
   A designer's first port of call is the **suppliers he and his colleagues already know about**, so the aim of any supplier should be to get onto that list. Also consider whether you can get your product onto the books of larger **distributors.**
2. **Maximise online presence**
   The second place he/she will look is on the **internet,** so you could also make sure **your online presence** is up to scratch and up to date, and that your webpage ranks highly on major **search engines**.
3. **Get an article in trade press, or advertise**
   Most designers have little time to spare, but they try to keep their knowledge up to date by reading **trade press**, so if you have an interesting story to tell about your product it's worth aiming to **get coverage** in **design and materials magazines and e-zines**.
4. **Send product information to materials databases**
   Also on the web are **independent materials databases** which list many different materials and offer another opportunity for getting your material noticed.
5. **Exhibit at trade shows**
   Although some designers don't have much opportunity to get out of the office, there are some trade shows that they are more likely to attend. If you can't afford to get a stand, **materials libraries** often put on an exhibition, so if they have your material they may show it for free.
6. **Send samples to materials libraries**
   Materials libraries offer another opportunity for designers to encounter your product, but more importantly the **materials librarians, commentators and curators** will become aware of it which maximizes the potential for exposure to design clients, readers and visitors.

Examples of all of the above are included in the **resource page** at the end of this document which you could use as a starting point.

Materials information for designers

Once you've got the designer's attention it's really important to give them the right information and in a format that will make it easily accessible. We've put together a document template (attached separately), developed to help you deliver product information that designers will notice, find useful and keep.

Here are some tips about how to create useful materials information for designers. They explain how to use the template (attached separately) but you could also use them as a reference next time you're creating product literature.

Figure 7.3.6: Supplier Guidelines page 3; explaining the key features of the Material Information Card
The supplier can either use this as a guide for creating their own literature, or they can use the template provided..

2 Materials information for designers: using the template

Please note: this example refers to a fictional material

Sheet 1 (front): Impact
This is your chance to sell the material to the designer so it's all about identifying the material using great images and key benefits.

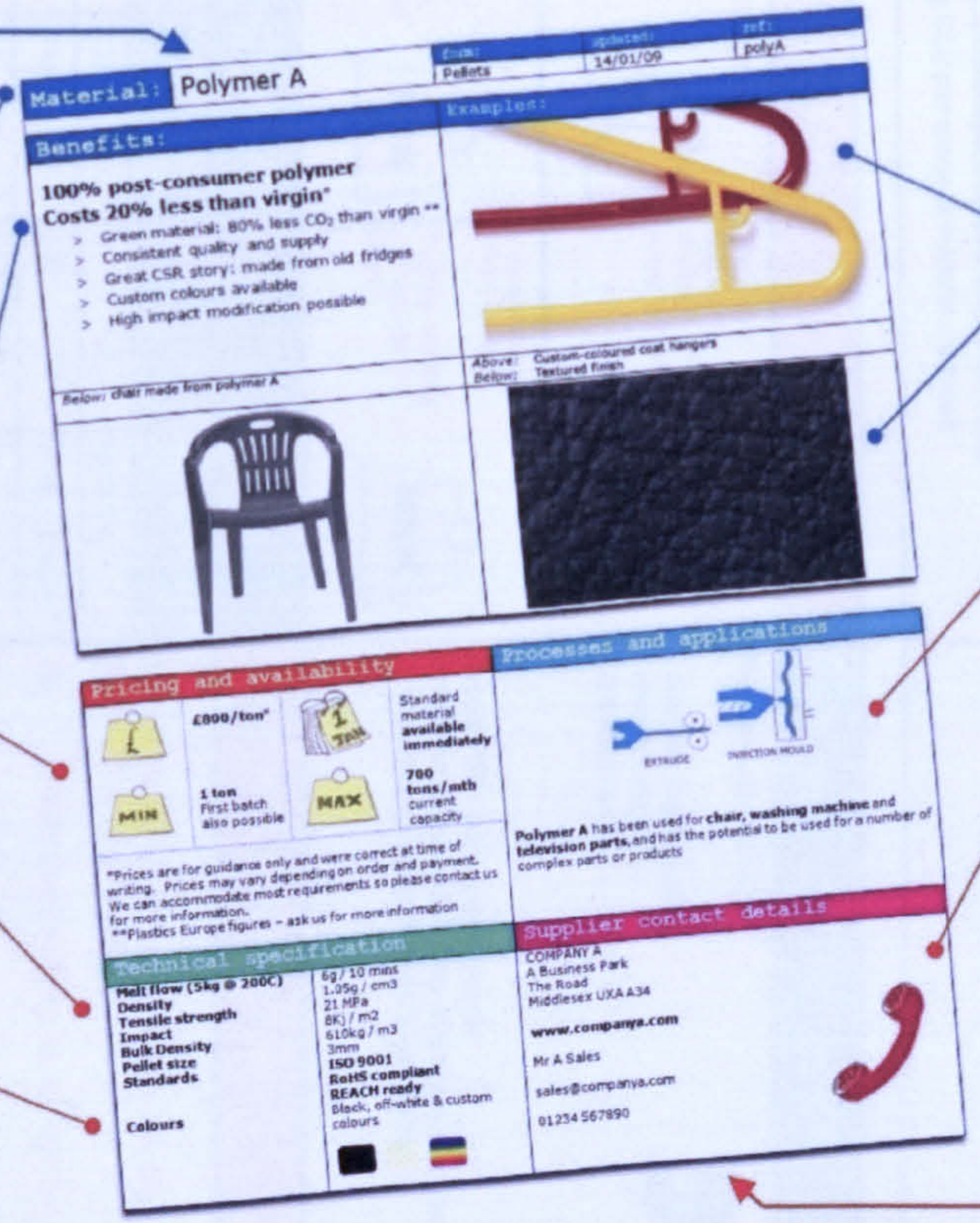
Title bar
Include the **name** of the material, the **form** it comes in (as sold), the **date** of the information and a **reference** number for the material so that it's easy to refer to and access on your website.

Benefits
Put **the top two benefits** of the material, the **unique qualities** that will catch the designer's attention; **cost and performance** are the most important but also include anything which could **capture the imagination**.

Pricing and availability
This is just a **general** guide for how much the material **costs,** how soon it can be **available**, and what **quantity** you can deliver. There is also space for any **additional information** or conditions of order.

Technical specifications
This is your opportunity to **prove that your material can perform**, so put all of the **testing data** and **standards** your material complies with, including **medical. food and environmental** standards.

Colours and finishes
Include basic colours in **text and colour** block. If you have an extensive range of **colours and finishes** refer to a separate document or to the relevant webpage.



Style
This template is not protected, which means that you can change the font, colours and content to suit your needs. However, we recommend keeping the layout and to one page if possible. Don't forget to emphasise key words and data with **bold.**

Examples
Images are really important, they convey tons of information that text doesn't. Use **good quality** images which show the material **in application**, use **close-ups** and **variations** to show the **material's potential**. Just **click the blue rectangle** in the template, **go to 'insert > picture from file'**. Once inserted resize using the corner arrows to ensure the layout isn't altered, and don't forget to **add an image title**.

Processes and applications
We've included a number of **process icons** to make it easier to see the material potential. Simply **select and delete the icons** to leave only the ones that apply to your material. There is also space to note **additional processes, existing and potential applications.**

Contact details
This is a no-brainer, if a designer likes the material they'll probably call. That conversation between designer and supplier is your opportunity to show the potential of your material, to advise and build rapport.

Samples
The next thing a designer is likely to ask for is a sample. The **most effective samples** are those that show the material once processed including **moulding, colours and finishes**. Samples are worth the investment, even if the material isn't used for that project, the sample will **be in the design office for future reference.**

Sheet 2 (back): Detail
This is the information the designer needs in order to understand if the material is suitable for the current project

Comparable information
Comparing different materials is really important for designers, so if you can reliably **compare your material to other materials**: competitors or different types of materials, then include this information, on a separate sheet if necessary, and preferably in a **graphical representation such as a bar chart .**

Saving & Printing
Create a PDF of the materials information sheet to send by email or for download from your website, using the ref. no. as the file name.
The template can be **printed as one side of A4** by selecting 'A4 portrait' paper size and choose to print 'two pages per sheet'.
Or create a **double-sided A5 card** by selecting 'A5 landscape' paper size and print sheet 1 on the front and sheet 2 on the back.

Figure 7.3.7: The Material Information Card produced by Axion Polymers marketing team in response to the supplier guidelines.

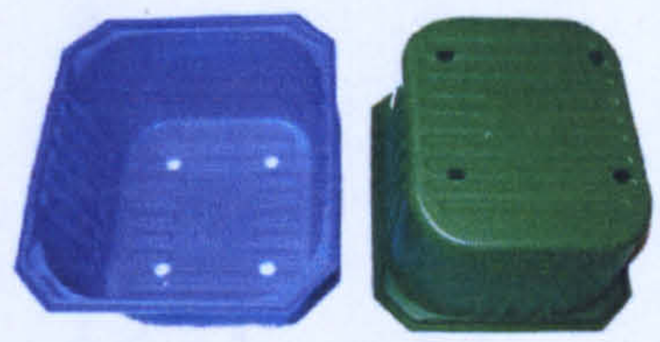
Material:	Axpoly® PS01 impact modified polystyrene	form:	updated:	ref:
		Pellets	27 Mar 2009	MI Card 1

Benefits:

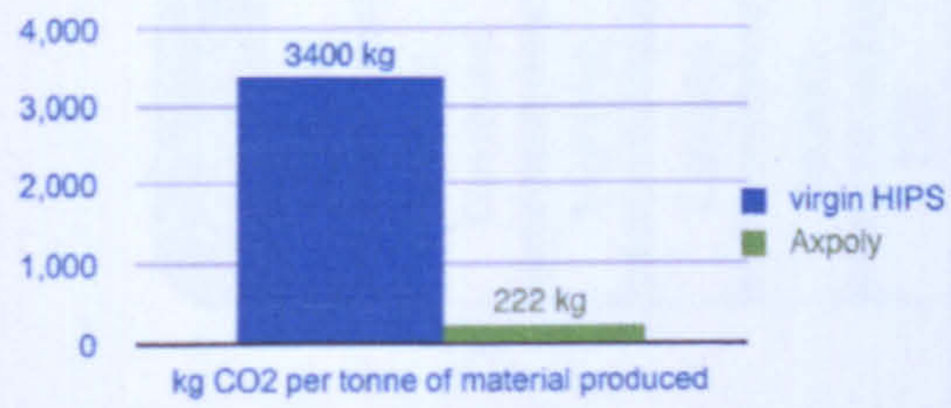
- 100% post-consumer recycled polymer (recovered from refrigerators)
- 93% less CO_2 impact compared with virgin*
- Successfully replaces virgin grade resin
- ISO9000 quality certified
- Available in a range of colours
- Cost savings compared with virgin polymer grades

* As detailed in Axion's report 'Carbon Footprint Evaluation of Recycled HIPS' August 2008. Calculation made using data provided by WRAP and Plastics Europe.

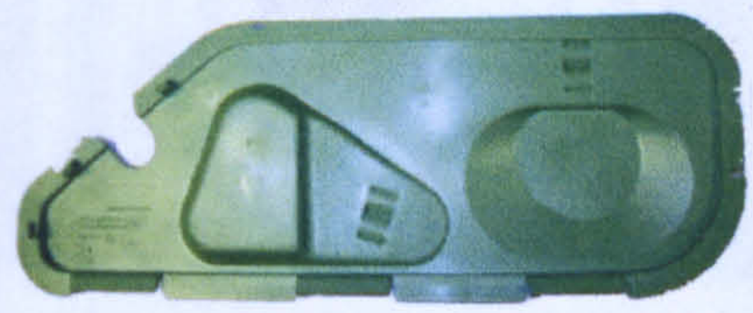
Examples:



Below: Graph comparing CO_2 impact of virgin HIPS versus Axpoly



Above: Horticultural pots made from Axpoly
Below: Washing machine part made from Axpoly



Pricing and availability

15-25% cost saving against virgin grades*

* price varies according to quantity and payment terms.

Same day dispatch available on material in stock.

Minimum order: 1 tonne

Smaller quantities and 25 kg samples available on request.

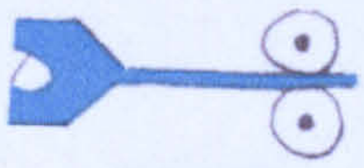
Complete shipment: 22-24 tonnes

Factory capacity: 700 tonnes per month

Processes and applications

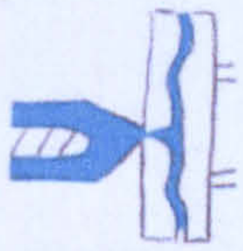
Previous applications:

- washing machine parts
- horticultural pots
- television parts



EXTRUDE

Axpoly PS01 polystyrene can be custom coloured and has the potential to be used for a number of complex parts or products.



INJECTION MOULD

Technical specification

Parameter	ISO	Spec Min	Spec Max	Typical Properties
MFI (5kg @200°C	1133	5	8	6g/10 mins
Density	1183-1	1.03	1.06	1.03g -1.05g cm^3 *
Tensile Strength	527 - 1/2	15	25	21 - 22 MPa*
Impact	180	6	10	8 kJ/m^2
moisture	%	<0.25%		0.17%
Elongation @break	527 - 1/2	25%	50%	35%
Pellet size	mm	2mm	4mm	3mm

RoHS compliant and REACH ready

* depending on grade

Supplier contact details

Call our friendly sales team to discuss your application requirements and for an up-to-date quote.

Tel: Keith, Laura or Edyta on +44 161 737 6124

Email: info@axionpolymers.co.uk

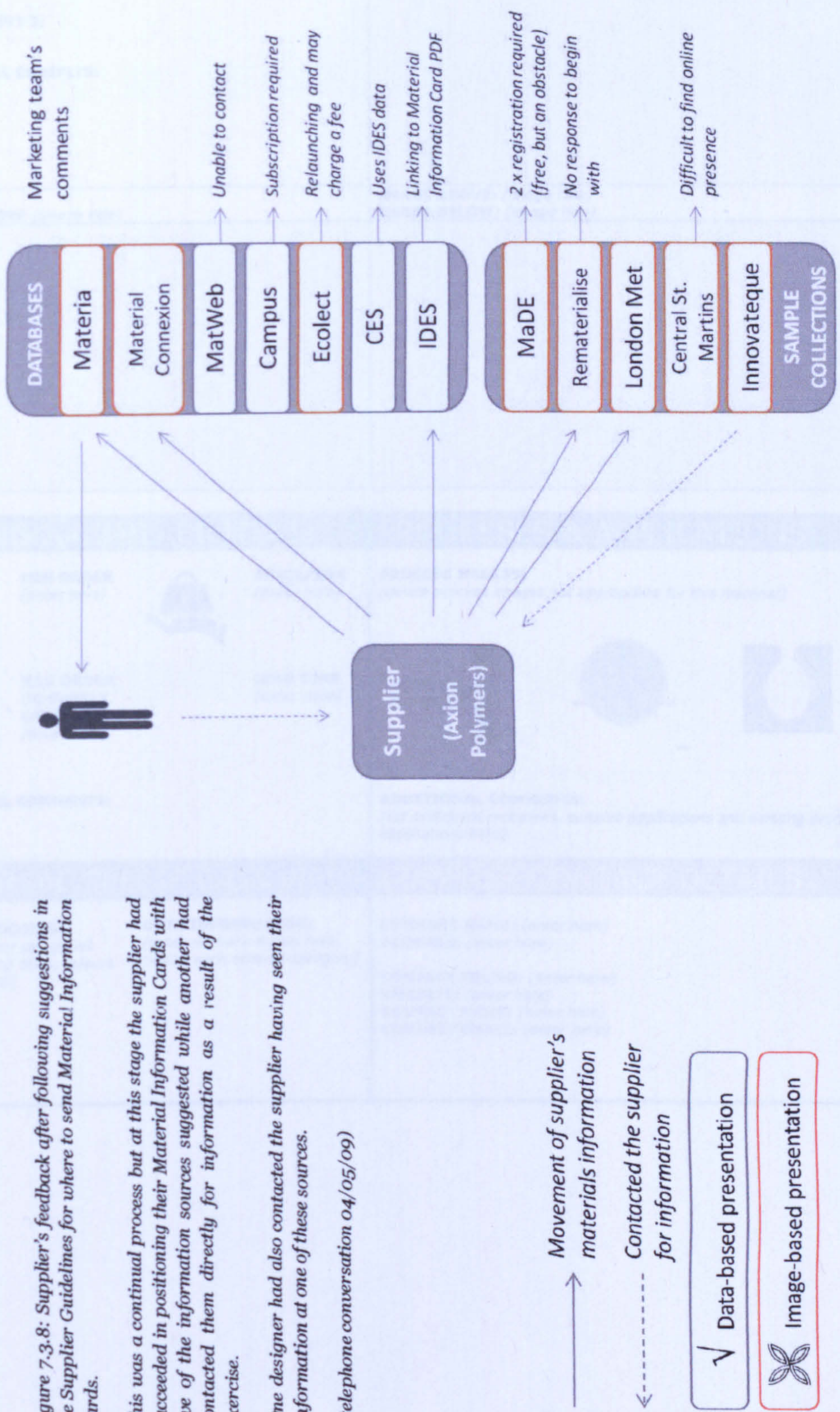


Figure 7.3.8: Supplier's feedback after following suggestions in the Supplier Guidelines for where to send Material Information Cards.

This was a continual process but at this stage the supplier had succeeded in positioning their Material Information Cards with five of the information sources suggested while another had contacted them directly for information as a result of the exercise.

One designer had also contacted the supplier having seen their information at one of these sources.

(telephone conversation 04/05/09)

Figure 7.3.9: The Material Information Card template following alterations made by graphic designer Sarah Howard

MATERIAL	(enter name here)	FORM	DATE UPDATED	REFERENCE
		(enter here)	(enter here)	(enter here)

BENEFITS	PRODUCT IMAGE EXAMPLES
MAIN BENEFIT 1: *(enter here)* **MAIN BENEFIT 2:** *(enter here)* **ADDITIONAL BENEFITS:** *(enter here)*	
IMAGE BELOW: *(image title)*	**IMAGE ABOVE:** *(image title)* **IMAGE BELOW**: *(image title)*

PRICING & AVAILABILITY	PROCESSES & APPLICATIONS
MIN ORDER *(enter here)* **PRICE/TON** *(enter here)* **MAX ORDER OR SUPPLY CAPACITY** *(enter here)* **LEAD TIME** *(enter here)* **ADDITIONAL COMMENTS:** *(enter here)*	**PROCESS IMAGES:** *(delete process images not appropriate for this material)* **ADDITIONAL COMMENTS:** *(list additional processes, suitable applications and existing product applications here]*

TECHNICAL SPECIFICATION	SUPPLIER CONTACT DETAILS
DATA CATEGORIES: *(enter relevant categories here, including tests, colours and standards)* **DATA INFORMATION:** *(enter relevant details here beside each entered category)*	**COMPANY NAME:** *(enter here)* **ADDRESS:** *(enter here)* **CONTACT TEL NO:** *(enter here)* **WEBSITE:** *(enter here)* **CONTACT NAME:** *(enter here)* **CONTACT EMAIL:** *(enter here)*

Figure 7.3.10: The Material Information Card template following alterations made by the author for use with the 'rematerialise' project. The card was presented in A4 format with the 'technical Specifications' section o the reverse.

rematerialise ecosmartmaterials

MATERIAL		FORM

ECO BENEFITS	MATERIAL IMAGES:
	ABOVE: **BELOW:**

PROCESSES & APPLICATIONS	PRICING & AVAILABILITY
	PRICE **LEAD TIME** **ADDITIONAL COMMENTS**
	SUPPLIER CONTACT DETAILS
	COMPANY NAME: **ADDRESS:** **CONTACT TEL NO:** **WEBSITE:** **CONTACT NAME:** **CONTACT EMAIL:**

7.4 Phase 3: Review

The purpose of exploring new tools and processes was to *learn about, challenge and 'demonstrate' the research findings through the use, reorganisation and real-world application of the knowledge gained, and to prepare the knowledge for use in future research, industry or education.* This section reflects on the achievements of that process.

The methods reported in this chapter enabled complex and intuitive integration and interpretation of findings from the empirical research enquiries which was not possible using written discussion and reasoning alone. Schön terms this "reflection-in-action" (1991:49) and suggests that an effective description of this process is difficult, maybe even inappropriate. Instead, critical reflection allows some questions to be posed and addressed, which relate to the original purpose of this exercise.

7.4.1 The Exploration Process as Enquiry

What did the exploration of possible tools and processes reveal about the findings which was not understood previously?

Exploration 1: Knowledge and Awareness Building (fig 7.3.1)

- The mapping process enabled the *approaches for sourcing secondary materials* to be linked to *locations of different types of secondary materials.* In turn, this could then be linked to established methods of *designing for secondary materials.* A pattern emerged that had not been seen during the written discussion, which was used to synthesise and visualise the findings in relation to established theory about material cycles.
- The designers' role within the material cycle as 'getter / sender' of material was framed during the exploration.
- Reorganising and applying the knowledge about secondary materials (Enquiry 2) so that it may be useful to designers, necessitated that it be clarified, refined and presented in bullet-point and visual form.

Exploration 2: Improving Material Information Provision (fig 7.3.3)

- The *Material Information Card* was the result of putting the findings of the empirical research into practice; particularly with regards to the types of sources designers find useful and appropriate characteristics of design tools. The designers' feedback strengthened many of those findings but also drew attention to some issues that are more significant than they appeared earlier in the research. For example, the importance of designers' seeking information directly from specific sources (often online) rather than using static or hub sources (eg. databases or books); the strength of designers' prejudices to secondary materials; and the importance of facilitating materials comparisons.

- Developing *Supplier Guidelines* necessitated that the *Material Information Card* be considered within the broader context of material information provision. Consequently, the author returned to the findings of Enquiry 3 to understand the context more deeply and produce a visual representation (fig. 7.3.5).

In summary, the exploration of possible interventions enabled the knowledge to be distilled to the most relevant and useful content and the connections between each element of the findings to be understood and visualised with the context of industry and professional practice.

7.4.2 The Conjectural Tools as 'Demonstration' of the Research Findings

In what ways do the conjectural tools 'demonstrate' the findings from the empirical enquiries?

- The findings from each of the enquiries were combined to form specifications for two conjectural tools or processes. During the exploration exercise these specifications were consulted and used to inform decisions made about how to progress. This enabled the findings to be translated into tools and processes that may support designers in the consideration and use of secondary materials. These 'conjectural tools' therefore demonstrate the real-world application of the empirical findings in terms of their content, format and delivery.
- With regards to the exploration into *knowledge and awareness building*, where feedback from end-users was not sought, the conjectural tool simply demonstrates one way of interpreting and responding to the specifications proposed and cannot be considered 'ideal' (Durling & Niedderer 2007).
- The tool resulting from the exploration into *improving material information* was also one possible response to the specifications proposed, offering a demonstration of the findings. However, the tool was further developed following feedback from end-users which can be used to validate the demonstration and consequently the research findings. Thus it is possible to say that the process has enabled the findings relating to the format (appropriate layout, graphical representation, balance of text and images), content (relevant information included), and delivery (from the supplier) to be demonstrated and validated.
- Further improvements could be made to both conjectural tools; these are proposed as recommendations for further research in Chapter Ten.

7.4.3 The Conjectural Tool as Dissemination of the Research in Industry

What are the conjectural tools and how could they be used in industry?

The two conjectural tools were developed in response to the specifications drawn from the findings of the empirical enquiries. While the *Material Information Card* and *Supplier Guidelines* can be used in their

current manifestations both these and *The Material Cycle* tool would require further development in order to meet the specifications and be fully effective in industry. There are two ways in which the conjectural tools can make an impact in the real-world: by being fully developed following the conclusion of the current project; or having contributed towards the development of specifications which may be used by others in the field to develop alternative support tools and processes.

7.4.4 Addressing Objective 5

How has the 'Integration and Interpretation' exercise contributed towards 'developing innovative models to support designers in finding new applications for surplus and waste resources' (Objective 5)?

The main contribution this exercise has made to the research was to further process the findings of the empirical enquiries and deepen understanding about what they really say about how designers could be better supported. By exploring potential interventions in the form of two conjectural 'tools' the author was able to gain new perspectives on the contexts or 'models' these tools operate within.

The model for *Knowledge and Awareness Building* offers a new way of conceptualising and visualising the designer's role in the material cycle which may involve sourcing recycled material as well as specifying recyclable material. The principal idea is that there are a variety of actions a designer can take depending on their particular work scenario and that even designers in the most constraining scenarios can make some contribution to improving the material cycle. This idea could be conveyed to designers through a 'tool' that meets the specifications outlined such as the conjectural tool proposed earlier: *The Material Cycle.*

The model for *Improving Material Information* provides a new perspective on how material information is accessed by designers. The conjectural tool – *Material Information Card* – has addressed the superficial but nevertheless important issue of presentation and content of visual and written information about materials. However, this exploration has also revealed the true purpose of these types of recorded material information as a means of supporting the network of agents who gather and translate it for designers. The development of *Supplier Guidelines* highlighted designers' preferences for accessing material information and exposed the relationships between the various information sources currently available in London. This model can be used to improve material information resources and help nurture aspects of material communication that previously have been neglected such as dialogue and translation of information for non-specialists.

7.5 Chapter Seven Summary

This chapter has presented the two approaches that were taken to integrate and interpret the empirical findings and address Objective 5. Phase 1 involved a discussion around some common themes which resulted in the identification of two main areas for further exploration: *knowledge and awareness-building* and *material information provision.* Phase 2 involved exploring these two areas for potential interventions and this led to the development of two conjectural tools: *The Material Cycle* and the *Material Story Card.* The *Material Story Card* was developed further with feedback from end-users (designers and suppliers). This resulted in the *Material Information Card* and *Supplier Guidelines.* Finally some reflections on the integration and interpretation exercise and its contribution to the research were presented.

Part II Summary

The four chapters in this part of the thesis presented the empirical research undertaken to meet the project aim and objectives. The findings were integrated and interpreted to understand how designers might be better supported in the consideration and use of secondary material. In turn this new knowledge will inform the main outcome of this research *'a framework for supporting secondary materials use in design practice'.* This, along with the main conclusions and recommendations, is presented in Part III.

PART III CONCLUSIONS AND RECOMMENDATIONS

This third part of the thesis presents the main outcome of the project: a framework for secondary materials use in design before drawing together the main conclusions of the research. The thesis concludes with recommendations for further work.

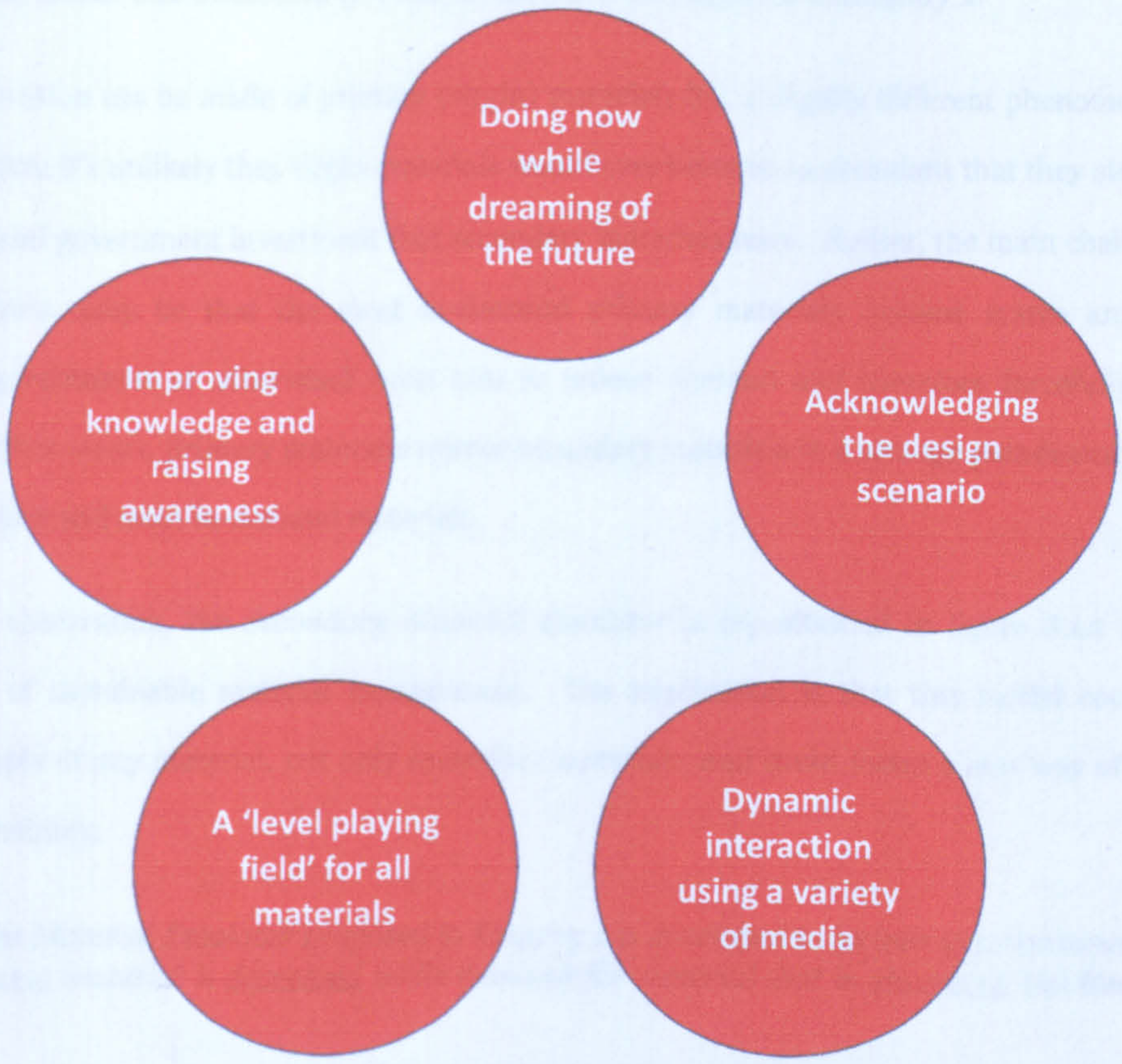
CHAPTER EIGHT A Framework for Supporting Secondary Materials Use in Design Practice

This chapter presents the main outcome of the study: 'a framework for secondary materials use in design' devised to meet the main project aim to 'create new models for utilising surplus and waste resources in design practice'.

Despite having narrowed the research focus down to specific tools to support designers in the previous chapter, the project aim actually involves a broad range of factors that together help to explain how the relationship between design and the materials cycle can be improved. Many of the issues with secondary materials bring into question general material production and use. Attempting to understand and support one specific activity – the use of secondary materials in design – has involved understanding, or at least acknowledging, a variety of problems on the periphery.

The use of the term *framework* seems appropriate; the problems are multiple and so must be the approaches used to bring about change.

Figure 8.1.1: A Framework for secondary material use in design



8.1 Doing Now, While Thinking of the Future

In the short-term problems with current ineffective 'recycling systems' are inevitable but in the long-term markets fluctuate, societies, economies, and politics evolve; it must be acknowledged that material cycles, as a necessary part of that future, will need to adjust to those conditions in the same way that all sustainable activities will.

That future might involve a flexible system for artefact production which welcomes changes in the abundance of different materials and can adapt to the needs of the local community and economy. This level of change can only be imagined yet the question remains; how to get from here to there?

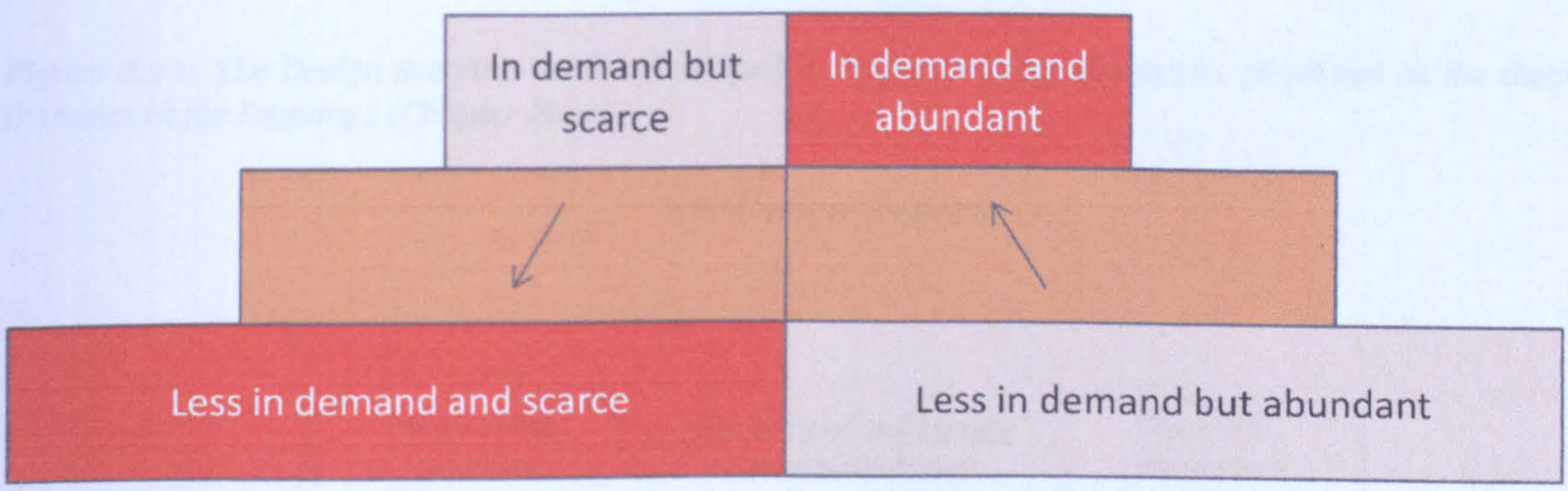
In Chapter Five the transition of secondary material markets from value-less to stable markets was discussed as well as the ease with which they, like all materials, are affected by fluctuations in the economy (particularly in reference to the slowdown beginning in October 2008). Secondary materials, therefore, are destined to be always in a state of transition, from unvalued to valued as demand increases and back again, constantly changing with the material needs of commerce or society. If this constantly evolving picture were to be frozen the materials at various stages might resemble a *ladder* formation, with the *least valued* materials at the bottom through the various rungs towards the *most valued* on the top rung. The aim at any one time has been to move the lower

abundant but less in-demand secondary materials up towards the top position of *abundant and in-demand,* transforming the ladder into a *Secondary Material Escalator* as proposed in Enquiry 2.

A similar observation can be made of primary (virgin) materials but a slightly different phenomenon occurs. In the current system it's unlikely that virgin materials would ever become so abundant that they attract the kind of EU legislation and government investment that secondary materials have. Rather, the main challenge, both now and in the future, may be that the most in-demand primary materials become scarce and, instead, any intervention (government or otherwise) must aim to reduce demand and therefore forcefully devalue those materials. In other words, primary materials mirror secondary materials in a strange paradoxical battle between the most abundant and most in-demand materials.

To reflect this observation, the *Secondary Material Escalator* is repositioned in figure 8.1.2 as one possible representation of sustainable material management. The implication is that this model could refer to the sustainable supply of any material, not only secondary materials, and could foster a new way of thinking about material sustainability.

Figure 8.1.2: The Material Escalator proposed in Enquiry 2 is developed to include two movements of material; demand for scarce material is decreased while demand for material that is abundant, but less in-demand, is increased.



With regards to the outcomes of this project, understanding the transitional nature of secondary materials necessitates an acknowledgement that a range of approaches are needed to address a range of material 'states' within the model. The ultimate aim is to *escalate* the most abundant material towards the most in-demand; reaching the top is the goal. However there are many steps in between, each with a different set of problems; the challenge is to identify which materials can (with encouragement) move effectively up and which materials require alternative treatment such as removal from the system.

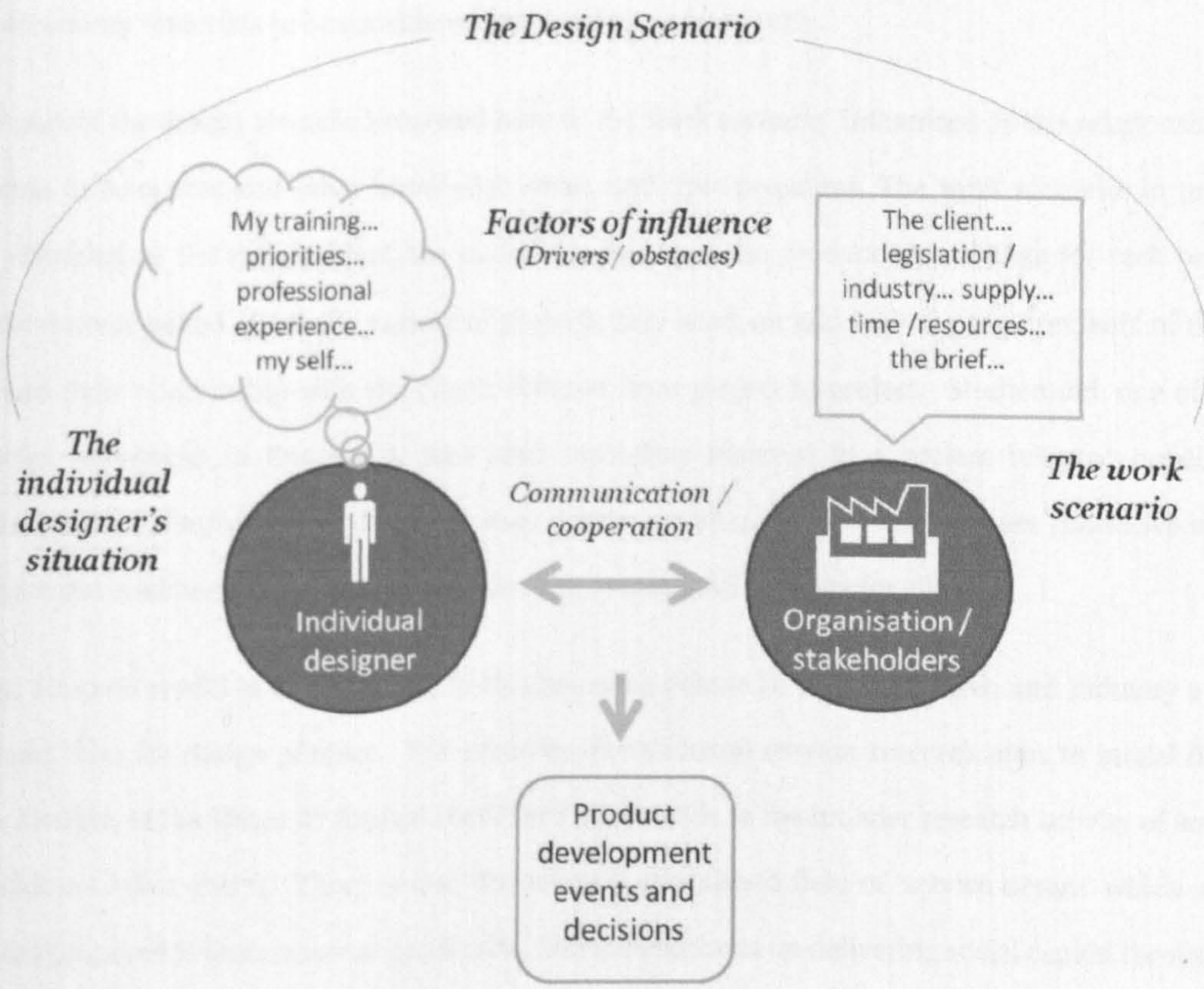
Clearly, in order to reach the ideal of effective material cycles in the future, small and sometimes awkward steps must be taken now and a range of approaches are necessary to deal with each material appropriately.

8.2 Acknowledging The Design Scenario

Design thinking is a method of finding solutions to 'wicked problems' (Buchanan 1992) and could be seen as holding great potential for stimulating The Material Escalator; for finding value in abundant secondary materials or reconsidering the use of virgin materials that are scarce. However this optimistic view of design's potential contribution must take account of the real world and the individuals and teams who are involved in design practice. Designers have their own context of practice and, as has been demonstrated through this research, this can be seen to influence their ability or inclination to engage with a given problem.

The results from the survey of designers suggest that, based on the original model of the design scenario (presented in section 4.3 and repeated in fig 8.2.1), the scenarios of product and industrial designers working in consultancies or in-house teams within UK manufacturers are not generally conducive to considering and using secondary materials. This was not intended to prove the accuracy of the model but rather to highlight areas where intervention may improve the situation. In Enquiry 2 the scenarios of designers who had been successful at sourcing secondary materials were discussed. This was not conducted with the same rigour as the survey and the findings are therefore not directly comparable, but some useful observations were made about the characteristics that may have made these design scenarios more conducive to considering and sourcing secondary materials.

Figure 8.2.1: The Design Scenario model developed in response to the literature, presented as the theoretical framework for Enquiry 1 (Chapter Four)



The design scenario model (fig 8.2.1) was constructed in response to the focused literature review for Enquiry 1. One criticism may be that the individual designer's situation was investigated while the specific situations of other stakeholders in the design process were not. This (unapologetically) is research into design practice which meant that the design scenario model was viewed from the perspective of the designer. However this does not undermine the value of the design scenario as a model for investigating the influence of different *factors* on design decisions; the viewpoint could be shifted to that of the client, the consumer, the supplier or any other stakeholder. The argument was made in the initial literature review (Chapter Two) and Enquiry 1 that, of all the parties involved in the design decision process, the designer is more likely to be motivated by functionality, end-users needs (empathy & ethics) and innovation as opposed to the financial motivations of the client (Sherwin 2000).

The design scenario is seen here as being constructed of a number of *factors* which may change or be changed to influence design events and decisions. In the literature factors relating to the design scenario have been framed as drivers/stimuli and obstacles/barriers (Chick & Micklethwaite 2004b; van Hemel & Cramer 2002) but these do not take into account the whole design scenario which involves factors embedded within the individual designer and the work scenario. This author proposes that considering the design scenario as a construct can help in understanding which factors may be involved, obstacles and barriers can then be identified if necessary.

With regards to the part of the design scenario that is influenced by the 'individual situation', education, professional development and the designers' values are proposed as the factors that may need to be 'changed' in order for secondary materials to be considered and used more frequently.

The other part of the design scenario proposed here is 'the work scenario' influenced by the relationship with the client, access to resources and other knowledge areas, and time pressures. The work scenario, in particular, is dynamic, changing as the stakeholders, the designer's role, and the product type change for each project. The survey interviewees talked about the variety of projects they work on and how the requirements of the product, the brief and their relationship with the client, differed from project to project. Studiomold, one of the design consultancies referenced in Enquiry 2, had used secondary material in a project initiated outside of their commercial practice, implying that designers may 'create' an alternative scenario, more conducive to pursuing ideas that are not commercially-driven, alongside their commercial projects for clients.

The design scenario model is also relevant to the emerging debate in design research and industry around new locations and roles for design practice. For example, Tan's (2009) current research aims to model design roles within the Designs of the Times 07 festival (DOTT07) which adds to the broader research activity of documenting design activism (Julier 2007). There is also the recently established field of 'service design' which attempts to decouple design practice from material production and instead focus on delivering social capital through services,

as well as a current debate around the role of university-based design units (Lovett 2009). The author proposes that these design practices could be described, or explained, in terms of the design scenario model and thereby ensuring that the influence of as many factors as possible (including the designers' situation and their work scenario) are acknowledged, investigated and understood. Mapping and documenting these new ways of working is a priority for those wishing to understand how design practice is evolving, and how the design scenarios that are more conducive to considering sustainability can become commonplace.

Returning to the particular focus of this research – *the use of secondary materials in design* – the design scenarios most conducive to the use of secondary materials are those where material can be included as part of the 'problem-space'. This was revealed in Enquiry 2 where it was proposed that this was either due to the prioritisation of sustainability (by the designer or the producer) or to a 'designer-maker' scenario where the material choice is part of a range of problems the designer must negotiate. Both of these scenarios enabled the use of material in the given product to be problematised, allowing secondary material to be considered and used. With a combination of factors determining how a designer may respond to concerns, such as the use of secondary materials, designers in different design scenarios will be limited or empowered in different ways. It follows that in different design scenarios designers will require different approaches to sourcing secondary materials. In turn, different types of secondary materials at different points in *The Material Escalator* may be more appropriate to different design scenarios, and so the possibility for a kind of 'matchmaking' was developed during the Integration and Interpretation process, discussed in Chapter Seven. Figure 8.2.2 illustrates this concept. In addition to matchmaking design project scenarios to materials sourcing approaches there are also relationships between *type of approach* and *type of secondary material* which perhaps sit more comfortably than others. This is due to the volume-timescale issue highlighted in Enquiry 2; for example, 'closing the loop' is far more feasible in a situation where similar materials are predictably available in large volumes within a given timeframe and so packaging fits this approach most effectively.

The design scenario is one way of understanding designers' abilities and inclinations towards a particular activity, to better understand the factors involved and how they may be influenced or changed. It was developed to understand how designers can be supported in utilising secondary materials but is useful beyond that specific task, for any researcher wishing to understand the factors affecting an individual designer's decisions in a given scenario.

A final note can be made about how investigating the design scenario has provided a 'snapshot' of product and industrial design which contributes to the current paradigm of unsustainable production and consumption. This 'snapshot' is not particularly surprising but for those who propose visions of a sustainable future this 'product and industrial design' scenario is moribund. As the theory around design and sustainability (discussed in Chapter

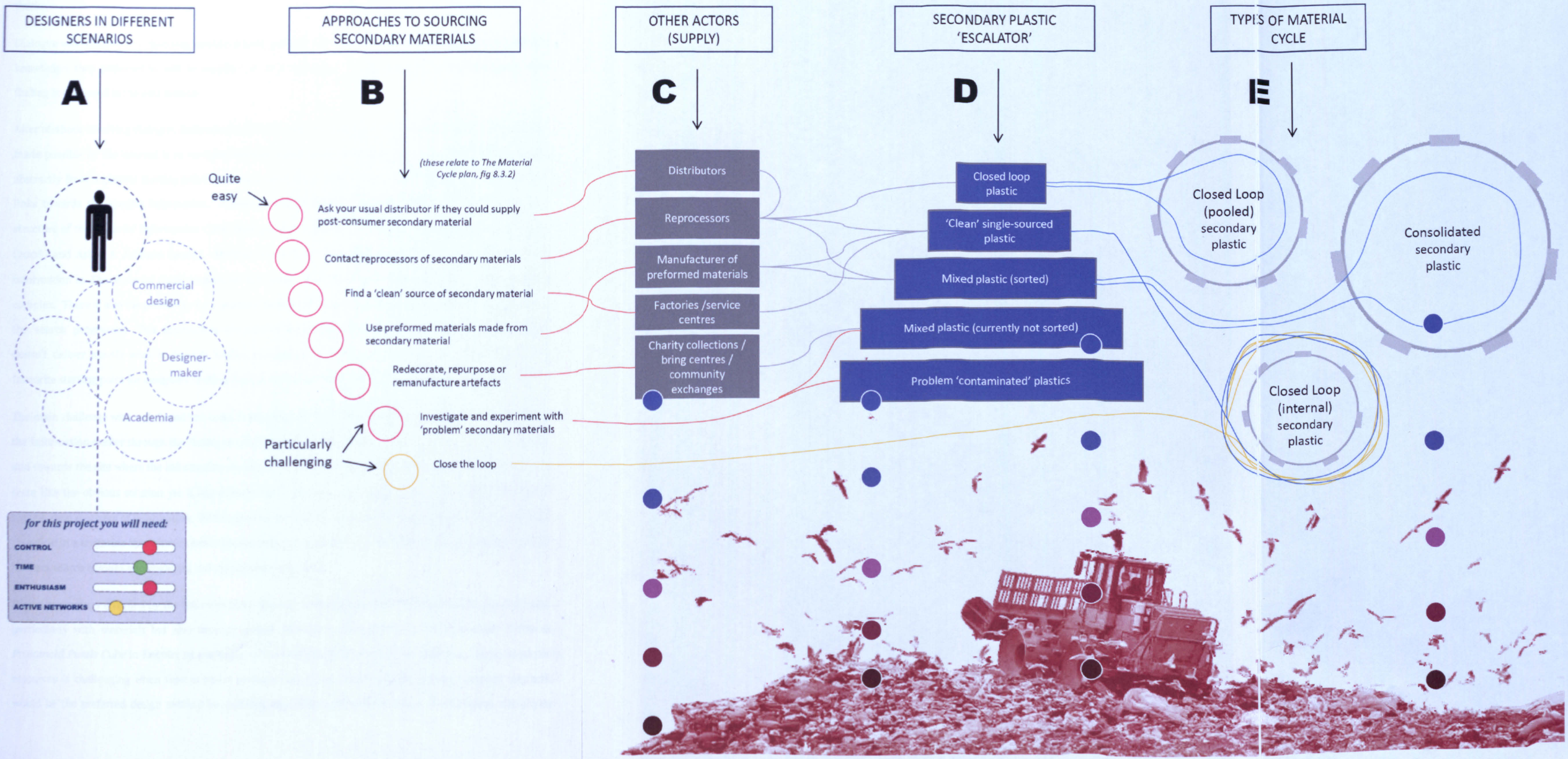
Two) suggests the future design scenario is multi-disciplinary, dynamic and focused not on a material outcome and a commercial benefit but on the best solution for the ongoing well-being of people.

Figure 8.2.2: (foldout page) Design and the Material Cycle, a visualisation of the links between designers in different scenarios, different types of secondary materials and material cycles.

Design and the Material Cycle

This is a visualisation of the relationship between designers in different scenarios (A), the various approaches to sourcing secondary materials (B), other actors in the supply of secondary material (C), secondary materials at different stages of development (D), and different types of material cycle (E).

These links, pathways and hierarchies are not strict or stable, they are flexible and ever-changing; the aim is to illustrate how the different parts of this complex system can connect in a beneficial way, according to the findings of this research. The focus of this illustration is on activities at the material's end-of-life, and doesn't show the important design intervention at the start-of –life, which is represented in *The Material Cycle* plan (fig 8.3.2).



8.3 Dynamic Interaction Using a Variety of Media

The user-centred approach to supporting designers was identified from the start of the research as being of particular importance. The suitability of this approach to the research aims has been affirmed throughout the various stages of the investigation. The designers in the study have their own ways of doing things and any support or intervention must be respectful of those methods – a view that is well established by this point in the thesis.

Dialogue was found to be a favoured method among designers for retrieving and understanding information and knowledge; they preferred to talk to suppliers or their colleagues to find materials. The significance of this finding is discussed in the next section.

After methods involving dialogue, designers preferred to use the internet. It was proposed that the main function made possible by the internet is to navigate multiple detail layers, providing the user with the ability to explore abstractly from a general starting point (such as a term typed into a search engine) through various levels and links towards the specific information. Utilising multiple detail layers was a strategy initially used in the structure of the *Material Information Card*, from general to specific information, as suggested by van Kesteren (2008) and Ashby & Johnson (2002). Multiple detail layers were also explored as a way of structuring the information in *The Material Cycle* conjectural tool where links between the various items of information were complex. There is also the possibility for a gradual learning process as more detail is picked up from each layer as the 'search' progresses. This approach is not without drawbacks; the internet promises much and frequently doesn't deliver exactly what is desired, leading to frustration. However, the research suggests that it is the favourite starting point for designers seeking information either from a known source, or something unfamiliar.

The main challenge with web-based information goes beyond that of navigation within the site itself; it is guiding the information-seeker through the throng of sites vying for their attention, away from the inevitable dead-ends and towards the site where the information resides. Delivering the site to the internet user (the designer) would seem like the obvious solution yet it has already been established through this study that designers are more <u>seekers</u> than <u>receivers</u> of information. Their attention must be given voluntarily through an event, a workshop, or an article in a magazine they already read. Importantly, if a designer is looking for a site it must be easy to find by internet search engines and engaging and useful when they reach it.

Digital technology (typified by the internet) is not the only medium aligned to design methods; physical contact particularly with materials but also through playful interaction (exemplified by the *Flowmaker Cards* and *Protomold Puzzle Cube* in Enquiry 3) was suggested as being particularly useful to designers. Access to physical resources is challenging when time is under pressure but, if this wasn't a limiting factor, physical interaction would be the preferred design method for building knowledge and understanding. Furthermore, the physical

world appears to be mimicking the virtual world and, in some cases, this method can be used to draw attention to virtual things by making them more real or memorable. This prompts the question... do multiple detail levels work without digital media? This was explored through the outcome developments. The *Material Information Card* – if it were to be hardcopy – uses this principle simply by positioning images (general information) at the top (A4) or front (A5) of the card and data (specific information) at the bottom or back. In earlier iterations *The Material Cycle* was conceived as a card 'spinner' and as a 'book', to resemble the ever popular *choose your own adventure series,*[148] where the mystery (of how to source secondary materials) unfolds, via the physical turning of pages, to reveal a hidden page where the next layer of exploration is described. Compared to using hyperlinks on a webpage this proved complex and largely unsuccessful. The limitations of the physical world cannot replicate the dynamic navigation and sophisticated structure of digital interactive media. What is more, designers explained that, as useful as the layered information in the hardcopy version of the *Materials Information Card* was, they would still prefer the primary format to be digital. How a digital system of materials information could successfully function is less certain; this is discussed further in the 'recommendations for further research' section of this chapter.

8.4 A 'Level Playing Field' for All Materials

There was an expectation from the outset of this project that providing designers with information about secondary materials that are available would be a necessary feature of the research. It was then considered that the enquiry into the design scenario of product and industrial designers (Enquiry 1) – aside from understanding the various factors affecting the designer's ability to consider and select secondary materials – would be an opportunity to reveal designers' existing use of material information sources. This knowledge could then be used to propose ways of delivering information about secondary materials in the same way as information about other materials. The overarching reason for this strategy was so that secondary materials might be considered on their own merits and properties in the same way as other materials.

As the research progressed a fuller picture emerged revealing that the problem is not confined to secondary materials. Indeed, any material that is unfamiliar to a designer faces a similar set of problems:

- By definition, the designer is unaware of the material;
- Designers consult their own experience, that of their colleagues, known suppliers or large distributors before they search elsewhere;
- Designers rarely have the time to read trade press, go to seminars, workshops, material libraries or tradeshows;
- Existing centralised databases are not that useful or appropriate to design methods;

[148] Chooseco Embarks on Its Own Adventure by Sally Lodge, Children's Bookshelf -- Publishers Weekly, 1/18/2007 http://www.publishersweekly.com/article/CA6408126.html last accessed 25/02/09

- 'Cold' delivery of information to designers is not appropriate to their methods;
- Most designers are unlikely to be able to understand a material's potential from reading property data.

Whereas an engineer is skilled at seeing the scientific potential of a material in the technical data, a product designer is skilled at reading signs and synthesising possibilities from visual and three-dimensional stimuli. What is more, the problem appears keener in product and industrial design than in those disciplines which use pre-formed materials such as architecture, interior and some types of furniture design. With preformed materials the potential can largely be understood through materials samples or images – What-You-See-Is-What-You-Get – which is ideal for visual materials databases and collections. These multisensory methods of imparting information about the material and its potential are also much more suited to design methods.

The same kind of multisensory information is not available for raw materials (those used in manufacture); the sample chips sent out in catalogues show little more than colour when the real potential of the material lies in the forms and textures it could take on and how it can contribute to product function, aesthetics, perceptions, environment (Ashby & Johnson 2002) and issues relating to the sustainable use of materials. In other words, product and industrial designers discern what a material is capable of through the existing products made from that material which speak more readily of the past rather than of future possibilities. While existing product examples are useful for explaining a material's properties, they can also be limiting.

This may be why preformed secondary materials have seen a greater amount of interest from designers than raw forms. The manufacturer of that pre-formed material has taken much of the hard work and risk out of using secondary materials; they have sourced an apparently secure supply and provided the material in a given form so that the aesthetic and functional performance is plain to see and, if necessary, tested.

Raw materials possibly need a multisensory representation of their properties and potential which avoids the various associations often prompted by seeing an existing product application. This would also enable a less prejudiced comparison between different materials, that engineers apparently achieve through comparing data, but through multisensory information more appropriate to the methods of product and industrial designers. One further implication is that better training in understanding material properties, if only rudimentary, would improve product and industrial designers' abilities to understand material potential.

The *Material Information Card* is one step towards achieving a level playing field for all materials. The weaknesses in the concept at this stage in its development have been acknowledged but it does offer guidance as to the type of information that needs to be made available in the consideration of any material for product and industrial design. The reorganisation and simplification of information and the use of images should make the information more accessible to anyone who is unable to determine a material's properties from scientific

language alone. This implies that the concept could be adapted to many situations where material exchange takes place, not least in the exchange of secondary materials where material properties cannot be taken for granted.

This research has revealed that current approaches to improving materials information exchange, such as material databases, libraries, workshops and books, are not ideally suited to the design scenario of product and industrial designers. But pursuing these types of support is understandable as there are few opportunities for drawing designers' attention towards the possibilities of other materials and presenting them with a range of alternative options. This was most evident when exploring the *Supplier Guidelines* which prompted the *Material Information Card* to be considered in the context of existing material information exchange in London, revealing a network of material information communication and translation. The conclusion of this part of the research is that the materials expert or librarian is central to this network, as boundary-spanner (Rieple, Haberberg & Gander 2005) of the material and design worlds, translating and distributing material information and knowledge. The use of dialogue is of great value to designers (as generalists) for drawing on the expertise of others, second only to physical contact with existing artefacts made from the material which is difficult to facilitate. The *Material Information Card* accommodates this finding by being a means of communicating material information between operators within the material information network, when direct dialogue is not possible, and for use during individual reflection.

The issues discussed here are faced by any material that a designer is unfamiliar with, or familiar materials which are confined to a particular type of application by their conventional use. If secondary materials are to be sourced and selected they must overcome all of these problems and then also contend with the prejudices associated with 'waste' or 'recycled' materials. Even if a level playing field for all materials were established, with the necessary information about price and availability, key benefits, and images of existing applications, this study has suggested that product and industrial designers would still be wary, which only emphasises the rationale for proposing a *framework* as opposed to one solution for addressing the project aim.

8.5 Improving Knowledge and Raising Awareness

Continuing with the theme from the previous section, this research has revealed complexities in the way designers perceive secondary materials (particularly plastics) that are likely to make it difficult for them to accept secondary materials as 'unfamiliar'.

Material 'streaming' is central to the secure supply of secondary material and as such commodity materials will always be the main input of reprocessing plants. *Polystyrene in, polystyrene out...* the expectation among designers is that secondary commodity materials should be the same as virgin commodity materials and, while this may be a reasonable assumption in the future, currently they are slightly different, if not in performance then in the melt-flow index, colour or additives. In essence, what secondary materials say to designers is 'we're the

same as the materials you already use but not quite as good' whereas, to fulfil the aims of this project, designers need to be thinking 'this is a unique material with its own properties and benefits'. This study suggests that getting designers to think about secondary materials in this way may prove challenging.

Essentially this is about managing expectations. Improving information exchange is unlikely to be enough on its own; designers need to be encouraged to expect something different from secondary materials. That is not to say that substituting virgin materials with secondary materials is not possible; there are examples where that has been successfully achieved.[149] Rather it is an invitation to designers to explore all facets of secondary materials, one that has a colourful story, one that could be a cost-effective alternative to virgin, one that inspires new technologies, one that contributes to social enrichment, one that makes more sense for resource sustainability and security. This was explored through *The Material Cycle* conjectural tool, aiming to achieve a shift in designers' understanding of materials cycles and their expectations of secondary materials.

It is hoped that improving designers' awareness of the realities of secondary materials, and the diverse options available for sourcing them, may foster the attitude that these materials offer many opportunities rather than there being only limited scope. Designers might even be prompted to reflect on their own position in relation to the range of possibilities (and design scenarios) available to them, moving along the 'path' towards an awakening to other aspects of sustainability (Argument, Lettice & Bhamra 1998; Wahl & Baxter 2008).

[149] For example Indesit were able to substitute the plastic in one of their washing machine parts for secondary plastic (WRAP 2008c)

CHAPTER NINE Final Conclusions

The penultimate chapter draws together the main conclusions from the research and how they answer the research questions, the project aim and objectives. The original contribution to knowledge and the limitations of the study are then presented.

9.1 Main Conclusions from the Research

9.1.1 Observations from The Current Product and Industrial Design Scenario

- The design scenario of product and industrial designers is not generally conducive to the proactive consideration and use of secondary materials (refer to Chapter Four).
- Design consultants are involved in a greater range of project types and materials than in-house designers so are more likely to encounter new opportunities for considering and selecting secondary materials. However their design scenario puts them at a disadvantage; the research suggests the following contributing factors:
    - Inadequate guidance on the sustainable use of materials in design training;
    - More important design priorities than sustainability;
    - Poor access to other stakeholders;
    - Client control over material selection;
    - Inertia of commercial design;
    - Inadequate information about secondary materials.

  (Refer to Chapter Four)

- Designers' are prejudiced against secondary materials. Their main concerns are Availability, Quality, Supply and Cost; these need to be addressed through improved information as well as building knowledge and awareness of secondary materials more generally (refer to Chapters Four and Seven).
- Whatever designers consider or use has to work and make sense, not within some idealised notion of future 'sustainable design practice' but within their own (current) value-systems, methods and practice (refer to Chapter Four).
- A gradual pathway towards more sustainable practices appears to be the most appropriate way to lead designers, who are locked in commercial scenarios, towards new ways of thinking about design and reframing their own activities (refer to Chapters Four and Seven).

9.1.2 Implications for Change and Support

- The consideration and selection of secondary materials is more likely to occur in design scenarios where:
    - Sustainability is prioritised;
    - Time, resources and control over materials selection are less constrained;

- The designer is able to locate clients and other stakeholders with whom they can foster good relationships;
- The project is materials-led;
- There is a clear innovation gain from using secondary materials;
- The designer is knowledgeable about material sustainability;
- There is good access to information and specialist expertise appropriate to design methods.

Scenarios with these characteristics need to become more commonplace in product and industrial design or at the very least designers can use these characteristics to identify projects where secondary materials can be considered and used more easily (refer to Chapters Four and Five; also discussed in Chapters Seven and Eight).

- Despite having a waste management system that struggles to produce material of suitable quality for ensuring stable markets, there are a variety of secondary materials available in the UK and there are different approaches to sourcing and using them. These offer designers the opportunity to positively influence the material cycle whatever their situation. For example:
  - Designers in a **constraining scenario** such as a consultancy can ask their usual suppliers and distributors about secondary materials, creating demand for material that is suitable for large volume production;
  - Designers in a **less constraining scenario** can locate a 'single-source' of secondary material for their project or investigate new ways of making use of a problematic waste stream;
  - **Designer-makers** can use waste material which has a limited supply, preformed materials or reclaimed artefacts to make new artefacts.

  (Refer to Chapters Five and Six; also discussed in Chapters Seven and Eight)

- There are four themes to focus on when attempting to support designers in the consideration and use of secondary materials:
  - Design training and knowledge-building (design education and professional development);
  - Material information provision;
  - The relationship between the spectrum of design scenarios and secondary materials;
  - Materials and methods that are fit-for-purpose.

  (Refer to Chapter Seven)

9.1.3 Specific Supports Tools

- Tools for *building knowledge and awareness of secondary materials* and those for *improving materials information* should have the characteristics identified in the tool specifications presented in Chapter Seven (also refer to Chapter Six).

- Encountering information about unfamiliar materials in an appropriate form appears to stimulate designers' curiosity and prompt them to consider the material's suitability for use in their practice. However, materials information is only a small part of a much larger system of communication where materials librarians and enthusiasts collect, translate and distribute information for designers via libraries, tradeshows, published material and databases. This network enables the designer to add to their personal list of suppliers and ultimately supports the most important activity: dialogue. This material information network and particularly the important role of the materials librarian need to be nurtured and supported if they are to work to their full potential (refer to Chapter Seven; also discussed in Chapters Four and Six)

9.1.4 A Framework for Secondary Material use in Design

- There are five central considerations when attempting to support the use of surplus and waste resources in design practice:
    - **Doing now while thinking of the future:** Secondary materials range from problematic waste streams to closed-loop 'clean' materials; taking steps now to develop and find uses for those materials will help build more effective and stable material cycles in the future.
    - **Acknowledging the design scenario:** Designers work in a variety of 'scenarios' which enable or inhibit them to act in different ways. These offer clues to the most appropriate methods of support and could help identify more conducive scenarios for sustainable design practice.
    - **Dynamic interaction using a variety of media:** Designers access information differently to other professionals, preferring to seek rather than receive information, to navigate abstractly and use dialogue to make sense of specialist information.
    - **A level playing field for all materials:** Information about secondary materials is currently inadequate; secondary materials (and other unfamiliar materials) need to be presented in the same way as conventional (familiar) materials so their benefits can be compared and prejudices avoided. All materials information needs to be more appropriate to design methods.
    - **Improving knowledge and awareness:** Designers generally do not relate lifecycle theory to their own practice "in action" (Schön 1991). This ability, as well as an awareness of appropriate approaches to secondary materials use (identified in this research), is necessary to improve the likelihood of designers selecting secondary materials.

(Refer to Chapter Eight)

9.2 Returning to the Project Aims, Objectives and Research Questions

The general aim at the start of the project was to *create new models for utilising waste resources in design practice.* From this apparently straightforward starting point a complex and challenging research programme has been pursued, introducing new questions as the investigation has unfolded.

To recap, the proposed research objectives were:

1. Investigate designers' perspectives on secondary material use in relation to their own professional practice, particularly in London;
2. Identify key potential product and design sector applications for secondary materials within London;
3. Investigate current processes and tools by which designers are enabled and supported in creating high-value applications for secondary materials;
4. Critically reassess these processes and tools to support design practice;
5. Develop innovative models to support designers in finding new applications for surplus and waste resources.

Each of these objectives was addressed by examining the assumptions and exploring the implications through literature reviews. These were then translated into research questions that could be answered through empirical enquiry to meet the aim of the project and help to answer the overarching research questions.

Fundamental to the approach taken in this project was the belief in a user-centred approach to the research and the desire to tackle the extremes of the research topic rather than continuing with the focus of previous work in this area. The main conclusions are now discussed in relation to the original expectations of the project; the aims, the overarching research questions and the anticipated outcomes.

9.2.1 Creating a 'New Model'

The project aim was to *create a new model for utilising secondary materials in design practice.* This 'new model' was described in Chapter Eight as a 'framework' involving five central considerations, representing a pluralistic approach to developing and using secondary materials on a path towards effective material cycles. It acknowledges the developmental stages of secondary materials, respects the importance of design methods and celebrates the contribution of designers in different scenarios.

9.2.2 Addressing the Overarching Research Questions

In the methodology overview (Chapter Three) two 'overarching research questions' were proposed which translated the research aim into enquiry. All of the research referred back to these central questions which can now be addressed.

Are designers in a position to consider and use secondary materials?

The research strongly suggests that the designers of high-value, mass-produced artefacts (product and industrial designers) are not currently in a good position to source and specify secondary materials, indeed, it was revealed that only in certain circumstances would they be able to do this:

- If an appropriate project presented itself (client, location, functional suitability);
- If the materials are fit-for-purpose (properties, volumes, supply capability);
- If the designer has a good understanding of materials cycles and is not unreasonably prejudiced;
- If the designer knows that the material exists and appropriate information is available.

However, in focusing on designers that are in the most challenging of scenarios the possibility of a spectrum of other design scenarios emerged (explored through Enquiry 2). This led to the conclusion that designers in different design-project scenarios could adopt different approaches to sourcing secondary materials so that, no matter how constraining a design-project scenario is, there is an opportunity to positively impact materials cycles if the right support and knowledge is available.

What can be done to support designers in the utilisation of secondary materials?

This question leads on naturally from the previous where it was discovered that a range of approaches could be offered to designers in different design scenarios as opportunities for sourcing secondary materials. In addition, it was proposed that designers' understanding of materials cycles and awareness of secondary materials could be increased through improved information, education and professional development. It was revealed that this may include guidance on the sustainable use of materials but also the engagement with, and appreciation of, materials in design education. Furthermore, this research suggests that an introduction to understanding material properties, perhaps in a post-graduate short-course or in design workshops or seminars, could be of great benefit.

9.2.3 Anticipated Outcomes

There was an expectation in the original proposal that there would be practical outcomes to the project; these were made explicit as 'anticipated outcomes' (outlined in Chapter One). It was decided that developing these outcomes to an appropriate standard to be considered the main outcome of the PhD would have required too much of the project time, so the author chose instead to explore possible solutions in the service of making sense of the empirical findings and understanding how they relate to the aim of finding new ways of supporting

designers. However it is worth returning to the anticipated outcomes and comparing these with the conjectural tools that were explored in Chapter Eight to reflect on how the project has evolved.

"A suite of resources in appropriate media to motivate, inform and support designers in finding new high-value applications for secondary materials"

All of the conjectural tools explored are resources developed to motivate, inform and support designers to achieve the project aim.

"A model for a workshop in which designers, manufacturers etc. collaboratively respond to an identified surplus (eg. 'manufacturing waste' surplus printed circuit boards which may otherwise be disposed of in landfill) to generate new applications"

Workshops were not directly investigated through this research for the reasons given in the 'limitations of the research' section of this chapter. However, it was proposed in Chapter Eight that *The Materials Cycle* conjectural tool could be used and indeed trialled in a workshop setting.

The statement above also suggests an intervention which aims to help link designers to specific waste sources and find applications for that material. *The Material Cycle* tool doesn't discount this approach but includes it as part of a broader strategy which aims to encourage designers to think about secondary materials as part of the wider system of materials cycles, and as the starting point for a variety of possible design interventions or decisions. Therefore, the workshop described above could be one of a number of workshops which stem from *The Material Cycle* resource.

"A browseable on-line database of available surplus waste materials. Designers could source materials from this database and respond with new uses for featured materials. Materials should be featured in sufficient detail, including images, material qualities and condition, dimensions, volumes etc., with samples available on request"

Databases have been discussed at length throughout this thesis and their weaknesses have been exposed. This anticipated outcome hints at an online exchange for secondary materials, rather than a materials database, targeted at problem waste streams. Like the aforementioned workshop, this approach would apparently assist designers in sourcing problematic secondary materials but doesn't take into account the broader picture and design's potential in tackling the cause of the problem material. In addition, a waste exchange would be challenging to administer and maintain[150].

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[150] There is one good example of this type of database called *Recyclicity*, which was 'live' for 1 year but had to be closed because the architect who initiated it couldn't maintain it. There are plans to relaunch the site at some point in the future but the challenge is sizable without long-term financial and organisational backing (Jongert 2009).

The *Material Information Card* addresses this issue from another angle; it proposes that if the right information is provided then any material, primary or secondary, can be considered on equal terms rather than isolating some materials for separate consideration. The *Material Information Card* incorporates many of the features listed in the description above but recommends that these be included for all materials. A potential method for searching all *Material Information Cards* is suggested in the 'recommendations for further research' section of this chapter, which is similar in some respects to the *anticipated outcome* detailed above.

What the *The Material Cycle* conjectural tool does not achieve, but which is indicated in the anticipated outcomes above, is to identify problem waste materials that ethically-minded designers can then work with in their practice. The reason for not directly developing an outcome for this purpose is that this type of intelligence is already available through various organisations and, with a little research, designers who have found the design scenario necessary to experiment with problem secondary materials could start to identify material streams of this type for themselves. It is intended that this advice and the relevant organisations to contact would be linked into *The Material Cycle* resource.

9.3 Original Contribution to Knowledge

One of the primary requirements of PhD research is that an original contribution to knowledge is made. The breadth of this investigation, comprising three separate empirical enquiries, has enabled several original contributions to be made. These are proposed here, each followed by a consideration of the 'trustworthiness' (Robson 2002) of the claim based on the research methods used.

9.3.1 Tool Specifications

The knowledge gained through the empirical enquiries was integrated and interpreted to develop two sets of original specifications for tools to build knowledge and awareness of secondary materials amongst designers and to improve materials information. Producing specifications which identify issues relating to format, content and delivery of tools is an original contribution to knowledge of how to support designers in these areas.

Trustworthiness of the claim

The tool specifications were initially developed in response to the findings of empirical research. Measures were taken to avoid threats to validity in each enquiry and are discussed in the relevant methodology sections. Conjectural tools were then explored to meet the specifications – in one case with feedback from end-users – and this enabled the criteria to be refined and clarified.

9.3.2 Sourcing Secondary Materials

A range of approaches to sourcing secondary materials based on existing examples were observed in the empirical enquires. Until now these have not (to the author's knowledge) been articulated as a range of approaches that

may be taken by designers in different scenarios and importantly within the metaphor of the *Secondary Material Escalator* which acknowledges the gradual development of secondary materials towards effective material cycles. The benefit of this concept is that it may now be used as a way of demonstrating to designers a range of opportunities for positively impacting materials cycles which vary from simple and easy, to complex and challenging.

Trustworthiness of the claim

The *Secondary Material Escalator* metaphor and the range of approaches to sourcing secondary materials was developed in response to a focused literature review for Objective 2 as well as observations in the field (Enquiry 2). Robson (2002) states that qualitative methods, such as those used in Enquiry 2, are open to interpretation but measures can be taken to avoid threats to validity. In this case attention was paid to careful note-taking and a wide range of data sources were consulted which improve the 'trustworthiness' of the findings. The study was conducted with the narrow focus of secondary plastic in London so generalisability beyond these areas cannot be confidently claimed.

9.3.3 Understanding the Design Scenario

A further valuable and original contribution is *The Design Scenario* model not as an outcome in itself but as a method for considering factors that may influence the decisions of individual designers and, therefore, identifying opportunities for change in a positive direction. Seeing the design individual as part of a construct allows for the possibility that some factors could be changed which may enable or empower the designer to make ethical rather than commercial decisions. In short, it allows for the possibility of creating different design scenarios that are more conducive to various design activities; considering and selecting secondary materials is just one such activity.

Trustworthiness of the claim

The design scenario model was developed in response to the focused literature review for Objective 1 (Enquiry 1) and the nine interviews with industry experts. The model was then used as the theoretical framework for Enquiry 1, the results of which were validated during interviews with four of the respondents. The model appeared to be an appropriate method of exploring the design scenarios of these designers and was also a useful reference for observations made about the scenarios of designers who had successfully used secondary materials during Enquiry 2. However, this was from the designer's viewpoint and further scenarios could be explored to view the design scenario from the perspectives of other stakeholders in the design process.

9.3.4 Material Sourcing Behaviour

There are other authors who have written extensively on the material sourcing behaviour of industrial designers (Pedgley 1999; Ashby & Johnson 2002; van Kesteren 2008) and their views must be given due respect. This

research has suggested that a centralised resource or database (which has been suggested by some of these authors), that meets the needs and expectations of product and industrial designers, is far from being realised and there are a number of substantial hurdles to overcome before that happens. Rather, the behaviour of designers reported in Enquiry 1 suggests that the relationship between suppliers and designers could be utilised and that dialogue (with suppliers or colleagues) is an important method that designers use to access the expertise required to understand the material options available to them. In addition, a network of materials information translation and exchange was observed (in London) involving various sources and distributed or disseminated by materials experts and librarians. To the author's knowledge this is an original contribution to theory in the field of material information for design. However, it was also noted that the designers in this enquiry worked in small consultancies which are less likely to have well-established in-house resources than large design organisations (which were the focus of other studies in this field).

Trustworthiness of the claim

The material sourcing behaviour of designers was investigated through a fixed research design (Enquiry 1) using established methods for avoiding validity threats such as feedback from experts in the field and a small pilot study. The results were further validated by four respondents who were given a copy of the results and interviewed. A rigorous sampling method was used for this enquiry which means that the results should be considered generalisable.

The material information 'network' was constructed from observations in the field and meetings with material information professionals. To avoid threats to validity, detailed notes were taken and a range of sources used. This is still in the early stages of theory-building; observations were made in the field, the theory unfolded and *seems to fit* the situation that was observed (Mason 2002). Therefore this would benefit from further investigation. The generalisability of these findings beyond the specific geographic focus of the research (London) cannot be confidently claimed.

9.4 Limitations of the Research

The 'limitations of the research' refer to the boundaries within which the research was conducted and are outlined here to inform the reader and ensure the findings are understood and used appropriately.

- The focus of this investigation was primarily in the UK and sometimes narrowed to the city of London. The findings are therefore in the most part specific to this geographic location.
- With regard to design scenarios investigated in this research, the focus of Enquiry 1 was on product and industrial designers while the focus of Enquiry 2 was kept to designers of small artefacts such as products and furniture. These findings are not therefore necessarily applicable to other types of designers not included in the study.

- The survey questionnaire (Enquiry 1) involved respondents from both consultancies and in-house design teams, however, the follow-up interviews and end-user feedback for the *Material Information Card* was conducted with design consultants only and, therefore, the findings from these later stages of the study are not necessarily applicable to designers working in in-house design teams.
- Throughout the project there was an intentional focus on the individual designer and the influences on their decisions. This was discussed in Chapters Two and Four. However, design decisions are also made and influenced by a number of non-designers who are involved in the process leading to the production of new artefacts. Although this was acknowledged in the research, the ability of these other individuals or organisations to select secondary materials for the production of new artefacts, was not investigated here. Therefore, the findings of this research cannot claim to be the 'only' or the 'best' way of increasing the use of secondary material in the production of new artefacts; there may be many approaches (which may include new legislation, business practices, clean manufacture, engineering etc.) one of which involves supporting designers in the ways proposed in Chapter Nine.
- Where the research looked specifically at the issues relating to secondary material recovery and use (mainly Enquiry 2), the focus was narrowed to plastic which was necessary to ensure feasibility of the research. Although there was a general awareness of other types of secondary materials in the research undertaken, the findings cannot claim to be wholly representative of all secondary materials.
- The design tools investigated in Enquiry 3 did not include workshops; this was for two reasons: Firstly, the findings of the survey suggested that product and industrial designers were unlikely to have time to attend workshops; secondly, because an assessment of workshops (which would inevitably involve attending them) would have been too time-consuming for this study. Therefore the outcomes and findings of this research have not included 'the workshop' as a type of tool which may be useful in supporting designers in the use of secondary materials.
- The tools explored in Chapter Seven are 'conjectural'; they were developed to demonstrate the research findings and refine the specifications and so cannot be claimed to be 'ideal'.
- With regards to the types of designers and design scenarios investigated, there was a disparity between the levels of investigation undertaken. For example product and industrial designers were investigated rigorously using a survey method whereas other types of designers, such as designer-makers, were not investigated with the same rigour. This was an unavoidable consequence of the flexible structure of the research which requires the researcher to respond to findings as the research unfolds and alter the research design accordingly. As a consequence the importance of 'other' design scenarios to the research was not understood until a late stage in the project after the empirical research had been completed and was being analysed. Therefore, direct and rigorous comparisons between the types of designers and

their respective scenarios could not be made; the characteristics were observed and discussed and, based on the research undertaken, findings were reported and models proposed.

CHAPTER TEN Recommendations for Further Research

This chapter concludes the thesis with recommendations for further work focussing on the use of secondary materials in design practice and more generally in the fields of design, materials and sustainability.

This research has highlighted areas which could benefit from further research. The recommendations begin by considering how the conjectural tools might be developed for use in education and industry, followed by suggestions for research beyond this project.

10.1 Supporting Designers to Select Secondary Materials

Two areas of design support were identified in the research and explored in Chapter Seven resulting in specifications for two tools. It is recommended that any attempt to build knowledge and awareness of secondary materials or to provide appropriate materials information for designers refer to these specifications for guidance. In addition two conjectural tools were explored and the possibilities for further developments of these tools are described below.

Conjectural tool for building knowledge and awareness: *The Material Cycle*

This tool was proposed to enable designers to visualise their role in the material cycle as 'getter/sender' of material but also to disseminate one of the main findings of the research that there are a variety of approaches to selecting and using secondary materials offering designers in different scenarios the opportunity to positively influence the material cycle. This concept would benefit from an industry trial to establish whether designers in a given scenario are able to use these approaches and achieve a positive outcome.

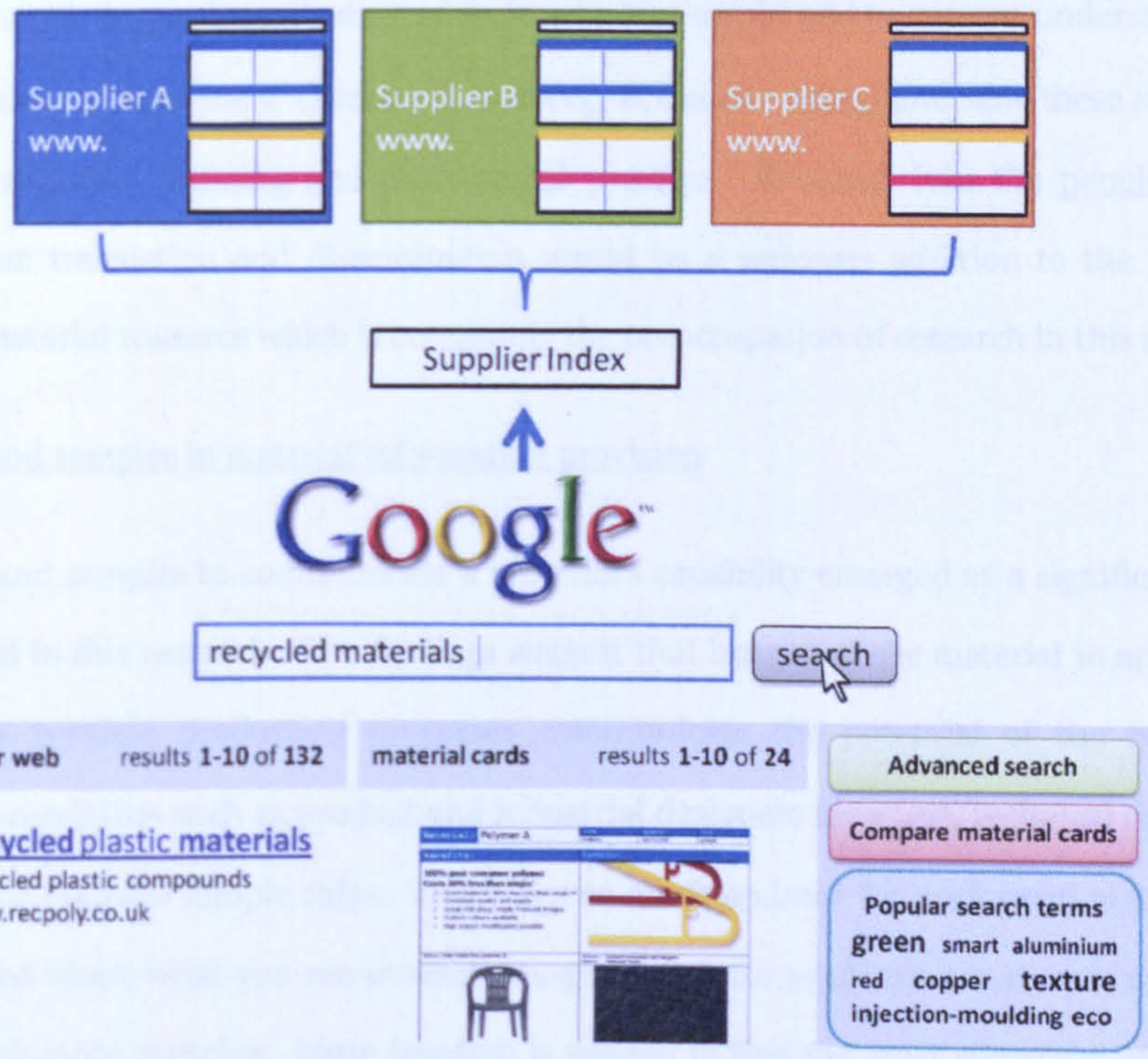
A necessary next step would be to consult experts in graphical communication and Human-Computer-Interaction (HCI) about the best way to make the interface of this virtual tool navigable, dynamic and visually stimulating. On the completion of a working prototype, further research could be undertaken to elicit user feedback on the success of the format, content and delivery of this tool. It would then be possible to make it available online, disseminating the website through workshops, talks and forums, and teaching to fulfil the requirements of 'delivery' identified in this research.

Conjectural tool for providing appropriate materials information: *Material Information Cards* and *Supplier Guidelines*

Although the *Supplier Guidelines* are a good starting point for implementing the findings of the research, digital consolidation of the *Material Information Cards* (in addition to hardcopy) was strongly suggested in the feedback as a necessary step towards making the concept useful for designers. Accessing information online, comparing and searching materials, are important features to designers that so far have only been pursued through material databases, which the research suggests designers don't find that useful. A digital interface for *Material Information Cards,* therefore, must avoid the weaknesses demonstrated by previous attempts at materials information consolidation, highlighted in Enquiry 3. Instead of a database a digital method of linking *Material Information Cards* to one site could be explored so that they could be accessed more easily and compared, whilst remaining fundamentally under the control of the supplier who is then responsible for maintaining their own information. Existing examples of online interfaces, which have the desired functionality, include search engines which were found to be a popular method for finding materials in the survey, and provide the ability to search for general or specific criteria. Some search engines, such as Google, also provide a range of tools that offer ways of using the internet more effectively. Investigating the possibilities of these types of internet architecture would be useful in developing this outcome further (for example see fig 9.5.1).

An additional step might be to elicit feedback from other users of material information and stakeholders in the design process, such as those who commission design (design clients) or other types of designers (such as those working 'in-house' who were not included in the latter stages of the study). As suggested previously, the *Material Information Cards* could be adapted and trialled in other situations where material information is translated and communicated, such as where reclaimed materials are available or with architectural materials.

Figure 10.1.1: Hypothetical scenario: the Material Information Card concept may benefit from exploring internet architecture and, in particular, the ability to search many locations from one site or search engine. This could allow designers to compare materials, to extract information in different ways, and to expose designers to unfamiliar themes or opportunities.



10.2 Further Research beyond the Current Project

The role of material librarians

This research has revealed the dynamic role of material librarians as translators and disseminators of material information. A deeper investigation of their activities would add to current understanding about the operation of 'boundary-spanners' (Rieple, Haberberg, & Gander 2005) and how these skills could be fostered through education, training and professional practice. Research into the people involved in material information translation and dissemination would be a welcome addition to the pursuit of an 'ideal' centralised material resource which is commonly the preoccupation of research in this area.

The use of images and samples in material information provision

The use of images and samples to communicate a material's capability emerged as a significant issue that wasn't fully resolved in this research. The findings suggest that images of the material in application and samples that show possible production processes communicate the potential of the material more successfully to non-specialists such as product and industrial designers than text, technical data, images of material samples and material sample chips. This is not so much an issue for preformed materials such as sheets and extrusions where what-you-see-is-what-you-get as it is for production materials where material capabilities are much more complex. More research is needed to find the most successful combination of images and material samples that communicate the potential of the material to designers and is feasible for suppliers to produce.

Closer investigation of specific phenomena within the design scenario

Enquiry 1 investigated the relationships between disparate aspects of the design scenario which haven't been explored before; in studying a range of issues some detail was inevitably sacrificed. These findings could therefore be used as a starting point for close investigation of one particular aspect of the *design scenario*. For example, Question 14 of the survey explored the relationship between materials training, confidence in materials selection, time spent investigating materials and access to information sources. Here, there appeared to be some significant relationships between the variables but the picture appeared incomplete and complex. To build on these findings further research could be undertaken to focus on these phenomena using additional research methods which produce richer data, such as observation or design diaries. A theoretical understanding about what constitutes 'successful materials selection' would need to be established prior to this research so that the activities, which result in a desirable outcome, could be identified. The purpose would be to find ways of improving materials guidance in design training which this research suggests would result in greater confidence when selecting the most appropriate and sustainable materials.

Fostering design scenarios that are more conducive to the selection of secondary materials and sustainable design

The research identified areas where the design scenario of product and industrial designers could be changed to improve the likelihood that secondary materials would be considered and selected for suitable projects and the characteristics of scenarios more conducive to the selection of secondary materials were also highlighted (summarised in Chapter 9). Together these provide a blueprint for the types of changes that need to occur if designers are to consider and use secondary materials. As these characteristics in the most part relate to general aspects of the design situation, they are likely to also be applicable for the consideration of other sustainability criteria. If sustainable practices are to become commonplace in design, more research needs to done to try to implement some of these changes.

Using the design scenario model to investigate other design scenarios, and from different perspectives

Using the design scenario model to describe or explain alternative design scenarios was suggested in the previous chapter. There is no doubt that new design scenarios will need to be understood and fostered if ethically-minded design students and practicing designers are to find 'space' to hone their skills and practice sustainable design. This may be as simple as identifying particular projects and circumstances within a designer's current working situation that are more conducive to sustainable design – as this project has begun to do in relation to secondary materials – or it may involve a more radical overhaul of the whole design scenario. Either way more research is needed to further understanding of how design scenarios operate and can be improved to benefit design practice. *The Design Scenario* is one model (presented earlier in fig. 8.2.1) which would allow scenarios to be compared and produce generalisable results, for example:

- To describe and compare other types of design scenarios, such as those of designer-makers, engineers and architects;
- To identify the weaknesses in existing design scenarios and propose areas for change;
- To construct hypothetical design scenarios that are more conducive to particular activities such as sustainable design.

The ability of designers to 'boundary-span' – to communicate with other stakeholders, and development of tactics to improve this situation

Boundary-spanning has been mentioned in relation to materials librarians but this research has also suggested that communicating effectively with other stakeholders and knowledge areas is a skill that designers are likely to need if they are to pursue sustainability in their practices. Some existing studies of boundary-spanning were presented in Chapter Four but they were not in the field of sustainable design research. Therefore more research is needed to understand the potential for boundary-spanning to be

used by designers to incorporate sustainability criteria into the design process and influence design decisions.

Materials guidance in design training

This research has suggested that there is a need for materials guidance to be included in design training, relating to the general use of materials, sustainability issues and the use of secondary materials. In particular it was evident that although designers knew something of lifecycle theory, they did not readily relate this knowledge to their own practice. As the majority of participants in the research received their training over 10 years ago conclusions about the current state of design training could not be drawn. However there was also anecdotal evidence from some of the interviewees that new graduates are lacking materials knowledge and experience. There is a need therefore for a thorough re-examination of materials experience and guidance, generally and relating to sustainability, in design training to establish if it is indeed absent from study programmes, affecting design skills and priorities.

Test the relationship between 'Design and the Material Cycle' with other types of secondary material

The relationship between the various design approaches to sourcing secondary material and the *Secondary Plastics Escalator* was presented in figure 9.1.4. Although this model was developed with a focus on plastic, the relationship between design and the material cycle may be applicable more broadly. Therefore, investigating the model in relation to paper or textiles, for example, could be the focus of further research.

The *Secondary Material Escalator*, which forms a significant part of the theoretical model, represents the development of a material from *volatile markets, no clear value* to *stable markets, clear value*, or more importantly – from the perspective of sustainability and building an effective material cycle – the development of a material so that its properties can be recovered through multiple cycles. It would worthwhile exploring the potential of this model for mapping the development of other types of secondary material or indeed to consider the sustainable management of abundant or scarce materials in the pursuit of more sustainable materials use, as was discussed in Chapter Eight.

The pursuit of a flexible system for artefact production that welcomes changes in the abundance of different materials

There was a strong suggestion in this research that current methods of production are not suited to the sustainable management or use of materials; a new system which is sufficiently flexible to respond to fluctuations in the abundance of different materials would be beneficial. Alternative methods of production were not investigated here but it was suggested that Rapid Manufacture offers great potential for shifting the current paradigm of production. The use of secondary materials in Rapid Manufacturing systems would be an interesting line of investigation, with the aim of pursuing local cycles of artefact production and use which is responsive to changing needs.

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APPENDIX A: THE SURVEY (Enquiry 1, Chapter Four)

A(i) Expert Interview Summaries

During the early stages of the project (Jan-Mar 07) the author undertook nine interviews with 'industry experts' to inform the development of theory for Enquiry 1. These were recorded and key themes extracted which are included below along with a short summary of each interview.

Key themes (codes)

Organisational mechanisms

Risk-aversion

Communication/collaboration/multi-disciplining

Design support

Improved knowledge for designers (professional training)

Improved information/support for designers

Improved business knowledge for designers

The individual designer's influence

Challenging convention

Designers' passion – own time and effort

Approaches to utilising recycled materials

Targeting specific 'problem' waste streams

Economic opportunism

Proof – demonstration, trusted advice, validation, case studies etc.

Product design co-coordinator for a solar panel producer: recorded telephone interview 28/02/07

Sourcing recycled materials is challenging. This interviewee appeared to have problems because she was pursuing this on her own, having to use her own time and knows little about materials or the requirements of supply. She also mentioned cost, consistency of supply and inability to meet the design requirements. The interviewee considered WRAP a useful source of information but there was no advice and calling up companies took a long time.

Sustainable engineering expert and academic: recorded telephone interview 26/02/07

Using materials in a sustainable way is about challenging convention. It's important to reassess how a virgin material is processed for a particular application and how that can affect its properties in second, third and fourth cycles. Secondary material validation would allow Designers to match material properties to an appropriate application which would de-risk the use of secondary materials. But it's about having the courage and passion to take risks – some designers aren't in the right scenario to challenge briefs (in-house) and others aren't passionate enough. Then there's the problem of IP. To use secondary materials there must be a guaranteed and consistent supply and the visible quality of the product must not be compromised. Multi-disciplining is important, which often means that creativity is best infused through a consultancy role in neutral ground. Companies are risk-averse.

Design Council manufacturing expert: recorded telephone interview 30/01/07

The challenge with incorporating design into manufacturing companies is firstly to make Managing Directors and Marketing Directors aware of the role and benefits of design. This can be achieved by having a 'voice in the boardroom' and also talking to them in their own language; to bridge the gap between design and business knowledge. For this to happen, design education and ongoing professional development needs to include more business and marketing orientated training. The use of great case studies, design

champions and peer-mentoring schemes are important tools for design individuals. Local forums setup and run by designers for designers are useful support mechanisms. Having one clear and simple service for all design issues is important.

London Remade manufacturing expert: recorded telephone interview 27/02/07

The performance of London Remade's Enhance project is measured by jobs or businesses created and this needs to be taken into consideration with all of their work. With their investigation into manufacturing in London, they couldn't offer to work with existing manufacturers to substitute virgin material with recycled ones because this wouldn't create jobs, so instead they were looking for a problem waste stream from manufacturing so that they could create new businesses to deal with it. What they found was that the biggest manufacturing sector in London is print and publishing with a waste stream of paper which is already heavily dealt with. They also found that many of the manufacturing businesses in central London are offices or assembly sites rather than for production. Their conclusion therefore was that they will assist the development of new manufacturing businesses through the existing Enhance service. The particular problem with manufacturing is that finding one thing to do is a challenge and getting someone to do it is even harder; it's a case of taking each situation on its own merits and very much specific to each material type.

Design Council sustainable design expert: recorded telephone interview 05/02/07

There are two extremes of approach to design for sustainability, the first focuses on greening products and looking at how designers can incorporate eco-design criteria in their work. The second, which is where this interviewee's concerns lie is to use design thinking to tackle the systemic problems and change behaviour on a much broader scale. The main problem with the first route in relation to manufacturing is that designers have enough problems trying to convince clients about the value of design without bringing sustainability into the equation. SMEs are resistant to investment and risk-taking and designers have little or no input into the development of a brief, so decisions have already been made. In terms of support, anything that is done must be strategic – it's about designers having the fighting power, the numbers to convince clients of the benefit. Another way of looking at it as a designer is how can you make ugly materials sexy, but this means starting with waste as a problem rather than incorporating waste into legitimate products.

Materials and engineering expert and academic: recorded telephone interview 20/02/07

When you prepare any material, you have to make sure there is an application and a market for that material, recycled materials are no different. There has to be a consistent and reliable supply of material which often means that the best way to approach this issue is to deal with one particular reliable waste stream and find a use for it. This is particularly successful when there is an economic incentive, such as investing the money that goes on Landfill tax on developing a profitable product from that waste material. Innovation is only necessary if the waste material is a problem and hence the need for design as a way of developing opportunities will only be necessary as long as recycling is not working effectively. Separation of components and plastics is one area where design has maximised from a problem situation.

The key to effective use of design in manufacturing is communication and collaboration. The best situation is where all parties involved in the project come together to form a multi-disciplinary team.

London Remade design expert: recorded telephone interview 06/03/07

Designers supported through London Remade's Inspired Recycling (IR) programme have been mostly designer/makers based in London which has made it easier for them to fulfill the remit of using waste to produce and sell products in London. Now there is the added challenge of business creation or growth as a remit of the Enhance programme. The main challenges have been about getting designers to understand the reality of what is involved in taking an idea or a prototype through to production, in other words designers are not informed about business. There is the potential for trade-off on design when trying to incorporate secondary materials but this wasn't experienced in IR projects. Designers working with manufacturers are often ill-informed of the manufacturing limitations and technical requirements which can lead to designs that are impossible to manufacture.

WRAP materials and manufacture expert: recorded telephone interview 22/02/07

The challenge is to find the best use for collected waste materials, which means finding new high-value applications. This involves targeting particular problem areas and using demonstration projects to convince industry of the benefits of using recycled materials, including technology trials and developing plants to improve the quality of materials. Cleaning up contaminated materials is where the high cost lies especially is used materials where contaminants are unknown. The three main problems with using recycled materials in manufacture are:

1) Quality of feedstock (contamination, risk, etc.)

2) Price (expectation is that it's cheaper – the customer won't pay more)

3) Security of supply (is there a reliable supply of feedstock?)

Legislation is increasingly a driver, but more importantly the business opportunities in finding a valuable application for a waste material.

Materials science expert and academic: face-to-face interview (recording failed) 09/02/07

Materials are never lost; the issue is about economic viability, energy use and contamination of land. Materials that are unwanted now could be stored as a future resource and mined when they're value is great enough. Human ingenuity will provide solutions to the changes in availability of different materials. Recycling is as much about society's perception of well-being as it is about necessity; the human instinct not to be wasteful is an emotional response that is valuable because it adds to our feeling of well-being. In a similar way our perception of materials, how we treat them and use them is inextricably linked to historical and cultural values, and our removal from being in a position to use, repair and deal with them ourselves has led to a cultural amnesia about the value of materials and the objects made from those materials.

A(ii)Expert Feedback on the Survey Instrument

Some of the industry experts who were interviewed were also asked to give their advice regarding the content of the survey questionnaire. Four responses were received and are included below as they provided a valuable outside perspective and influenced the design of the survey instrument.

Industry expert 1 - Design Manager; personal email correspondence 01/04/07

"in general it looks good and has some well researched and pertinent questions.

Comments I would make are as follows:

Section 2 - your headings - initially looking etc could be refined, I think. How about 'Awareness of material' and 'Final specification of material'?

In section 8 could buying be buying, sourcing or purchasing?

In section 9 could you add something about profit generation/financial success - either as an individual or for one's employer? Money shouldn't be a dirty word - greed is the enemy!

Length about right - it's really quick to get through which should allow someone the chance to think about their own contributions where required."

Industry expert 2 - Sustainable design academic and practitioner; telephone conversation 02/04/07

"Section 5: Additional options for sourcing recycled materials

- *Sourced from a reprocessor*
- *Wholesale – waste exchange*
- *Are you tied contractually to a particular source of material?*

Section 6: This may be sensitive information – they may not want to answer.

Not confident

Section 9: Additional design factors:

- *Cost*
- *We've always done it this way*
- *Brand image"*

Industry expert 3 – Sustainable design manager for Design Council; personal email correspondence 19/04/07

"The length is OK and the questions are very clear (although like all questionnaires, not always easy to answer).

I would be very interested to see the results of this questionnaire to see where designers are at with their thinking and knowledge of sustainability."

Industry expert 4 – Materials policy for DTI; personal email correspondence 25/04/07

"Looks pretty comprehensive to me.

A lot of potential respondents could be put off by the length of the questionnaire, so, if there are areas where you could scale it back it might be useful to do so."

A(iii) Survey Instrument (Questionnaire) and Detailed Rationale

The survey questionnaire was organised into 10 sections, each with a new webpage containing the questions within that section. 'Screen-grabs' taken from the online survey of each section are included at the beginning of each group of questions to illustrate the question presentation. Text boxes contain the introductory phrase given at the beginning of each section of questions in the questionnaire, and are provided here as a guide.

The following rationale was prepared prior to the questionnaire being distributed and is therefore written in the present and future tense. *Note: **the question order** used here is the same as in the survey instrument that was deployed, but is different to the order used in the Results & Discussion for Enquiry 1 (Chapter Four).*

Question types

A variety of response methods have been utilised in this questionnaire including multiple choice (single and 'all that apply'), yes/no, open, and scales. While it has been decided that open questions should be kept to a minimum for ease of response and analysis and a variety of response methods should be utilised to keep the respondent's attention, the most appropriate response method has been chosen for each question.

The ordering of questions has been carefully considered as it was noted that the use of easy-to-answer and non-probing questions could be used at the start to ease the respondent into the questionnaire. More complex questions are positioned 3rd quarter of the questionnaire and the remaining easy-to-answer but slightly more personal questions are positioned at the end. An opportunity to comment is also given to provide space should the respondent feel they haven't been able to respond as fully as they would like in the questionnaire body. Although it is stated at the beginning that the questionnaire is anonymous unless the email address is given, the respondent is advised to give their email at the end of the questionnaire if they want to be included in the prize draw.

Scaled responses:

Most of the response methods chosen are explicit in their answers (yes/no or select all), however five scales have been used which could be more difficult to analyse and as such should be discussed briefly here. The classic Likert 5 point scale of agreement is commonly understood as meaning 'strongly disagree', 'disagree', 'undecided', 'agree' and 'strongly agree' (Robson 2002: 294). In addition the following scales have been devised in response to the demands of the questions.

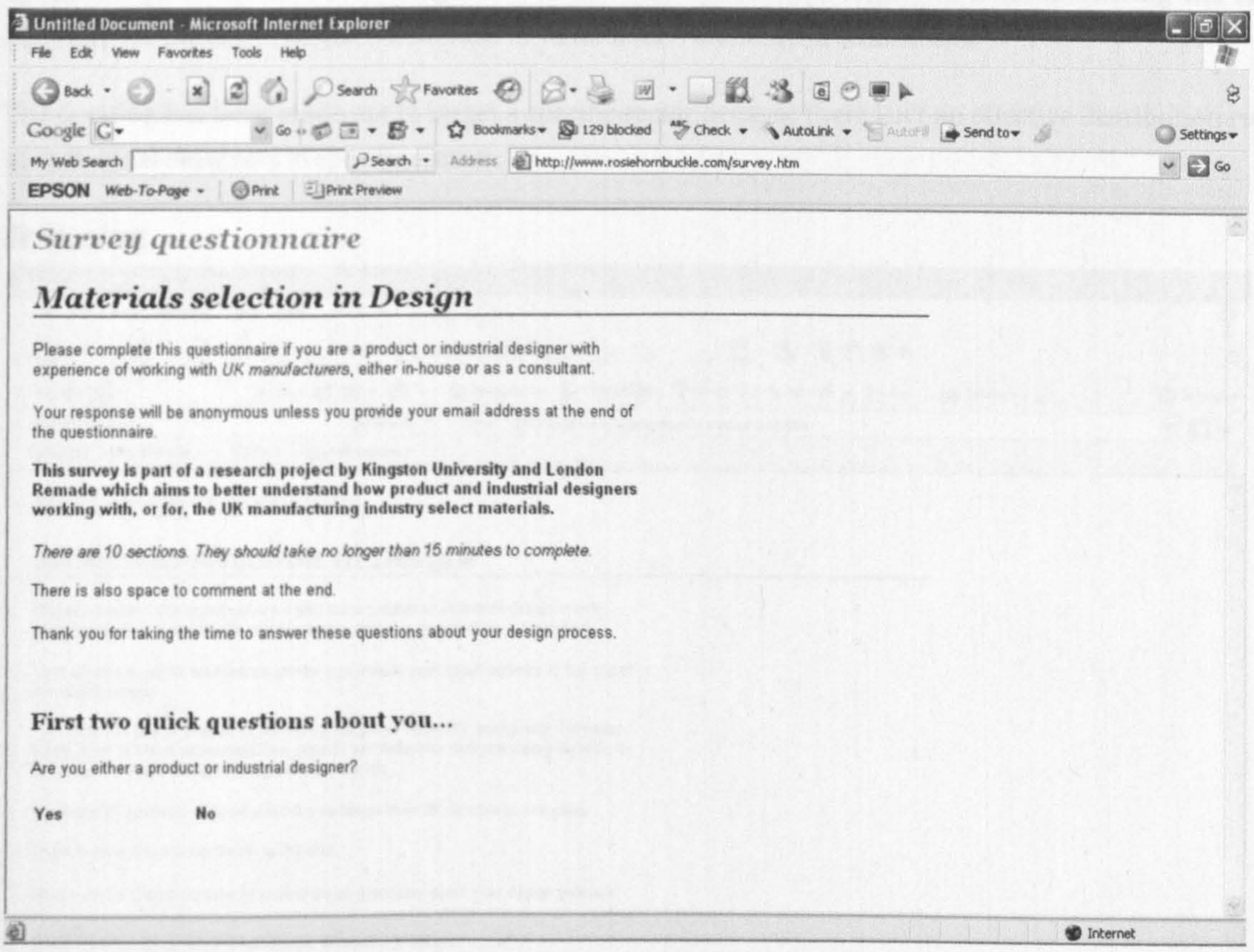
- Question 11: 1 is 'None' and 5 is 'all'.
    - This is a quantity scale and therefore can be taken to mean that 3 as the midpoint is greater in quantity than 2 and lesser in quantity than 4.
- Question 17 & 21: 1 is 'never' and 5 is 'always'.
    - This is a frequency scale and similarly to the quantity scale 3 can be taken to mean more frequently than 2 and less frequently than 3.
- Question 19: 1 is 'inadequate' and 5 is 'adequate'.

- This scale asks the respondent to quite simply choose the 'level' of adequacy between 1 and 5 and as such 3 can be taken to mean more adequate than 2 and less adequate than 4.

- Question 20: 1 is 'unimportant' and 5 is 'important'
  - This scale also offers 5 'levels' of importance with 3 being more important than 2 and less important than 4.

In these cases the midpoint always means 'greater than 2 and less than 4', but respondents who are familiar with the common Likert scale may use the midpoint as 'neutral' or 'undecided'. This means that with any response involving the mid-point it must be considered that as well as the actual meaning it may have these other connotations to the respondent.

Introduction to the survey



The introduction is designed to provide the respondent with some information about the aim of the survey, its provenance and what is required to complete the survey. It has been decided that in order to capture as unbiased a view as possible, the true focus of the project on the use of recycled materials will not be made explicit to respondents. Respondents are informed that their response will be anonymous unless they decide to provide their email at the end; this is intended to help make the respondent feel at ease and speak openly and honestly about their experiences to obtain a higher quality of data.

Ideal target audience: London-based product or industrial designers working with or within London-based manufacturers.

The survey is aimed initially at UK manufacturers because it is difficult to tell if the population of designers working with London-based manufacturing is large enough to elicit a large enough response.

The design discipline targeted can be described as 'product and industrial designers'. This category was defined by the Design Council (2005) as the design of *Consumer/household products, Furniture, Industrial design (incl. automotive design, engineering design, medical products).*

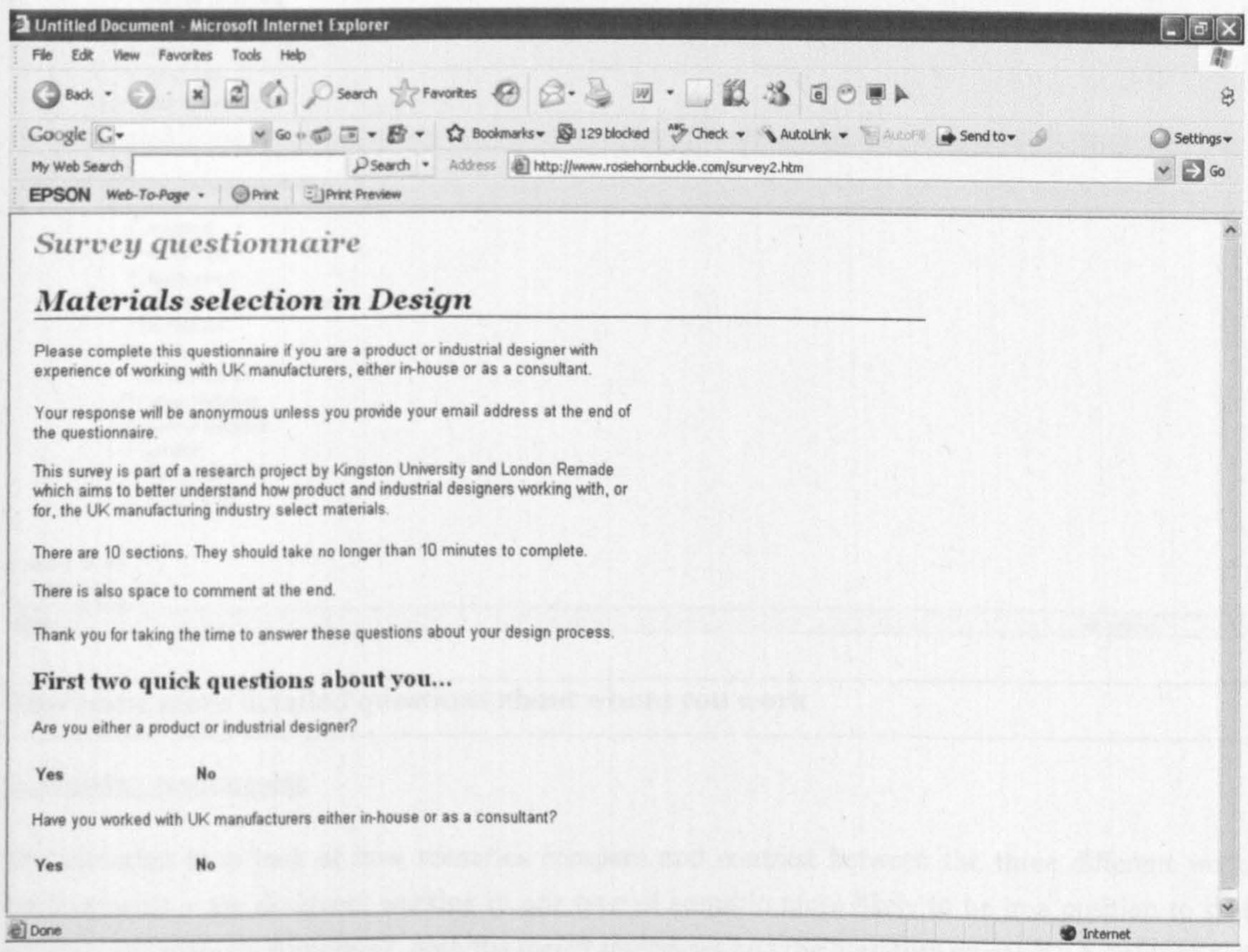
The full list of categories is:

- Communications design
- Product and industrial design
- Interior and exhibition design
- Fashion and textiles design
- Digital and multimedia design
- Service design.

When compared to the other categories Product and Industrial Design was seen as offering the most potential for the use of recycled materials in value-added manufactured artefacts.

The decision has been made not to target a specific sector because there isn't an effective distribution route to individual designers in specific sectors.

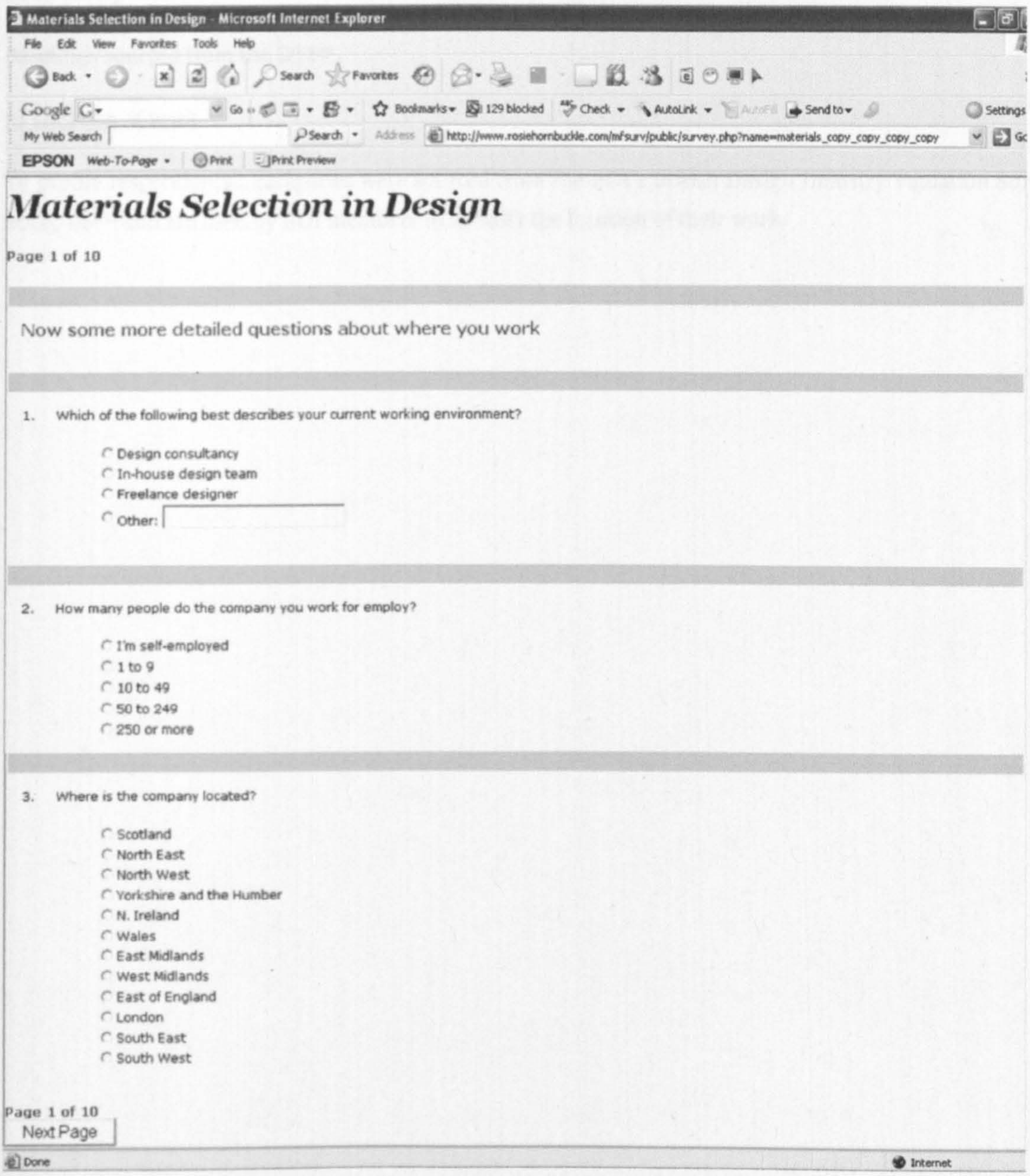
Screening



First two quick questions about you...

These two questions are aimed at screening potential respondents to reduce the risk of receiving data from individuals who are not in the target population. In either question if the respondent ticks 'No' they are directed to an end page and are not able to continue with the questionnaire.

Section 1: Questions 1 to 3



Now some more detailed questions about where you work

1) Working environment

The intention is to look at how scenarios compare and contrast between the three different working environments – are designers working in one type of scenario more likely to be in a position to specify recycled materials than another? Both the expert interviews and the literature revealed a belief that design consultants may be in a better position to influence design decisions than in-house designers, but that there may also be some areas of similarity.

2) Employee numbers

In line with the discussion above relating to Lauche's (2005) study, it is anticipated that the size of organisation may have an implication on the effectiveness of the designer's working scenario. Therefore,

this data may be used to compare and contrast between designers working for small, medium and large-sized enterprises.

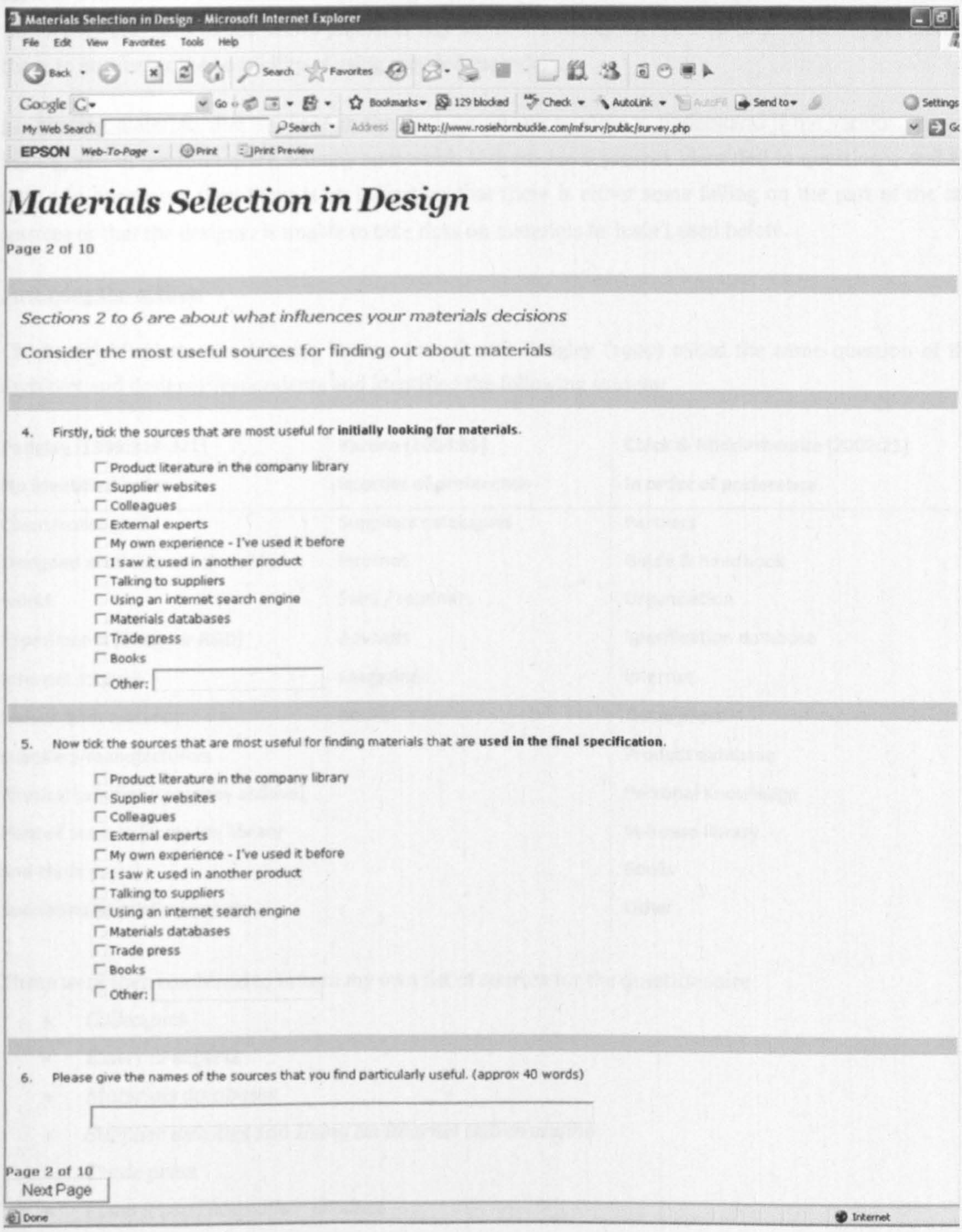
Bandings sourced from the DTI[151].

3) Location of work

To profile respondents... categories were sourced from the BDI's British Design Industry Valuation Survey 2005/06[152] and are used by BDI members to identify the location of their work.

[151] http://www.dti.gov.uk/innovation/nms/faqs/page32346.html (accessed 17/10/06)
[152] http://www.britishdesigninnovation.org/BDI_val_survey06.pdf (accessed 17/10/06)

Section 2: questions 4 to 6



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Sections 2 to 6 are about what influences your materials decisions

Consider the most useful sources for finding out about materials

4. Firstly, tick the sources that are most useful for **initially looking for materials**.

- ☐ Product literature in the company library
- ☐ Supplier websites
- ☐ Colleagues
- ☐ External experts
- ☐ My own experience - I've used it before
- ☐ I saw it used in another product
- ☐ Talking to suppliers
- ☐ Using an internet search engine
- ☐ Materials databases
- ☐ Trade press
- ☐ Books
- ☐ Other:

5. Now tick the sources that are most useful for finding materials that are **used in the final specification**.

- ☐ Product literature in the company library
- ☐ Supplier websites
- ☐ Colleagues
- ☐ External experts
- ☐ My own experience - I've used it before
- ☐ I saw it used in another product
- ☐ Talking to suppliers
- ☐ Using an internet search engine
- ☐ Materials databases
- ☐ Trade press
- ☐ Books
- ☐ Other:

6. Please give the names of the sources that you find particularly useful. (approx 40 words)

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Next Page

Done

Internet

Sections 2 to 6 are about what influences your materials decisions

Consider the most useful sources for finding out about materials

Sources of information

These two questions aim to identify the behaviour of designers when researching materials to use in their design work. The most popular information sources may give an indication of where an intervention for supporting the use of recycled materials might be best placed.

4) Initially looking for materials: - aims to understand where designers first go when investigating possibilities.

Arguably this is the best chance of coming into contact with recycled materials as designers are likely to look in a number of places before narrowing down their selection. The implication could be for example, that if they only look in one or two places, or rely on their own experience then there is less opportunity for them to encounter the possibility of using recycled materials.

5) Finding materials that are used in the final specification: aims to understand if the various resources highlighted in question 4 are actually successful, if there are 6 sources identified in question 4 and then only 1 in question 5 then there is an indication that there is either some failing on the part of the other sources or that the designer is unable to take risks on materials he hasn't used before.

Justifying the options

Chick and Micklethwaite (2002), Karana (2004) and Pedgley (1999) asked the same question of their architect and designer respondents and identified the following sources:

Pedgley (1999:319-321) **No identified order**	**Karana (2004:81)** **In order of preference**	**Chick & Micklethwaite (2002:21)** **In order of preference**
Client/colleagues	Suppliers catalogues	Partners
Designed artefacts and the wider world	Internet	Guide & handbook
Experiments (Designer R&D)	Fairs / seminars	Organisation
Internet sources	Advisors	Specification database
Liaison with material suppliers/manufacturers	Magazines	Internet
Physical samples [company archive]	Books	Trade press
Printed sources [company library and trade press]		Product database
Specialists/specialist services		Personal Knowledge
		In-house library
		Books
		Other

These were then combined to inform my own list of sources for the questionnaire:

- *Colleagues*
- *External experts*
- *Materials databases*
- *Supplier websites* and *Using an internet search engine*
- *Trade press*
- *I saw it used in another product*
- *My own experience - I've used it before*
- *Talking to suppliers*
- *Product literature in the company library*
- *Books*
- *Other*

The differences compared to Chick and Micklethwaite (2002):

- ***Partners*** – is commonly used to refer to colleagues in an architectural practice but is less appropriate for product and industrial designers.
- ***Guide and handbook*** – Arguably this is covered in 'books' and is less likely to apply to product and industrial designers in the same way as it does to architects.

- ***Organisation*** – I presume this refers to organisations with specific knowledge, in which case 'external experts' or 'talking to suppliers' would cover this and are arguably less ambiguous.
- ***Specification database*** – 'materials database' arguably describes a wider variety of online materials sites.
- ***Internet*** – I have divided this into 'supplier websites' and 'Using an internet search engine' because using the term internet seemed too broad for the huge range of research activities that could take place on the web. The two categories I have chosen cover the most likely possibilities.
- ***Product database*** – This is possibly also covered by 'materials database', but I've included 'I saw it used in another product' because the expert interviews revealed that demonstration or best practice examples are often more powerful at persuasion than any other sources of information with the exception of previous experience and advice from peers. For example the Design Council Manufacturing expert stated:

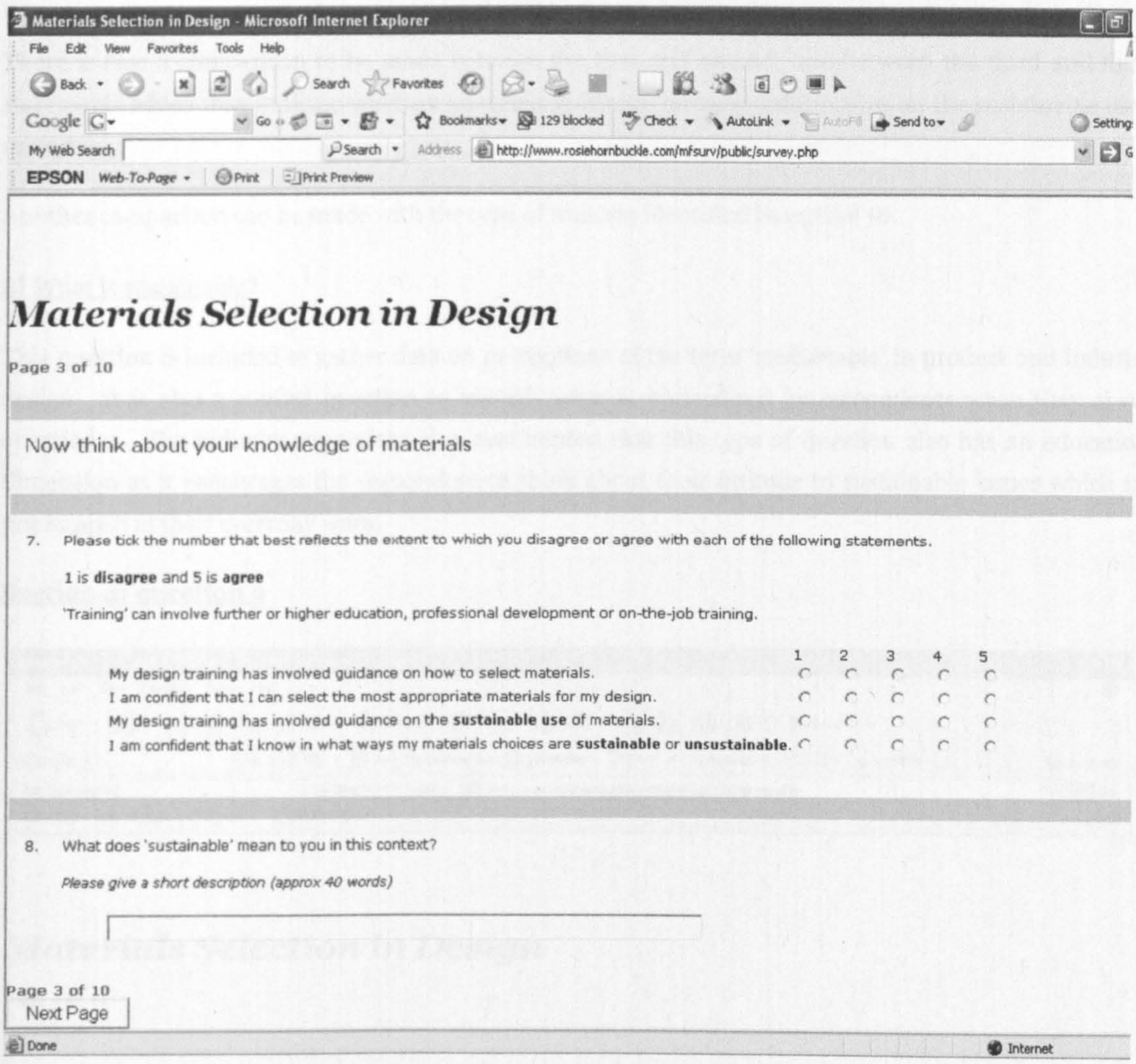
  > It's really important that we are seen in the new and the media, various broadsheets and magazines, great case studies of tangible effects of design.

- ***Personal knowledge*** – this is very similar to 'my own experience - I've used it before' but I would argue the latter is more in keeping with the literature which states that designers are most likely to use solutions that they have used before (for example Emmitt 2001); 'knowledge' could be seen to include that which is learned from others whereas 'experience' and 'used it before' is explicit.
- ***In-house library*** – In-house library could cover books as well as product literature and there appears to be little sense in using a broader term when 'books' is a separate option.
- ***Talking to suppliers*** – the literature (for example Emmitt 2001) indicates that talking to someone who knows their product well is often a key stage in the decision-making process; if the supplier is consulted and cannot give answers this often leads to the material being abandoned.

6) Most useful sources

This simply gives the respondent the opportunity to name a particular source they find useful adding detail to the data given in questions 4 and 5. The word count is a rough estimate based on a 250 character limit which was adjusted following the pilot.

Section 3: questions 7 to 8



Now think about your knowledge of materials

7) Four statements about how training relates to confidence in selecting materials with an agreement scale of 1 to 5.

- *Guidance: how to select materials*

  To indicate to whether the respondent has been given guidance on materials selection during design training and whether this has any connection to whether they are confident in selecting materials in the second statement. If it has a negative impact this may indicate that there is a failing in design education and professional development.

- *Confidence: to select appropriate materials*

  Correlating to the first statement.

- *Guidance: sustainable use of materials*

  To indicate whether the respondent has been given guidance on the sustainable use of materials during design training and whether this has any connection to whether they are confident about the sustainability of their materials choices in the fourth statement. If it has a negative impact this may indicate that there is a failing in design education and professional development.

- *Confidence: sustainable issues*

  Correlating to the third statement.

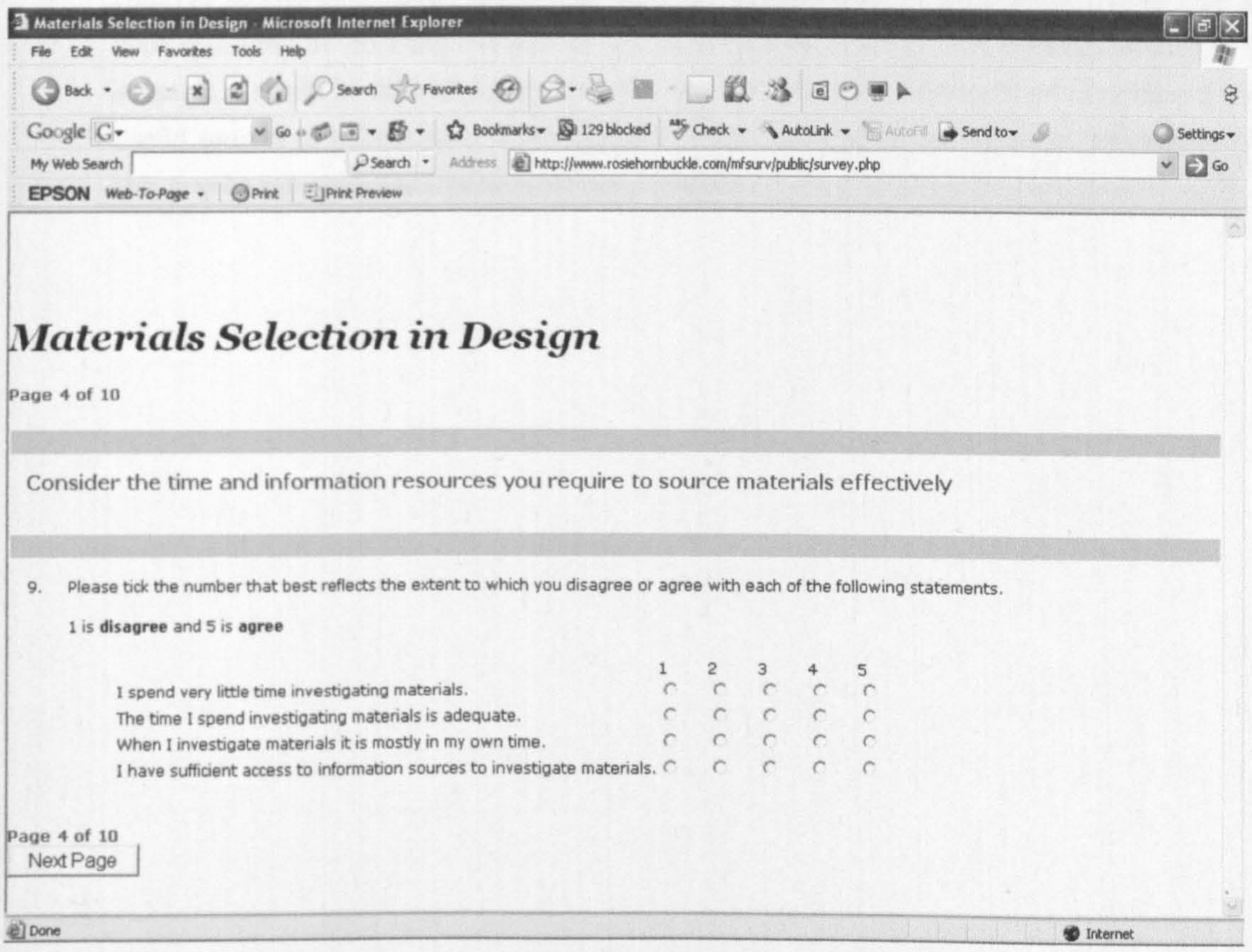
There is also a comparison to be made between the first and second, and between the third and fourth statements which may indicate whether materials guidance includes information on the sustainable use of materials.

Another comparison can be made with the type of training identified in section 10.

8) What is sustainable?

This question is included to gather data on perceptions of the term 'sustainable' in product and industrial design. It is also a control question to identify what is understood by respondents when they answer question 7. The industry supervisor also commented that this type of question also has an educational dimension as it encourages the respondent to think about their attitude to sustainable issues which may not happen in their everyday work.

Section 4: question 9



Consider the time and information resources you require to source materials effectively

9) Four statements about whether designers are in a situation where they have sufficient freedom to research materials with an agreement scale of 1 to 5.

- *Total time spent*

  This should give an indication of the general pattern of time spent and can be compared to a number of other responses including confidence and number of years experience to see if the amount of time spent decreases as confidence and experience increases.

- *Time spent is adequate*
  When compared to the first statement this could give an indication of what amount of time is adequate for investigating materials and whether the amount of time spent is down to individual choice or is imposed by practice constraints.

- *Mostly my own time*
  Firstly this gives an indication of passion. As discussed earlier (see page 23) the literature and expert interviews indicate that a passionate individual may be more likely to be successful in challenging convention. Therefore, the amount of their own time spent on investigating materials may indicate their level of commitment, determination and passion. This can be compared to the first and third statements to give an overall picture of how an individual's time is allocated when investigating materials. This could also be linked to section 7 which looks at whether designers are inclined to, and successful in, challenging briefs.

- *Access to information sources*
  This gives a further indication of whether designers are in a situation where they can effectively investigate materials. If they have enough time but not enough access to information then this could be an area of concern. If they don't have enough time or enough access to information then time could be the deciding element as you need time in order to find information and in this scenario it would be difficult to separate the two. This can also be compared to section 2 about useful sources of information; if the designer doesn't have sufficient access to information then this may be substantiated if their selection is limited.

Section 5: questions 10 to 14

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Now a couple of questions about what types of materials you use

10. What types of materials do you most commonly specify?

Please tick all that apply

- ☐ Thermoset plastics
- ☐ Thermoplastics
- ☐ Plastic foams
- ☐ Metals
- ☐ Rubbers
- ☐ Composites
- ☐ Wood
- ☐ MDF
- ☐ Natural fibres
- ☐ Paper or pulp
- ☐ Man-made textiles
- ☐ Natural textiles
- ☐ Glass
- ☐ Ceramics

11. When working with UK manufacturers to what extent are your materials decisions affected by a contractual obligation to a particular material or material supplier?

1 is **none** and 5 is **all**.

1 ○ 2 ○ 3 ○ 4 ○ 5 ○

12. Have you ever specified recycled materials?

The term 'recycled' is used here to describe waste materials that are reprocessed before further use rather than those that are reused in their current form.

- ○ Yes
- ○ No
- ○ Not sure

13. If you answered yes, what was the source of the waste material?

- ☐ It was a by-product of the manufacturer's own production
- ☐ It was bought from other manufacturers
- ☐ It was bought from a reprocessor
- ☐ It was post-consumer waste
- ☐ Other:

14. What is your opinion of recycled materials?

Please give a short description (approx 40 words)

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Now a couple of questions about what type of materials you use

10) Types of materials specified

This information will simply help to contextualise the designers' working scenario. As the distribution is broad, this type of information will be invaluable in building profiles for the respondents. The material types were adapted from the DTI's materials validation survey[153] and to be sure that none were missed out an 'other' box is also used.

11) Contractual obligation

This question was not originally in the questionnaire, but it was noted by one of the expert interviewees that designers may be obligated to certain suppliers or types of material. This is significant because if 'all' of their materials decisions are affected by contractual obligations their role in materials selection is going to be quite different, it may point to a need for designers to be supported in negotiations with the supplier as well as the manufacturer.

12) Specified before?

This will give a simple indication of experience with recycled materials for the sample but will also enable comparison between the two groups – those who have and those who haven't. This information may also be necessary when selecting candidates for follow-up later in the research. A definition of 'recycled' is given here to allay any misunderstanding and keep the potential for error low.

13) Source of waste material

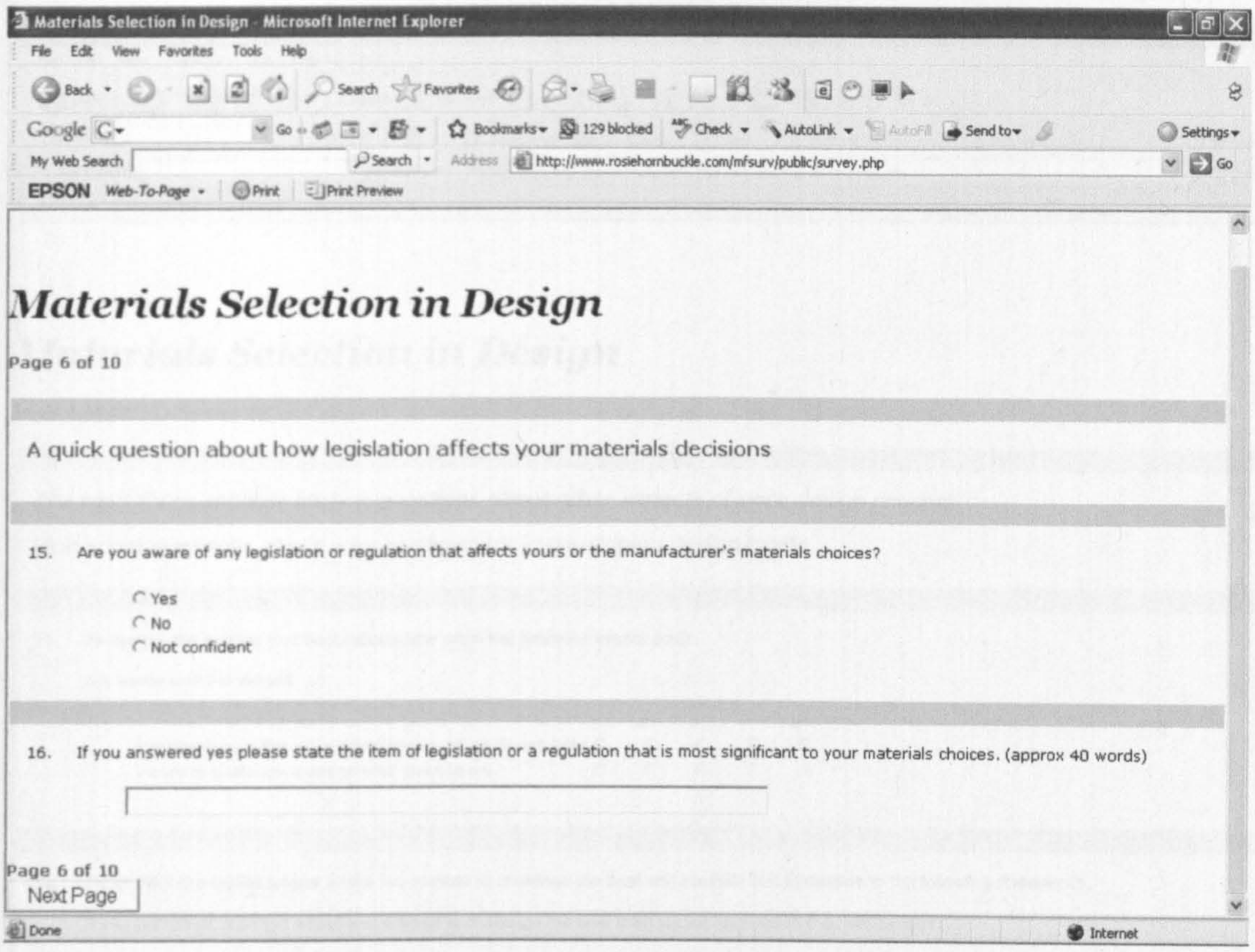
This gives some extra detail to question 12 and helps to build a profile of waste materials use in design and manufacture. These categories were developed with the help of one expert interviewee to make sure the most likely possibilities are covered but if not, there is also an 'other' box.

14) Opinion of recycled materials

This text data may be used to get a general feel for perceptions of recycled materials in the spirit of the original intention of objective 1, for example a simple analysis may include positive v. negative or coding key themes. This can also be compared with question 12 to see whether there is a difference in perception between those who have and those who haven't used recycled materials. Similarly to question 8 this also has potential to have an educational dimension.

[153] This was forwarded to the author by one of the industry expert interviewees, but no further reference to the survey can now be found.

Section 6: questions 15 to 16



A quick question about how legislation affects your materials decisions

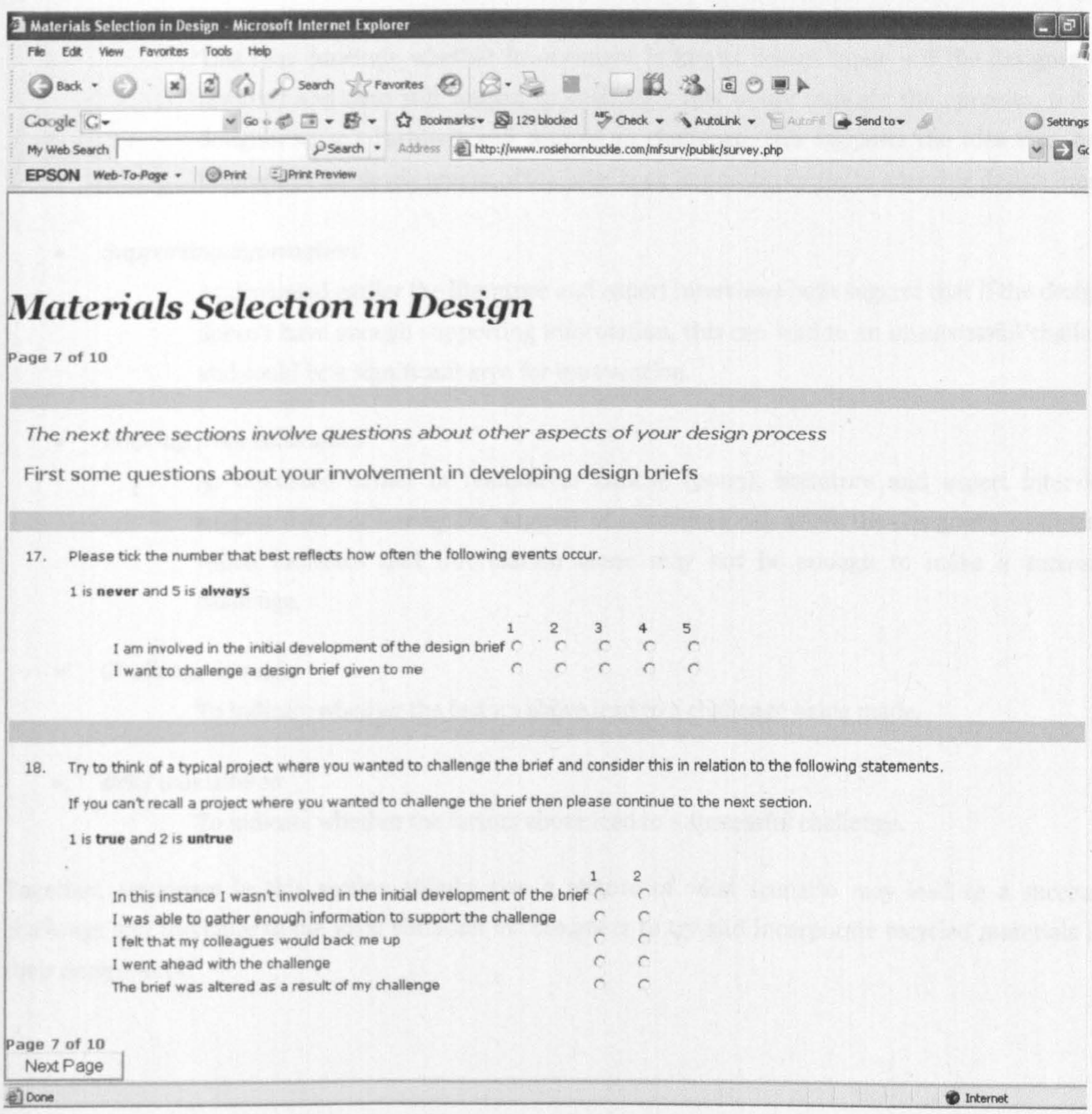
15) Awareness

Simple data that will provide a straightforward divide. Knowledge of legislation could be used by designers as an argument for selecting recycled materials. If they don't know about it, they can't use it. In response to one of the expert interviewees' concerns about the potential unease that may be felt by respondents when answering this question (they may think answering 'no' is incriminating), an additional option of 'not confident' is given. This will have the same affect as 'no' in that it is not a confident 'yes' and the designer is unable to use legislation as a tool for change.

16) Identify

This will act as a control question for question 15 to see if designers are being honest, but also to identify which pieces of legislation are having a perceived impact. Similarly to questions 8 and 14 this also has potential to have an educational dimension.

Section 7: questions 17 to 18



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The next three sections involve questions about other aspects of your design process

First some questions about your involvement in developing design briefs

17. Please tick the number that best reflects how often the following events occur.

1 is **never** and 5 is **always**

	1	2	3	4	5
I am involved in the initial development of the design brief	○	○	○	○	○
I want to challenge a design brief given to me	○	○	○	○	○

18. Try to think of a typical project where you wanted to challenge the brief and consider this in relation to the following statements.

If you can't recall a project where you wanted to challenge the brief then please continue to the next section.

1 is **true** and 2 is **untrue**

	1	2
In this instance I wasn't involved in the initial development of the brief	○	○
I was able to gather enough information to support the challenge	○	○
I felt that my colleagues would back me up	○	○
I went ahead with the challenge	○	○
The brief was altered as a result of my challenge	○	○

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The next three sections involve questions about other aspects of your design process

First some questions about your involvement in developing design briefs

In order to specify recycled materials it is often necessary for designers to go against the norm and challenge the brief given to them. Their ability to do this is key to whether they represent any real opportunity for using recycled materials.

17) Two general statements with a frequency scale of 1 to 5:

- *Involvement in developing the brief*
  The simple way to influence the brief is to be involved when it is first being defined and this question should indicate whether that is the case for designers in different scenarios. This can be compared to the type of working environment as well as company size.

- *Frequency of wanting to challenge*
  This should indicate whether the designer is happy with the briefs they are given and also whether they are passionate about their design values. This can be compared to 'time spent' in section 4 and how often 'design values' are reflected in designers' work in section 9.

18) Six 'yes/no' questions about a particular project:

- *Involved?*

  This may conclude whether involvement is key to design input – if the designer was involved and then still wanted to challenge, this would indicate the opposite, but if a designer wasn't involved and wanted to challenge, this supports the idea that being involved in the development of the brief is an important factor in ensuring design input.

- *Supporting information*

  As discussed earlier the literature and expert interviews both suggest that if the designer doesn't have enough supporting information, this can lead to an unsuccessful challenge and could be a significant area for intervention.

- *Back-up from colleagues*

  As discussed earlier in relation to Lauche (2005), literature and expert interviews suggest that not having the support of colleagues can affect the designer's confidence, which indicates that information alone may not be enough to make a successful challenge.

- *Challenge is made*

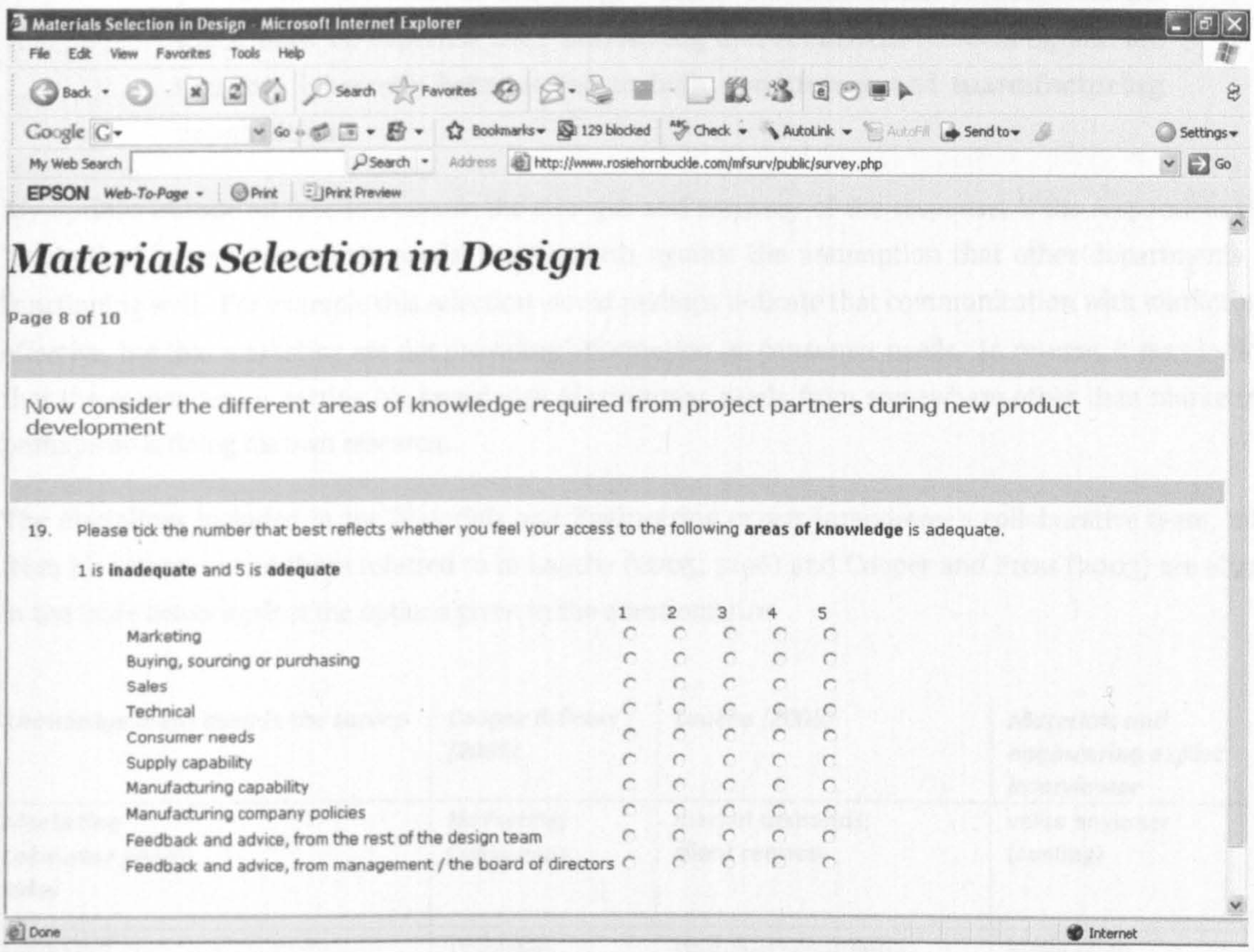
  To indicate whether the factors above lead to a challenge being made.

- *Brief was altered*

  To indicate whether the factors above lead to a successful challenge.

Together, responses in this section should give a picture of what scenario may lead to a successful challenge and therefore to the ideal situation for designers to try and incorporate recycled materials into their design work.

Section 8: question 19



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Now consider the different areas of knowledge required from project partners during new product development

19. Please tick the number that best reflects whether you feel your access to the following **areas of knowledge** is adequate.

1 is **inadequate** and 5 is **adequate**

	1	2	3	4	5
Marketing	○	○	○	○	○
Buying, sourcing or purchasing	○	○	○	○	○
Sales	○	○	○	○	○
Technical	○	○	○	○	○
Consumer needs	○	○	○	○	○
Supply capability	○	○	○	○	○
Manufacturing capability	○	○	○	○	○
Manufacturing company policies	○	○	○	○	○
Feedback and advice, from the rest of the design team	○	○	○	○	○
Feedback and advice, from management / the board of directors	○	○	○	○	○

Done Internet

Now consider the different areas of knowledge required from project partners during new product development

19) Access to different areas of knowledge

As discussed above the expert interviews and the literature (see page 10) both point to communication with project partners as being essential for effective product development, especially with regards to designers having influence over any decisions made. So understanding this is necessary to complete a profile of the designer's working scenario and the impact that has on whether they can challenge the brief in section 7, whether they can impose their design values on their work in section 9, and whether they are motivated to work over-time on projects in section 4. Also, understanding how knowledge transfer varies between different departments may indicate weak areas of communication such as being able to communicate with business functions in their own language, as highlighted by the interviews and discussed above (see page 15).

Justifying the options

These options are based on the literature, which discusses the importance of different areas of knowledge during product development, in particular Cooper & Press (2003) and the Materials and Engineering expert interviewee. These options were also further developed in response to feedback and advice from the expert interviewees.

Press and Cooper (2003:148) use the rugby team metaphor for modern and effective product development:

> The 'ball' is passed freely from one team member to another until it reaches the 'touchline' of a product launch". This illustrates the authors' belief in an ongoing exchange of knowledge between project partners, or 'cross-functional integration'.

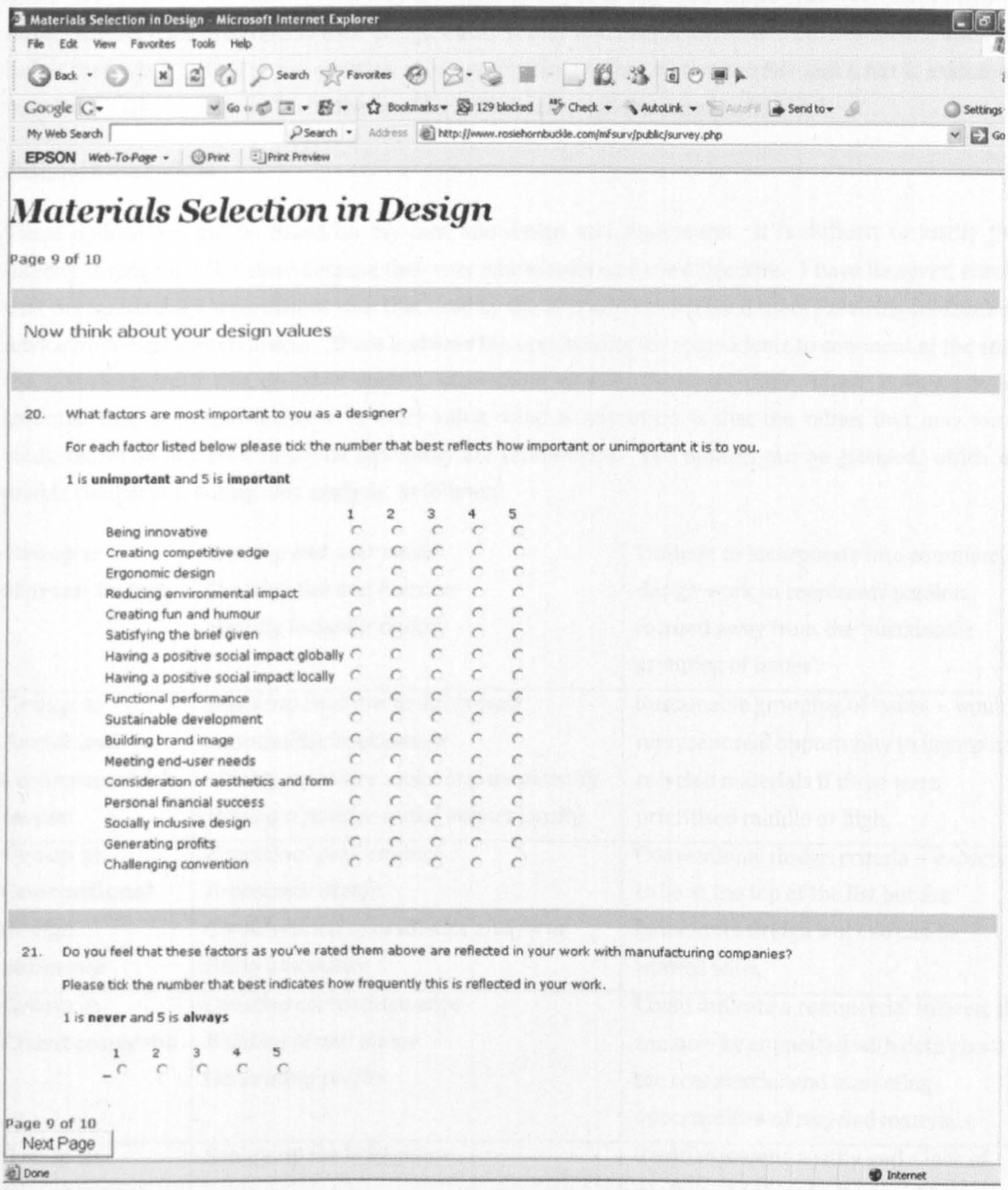
> They go on to place specific importance on two areas of expertise which in turn provide two key areas of knowledge: "Closer communication produces designs which draw on expertise from **marketing** and **technical functions**, and are therefore inherently better suited to both **consumers** and **manufacturing capabilities.**

My options include all four to increase the strength and accuracy of the response; if the respondent ticks 'marketing' but not 'consumer needs' it safeguards against the assumption that other departments are functioning well. For example this selection would perhaps indicate that communication with marketing is effective, but that marketing are not providing information on consumer needs. In reverse, it may indicate that the respondent is getting his knowledge of consumer needs from somewhere other than marketing - perhaps he is doing his own research.

The disciplines included in the Materials and Engineering expert interviewee's collaborative team, taken from his interview and those referred to in Lauche (2005; p196) and Cooper and Press (2003) are aligned in the table below against the options given in the questionnaire:

Knowledge areas used in the survey	*Cooper & Press (2003)*	*Lauche (2005)*	*Materials and engineering expert interviewee*
Marketing ***Consumer needs*** ***Sales***	Marketing; Consumers	market demands; client request	value engineer (costing)
Technical ***Manufacturing capability***	Technical; Manufacturing capabilities	technical constraints; production optimisation	application engineer; equipment manufacturer
Buying, sourcing or purchasing ***Supply capability***		specifications of material stress	material supplier; materials engineer
Manufacturing company policies ***Feedback and advice from management / the board of directors***		Organisational support for design; feedback on previous products	
Feedback and advice from the rest of the design team		Feedback from agents (for learning and support)	

Section 9: questions 20 to 21



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Now think about your design values

20. What factors are most important to you as a designer?

For each factor listed below please tick the number that best reflects how important or unimportant it is to you.

1 is **unimportant** and 5 is **important**

	1	2	3	4	5
Being innovative	○	○	○	○	○
Creating competitive edge	○	○	○	○	○
Ergonomic design	○	○	○	○	○
Reducing environmental impact	○	○	○	○	○
Creating fun and humour	○	○	○	○	○
Satisfying the brief given	○	○	○	○	○
Having a positive social impact globally	○	○	○	○	○
Having a positive social impact locally	○	○	○	○	○
Functional performance	○	○	○	○	○
Sustainable development	○	○	○	○	○
Building brand image	○	○	○	○	○
Meeting end-user needs	○	○	○	○	○
Consideration of aesthetics and form	○	○	○	○	○
Personal financial success	○	○	○	○	○
Socially inclusive design	○	○	○	○	○
Generating profits	○	○	○	○	○
Challenging convention	○	○	○	○	○

21. Do you feel that these factors as you've rated them above are reflected in your work with manufacturing companies?

Please tick the number that best indicates how frequently this is reflected in your work.

1 is **never** and 5 is **always**

1	2	3	4	5
○	○	○	○	○

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Now think about your design values

20) Important factors

This question aims to better understand where environmental and social issues rate alongside other design values to establish whether designers have a personal inclination towards values that support the use of recycled materials. Originally it was intended that this question solicit a true rating response, forcing designers to prioritise between the different options on a 10 point scale. However, this would take a considerable amount of time and concentration and considering the length of the full questionnaire, may put respondent's off completing. It was also questionable whether rating these answers would provide a true picture of how the different values relate to one another, for example Robson (2002) notes that a ratings system doesn't enable you to understand whether the gap between 5 and 6 is greater than the gap between 4 and 5. In light of this issue several scaling systems were considered and on balance it was decided that an importance scale of 1 to 5 would be used that would allow respondents to rate multiple

options at the same level. Using this method, the implication could be that if they rate environmental and social issues lower than others, then they are unlikely to put in the extra effort often required to find and implement recycled materials in their design work. If they don't seem inclined to environmental and social issues then why? A link to the question about *perceptions of recycled materials* and *what is sustainable* may form a clearer picture. To further avoid question error options were randomised.

Justifying the options

These options are mainly based on my own knowledge and experience. It is difficult to justify them directly through the literature because they vary enormously and are subjective. I have however, checked that the terminology is consistent with that used by the BDI and have revised them following feedback and advice from expert interviewees. There is always the opportunity for respondents to comment at the end of the questionnaire if this question doesn't allow them to fully represent their values, however it isn't essential that this list is inclusive of every value, what is important is that the values that may force a compromise on any environmental sensibility are represented. The options can be grouped, which may enable comparison during data analysis, as follows:

Group 1: Human factors	*Meeting end-user needs* *Creating fun and humour* *Socially inclusive design*	Difficult to incorporate into commercial design work so represents passion focused away from the 'sustainable grouping of issues'.
Group 2: Social and environmental issues	*Reducing environmental impact* *sustainable development* *Having a positive social impact globally* *Having a positive social impact locally*	Sustainable grouping of issues – would represent real opportunity to incorporate recycled materials if these were prioritised middle or high.
Group 3: Conventional design concerns	*Functional performance* *Ergonomic design* *Consideration of aesthetics and form* *Being innovative*	Conventional design criteria – expected to be at the top of the list but are inherent to design work so can be worked with.
Group 4: Client concerns	*Creating competitive edge* *Building brand image* *Generating profits*	Could indicate a commercial interest that can only be supported with data about the commercial and marketing opportunities of recycled materials.
Group 5: Reactionary attitude	*Satisfying the brief given*	Could represent apathy and a lack of passion. As already discussed an individual who is going to implement recycled materials has to be prepared to go beyond the brief, to challenge with determination. This is also linked to 'own time spent' in section 2.
Group 6: Designers' other personal motivations	*Personal financial success* *Challenging convention*	Both represent a passionate individual, however one is often at odds with the other; as discussed above, seeking financial success in some individuals means not taking risks while in others entrepreneurship is viewed as essential. Obviously one is desirable for the use of recycled materials while the other is not.

21) Reflected in work

This is to find out if designers are able to put their own passion and values into their work for manufacturers using a frequency scale of 1 to 5. If they are not, this doesn't bode well for recycled materials. This could be linked to 'challenging the brief' as there could be a parallel between not being able to influence the brief and their values not being reflected in their work for manufacturers.

Section 10: questions 22 to 27

Materials Selection in Design - Microsoft Internet Explorer

Materials Selection in Design

Page 10 of 10

And finally a few more questions about you...

22. How many years have you been working as a designer?

- ○ 0 to 2
- ○ 3 to 9
- ○ 10 or more

23. What type of products have you been involved in designing for UK manufacturers?

Please tick all that apply

- ☐ Automotive
- ☐ Business To Business
- ☐ Capital Goods
- ☐ Consumer Goods
- ☐ Electronic
- ☐ Furniture
- ☐ IT / Telecoms
- ☐ Luxury Goods
- ☐ Marine
- ☐ Medical / Scientific
- ☐ Sport
- ☐ Toys
- ☐ Transport
- ☐ Interior Products
- ☐ Lighting
- ☐ Machinery & Equipment
- ☐ Fashion accessories
- ☐ None
- ☐ Other:

24. How did you receive your design training?

Please tick all that apply

- ☐ On-the-job training
- ☐ GNVQ
- ☐ HND
- ☐ BA degree
- ☐ BSc degree
- ☐ BEng degree
- ☐ MA
- ☐ MSc
- ☐ MPhil or PhD

25. How did you find out about this survey?

- ☐ Manufacturing Network email
- ☐ Business Design Initiative email
- ☐ www.rosiehornbuckle.com
- ☐ O2 Network email
- ☐ A colleague
- ☐ Other:

26. If you would be happy to assist with the later stages of this research please provide your email address here.

We will also need this in order to contact you if you win the prize draw.

27. If you have any further comments please use the space below:

And finally a few more questions about you...

22) Experience

The literature has indicated that there may be link between experience and a designer being more likely to use materials he's used before rather than looking for new ones (Taura 2002; Pahl, Badke-Schaub & Frankenberger 1999). Therefore this question can be used as a basic piece of categorisation data, and also linked to section 2 about sources used for finding materials, it may support or dispute this theory. If the theory is substantiated, younger, less experienced designers are more likely to use recycled materials than those who are more experienced.

These bands are defined by the Design Council (2005) as Junior, Middleweight and Senior designers[154]

23) Type of products

As it is unfeasible to target specific sectors with the survey, it is important to get a sense of what type of products the respondents are involved with designing for manufacturing companies. This links to 'type of materials specified' in section 5 and will hopefully give an indication of what products would be influenced by respondents' behaviour.

These bands are taken from the BDI directory[155].

24) Design training

Not only is this a way of categorising designers, but also will give an indication on whether they have come from a science, art or engineering background the implications of which were discussed earlier. Bachelor degree types were checked[156] to make sure that the most likely courses were included. Post graduate courses have also been included, not only to give an indication of levels of training but perhaps more importantly range and depth of training (ie research degrees) as students may have sought arts training to compliment an engineering background or visa versa. This could also be compared with the materials training question in section 3.

25) distribution route

There are potentially several ways that respondents may hear about and access the survey. In order to be able to identify distribution groups, respondents are asked to select the route they took. This will also help to identify biases.

26) Email address

As stated earlier it is hoped that respondents will leave their email address so that they can be invited to be involved in later stages of the research. The prize draw incentives this as respondents will only be able to be entered if they can be contacted later.

27) Further comments

To ensure we capture all possible information from respondents and as a failsafe in case the questions fail to give the desired options.

Finishing message

When the survey is submitted the respondents are directed to a finishing message which thanks them for their assistance.

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[154] http://www.keepbritishdesignalive.co.uk/pdf/DESIGN_A_NEW_DESIGN_INDUSTRY.pdf (accessed 17/10/06)
[155] http://www.britishdesign.co.uk/?page=newlook/ddsearch (accessed 17/10/06)
[156] http://www.bachelordegrees.net/bachelor/types-of-degrees.asp (accessed 17/10/06)

A(iv) Data Analysis Plan

Plan for cross-tabulation

To assist with data analysis a table outlining the plan for cross-tabulation was produced, with each row representing one variable. Features included in the table (included below):

- Relationships between variables are highlighted in the four 'relationship' columns, the numbering denotes the order that relationships will be explored
- This symbol " indicates that the response is part of a group of responses and should be analysed as part of that group.
- **'coding'** indicates that the responses will need coding.
- **'profile'** identifies questions that provide extra data for profile-building and do not require cross-tabulation.
- **'C-'** indicates a response which can be used to categorise groups used for difference-testing
- Response type:
  - 'M' multiple choice
  - 'A' all that apply
  - 'T' text
  - 'S' scale
  - 'Y' yes/no

Responses for question 20 are assigned to 6 groups which can also be compared in the analysis.

Data analysis tasks

The data analysis tasks are anticipated to occur as follows

1. **Coding** of text responses including 'other' fields
2. **Basic statistics** – for each question analysed
3. **Section statistics** – relationships analysed between questions within section groups
4. **Profile-building** – exploration of profiles to reveal patterns
5. **Categorisation** – analysis of all questions or section groups against the seven profile categorising responses (**C**)
6. **Other potential relationships** – analysis of other highlighted cross-tabulations not already covered in tasks 1 to 4

Section	Question	Grid ref	Database variable identity	Relationships to be explored				Response
				1st	2nd	3rd	4th	
1	1	D4	WORKING_ENVIRONMENT	C-SPLIT	ALL			M
	2	E5	NUMBER_OF_EMPLOYEES	C-SPLIT	ALL			M
	3	F6	COMPANY_LOCATION	C-LON/UK	D			M
2	4	G7	FINDING_OUT	H				A
	5	H8	INFO_FOR_USING	G				A
	6	I9	GIVE_NAMES_SOURCES_THAT_FIND_P	CODING	G/H			T
3	7	J10	DESIGN_TRAINING_HAS_INVOLVED_GUIDANCE_MATERIALS	K	L	BL		S
		K11	CONFIDENT_MOST_APPROPRIATE_MATERIALS	J	M	"		S
		L12	DESIGN_TRAINING_GUIDANCE_SUSTAINABLE_USE	M	J	"		S
		M13	CONFIDENT_MATERIALS_CHOICES_SUSTAINABLE	L	K	"		S
	8	N14	DEFINE_SUSTAINABLE	CODING	M			T
4	9	O15	VERY_LITTLE_TIME_INVESTIGATING_MATERIALS	O-P	K	BJ		S
		P16	TIME_INVESTIGATING_MATERIALS_ADEQUATE	"	"			S
		Q17	INVESTIGATE_MATERIALS_MOSTLY_IN_MY_OWN_TIME	"	"			S
		R18	SUFFICIENT_ACCESS_TO_INFORMATION_SOURCES	O/P/Q	G/H			S
5	10	S19	MATERIAL_TYPES	PROFILE				A
	11	T20	CONTRACTUAL_OBLIGATION	PROFILE				S

	12	U21	SPECIFIED_RECYCLED	C-SPLIT	M			Y
	13	V22	RECYCLED_SOURCE	PROFILE				A
	14	W23	RECYCLED_OPINION	CODING	U			T
6	15	X24	LEGISLATION		Y			Y
	16	Y25	LEGISLATION_ITEM	CODING	X			T
7	17	Z26	INVOLVED_IN_INITIAL_DEVELOPMENT_DESIGN_BRIEF	AA	D	E		S
		AA27	WANT_TO_CHALLENGE_DESIGN_BRIEF_GIVEN_TO_ME	Z	Q	BI		S
	18	AB28	WASN_T_INVOLVED_IN_INITIAL_DEVELOPMENT_BRIEF	AB-AF	Z/AA			Y
		AC29	ABLE_TO_GATHER_INFORMATION_TO_SUPPORT_CHALLENGE	"	"			Y
		AD30	MY_COLLEAGUES_WOULD_BACK_ME_UP	"	"			Y
		AE31	I_WENT_AHEAD_WITH_CHALLENGE	"	"			Y
		AF32	BRIEF_WAS_ALTERED_AS_RESULT_MY_CHALLENGE	"	"			Y
8	19	AG33	MARKETING	AG-AP	AB-AF	BI	Q	S
		AH34	BUYING	"	"	"	"	S
		AI35	SALES	"	"	"	"	S
		AJ36	TECHNICAL	"	"	"	"	S
		AK37	CONSUMER_NEEDS	"	"	"	"	S
		AL38	SUPPLY_CAPABILITY	"	"	"	"	S
		AM39	MANUFACTURING_CAPABILITY	"	"	"	"	S
		AN40	MANUFACTURING_COMPANY_POLICIES	"	"	"	"	S
		AO41	FEEDBACK_AND_ADVICE_FROM_REST_DESIGN_TEAM	"	"	"	"	S
		AP42	FEEDBACK_FROM_MANAGEMENT_BOARD_DIRECTORS	"	"	"	"	S
9	20	AQ43	BEING_INNOVATIVE	AQ-BG		GROUPS:	3	S
		AR44	CREATING_COMPETITIVE_EDGE	"			4	S
		AS45	ERGONOMIC_DESIGN	"			3	S
		AT46	REDUCING_ENVIRONMENTAL_IMPACT	"	N	W	2	S
		AU47	CREATING_FUN_AND_HUMOUR	"			1	S
		AV48	SATISFYING_BRIEF_GIVEN	"	AA		5	S
		AW49	HAVING_POSITIVE_SOCIAL_IMPACT_GLOBALLY	"			2	S
		AX50	HAVING_POSITIVE_SOCIAL_IMPACT_LOCALLY	"			2	S
		AY51	FUNCTIONAL_PERFORMANCE	"			3	S
		AZ52	SUSTAINABLE_DEVELOPMENT	"	N	W	2	S
		BA53	BUILDING BRAND IMAGE	"			4	S
		BB54	MEETING_END_USER_NEEDS	"			1	S
		BC55	CONSIDERATION_AESTHETICS_AND_FORM	"			3	S
		BD56	PERSONAL FINANCIAL SUCCESS	"			6	S
		BE57	SOCIALLY_INCLUSIVE_DESIGN	"			1	S
		BF58	GENERATING PROFITS	"			4	S
		BG59	CHALLENGING CONVENTION	"			6	S
		BH60	DESIGN_VALUES_P_OTHER	"	CODING			S
	21	BI61	VALUES_IN_WORK	AQ-BG	Z/AA	AB-AF		S
10	22	BJ62	EXPERIENCE	C-SPLIT	G/H	J-M	O-R	M
	23	BK63	SECTORS	PROFILE				A
	24	BL64	TRAINING	C-ART/SCI	ALL			A
	25	BM65	DISTRIBUTION	C- SPLIT	ALL			M
	26	BN66	EMAIL					T
	27	BO67	COMMENTS	CODING				T

A(v) Pictograph Key & Pictograms: Overview of the Results (averages and relationships)

In addition to statistical analysis, the survey data was translated into twenty-two A4 *respondent profiles*, each containing the responses for one case, represented in graphical format. The purpose of this method was to aid exploration of the data, as a quick reference during the follow-up interviews, to present the dominant profile characteristics and preserve a sense of the individual respondent. A key to the profile sheet used is included below followed by a key to the pictographs used to represent different variables. This is then followed by two overviews of the results using the pictogram method of visualisation: the first shows the averages across all variables contributing to a profile; the second shows the statistically significant relationships between variables

Respondent Profile Sheet Key

[Respondent number]	**1** [Design experience] [Design training]	**2** [regional location] [type of company]	[Sectors of operation]
Materials sourcing			
3 [Sources of information useful for first finding out about materials]			
3 [Sources of information useful for finding out about materials that are then specified]			
[specific examples of useful sources of information]			
Knowledge of materials	[5 scale response]	End of life	material production
Knowledge of sustainable materials	[5 scale response]	[areas of the lifecycle which were referred to in the definition of sustainable use of materials]	1
[definition of sustainable use of materials – coded] > > >		4	
Time spent investigating	[5 scale response]		
[types of material that the respondent specifies]			
Contractual obligation	[5 scale response]	3 Product use	2 product manufacture

Recycled Materials		**4** [specified before y/n]	[type specified]
General feeling	**5** [feeling taken from opinion of recycled materials]	Concerns	**6** [concerns taken from opinion of recycled materials – coded]
Legislation	**7** [knowledge of legislation affecting materials use]	[particular items of legislation identified]	
Design scenario			
Challenging the brief	**8** [involvement in the brief and challenging it – 5 scale]	**9** [involvement in the brief and challenging it - a particular example – true/untrue]	
Access to knowledge	**8** [access to different areas of knowledge – 5 scale]		
Design factors [how often these are reflected in work]	**8** [factors considered important in design – 5 scale]		

Pictograph key for Respondent Profile Sheet

General rule: highlighted in orange indicates a given response, therefore greyed-out areas are answers not given by respondents

1. Design experience

Junior 0-2 yrs

Middleweight 2-10yrs

Senior 10+ yrs

2. Company size

Micro 0-10 employees

Small 10-49 employees

Medium 50-249 employees

Large 250+ employees

3. Sources of materials information

Information in company library

www Supplier websites

Talking to colleagues

External experts

My own experience, used it before

I saw it used in another product

Talking to suppliers

Internet search engine

Materials database

Trade press

Books

4. Specified recycled mateirals

☑ Yes

☒ No

☐ Not sure

5. General feeling about recycled materials

Positive

Positive but with concerns

Negative

6. Concerns about recycled materials

Fit for purpose

Need more information

Unsure what's available

Image problem

Increased cost

Reliable supply

Consistent and equal quality

7. Knowledge of legislation affecting materials specification

Yes

Not confident

No

8. 5 scale colour gradient

1 = low

2

3

4

5 = high

9. Challenging the brief – a particular example

Highlighted in orange = true
Greyed-out = untrue

Pictogram Showing an Overview of the Survey Results (averages)

	On-the-job BA or Bsc	London Design consultancy or In-house teams	Consumer Goods Medical / scientific Machinery & Equipment Interior Products Lighting Electronics Furniture Capital goods IT/telecoms	Toys Business to business Transport Automotive Luxury goods Marine Sport Other

Material sourcing				
www			Access:	
www			3	
Knowledge of materials:	Trained 4	Confident 4	End of life	material production
Knowledge of sustainable materials:	Trained 3	Confident 3	↗	↘
Abundant or renewable, recyclable or re-usable				
Time spent:	Very little 2	Adequate 3	Own time 2	
Types of materials specified: Thermoplastics,Metals,Rubbers			↖	↙
Contractual obligation:	2		Product use	product manufacture
Recycled Materials		Specified before ☑ ☒		
General feeling:	☺ ☹	Concerns:		
Legislation	☺ 😐 ☹	Sector-specific standards, RoHS, banned materials		

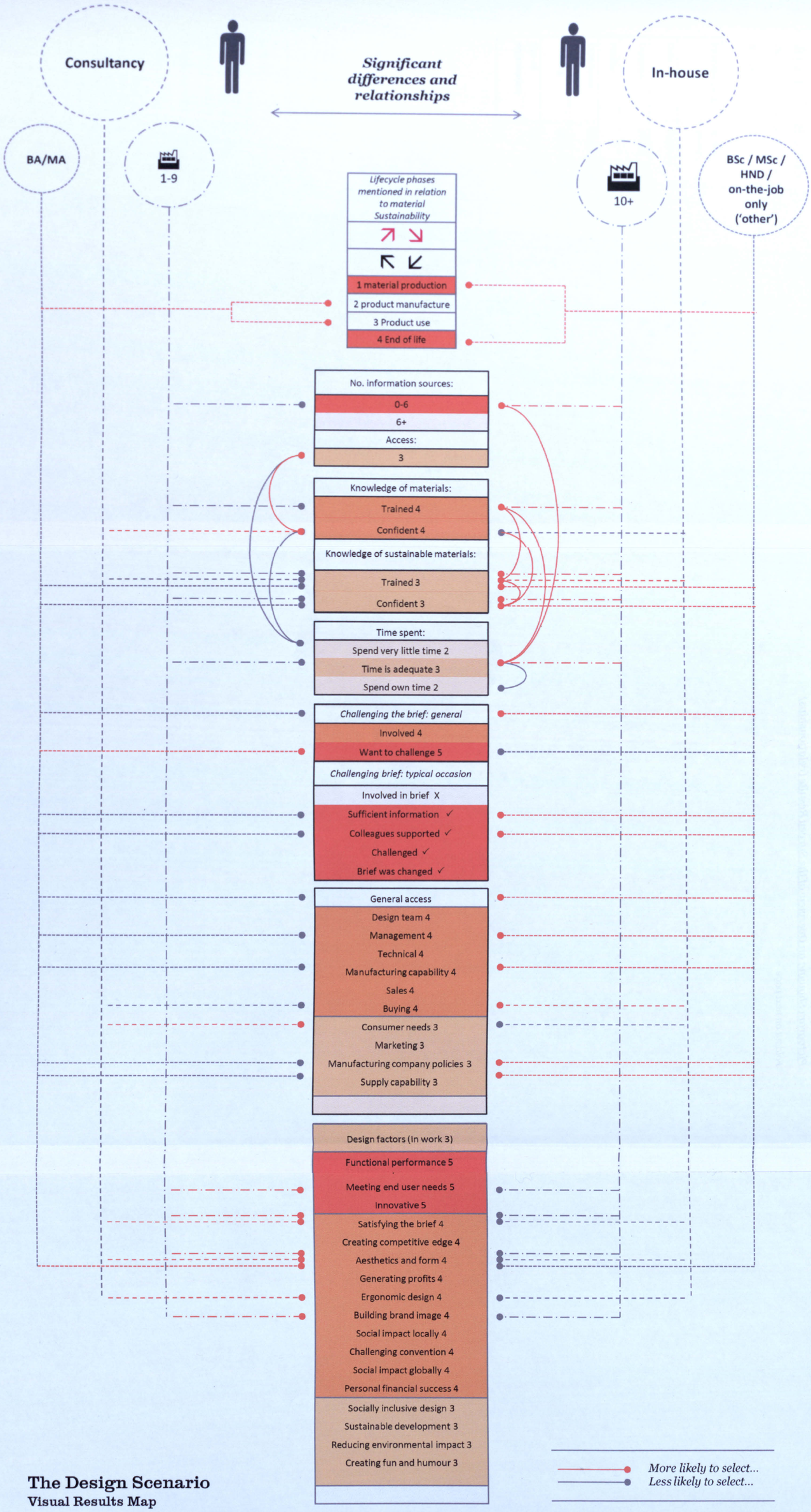
Design scenario	Challenging the brief – general:		Involved 4	Want to challenge 5	
- specific:	Involved X	Informed ✓	Supported ✓	Challenged ✓	Changed ✓

Access to knowledge	Design factors (In work 3)
	Functional performance 5 Meeting end user needs 5 Innovative 5
Design team 4 Management 4 Technical 4 Manufacturing capability 4 Sales 4 Buying 4	Satisfying the brief 4 Creating competitive edge 4 Aesthetics and form 4 Generating profits 4 Ergonomic design 4 Building brand image 4 Social impact locally 4 Challenging convention 4 Social impact globally 4 Personal financial success 4
Consumer needs 3 Marketing 3 Manufacturing company policies 3 Supply capability 3	Socially inclusive design 3 Sustainable development 3 Reducing environmental impact 3 Creating fun and humour 3

Overview 'respondent profile'; containing averages, rankings (rankings are shown in average order of preference); most common responses (highlighted in orange) for the whole survey sample

Pictogram Showing an Overview of the Survey Results (relationships)

Foldout on next page.



The Design Scenario

Visual Results Map

This is a visual map of the statistically significant relationships between the variables included in the survey, represented by lines linking one variable to another. The most popular and average responses are also included in the central column.

The majority of significance testing was to establish differences between designers working in different scenarios: consultancy/in-

The information is therefore split between the two most likely design scenarios combinations according to the survey, highlighted in the balloons at the top of the diagram.

The purpose is to create an overview of designers' experiences in different design scenarios.

A(vi) Survey Follow-up Interview Schedule

This is the schedule for the interviews conducted with designers as a 'follow-up' to the survey questionnaire.

Interviewee ID	JB (& TL) (example transcript)	BG	SF	PB
Date	04/09/08	24/09/08	26/09/08	29/09/08
Duration	37mins	35mins	1h 02mins	1h 34mins
Profile:				
Experience	Middleweight	Senior	Senior	Senior
Training	BSC and 'on-the-job'	HNC and 'on-the-job'	BA and MA and 'on-the-job'	BA and 'on-the-job'
Size of organisation	3 employees	25 employees	3 employees	3 employees

A(vii) Example Transcript (Survey Follow-up Interview)

This is an example transcript from the interviews that were conducted with designers as a 'follow-up' to the survey questionnaire. A draft summary of the survey findings was emailed to each of the four designers prior to the interview as a lead-in to the discussion. The designers were informed of the interview format:

- The interviewer (author) reminded them of their own response to each survey question and then explained how it compared to the overall findings (this equated to lengthier interviewer dialogue than normal, as can be seen in the following example);
- They responded;
- The discussion was allowed to develop freely, returning to the survey responses when appropriate;
- Interviews lasted between 30 and 50 minutes and were audio recorded.

Interview with Designer [JB & TL] 04/09/08

Transcription with commentary *NB. Interviewer is the author*

Themes (codes):

Training / background / experience	Storing / retrieving information
Attitude to secondary material	Relationship with the client
Use of resources	Location of manufacturing
Relationship with supplier	Understanding of sustainability
Design oriented material information	Time pressures

Shaded dialogue highlights instances where the interviewee is imagining scenarios, rather than reporting actual experiences.

Interviewer's notes on the office

[Design consultancy] operates from a small office with three designers. There is room for three desks and a couple of book shelves with product examples and samples perching in various places. On one book shelf four large plastic boxes are stacked which archive the team's project information, storage space is limited. A central table takes up the floor space to allow for team, client or visitor discussions. Any 'playing' with materials appears fairly limited with no machinery or workshop space.

INTERVIEWER: *So how much... did you just have a flick through the report?*

Interviewee(s): urm... not sure if we've read it. Oh yeah its quite interesting.

INTERVIEWER: *There are some things that seem obvious like some things, you could of said things about how designers work, but there are some interesting things...urm...and because there are only 22 people who responded to the survey you'd think they wouldn't come out as significant but they did and I worked with someone form the psychology department at Kingston (University) to do a proper analysis of the results..urm... and the results that I've noted down are the things that significantly came out according to the proper analysis.*

Interviewees(s): it is quite interesting to have it proved by your research you know the things that you kind of have an idea that people would be acting that way. People from an arts background were slightly less confident about specifying and research.

INTERVIEWER: *That was actually one of the most interesting things, between art and sciences...urm and the combination between an arts background and working in consultancy, and you kind of think that might be how it is. But, although you've got an MSc...*

[JB]: Urm.. a BSc.

INTERVIEWER: *Oh right. Good job, maybe I've got the wrong one then? Oh no that's right ok. But it did tend to be, people with arts backgrounds tended to work in consultancy..urm and science (background) in house [inaudible]. Yeah so some interesting things came out and I've brought along your particular answers.*

[TL]: Right. Ok I can't remember it at all.

The interviewer produces a summary of the interviewees responses for her own reference which the designers were not sent in advance and therefore is unfamiliar to them, however it is interesting to note that the layout is visual using pictograms and diagrams and that the designers' attention was drawn to this format.

INTERVIEWER: *No its fine I just thought [the graphical representation] might be a way of talking through the results in order to compare your results on how typical your results were compared to other people*

[TL]: Right.

INTERVIEWER: *were there any sort of other comments you had about the, about what could happen?*

Interviewee: urm...

INTERVIEWER: *the report in terms of, was there anything else that came out of it?*

[JB]: It would be interesting to find out..urm.. about the secondary materials and if there are any sort of.. I don't know what you have to say about that? That was the thing that stuck in my mind as being...made me kind of think 'yeah I don't really think about secondary materials' all I think about is premium virgin materials to use on anything.

INTERVIEWER: *Ok...so... I might just go through you know some of your answers because those are the things that you know about...urm...so in terms of the types of sources that you use to look for materials that was one of the key areas we were looking at ..urm... and you actually were quite unique in your response in that you actually selected a lot or sources, a wide range of sources to first start looking at materials. In fact you selected everything apart from books, where as typically most of the designers would just select five or less sources to begin with. And so it was quite..urm.. interesting but..there was quite a limited number of sources that people look at. Especially as there is quite a lot of work in London going into new material resources, like libraries and things like that, and that was one of the most interesting things designers don't tend to look there, so it actually gave us some interesting pointers of how to get materials information to designers.*

[JB]: Are there sort of free libraries and stuff?

INTERVIEWER: *There are but it requires..urm.. you to go there to the actual site that has the material.*

[JB]: Like Campus (database)?

INTERVIEWER: *There are databases like that and that was also interesting that designers also tend not to use databases, I mean you put down that you do. But,..urm.. most people, I mean quite a few people said that they didn't look at databases at all. In fact the most common way of finding out about materials was to just talk to suppliers or people in (the office).*

[JB]: I think that's something that we do. I'd say it was two of the strongest ones..urm..but also we keep our eyes open, have a look on the internet and just start searching.

INTERVIEWER: *And that's particularly interesting form the point of view of recycled materials [inaudible], it would be better if we could work with suppliers to get that information. Would that be a better way forward?*

[TL] Yeah it would be a better way 'cos we wouldn't come across recycled materials. You want the material to be compatible.

[JB]: Because you're doing yourself a favour, to my mind anyway, choosing something that is perfectly brand new, repeatable and you know exactly what's in it.

INTERVIEWER: *And its actually not just recycled materials I mean if you look at all sources..urm...there is a thing called and don't know if you've heard of this..Materials and Design Exchange (MaDE) that's been set up in London which is about trying to get designers and material suppliers together and one of the things that they've looked at is..urm.. is all sorts of new technologies, new materials, things that do different things.. yeah..and so it's all sorts of new materials that designers are not familiar with and how to make designers aware of those materials. So that's..um..that's one of the strongest things that came out of the survey that really suppliers, that relationship between designers and suppliers is really quite an important thing and something which could be used and exploited I guess.*

[JB]: I'd agree with that. I think that's excellent.

INTERVIEWER: *OK great.*

[TL]: We did go to the design festival last year and it was quite interesting to see the models of goalkeepers gloves, the iPod it just made you aware because you could actually (touch).

INTERVIEWER: *So that actually leads me to think that maybe if you knew more about where the materials libraries were, do you think you'd make use of those?*

[TL]: Yes I think so, definitely. You'd certainly go to find someone who actually manufactures a material that you're looking for..urm... where as if you've got somebody who said "well why don't you try this material", well this is pretty similar to ABS but can be recycled I think that would certainly be of benefit.

[JB]: I think it would be fantastic if there was one physical library that you could visit and it has samples of everything.

[TL]: Just giving you alternatives.

INTERVIEWER: *And how often would you think you would travel to look up a resource like that?*

[TL]: Well I think it would be web based principally

INTERVIEWER: *Right so you'd look at...*

[TL]: You wouldn't want to go anywhere.

[JB]: I wouldn't mind going and touching and feeling stuff because what we've been doing with (client) at the moment we've been doing a watch strap design.

There was some conflict here between the value of a place where samples could be touched, and habitual behaviour based on time pressures. The designers appear more in favour of physical resources because they had recently had the experience of doing a project where tactility was really important.

What comes across is that they need more from the resource, a dedicated expert, a consultant to do the work for them and suggest alternatives. They even suggested that they had been in search of a materials 'shop', both in London and in their local neighbourhood, but this was for inspiration, not for the specific supplier information they have in mind for the imaginary resource.

INTERVIEWER: *Ok.*

[JB]: That urm

INTERVIEWER: *Oh that one (signals prototype)*

[JB] Yeah, yeah, yeah and um because it's such a tactile object that you interact with physically you need to sort of gauge how sort of bendy, stretchy and tactile something is. That's done quicker by actually holding it.

INTERVIEWER: *Did you get a sample sent through for that?*

[TL]: We mainly contact a load of different suppliers and got a load of samples. We've still got them all. We're still researching materials at the moment on that one.

[JB]: Thames Valley Suppliers. All bits and bobs.

Thames Valley Supplies www.tvsl.co.uk is a Brentford supplier of rubber and foam matting – the designers did not use this source for finding materials to specify, but to understand what's possible (inspiration) and for prototypes.

[TL]: That's the sort of thing we get here.

INTERVIEWER: *Yeah. So when you, have you done that in the past, got a sample sent here and if so do you have somewhere where you keep those or somewhere where you store that information?*

[TL]: Project by Project you would leave it with the project.

[JB]: What we tend to have is these sort of big storage bins into which we put all our samples and things we remember and between us we remember 'oh yeah for (client) we used a particular rubber' and go to the box that's relevant to that project.

INTERVIEWER: *Ok yeah. Interesting.*

[JB]: ...revisit it... that's kind of how we do it. I don't know if it is the best...

[TL]: you know it's not a store of materials.

This relates to the survey finding that 'colleagues' are a useful source; the designers draw on each other's memories of the projects to retrieve that material information, which is very much linked to the project it was used for.

INTERVIEWER: *No, it's interesting how... um... you know if designers could build up their own sort of... rather than having to go out to a centralised material library, that they could build up their own sort of store or...*

[TL]: We sort of have samples () but then we took along another project box, but it would be good as you say to have a materials section or cupboard.

[JB]: Literally fill it with plastic samples.

INTERVIEWER: Do *you have objects in the office I notice you have a Protomold (sample cube).*

Interviewee(s): Yeah.

INTERVIEWER: *So you have, you do have objects in the office that kind of inspire you about processes and materials*

[TL]: and (material) finish

INTERVIEWER: *and finish and that kind of thing. Right ok and they are just sort of scattered around and about.*

[JB]: we have a scattered filing system [laughs].

[TL]: [laughing]

INTERVIEWER: *That makes absolute sense that's how I do all my filing [laughing]. Ok that's really interesting...um... it does sort of ring true with what we found. um...ok.. So you are fairly confident about your materials training and your knowledge about materials and fairly uniquely, um, you felt fairly confident about sustainable materials or how to use materials sustainably as well.*

[JB]: Ooh I'm not sure, I might contradict myself there.

INTERVIEWER: *[laughs] No, no this not like, this is not a test.*

[JB]: I think that as you progress in industry you sort of pick up and write things down in your book of good places where you can go for information and that kind of comes with time. You know ten years or so working in the consultancy you a sort of ever increasing list of awareness of things. I think that's probably common, so

INTERVIEWER: *um yeah.*

[JB]: I'm not sure sustainable materials are particularly, sort of, I know much about.

INTERVIEWER: *Right ok is it something that you've received any training on when you were doing your design training or anything like that?*

Interviewees (1, 2): no, no, no.

[JB]: I can't remember it being part of anything I did at uni

INTERVIEWER: *No. And you haven't been on any like um workshops or events or anything like that in that area.*

[JB]: no

INTERVIEWER: *No, ok. It's not unusual as those were the results that we got really.*

[TL]: You can have a look at that, that's a workshop (where you) bring a material.

[JB]: Brighton?

[TL]: No not Brighton this is at the RCA.

[JB]: There's one in Brighton.

[TL]: That's on the 8th of this month. You've got to take a material along.

[JB]: Right yeah.

[TL]: What (materials) you've got experience with.

INTERVIEWER: *ah right.*

[TL]: I think everybody else speaks about why that material is important to you.

INTERVIEWER: *right ok. Is that RCA did you say?*

[TL]: Yes I think yes it's the Royal College of Art.

INTERVIEWER: *Oh 'Materials Experience', I'm going to that. Yeah on the nineteenth.*

Material Experience was an event hosted by the RCA and MaDE (19/08/08) with material experiments aimed at professional designers.

[TL]: That's it.

INTERVIEWER: Yeah, yeah.

[TL]: On the Friday.

INTERVIEWER: *Yeah, yeah. That's interesting that you're going to that.um well see you there. [Laughs]. Um ok.*

[TL]: We're interacting.

INTERVIEWER: *Yeah, yeah. There's definitely um an engagement there. Um so most people generally said that they felt like they spent their time, they didn't spend any extra time out of hours looking at materials and that kind of thing. So it seems like materials is not something that is at the forefront of*

your design brief you know you might spend some extra time doing or finishing off a design brief but you're not going to spend your extra time looking for materials.

[TL]: I do when I go round shops I'm always looking at different products.

INTERVIEWER: *So it's part of your everyday inspiration. Um.... so you haven't specified recycled materials before. That was sort of a split in the survey, sort of half of the people had, and half of people hadn't.*

[TL]: Yeah.

INTERVIEWER: *Um and uh your main concern was quality I think...*

[JB]: It's just that you're not sure if it's going to be of repeatable quality and the last thing you want as a designer is to be specifying something that falls apart.

INTERVIEWER: *Of course, yeah.*

[JB]: You know one batch is quite stiff and another batch is quite bendy.

INTERVIEWER: *have you had. What are those ideas based on? Have you had any encounters with recycled materials or what have those encounters been?*

[JB]: I think it's just my inherent prejudice.

INTERVIEWER: *[laughs] It is sort of obvious when you think about and sometimes the products that you come across which say they're recycled... is that kind of as well what your encounters have been?*

[TL]: The one that we're specifying at the moment, for the watch strap. We're still in the middle it's still up in the air. But that was interesting when I spoke to the supplier and he said 'that [material] in grey we regrind and reuse the whole thing again' which was I thought, all the waste material could be reground and reused.

[JB]: I think if you've got a choice of two materials and one you can re-grind and re-use you would kind of go 'ok if there is no risk for me to specify and there is an obvious benefit'.

INTERVIEWER: *Is that a question that you might ask in the future now you know about that, you know to ask suppliers if there is something easily recyclable?*

[TL] Or green I think I'd be looking for green materials.

[JB to TL] Do you think you'd be asking though?

[TL] I think if you get the quality right and then say 'have you got an alternative the same quality?'...

[JB]: I'd probably wait for the supplier to say um you have a choice of um things, materials which you could use this one is the same but has the added benefit.

[TL]: But if the price point was different when compared it would be up to the customer you'd tend to go with the customer. We've got these two materials this one's gonna cost ya 10p more.

One supplier had raised the point that their material was easily recyclable – this information was offered, the designer hadn't requested it and it made him think about it. But he admitted that it wouldn't be the type of question he would normally ask suppliers. The next question would be about cost and that would be up to the client to decide.

'Benefits' to the client or the design, or the designer, are clearly one way that this designer would be persuaded to consider one material over another

INTERVIEWER: *do you think clients would see it as marketing benefit to have...*

[JB]: It depends on the industry um I think I'm not sure you can put a blanket answer on that.

[TL]: The other thing is we supply or specify a material and it goes to China and they use the Chinese we have no control on that. They say there using that material and I think that's an interesting , because you

know were talking to china at the moment about the watch strap and there saying we can't do this (....). Then they say they can mould that and they can get that detail so its, ya know, its complex yeah.

INTERVIEWER: *And, and what sort proportion of your products that you design are manufactured in the UK? Is that sort of very low or not very many?*

[TL]: Recently, very few.

[JB]: Its metal work (....) we've got bits with [company]. Things first get fabricated in the UK.

[TL]: Yes, yeah we have mouldings (.....) China.

[JB]: yeah, yeah (....)

[TL]: I can't think of anything that's theirs (company)(.....)

INTERVIEWER: *Ok, interesting ummm.*

[TL]: You have a lot of industry going to china. Well it makes sense. But all the skills are over here though. There comes a problem when it becomes service. (.....)

INTERVIEWER: *ahhh*

[TL]: it's also going to India as well. India is, you've got costs from an ice bucket and that it's suddenly cheaper in India and so it goes over there.

INTERVIEWER: *It's always down to cost. Um ok um so when you're asked about legislation you said you weren't sure about legislation. Yeah, that, yeah there a few people who could sort of mention sector specific... um.. You know products that were to do with transport and things like that which were specific. But, in terms of in environmental legislation to do with product design, no one was too sure about that.*

[JB]: I really wouldn't that I could say anything about it.

INTERVIEWER: *would you say that.....*

[TL]: you just believe that the materials manufacturers wouldn't be supplying it if it wasn't, If it didn't meet the governments spec.

[JB]: You're putting a certain amount of trust in what you're being supplied with.

INTERVIEWER: *And not just from the supplier, as well from the client. If it is a legislative things about a product to do with that, how a product is designed, you are trusting that the client is going to put that into the brief if it's required. Is that kind of the way it goes or?*

[JB]: Perhaps, I mean, briefs can vary so much between a client that really knows a lot about what they're doing and clients that have a vague idea of what they want to achieve. So, so it's quite wide open now.

With legislation it was clear that both rely on the supplier and the client to make sure that their activities conform to legislation; it wasn't a driver they could use to make a case for decisions.

INTERVIEWER: *Yeah. Ok, um again you were pretty typical in terms of um your, the design factors that you thought were important to you in product design, um environmental factors always come right at the bottom...*

[JB]: Right at the bottom of the list was 'humour'.

INTERVIEWER: *Yeah [laughs] 'Humour' wasn't scored very highly but in the results I have put that that was probably down to um sort of ambivalence you know 'what's that all about? I don't know what that's about?'*

[JB]: I just thought it was about funny things [laughs].

INTERVIEWER: *Yeah it wasn't very well phrased and that's entirely my fault. Um [laughs] but um but yeah generally speaking the typical product design factors that you would expect to be up there at the top were to do with 'innovation', 'user needs' um and all those kind of things.*

[TL]: performance costs

INTERVIEWER: *Yeah all those kind of things, although 'costs', they tended to be grouped together the things that you would expect to be grouped together. Then people who were sort of more interested in um the businessy things like 'competitive edge' and 'cost' tended to be grouped together and people who were more interested in the traditional product design things, like 'innovation' and the things that drive you as a designer were grouped together. As well as 'aesthetics', 'user needs' came out very high which is great because sometimes in the past that has been neglected. But environmental always at the bottom and um and 'sustainable development' and 'social impact' they kind of came up sort of a bit higher than 'environment' but not, not greatly.*

[TL]: I understand.

INTERVIEWER: *Um but interestingly 'sustainable development' which is sort of, I mean what does that mean to you?*

[JB]: Sustainable development?

INTERVIEWER: It seemed to imply more holistic idea of how you could design better for everything [laughs] and it came up higher as a result I think because people kind of, I got the impression from the results that people were sort of disillusioned with the idea that we have to design things to be friendly to the environment as a opposed to, sustainable development implies something more holistic I think...

[JB]: O..k...

INTERVIEWER: *What do you think about that?*

[JB]: So it's kind of like the designer is getting a benefit back, it's not just for the benefit of the environment uhh...

INTERVIEWER: *The benefit of society I guess as well and what did you, when you saw the term 'sustainable development' what was your initial reaction to that?*

[JB]: I think they're big words that can be interpreted in a lot of different ways uhh sustainable is about closing the loop and going back again and when something becomes sustainable it can be repeated, it's not a infinite resource or process so um what does that mean?

INTERVIEWER: *But I guess what you are saying actually, sort of um does imply that sustainable design means more in a way than just environmental design, which doesn't really I think people feel kind of a bit cold when you talk about the environment [laughs]*

[JB]: The environment is one factor and quite often people see it as just uhh quite a costly thing they don't actually get the benefit out of it.

INTERVIEWER: *Ok.*

[JB]: Ok to save the world but the business that's manufacturing doesn't get any benefit out of it. If something's sustainable then perhaps there is a benefit to the business as well.

INTERVIEWER: *Ok Yeah Ok. That makes sense. Umm so in line with the kind of um with the results generally the trend was when it came to 'access to knowledge' people in consultancies seemed to feel less close to all the sorts of areas that were to do with the client, so 'marketing' information, 'manufacturing' information and that kind of thing. You scored it quite highly actually, um 'marketing', 'manufacturing', 'design team', 'management' are sort of obvious ones. 'Manufacturing' I guess because that's something you know about because, you know, you're a designer. Things like 'buying', 'sales', and 'consumer needs' and 'supply' you've sort of marked them further down and in consultancy that kind of rang true.*

[JB]: Typical.

INTERVIEWER: *Yeah, I mean I interpreted it as um that you were more distant from the client therefore the access to that kind of thing to those knowledge areas is a bit a bit less than say you were in an in-house design team.*

[TL]: In-house?

[JB]: I think if you're in-house you know completely the ins and outs of the production industry that you are, that you're in. As a consultant you have a very fast learning curve on every single project that you're doing umm there's obviously certain technicalities uhh that you learn about with if your an in-house person that specific to company that your working with so.

INTERVIEWER: *OK so basically the way that I'm sort of thinking of taking this is in two sort of directions. Firstly I'm thinking of developing a guide for designers as sort of a knowledge base about recycled materials basically, because recycled materials um when you start thinking about recycled materials it kind of, it actually is a starting point for a whole lot of information you can find out about how materials can be used more sustainably, because as you say it's about closing the loop and it's also about going back down the design chain, if you like, to say ok this is how the product material at the end this is what's going to happen to it... if we can't use that material then maybe there are other ways to design the product differently, or with different materials to make it more sustainable. So, sort of a starting point for other things. So that's sort of one area that I was going to look at. Do you think that would be a useful thing to have something that is more, thinking about knowledge?*

[JB]: How would that be available? Would that be on the internet?

The designers confirm that mode of delivery for any advice is very important

INTERVIEWER: *Well that's another area that I've looked at as part of my research... what is it? The sort of things that we spoke about, sources. What are the best sources for designers and how is it best to portray that information to designers, because umm a sheet of writing - although I gave you a report to read at the beginning - a sheet of writing is not the most engaging thing in the world so um so if I was to develop that area that would be something I would be interested to talk to you about how the information would be best put forward to you I guess, in a way that you would find useful and where you might go to get that information that would be all part of that sort of area.*

[JB]: I could imagine visiting quite a sort of friendly on the eye website uhh something that I could just browse through and then my decision making process sort of mapped as I go through. Looking at plastics or rubbers then it could sort of guide me and then at the end of it there could be a selection of suppliers uhh who I could talk to for you know about further information about what particular (.....)

INTERVIEWER: *Ok.*

[JB]: So maybe the suppliers could put money into the website to fund it.

[TL]: or a newsletter for designers.

INTERVIEWER: *would that be something that you would read?*

[TL]: if it's the new material I tend to read about mobile phones, the different, you know the different materials and that, the different materials they develop for the mobile phones industry.

INTERVIEWER: *Right, do you get the MaDE magazine...?*

[TL]: We do yeah I don't read it though.

INTERVIEWER: [laughs] ok.

[TL]: It's more of a design magazine that we've got... disappeared actually

[JB]: I must say I do actually read the MaDE magazine.

INTERVIEWER: *Do you read that type of thing, would it be better if it came through electronically?*

[JB]: I'm quite happy to have it as a magazine. Because it looks quite nice.

[TL]: Yeah I've got loads there's one over there.

INTERVIEWER: *yeah there posted aren't they.*

[TL]: it just takes too much time you haven't got the time to you know that's not important to read those.

Time pressures are clearly an important consideration when developing tools for design

INTERVIEWER: *Umm yeah.*

[TL]: but if I'm looking for something we'll probably I use those magazines. I used to have a library of catalogues you know if there's component I'm looking for. But with the internet now it's all there.

INTERVIEWER: *So do have like a library of your favourite sites where you go to regularly um to access.*

[TL]: Yeah I've got mine yeah yeah.

Where a library of supplier literature was once the primary method of material-sourcing, the internet would appear to have made that method redundant.

INTERVIEWER: *Ok. Um and the other idea, which is sort of linked, but its more to do with general materials information, was perhaps to develop something uniform or standard which has all the information that designers are going to want about a material, because their tends to be different approaches. There tends to be the engineering approach which has a lot of numbers on it or another approach, which is less common which is to do with pictures and what the materials feels like and what it could be used for and that kind of thing. So it would be about developing something which takes all those factors into consideration, and how that would be delivered to you as a designer, and what you then did with that information here in your office....*

[JB]: That sounds like the sort of thing which would be quite... I don't really like all the figures and that because they come quite faceless but I tend to prefer the things that say 'this material typically used in applications such as...' 'oh yeah I know what that is and yeah I know how stiff that is because you it's used in disposable cutlery or you know something like that.

INTERVIEWER: *Yeah, ok.*

[JB]: I would imagine it better.

Format and language of material information is also clearly very important

INTERVIEWER: *yeah and that's also, I'm thinking, a way of introducing some aspects of how that material might be used sustainably or not. So, umm putting all that information in one place rather than you having to go to some other you know....*

[TL]: Going up to London there was supposed to be a store near Soho you can go in they've got all these fabrics and materials but we haven't found it yet. An Aladdin's cave of materials.

INTERVIEWER: *right and what's that called?*

[TL]: we tried to track it down...

INTERVIEWER: *Oh right [Laughs].*

[TL]: The guys told me about it, we're looking for the watch strap, that's right we were looking at...it was early days and we were looking at woven materials and just wanted to go and, you know, and touch and feel materials. So that would be the right sort of...

INTERVIEWER: *ok.*

[JB]: A good place to visit.

INTERVIEWER: *It's kind of like having the information first but then also being able to follow that up with a visit kind of thing because you're not always I guess gonna have time to do that. Ummm ok that's interesting...*

[TL]: well I think that if you've got a project and you wanted to get out and get some materials, like ourselves we went to New Malden to have a look round for materials as well. You know it's getting out there...waiting for samples to come in can take a week and you wanna go somewhere that's quite quick.

[JB]: you want to be more time efficient. If I go 'right this afternoon I'm gonna go off to this central library' and I'm try out all the samples in one place rather than waiting for the materials to come in and take two days and then get back to them and say oh actually you need something a bit stiffer than those three and that's another two days.

INTERVIEWER: *So if there was this sort of central place, you'd want to take samples away with you as well?*

[TL]: Yes definitely

INTERVIEWER: *[laughs] that's one of the key problems with the whole 'materials library' idea, apart from the fact that's its incredibly resource-intensive to run it, they need multiple examples.....*

[TL]: I'd say the best thing is if you feel the sample you want and you've got the manufacturer then we go away and contact the manufacturer.

INTERVIEWER: *Right ok.*

[TL]: But we'd have a good idea of which way to go because in the early days I was phoning companies in Switzerland and Germany trying to get fabrics (.....) and they suddenly got some replies from the guys in Switzerland and quantity is not big enough and you've put the phone down on it. So it's that that would be really (.....) and so directing me to (.....).

INTERVIEWER: *Ok. Um there is, do you know about, as part of MaDE they do have a resource centre...*

[TL]: I did contact (a) guy and I did contact MaDE as well. We did a lot of research first so you know.

INTERVIEWER: *I wonder if, I've been doing this research for like at least a year so I've got a quite a few sort of online and physical type material resources that are available, I wonder if umm as a way of taking this forward, there might some way of getting feedback on how useful something is umm like a site, or if either of you get round to going to the Institute of Materials (MaDE) you might be able to give me some feedback?*

[JB]: I see you've got a list of places for us to visit...

INTERVIEWER: Uh yeah.

[JB]: So we'll look at and you want us to offer you feedback of what we think about them?

INTERVIEWER: *Well I basically come to these meetings with designers open minded as to how I might move it forward, based on the feedback you have given me about the survey umm I haven't define yet how you know I was hoping you would say you'd be interested to take this sort of forward and work with you a little on how to progress this work. I'll go away and have a think about what that might be and... umm... it has just occurred to me now that that might be a way of getting more idea of what is useful to you, giving you all the links and saying, can you, when you've got time go through these, have a look see what's useful, give a bit of feedback, I guess I could put something together which is just sort of tick boxes or whatever.*

[JB]: I think that would be something which could even be quite beneficial for us. To have you know just a comprehensive list of things to track down, you know twenty or thirty good sites. That would be quite interesting for us to have a look at. Not in any sort of urgent do that more sort of.....

[TL]: Yeah I'd agree with that...

INTERVIEWER: *Maybe at some point, a bit further on as well with the things I sort of develop, maybe your feedback on that would be useful as well to see what you would think of it and if you think it would be useful.*

[JB]: You could become a materials consultant?

INTERVIEWER: Well that's my ultimate goal [laughs].

[TL]: You could set up your own....

INTERVIEWER: I'll just sit here [laughs] you won't have to go anywhere I'll just be here

[TL]: We'll just contact you....

INTERVIEWER: *yeah, well that would be fantastic....*

[TL]: Save all that legwork....

INTERVIEWER: *Yeah well I'm amazed actually given that this actually quite a big area at the moment, that there aren't more materials consultants uhh but I guess it depends on how much designers are willing to pay for that service, that's the thing whether or not is viable so umm I have like a group of umm other people who are sort of interested in the same area and we're kind of looking into whether or not there is a market for something like that umm.....*

[TL]: I'd definitely say so. I'd pay you to go away and spend some half a day or a day then come back and say right here's a selection I've done all the leg work that I've just done spending my time.

INTERVIEWER: *Yeah ok that's interesting I'll bare that in mind. [Laughs] Great ok is there anything else because that's I think I've got quite a lot information from you now and I can go away and have a think about it, and if your happy to sort of stay in the loop as you like, I'll put something together for us to take it forward and basically because of the timescale I'm hoping to have developed something which is good enough for my thesis if not you know it might need further (..) after that by sort of January so that's the sort of timescale I'm thinking of umm so I mean it's not too rushed but umm take it from there really.*

Interviewees: I think that's good...

INTERVIEWER: Right ok, brilliant I'll turn this off then.

[End]

A(viii) Statements of Statistical Significance

Analysis of the survey questionnaire data was conducted using SPSS (Statistical Package for the Social Sciences) software and included three types of statistical test:

- *Difference testing* — *To test differences between groups against specific variables*
- *Tests of association* — *To test the degree of association between two variables*
- *Correlation* — *To test the strength and direction of the relationship between two variables*

In typical statistical analysis, for an effect to be statistically significant the probability of a chance occurrence must be low, conventionally less than p=0.05. However, as the sample set in this investigation is small, any difference, association or correlation had to be very strong for it to produce a significant outcome as Robson (2002) explained: "The chance of obtaining a statistically significant result increases as the sample size increases, [...] if one is relying on statistical significance, there is much to be said for keeping the sample small so that only robust effects are going to be picked up." (Robson 2002:401). Therefore a probability of [0.05<p< 0.099] is interpreted as being *marginally* significant. Where correlations are referred to, it is generally accepted that a strong correlation will correspond to a value of 0.4 or higher, a moderate correlation being 0.3 to 0.4, and anything lower is considered weak (Robson 2002:423). Therefore only correlations above 0.3 have been considered in this analysis. Three open questions were also included in the survey questionnaire. These were manually coded to extract common themes.

'Other backgrounds' refers to designers who did not have an arts-based degree such as a BA or MA.

The findings from these analyses are discussed in the main text (Chapter Four), but the results themselves are presented here as statistical statements (referenced in the main text) to show the context of the findings.

1. Design consultancies typically have 9 or fewer employees, whereas companies with in-house design teams usually have 10 or more (p=0.022)

2. Designers with an arts background scored 'aesthetics and form' higher as an important design factor than designers with 'other backgrounds' (t=2.089 df=19 p=0.050)

3. Designers working in companies with 1-9 employees valued 'satisfying the brief given' (t=3.149 df=20 p=0.005), 'building brand image' (t=1.796 df=20 p=0.088), 'meeting end user needs' (t=2.182 df=20 p=0.041) and 'consideration of aesthetics and form' (t=1.905 df=20 p=0.071) more highly than designers working in companies with 10 or more than employees.

4. Designers working in consultancies valued 'ergonomic design' (t=2.653 df=20 p=0.015) 'satisfying the brief given' (t=2.072 df=20 p=0.051) and 'consideration of aesthetics and form' (t=2.001 df=20 p=0.059) more highly as than designers working in-house.

5. Designers who considered 'personal financial success' an important design factor were also more likely to value 'functional performance' (r=0.44 p=0.013), 'profits' (r=0.55 p=0.003) and 'competitive edge' (r=0.447 p=0.010)

6. Designers who considered 'aesthetics and form' an important design factor were also more likely to value 'end user needs' (r= 0.43 p=0.016), 'positive social impacts globally' (r= 0.40 p=0.018) and 'locally' (r= 0.53 p=0.003), 'ergonomics' (r= 0.43 p=0.013), 'functional performance' (r= 0.42 p=0.020), 'competitive edge' (r= 0.49 p=0.007), and 'satisfying the brief' (r= 0.66 p=0.000)

7 Designers who considered 'reducing environmental impacts' an important design factor were also more likely to value 'socially inclusive design' (r= 0.47 p=0.005), and 'positive local social impacts' (r= 0.47 p=0.006)

8 Designers who considered 'socially inclusive design' an important design factor were more likely to value 'reducing environmental impacts' (r= 0.47 p=0.005), 'sustainable development' (r= 0.51 p=0.002), 'positive local social impacts' (r= 0.50 p=0.003) and 'functional performance' (r= 0.48 p=0.007)

9 Designers who considered 'sustainable development' an important design factor were also more likely to value 'end user needs' (r= 0.54 p=0.003), 'socially inclusive design' (r= 0.51 p=0.002), 'positive social impacts globally' (r= 0.46 p=0.006) and 'locally' (r= 0.51 p=0.003), 'ergonomics' (r= 0.45 p=0.008), 'functional performance' (r= 0.47 p=0.008), 'brand image' (r= 0.57 p=0.001), 'competitive edge' (r= 0.55 p=0.002) and 'satisfying the brief' (r= 0.46 p=0.009)

10 Designers who considered 'building brand image' an important design factor were also more likely to value 'end user needs' (r= 0.67 p=0.000), 'sustainable development' (r= 0.57 p=0.001), 'positive social impacts globally' (r= 0.60 p=0.001) and 'locally' (r= 0.48 p=0.005), 'ergonomics' (r= 0.50 p=0.004), 'innovation' (r= 0.42 p=0.0016), 'competitive edge' (r= 0.64 p=0.000), 'satisfying the brief' (r= 0.59 p=0.001) and 'personal financial success' (r= 0.43 p=0.011)

11 Designers who scored 'having a positive social impact globally' (r=-0.36 p=0.030), 'having a positive social impact locally' (r=-0.45 p=0.010), 'sustainable development' (r=-0.30 p=0.057) and 'generating profits' (r=-0.38 p=0.023) highly, were less likely to feel that these values were reflected in their work.

12 During their training designers received less guidance on the sustainability of their materials choices than guidance on choosing the most appropriate materials (t=2.737 df=21 p=0.012).

13 Designers were not as confident about the sustainability of their materials choices as they were about choosing the most appropriate materials (t=2.453 df=21 p=0.023).

14 Designers whose training involved more guidance on the sustainability of their materials choices were more confident that they knew in what ways their materials choices were sustainable (r=0.35 p=0.030).

15 Designers whose training involved more guidance on how to select appropriate materials were also more likely to have received guidance on the sustainable use of materials (r=0.30 p=0.048)

16 Designers who were confident about choosing the most appropriate materials for their work were also more likely to be confident that their materials choices were sustainable (r=0.30 p=0.059).

17 For designers in companies with more than 10 employees, design training has involved more guidance on how to select materials (t= -2.067 df= 20 p= 0.052) and how to select sustainable materials (t=-3.773 df=20 p=0.001) and were more confident about knowing in what ways their materials choices are sustainable (t=-2.860 df=20 p=0.010) than designers in companies with up to 9 employees.

18 For in-house designers, their training involved more guidance on the sustainability of their materials choices than the training of designers working in consultancies (t=-1.902 df=20 p=0.072).

19 Designers with 'other backgrounds' received more training on the sustainable use of materials (t=-2.813 df=19 p=0.011) and were more confident that they knew in what ways their materials choices were sustainable (t=-1.773 df=19 p=0.092), than designers with an arts background.

20 Middle-weight designers were more confident about the sustainability of their materials choices than senior designers (t=1.873 df=19 p=0.076).

21 Design consultancies design products for more sectors than in-house design teams (t=4.83 p=<0.001)

22 Designers with an arts background wanted to challenge the brief more often than those with 'other backgrounds' (t=1.735 df=19 p=0.099).

23 Designers with an arts background were more likely to select 'untrue' when asked if they were able to find sufficient information to challenge a brief (p=0.041) and if they felt that their colleagues would back them up in the challenge (p=0.082), while designers with 'other backgrounds' were more likely to select 'true'.

24 Designers with 'other backgrounds' were generally more positive about their experiences when challenging a brief, while designers with an arts background tended to be more negative. (t=2.433 df=15 p=0.028)

25 Designers who had access to 'sales' knowledge were more likely to have access to 'marketing' knowledge (r=0.55 p=0.044)

26 Designers who had access to 'supply capability' knowledge were more likely to have access to 'buying sourcing and purchasing' knowledge (r=0.51 p=0.003)

27 Designers who had access to 'manufacturing company policies' were more likely to have access to 'manufacturing capability' knowledge (r=0.76 p=<0.001)

28 Designers who had access to 'manufacturing capability' knowledge were more likely to have access to 'supply capability' knowledge (r=0.40 p=0.018)

29 Designers who had access to 'feedback from management or board of directors' were more likely to have access to 'buying, sourcing and purchasing' (r=0.46 p=0.009), 'sales' (r=0.41 p=0.017), 'supply capability' (r=0.41 p=0.019), 'manufacturing capability' (r=0.50 p=0.006), 'manufacturing policies' (r=0.45 p=0.009) and 'feedback from the design team' (r=0.63 p=0.001).

30 Designers working in consultancies have better access to 'consumer needs' knowledge (t=1.930 df=20 p= 0.068) than those working in-house.

31 Designers who had access to 'feedback from the design team' were more likely to have access to 'technical' (r=0.53 p=0.004) and 'consumer needs' knowledge (r=0.59 p=0.001)

32 In-house designers have better access to 'buying, sourcing or purchasing' knowledge (t= -1.778 df= 20 p= 0.091) and 'supply capability' knowledge (t= -1.947 df=20 p=0.068) than designers working in consultancies.

33 Designers with 'other backgrounds' scored their access to 'supply capability' (t=-2.695 df=19 p=0.014) and 'manufacturing capability' (t=-2.455 df=19 p=0.024) knowledge, 'manufacturing company policies' (t=-4.311 df=19 p=0.000) and 'feedback and advice from management and board of directors' (t=-2.118 df=19 p=0.048) higher than those with an arts background.

34 Designers with 'other backgrounds' had a higher mean score for access to the knowledge areas included in the survey than those with an arts background. (t=-2.789 df=19 p=0.012)

35 Designers who said that the time they spent investigating materials was adequate, were less likely to say that they investigated materials in their own time (r=-0.31 p=0.049).

36 Designers who didn't agree that they spend very little time investigating materials were more likely to feel that they have sufficient access to information sources (r=-0.31 p=0.049).

37 Designers whose training had involved guidance on how to select materials, were more likely to feel that the time they spent investigating materials was adequate (r=0.37 p=0.024).

38 Designers who were confident that they knew the most appropriate materials for their work, were less likely to agree that they spent very little time investigating materials (r=-0.32 p=0.047) and more likely to say that they had sufficient access to materials information sources (r=0.40 p=0.017).

39 Designers in companies with more than 10 employees felt more strongly that the time they spend investigating materials is adequate than designers working in smaller companies. (t=-2.443 df=20 p=0.024)

40 The materials selection decisions of designers with an arts background were more subject to contractual obligation than designers with 'other backgrounds' (t=3.001 df=19 p=0.007)

41 Senior designers are more aware of legislation that may affect their materials choices than middle-weight designers (p=0.080)

42 'Product literature in the company library' (p= 0.063), 'colleagues' (p=0.063), 'saw it used in another product' (p=0.021) and 'internet search engine' (p=0.021) are more useful in the phase when designers are finding out about materials than for the phase when they are looking for materials to use in their work.

43 'Talking to suppliers' (p=0.070) is found more useful in the second phase of looking for materials to use in designers' work than for the first phase when they are finding out about materials.

44 Designers find more sources useful for the phase when they are finding out about materials than for the phase when they are looking for materials to use in their work. (t= 2.491 df= 21 p=0.021)

45 Designers working in companies with 10 or more employees were more likely to find fewer than 6 sources useful for finding materials than designers working in smaller companies (p=0.095).

46 Designers who found fewer than 6 sources useful for finding materials also scored the adequacy of the time they spent investigating materials higher than the group who found 6 or more sources useful (t=2.563 df=20 p=0.019).

A(ix) Variable Regroupings

There were four questions included in the survey questionnaire which were intended to provide grouping variables, to determine differences between defined groups; two were aimed at grouping respondents by their *design experience* and two by their *working environment*. Due to the small sample, the best results are achieved by re-grouping the variables so that there are two near-equal subgroups in each. These re-groupings are included below.

Variable	*Original groups*	*New groups*
Company type	In-house Other (2)	In-house
	Consultancy Other (1)	Consultancy
	Freelance	No response
Company size	1-9 employees	1-9 employees
	10-49 employees 50-249 employees 250+ employees	10+ employees
Design background (Isolating those with arts-based training):	BA MA	Arts (at least one arts)
	BSc MSc HND On the job training (ONLY)	Other (Non-arts)
	PhD/MPhil	No response
Design Experience:	Junior (1-2 years) Middleweight (3-10 years)	Junior/middleweight (0-10 years)
	Senior (10+ years)	Senior (10+ years)