An exploration of the roles values play in design decision-making

This item was submitted to Loughborough University’s Institutional Repository by the/an author.

Additional Information:

- A Doctoral Thesis. Submitted in partial fulfillment of the requirements for the award of Doctor of Philosophy of Loughborough University.

Metadata Record: [https://dspace.lboro.ac.uk/2134/7975](https://dspace.lboro.ac.uk/2134/7975)

Publisher: © Rhoda Trimmingham

Please cite the published version.
This item is held in Loughborough University’s Institutional Repository (https://dspace.lboro.ac.uk/) and was harvested from the British Library’s EThOS service (http://www.ethos.bl.uk/). It is made available under the following Creative Commons Licence conditions.

For the full text of this licence, please go to:
http://creativecommons.org/licenses/by-nc-nd/2.5/
AN EXPLORATION OF THE ROLES VALUES PLAY IN
DESIGN DECISION-MAKING

By

RHODA LOUISE TRIMINGHAM

A Doctoral Thesis
Submitted in partial fulfillment of the requirements for
The award of

Doctor of Philosophy
Of Loughborough University

© by Rhoda Trimingham 2007
BEST COPY

AVAILABLE

Variable print quality
## Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figures in text</td>
<td>6</td>
</tr>
<tr>
<td>Tables in text</td>
<td>7</td>
</tr>
<tr>
<td>Declaration of originality</td>
<td>9</td>
</tr>
<tr>
<td>Abstract</td>
<td>10</td>
</tr>
<tr>
<td>Acknowledgements</td>
<td>12</td>
</tr>
<tr>
<td>List of Publications</td>
<td>13</td>
</tr>
</tbody>
</table>

### Chapter One: Introduction

1.1 Research background ............................................................................... 14
  1.1.1 Personal motivations ......................................................................... 15
1.2 Understanding and categorising values within design decision-making .... 15
  1.2.1 Categorising values in design decision-making ................................ 15
  1.2.2 Researching values in design decision-making ................................ 15
  1.2.3 Understanding values in design decision-making ............................... 16
1.3 Researching values through sustainable design ..................................... 16
  1.3.1 Heightened responses ......................................................................... 17
1.4 Expertise ................................................................................................... 19
1.5 Educational context .................................................................................. 19
1.6 Summary of the research programme ....................................................... 19
  1.6.1 Aim ........................................................................................................ 19
  1.6.2 Objectives ............................................................................................. 20
  1.6.3 Research questions ................................................................................ 21
  1.6.4 Data ........................................................................................................ 21

### Chapter Two: Design decision-making

2.1 Models of designing .................................................................................... 24
  2.1.1 Linear models ...................................................................................... 25
  2.1.2 Generic models .................................................................................... 28
2.2 Knowledge, skills and values .................................................................... 31
  2.2.1 Values ................................................................................................... 31
  2.2.2 Knowledge and skill ............................................................................ 34
2.3 Summary ....................................................................................................... 45

### Chapter Three: Values in depth

3.1 Introduction ............................................................................................... 46
3.2 A more general understanding of values ................................................... 49
  b. South Australia ......................................................................................... 49
    3.2.1 Additional values taxonomies .............................................................. 52
3.3 Internal and external values ....................................................................... 54
  3.3.1 Personal Values .................................................................................... 54
  3.3.2 Social values ....................................................................................... 57
  3.3.3 Values embedded in design .................................................................. 62
3.4 Methodological approaches for assessing values ....................................... 67
3.5 Values embedded in a designer's visual representations ............................ 73
  3.5.1 Visual representations and design decision-making ............................... 74
  3.5.2 Values and visual representations ......................................................... 78
3.6 Values and expertise ................................................................................... 79
  3.6.1 Decision-making strategies .................................................................... 81
  3.6.2 Prior experiences (personal values) ...................................................... 82
  3.6.3 The use of existing examples (values embedded in design) ..................... 86
  3.6.4 Expertise and a designer's personal values .......................................... 86
  3.6.5 Expertise and a designer's use of social values ..................................... 87
3.7 Summary ....................................................................................................... 88
Chapter Four: Pilot data collection methods

4.1 Key aims for the pilot studies ................................................................. 89
4.2 Uncovering the use of values in design decision-making ................. 89
  4.2.1 What people say at the time ....................................................... 69
  4.2.2 What people do ........................................................................... 69
  4.2.3 What people tell you afterwards ................................................ 91
  4.2.4 Tacit processes ......................................................................... 91
4.3 Selected methods .................................................................................. 92
  4.3.1 Retrospective interviews .............................................................. 92
    4.3.1.1 Dataset one - NN and RG .................................................. 93
    4.3.1.2 Dataset two – SG .............................................................. 96
    4.3.1.3 Dataset three – LG, ER, RW, JP and RT ............................ 98
  4.3.2 Concurrent verbalisation and protocol analysis ............................ 100
    4.3.2.1 Dataset four – KB and IS ................................................. 102
4.3.3 The diary of designing ................................................................. 104
  4.3.3.1 Dataset five - Table/chair project ......................................... 106
  4.3.3.2 Dataset six - Recoup lectern project ..................................... 107
4.4 Summary ............................................................................................ 109

Chapter Five: Key findings from the pilot studies

5.1 Knowledge, skills and values as a model of decision-making .......... 110
5.2 Findings from the literature ................................................................. 112
  5.2.1 Personal values .......................................................................... 115
  5.2.2 Social values ............................................................................. 117
  5.2.3 Values embedded in design ....................................................... 118
5.3 Values and expertise .......................................................................... 120
5.4 Findings from visual representations ................................................ 121
5.5 New understandings from the pilot studies ...................................... 122
  5.5.1 Stakeholder values as different from societal values ............... 122
  5.5.2 Internal perception of external values ...................................... 123
  5.5.3 Designers use of meta-values ................................................... 124
  5.5.4 The importance of value judgements ...................................... 124
5.6 Summary ............................................................................................ 125

Chapter Six: Developing a values taxonomy

6.1 Development ....................................................................................... 127
  6.1.1 Looking at the prior art ............................................................... 127
  6.1.2 Observations during the pilot studies ...................................... 127
  6.1.3 The use of focus groups ............................................................. 128
    6.1.3.1 Phase 1 – separating internal and external values ........... 128
    6.1.3.2 Phase 2 – developing possible sub-categories ............... 129
    6.1.3.3 Phase 3 – assessing the new values taxonomy ............ 129
6.2 The new values taxonomy ................................................................. 130
  6.2.1 External values ........................................................................... 130
    6.2.1.1 Societal values .................................................................. 130
    6.2.1.2 Identified stakeholder values .......................................... 132
    6.2.1.3 Economic system values ............................................... 133
    6.2.1.4 Values embedded in design .......................................... 134
  6.2.2 Internal values ........................................................................... 136
    6.2.2.1 Perceived societal values ............................................... 136
    6.2.2.2 Perceived identified stakeholder values ......................... 137
    6.2.2.3 Perceived economic system values ................................. 137
    6.2.2.4 Designer’s personal values ........................................... 137
    6.2.2.5 Meta-values .................................................................... 138
6.3 Values as the sole influence in design decision-making .................. 140
9.1.4 Identifying any similarities or differences in the influence of values in novice and expert design decision-making ................................................................. 207
9.2 Contributions to knowledge .......................................................................................... 207
9.3 Suggestions for further work ....................................................................................... 222
  9.3.1 Design education .................................................................................................... 222
  9.3.2 The importance of value judgements ...................................................................... 223
  9.3.3 Management decision-making ................................................................................ 223
  9.3.4 Contexts for researching the designer's use of values ........................................... 224

References .......................................................................................................................... 225

Appendix

Appendix i: Project details – pilot studies, dataset three .................................................. 242
Appendix ii: Eco-indicator test results – pilot studies, dataset four .................................. 246
Appendix iii: Project guide – pilot studies, dataset four .................................................... 247
Appendix iv: Private email from Dr Pedgley ..................................................................... 248
Appendix v: Example values cluster .................................................................................. 252
Appendix vi: Video data documentation ............................................................................ 267
Figures and tables in text

Figures in text

Figure 1.1 John Vann's electric violin made from recycled polymer (HIPS) .................. 17
Figure 1.2 James Duder's 'love chair' made from recycled polymer (HDPE) .............. 17
Figure 1.3 Jane Atfield's RCP2 chair ................................................................. 18
Figure 1.4 An overview of the research programme ............................................. 23
Figure 2.1 Reflective practice ............................................................................ 25
Figure 2.2 Total design activity model ............................................................... 26
Figure 2.3 Design activity model for A-level comment core design and technology syllabuses ......................................................... 26
Figure 2.4 A model towards understanding the nature of design education activity................................................................. 27
Figure 2.5 The design process from the Design and Craft Education Project ........... 28
Figure 2.6 The convergent nature of the design process ...................................... 29
Figure 2.7 Other forms of design activity model ................................................ 29
Figure 2.8 Pugh's Plates – the elements of a design specification ................. 30
Figure 2.9 Technology as the summation of knowledge, skill and values ....... 31
Figure 2.10 'When is a problem?' ................................................................. 33
Figure 2.11 From problem state to resolution ................................................... 33
Figure 2.12 Some knowledge areas in design .................................................... 34
Figure 2.13 Knowing that is not only that which is held in memory ...................... 38
Figure 2.14 Things I know but still not know how ............................................. 38
Figure 2.15 A dhow made using indigenous knowledge? .................................... 39
Figure 2.16 Restructuring of designerly knowledge ........................................... 42
Figure 2.17 Overlaps of the various schemata constructed by the mind ............ 43
Figure 3.1 Philips value added design solutions .............................................. 59
Figure 3.2 Philips value added design solutions ............................................... 59
Figure 3.3 The Audi TT filler cap ..................................................................... 59
Figure 3.4 Ways of influencing design activity open to the consumer ............... 60
Figure 3.5 User value types ............................................................................. 61
Figure 3.6 Polystyrene and real glass cups ....................................................... 63
Figure 3.7 Design of office furniture preserving occupational hierarchies ....... 63
Figure 3.8 An example of a section of a value opportunity chart ................. 71
Figure 3.9 Examples of some visual representations used by industrial designers ............................................................................................................. 74
Figure 3.10 The APU model of designing ....................................................... 76
Figure 4.1 Three phases of retrospective pilots .............................................. 93
Figure 4.2 Dataset one topic guide ................................................................. 95
Figure 4.3 Dataset two of the pilot studies ..................................................... 98
Figure 4.4 Dataset three of the pilot studies ................................................... 98
Figure 4.5 The final topic guide ..................................................................... 99
Figure 4.6 Dataset four of the pilot studies .................................................... 102
Figure 4.7 The current toaster ..................................................................... 103
Figure 4.8 The set-up .................................................................................... 104
Figure 4.9 Datasets five and six ................................................................ 105
Figure 4.10 Diary folder and Diary archive .................................................... 107
Figure 4.11 The outcome of dataset six .......................................................... 108
Figure 4.12 An overview of the pilot studies ................................................... 109
Figure 5.1 Dataset five, RC: Model M1 ............................................................ 122
Figure 5.2 A section of an outcome sheet from the focus groups ............... 128
Figure 5.3 Some of the resources made available to participants ........... 150
Figure 5.4 One-day event lectern project brief ............................................. 151
Figure 5.5 Models made during the one day event ...................................... 153
Figure 5.6 Comparing the concurrent verbalisation and retrospective transcripts ................................................................. 156
Figure 5.7 An overview of the data analysis method .................................. 157

6
Table 6.4 Summary of prior art regarding economic values ....................................... 134
Table 6.5 Summary of the prior art regarding values embedded in design .................... 135
Table 6.6 Summary of the prior art regarding a designer's personal values .................. 138
Table 6.7 Additional values recognised in focus group one ....................................... 138
Table 6.8 A summary of the prior art regarding meta-values ...................................... 139
Table 6.9 Meta-values as values of satisfaction ...................................................... 139
Table 6.10 Additional meta-values ......................................................................... 140
Table 6.11 Summary overview of the new values taxonomy ...................................... 141
Table 7.1 data collection methods and participants used during the...................... 142
   pilot studies ..........................................................................................
Table 7.2 Research methods and participants used for the main study ...................... 142
Table 7.3 Retrospective interview topic guide ......................................................... 144
Table 7.4 Prompting questions for the retrospective interviews ................................. 145
Table 7.5 List of selected participants for the main study ......................................... 147
Table 7.6 Additional resources ............................................................................. 149
Table 7.7 Some data analysis methods ................................................................... 154
Table 7.8 Participant coding for analysis ............................................................... 155
Table 7.9 Coding for the values categories for analysis ............................................ 155
Table 7.10 An overview of the main study ............................................................... 157
Table 8.1 Products and materials used by participants in the one-day event ................. 161
Table 8.2 Words used by participants to describe the sense they were trying to portray, or avoid in their designs .............................................. 164
Table 8.3 Existing materials and designs used to combine with new designs to transfer embedded value .......................................................... 167
Table 8.4 Perception of societal values made with three distinct drivers .................... 169
Table 8.5 The total number of value judgements for each of the eight participants ......................................................... 174
Table 8.6 Totals observed for each value during the two retrospective interviews ......... 181
Table 8.7 Transcript excerpt - ODE-ADI: Professional designer ............................... 195
Table 8.8 transcript excerpt – ODE-ALI: A-level student ......................................... 197
Table 8.9 A summary of the evidence provided by the main study ........................... 199
Table 9.1 A summary of societal values based on all sources of evidence .................. 212
Table 9.2 A summary of identified stakeholder values based on all sources of evidence .................................................................................................................. 213
Table 9.3 A summary of economic system values based on all sources of evidence .... 214
Table 9.4 A summary of values embedded in design based on all sources of evidence .................................................................................................................. 215
Table 9.5 A summary of perceived societal values based on all sources of evidence .................................................................................................................. 216
Table 9.6 A summary of perceived identified stakeholder values based on all sources of evidence ........................................................................................................ 217
Table 9.7 A summary of perceived economic system values based on all sources of evidence ........................................................................................................ 218
Table 9.8 A summary of embedding values in design based on all sources of evidence .................................................................................................................. 219
Table 9.9 A summary of designer's personal values based on all sources of evidence .................................................................................................................. 220
Table 9.10 A summary of meta-values based on all sources of evidence .................... 221
Abstract

The overall aim of the thesis is to explore the role of values within design decision-making. The research is carried out within a context of sustainable design, specifically the use of recycled materials. The literature and pilot studies highlighted the nature and role of values in design decision-making. These include the observation that stakeholder values are different from societal values, that designers have an internal perception of external values (or that they make decisions 'on behalf' of external influences), and that designers use 'meta-values' (a sub-set of internal values) to organise their activity.

The main body of the research includes a series of nine case studies using retrospective interviews and concurrent verbalisation and protocol analysis. Previous research suggested that a designer's values can be researched through looking at their visual representations. This was investigated through an analysis of participants design work. A taxonomy was explored and evidence sought to validate the categories of values influencing industrial design decision-making. Key findings show that values embedded in design, initially considered an external value, could also be an internal value, as designers use these principles to embed value into their designs. It was also found that the choice to be influenced by one set of values and not another, can differ from project to project. The changing role of values in relation to design expertise was explored and, in contradiction to the prior art, there was little evidence that distinguished the influence of values between novices and experts. A primary research output is the development of a new taxonomy, which divides the values influencing industrial design decision-making into external values and internal values.

External values:

- Societal values (e.g. cultural aspects).
- Identified stakeholder values (e.g. paying attention to a brief).
- Economic system values (e.g. use value, intrinsic value and value in exchange).
- Values embedded in design (e.g. using existing design examples).

Internal values:

- Perceived societal values (e.g. the perception of the needs of a society); perceived identified stakeholder values (e.g. the perceived acceptability of a design for an identified stakeholder).
- Perceived economic system values (e.g. the perception of economic competition).
- Embedding values in design (e.g. the desire to convey a message through design).
- Designer's personal values (e.g. personal rules and heuristics).
- Meta-values (e.g. evaluating ideas).

Rhoda Louise Trimingham
Acknowledgements

Firstly I would like to thank my supervisor, Dr. Eddie Norman. Without his common-sense, knowledge and enthusiasm I would never have finished. I would also like to thank my director of research Dr Tracy Bhamra, and the staff in the Department of Design and Technology for all their support.

I would like to say a big 'Thank you' to all the people who agreed to be participants for this thesis in some form or another. Without their effort there would be no data to discuss and no findings to find.

On a different note, I would like to thank the university cafes and Tony Hodgson, for agreeing to a chocolate machine, both of which kept me thinking. I would also like to thank my friends, who not only acted as sounding boards but also provided light relief. In particular I would like to thank Clare Allsop and Beccy Cain, who I have watched turn into both proficient researchers and well-timed comedians, the Loughborough University ski club, and the many friends who took the time to visit over the last few years.

Finally I would like to thank my family, especially my parents Jules and Anna, and Mark, my endlessly supportive husband. It would have been impossible without them.
List of Publications

(My maiden name is Coles)


This page has been left intentionally blank
Overview: Chapter 1 introduces the research project and defines its scope in relation to design decision-making, values and sustainability. The key focal areas and research questions are stated. An overview of the research design and data collection methods is presented.

1.1 Research background

Research regarding decision-making is not new. The concern of this thesis is design decision-making, and particularly in the context of industrial design, of which there is little prior art. Industrial designers are those involved in work known as 'new product development' (NPD) or 'product design' (Pedgley, 1999). The journey from start to final proposal is complex, and there is still little research-based evidence of what designers do that comprises this complex journey.

The design education movement was established in the 1970s when key researchers such as Archer argued the case for Design as a third area of human knowledge (alongside The Arts and Sciences). Secondary school design courses started to become established in the 1980s. The debate of the 1970s and 1980s resulted in a working party being set up by the Assessment of Performance Unit (APU) under the Chairmanship of Hicks. In 1982 Hicks et al came up with a document concerning Understanding Design and Technology (Hicks et al, 1982). This was a very important document that categorised the factors involved in design decision-making under three headings: knowledge, skills and values. In the 1990s Dr Eddie Norman published a paper entitled 'The nature of technology for design' (1998). It described the idea that technology for the purpose of those engaged in designing could also be thought of as the summation of knowledge, skills and values. The 1990s saw many contributions to the debate surrounding the use of knowledge (see de Vries 2003, Dasgupta 1996, Norman 1998, Vincenti 1990) including a PhD completed in 1999 by Pedgley. This thesis explored design decision-making and focused on design epistemology (ways of knowing), or the use of knowledge and information during the creation of new artefacts and systems. The case study explored as a key aspect of this PhD was the design of a polymer acoustic guitar. Pedgley found that even when the guitar had not been seen or heard, there was a general opinion that it could never be as good as wooden ones and would always be perceived as a low value artefact. (Norman, Pedgley and Coles, 2004a:3). This kind of response was one of the drivers to research the role of values as it suggests that people's responses are governed
by emotional factors, or values, as much as by rationality. Values in general are cultural constructs and designers are educated, and practice within the same constructs.

1.1.1 Personal motivations

The author graduated from Loughborough University with a BA (Hons) in Industrial Design and Technology. The project work undertaken for the degree raised awareness about the complexity and number of decisions industrial designers face and highlighted the need for more sophisticated decision support to be developed.

As the author studied as an industrial designer it was felt to be appropriate to research within this field. When researching elements as intangible as how designers think, it is impossible not to assume that elements of our understanding will come from inferences based on the data received. Therefore it was felt that to research within one's own discipline would be most appropriate.

1.2 Understanding and categorising values within design decision-making

1.2.1 Categorising values in design decision-making

An initial literature review found that the role of values within design decision-making had been largely unexplored, and that what little there was reflected more on educational practices and engineering added value for increased profit.

A key aim of the research was to develop a complete classification system for values influencing design decision-making as this was felt to be a significant issue and absent from any previous literature. The development of this new classification system can be found in Chapter 6.

1.2.2 Researching values in design decision-making

Best practice for the analysis of design activity is still being developed and so the opportunity that this research presented was taken as a vehicle for further investigation of this area. This was done firstly through a thorough review of literature and methodology as a result of which three methods were selected for the pilot studies; concurrent verbalisation and protocol analysis, retrospective interviews and a diary of designing (For more information about the pilot studies see chapter 4). These methods were then reviewed as to their effectiveness and retrospective interviews and
concurrent verbalisation and protocol analysis were selected for the main study (For more information about the main studies see chapter 7).

1.2.3 Understanding values in design decision-making

Having developed this new nomenclature for values and effective methods for analysing values in design decision-making it was natural to assess the success of the classification system and, through this, further our understanding of the influence of values during design decision-making. The discussions and conclusions from this work are presented in chapters 8 and 9.

1.3 Researching values through sustainable design

Sustainable design, or design that 'meets the needs of the present without compromising the ability of future generations to meet their own needs' (WCED, 1987:43), has been a subject for discussion for many decades and has recently emerged as a key research agenda. David Layton (1992) in his presentation to the International Conference on Design and Technology Education Research and Curriculum Development held at Loughborough University recognised the need to incorporate explicit value considerations, especially ethical and environmental ones (1992:2). Decisions regarding sustainability are crucially value driven and the role and influence of values must be better understood.

The job of the industrial designer is to facilitate (some decisions will be more democratically based) a number of decisions that will take an initial brief, or idea, through to a (hopefully) successful final product proposal. These decisions will determine many vital aspects of the product including its environmental performance. Therefore we can say that the '...decisions designers make have a profound influence on sustainability issues' (Norman, Pedgley and Coles, 2004a:1), and that 'designers are at the forefront of developing a benign and socially responsible material world' (Baynes, 2005:6).

Sustainable solutions are those that minimise negative and maximise positive environmental, social and economic impacts while fulfilling acceptable social demands and needs (Charter and Tischner, 2001). Design decisions regarding sustainability are also often taken in the face of uncertainty, creating a key role for the use of values.
1.3.1 Heightened responses

The decisions a designer makes not only determine a product’s physical and functional properties but also aspects that determine emotional responses (Norman, Pedgley and Coles, 2004:1). Products made from recycled polymer materials can invoke even more polarised responses (Norman, 2001). Figures 1.1 and 1.2 show two products designed by Industrial Design and Technology undergraduates at Loughborough University, John Vann’s electric violin and James Duder’s ‘Love chair’.

John Vann decided that it was necessary to spray paint his polymer violin, but James Duder decided that this was not necessary for the ‘love chair’ design. The violin was made from recycled high impact polystyrene (HIPS) and the chair from recycled high density polyethylene (HDPE), which came from Smile Plastics Ltd, (www.smile-plastics.co.uk). John Vann judged that the market was not ready for such a strongly patterned material and that spray painting would give the necessary ‘surface beauty’. The outdoor environment of the love chair is already essentially variegated and James Duder judged that the surface finish with its marble-like qualities was appropriate as it was.

Designs from recycled materials can now achieve a level of controversy, which was not perhaps possible when the materials were designed and developed by Jane Atfield at the Royal College of Art in the 1990s. In 1996 her RCP2 chair (Figure 1.3) was included in the Recycling: Forms for the Next Century - Austerity for Posterity exhibition that toured the UK (Atfield 1996:58). The recycled material was developed to reflect the ‘pop art’ movement of the time.
So, when it came to designing the PhD programme to explore the role of values in design decision-making, designing sustainable products seemed to be the ideal context for timely research. Within the sustainability context it was necessary to focus further in order to gather data. Materials was a natural choice, partly because material choice is a key decision regarding the sustainability of a product, and partly because materials were the focus of the PhD completed by Pedgley (1999) for which this body of research is to some degree the sequel. Recycled materials were chosen because it was known that people had strong value driven views about them (see above) and therefore the data was likely to reveal more about value issues. Clearly if less extreme materials had been prescribed then the influence of values may have been harder to discover. The main study briefs, developed for this research, included the use of recycled materials.
1.4 Expertise

Another aspect of the research was to assess how the role of values changes with age and experience. It was decided that participants would be selected with differing levels of experience in order to research the influence of values in novice and expert decision-making.

1.5 Design Education

A link to design education is inherent throughout this body of research. Much of the prior art regarding values (see chapter 3) has been developed within an educational context and many of these discussions have influenced the final values taxonomy presented in chapter 9. The research itself, although not confined within an educational context (as professional designers were also observed), looked at designers with varying levels of expertise, with 6 participants from the main study still in full time education. The need to include values considerations within education has been made explicit by many authors (for example: Layton, 1992; Pedgley, 1999; Cross, 1982) and is reiterated by the author on completing this body of work (see section 9.3.1).

1.6 Summary of the research programme

1.6.1 Aim

The overall aim of the thesis is to explore the role of values within design decision-making. The main drivers to explore values came from a PhD written by Pedgley (1999, see section 1.1). The PhD explored the use of knowledge by designers but highlighted many interesting observations of the use of values. Combined with the author's experiences of the complexities involved in the act of designing this sparked a curiosity to explore the influence of values further.
1.6.2 Objectives

The PhD has five main objectives;

During the course of an undergraduate degree in industrial design the author concluded that the act of designing was far less structured than the linear process models used to describe its nature would suggest. A model of design being 'bound' (Norman, 1998) by the designer's knowledge, skills and values was deemed to be a more appropriate reflection of the activity. The author felt that this initial observation required further research and therefore one objective of the PhD was:

- to analyse and develop a fit-for-purpose model of design decision-making being made up of knowledge, skills and values.

The author felt that although the importance of values within design decision-making had been highlighted by many authors as being of great importance (see sections 1.1, 2.2, and chapter 3) there was no concise classification of the values influencing design decision-making. The second objective of the PhD was therefore:

- to develop a categorisation system of values within this model of design decision-making.

Although many authors discuss the importance of values in design decision-making (see chapter 3) there is no definitive method for the collection and analysis of values. In order to achieve the aim of the research it was important to develop a robust methodology. It became apparent that a clear explanation of the development of these methods, and a review of their effectiveness, would be beneficial to subsequent research within this field. Therefore it was important to include a third objective:

- to explore, analyse and develop methods for the analysis of design decision-making and review their effectiveness within this body of research.

An important part of the research was to develop a classification of the values involved in design decision-making. However, as described in the main aim, there was a strong desire to explore their role in design decision-making. Through the collection of data regarding values in design decision-making it was clear that the influence of values could also be discussed within this thesis. An additional objective was:

- to develop a clear understanding based on evidence from multiple sources of how values affect the design decision-making process.

The author felt that during the course of her education she had developed as a designer and that although the design briefs she was tackling had grown more complex, her ability to resolve them to a satisfactory degree had also developed. This observation was
highlighted in the 6 months preceding the start of this research when the author worked with AS and A-level students. The AS and A-level students appeared to exert the same high level of effort in solving simple briefs as the author felt she exerted towards more complex briefs. It was of interest to the author to explore how a designer's ability to make design decisions (and specifically the influence of values) developed as they became more expert. The final objective for this body of research was therefore:

- to develop a clear understanding of how expertise affects the role of values in design decision-making.

### 1.6.3 Research questions.

- Can the values influencing industrial design decision-making be identified and described?
- When during industrial design decision-making are decisions influenced by values?
- Can we identify any similarities or differences in the influence of values in novice and expert industrial design decision-making?
- Can data be collected and analysed regarding the use of values in industrial design decision-making?

### 1.6.4 Data

The following primary data sources were used.

*Pilot studies:*

- Three retrospective interviews with A-level students who were involved in the following projects linked to the Sustainable Design Award (SDA, www.sda-uk.org) run by Practical Action (formally ITDG, www.practicalaction.org):
  - cardboard desk for disaster areas;
  - recycling centre for a primary school;
  - bag for Kenyan paravet.
Five retrospective interviews concerning finalist designers' recycled plastic projects, in which they developed:
  - 'Serenity' garden bench;
  - 'Lumina' portable lighting;
  - 'Frost lights' floating candles;
  - 'Axis' entertainment stand; and
  - 'Flex' wine rack.

Two concurrent verbalisation and protocol analysis recordings of two professional designers involved in redesigning a toaster from a sustainable perspective.

Two diary studies of the researcher's chair and lectern projects also using recycled plastic.

Main study:

Concurrent verbalisation and protocol analysis and retrospective interviews with eight designers involved in a one day brief to redesign a lectern using recycled plastic sheet:
  - two A-level students;
  - two finalist students;
  - two postgraduate students; and
  - two professional designers.

Retrospective interview with a professional designer involved in a 10 day project to design a guitar using recycled polymers.

For an overview of the research programme see Figure 1.4.
Figure 1.4. An overview of the research programme
Overview: Chapter two provides the context for the consideration of design decision-making, by exploring some key models of designing from the literature. The role of knowledge, skills and values within design decision-making described by prior art is discussed.

2.1 Models of designing

It could all have been different. Other options were available. What we encounter today is the result of decisions which reflect the value judgements of those who shaped a development which was in no sense inevitable (Layton 1992a:10).

In order to effectively research design decision-making, a basis, or structure of decision-making, needs to be identified, from which to work. As Dorst explains, 'understanding the structure is a first step to understanding how designers' tackle design problems' (2003:1).

Design models are useful as they give an indication of what designers do (Lawson, 2004:15). Design process models were originally developed by educators in order to support design education. The hope was that by understanding the process of designing teachers would be able to teach designing more effectively, and students consequentially would improve their design capability (Norman, 2005:1-2). They were also developed for use by managers in order to direct designers effectively (Lawson, 2004:15). These process models are also useful to designers as it makes them aware of their meta-cognitive abilities, or their ability to apply strategies to their design activities (Norman, 2005:2).

There are two general descriptions of decision-making adopted by academics but they essentially describe a similar process; decision-making as a problem solving activity, where the designer is learning on route, engaging with the problem, (Simon,1973); and decision-making as reflective practice, a more intimate, personal and less predictive process where the designer is asked to name, frame, move and reflect (Dorst and Valkenburg, 1998, based on previous work done by Schön, 1983, See Figure 2.1). Within both these descriptions values will undoubtedly play a part.
Schön presented three types of reflection:

- **Reflection-in-action** – reflecting in the midst of an action without interrupting it, in such a way as to influence further action (e.g. tacit processes).
- **Reflection-on-action** – or 'stop and think', where reflection has no connection to the action (e.g. critical evaluation).
- **Reflection-on-practice** – criticising tacit understandings that are built on experiences (e.g. pattern recognition) (Reyman 2003:2).

### 2.1.1 Linear models

The most well known linear process model of designing is the 'Total design activity model' (Pugh 1990, see Figure 2.2) which was developed as a model for engineering designers. It was specifically developed to have a clear and easily comprehensible structure.
A linear model of designing was set by the CNAA committee which reviewed A-levels in the 1980s and established the common core model used in the UK in the 1990s. In the 1990s Norman placed it within Pugh's framework to provide continuity from secondary to higher education. It was developed for A-level design and technology education and was based on Pugh's model, making it obvious that it is there as a structure, and not a definitive process. (Norman 2005:3, see Figure 2.3) However it still follows a route from definition of user needs to the final emergence of a working prototype for evaluation.

In 1992 Roberts produced his 'Transitive model' (See Figure 2.4) that takes into account Schön's reflective practice nature of designing, suggesting that design activity involves continuous appraisal and reappraisal. However it still relies on a linear structure of events.
the child acting in and on the world as the USER and the OBSERVER of design activity: that is the participant user of design

identifies situation requiring resolution: requires situation - the ill-defined problem - he/she is in to be changed

analyses situation articulates the problem(s) requiring solution/resolution

what is required? needed? wished for? absent? what is the nature of the ‘mis-fit’? what is the primary function required? What, if anything, ‘needs doing’?

leads to a sufficient statement of the problem(s) - the ill-defined problems; not a solution: as open-ended as possible: statement avoids specifying particular solutions/responses

considers possible solutions to problem(s) and ...

... constraints on capacity to obtain (expense, availability, size, maintenance, ease of use, whether (it) will perform to acceptable standards); reveals alternatives and the USER's criteria

chooses buys

uses, evaluates against identification and specification of the ill-defined problem(s)

in going from the beginning to arriving at this stage, the original state of affairs has been changed (probably, usually) to one that is more acceptable

the child acting in and on the world as the DESIGNER and the MAKER in design activity

the designer is placed in, or accepts, a situation - an ill-defined problem - where some change (to other than present conditions) is ‘needed’ (probably)

analyses situation articulates the problem(s) requiring solution/resolution

what is required? needed? wished for? is absent? what is the nature of the ‘mis-fit’? what is the primary function required? What, if anything, ‘needs doing’?

leads to a sufficient statement of the problem(s) - the ill-defined problems; not a solution: as open-ended as possible: statement avoids specifying particular solutions

considers possible solutions to problem(s) and ...

... constraints on freedom and ability to achieve (skill, cost in time, finance, materials, facilities, user’s requirements): reveals alternatives, and probable acceptable solution to both the USER and the DESIGNER

chooses plans

makes ‘mock-up’

tests

makes prototype

tests, evaluates

delivers

in going from the beginning to arriving at this stage, the original state of affairs (represented in the ill-defined problem(s)) has been changed (probably, usually) to conditions that are more acceptable

Figure 2.4. A model towards understanding the nature of design educational activity (Roberts, 1992: 36).

It is hard to say how these linear process models came to be. There is a time dependant nature to a design project that denotes there must be a start point, and a finish point, and that a designer must move forward. However, what occurs in between is not so structured. That a successful designer would be able to report how a certain process was executed in one way and not another, and how that eventually led to one result and not another is inconceivable. Most models have been developed as frameworks to enable designers, educators and managers to understand the stages involved in designing and therefore impose some control over design activities. However, they probably do not adequately reflect the dynamic nature of designing. The nature of designing, which
makes methodologies that try to impose a structure on the problem–solution relationship futile, is aptly described by Lawson who comments:

Designing then, in terms of chess, is rather like playing with a board that has no divisions into cells, has pieces that can be invented and redefined as the game proceeds and rules that can change their effects as moves are made. Even the object of the game is not defined at the outset and may change as the game wears on. Put like this it seems a ridiculous enterprise to contemplate the design process at all (Lawson, 2004:20).

2.1.2 Generic models

This view that designing cannot be represented by linear presentations of distinct stages is not new. In 1971 Professor John Eggleston developed the model shown in Figure 2.5 for the Design and Craft Education Project (Eggleston, 1974:2) Although still containing elements of the linear models it is less contrived and represents the divergent, convergent nature of design activity and the less structured application of actions (such as the application of knowledge and social factors).

![Figure 2.5. The design process from the Design and Craft Education Project (Eggleston et al, 1974:2)](image-url)
This idea of design as an activity of convergent thinking is repeated in Cross's 1983 model (See Figure 2.6). It shows the nature of design problems as changing from ill-defined to well-defined as the project progresses (For a discussion on the ill-defined nature of design problems see section 2.2.2).

Figure 2.6. The convergent nature of the design process (Cross, 1983:11)

To highlight this view that design is not and therefore cannot be presented as a linear process Norman's alternative design activity model (See Figure 2.7) shows the more cyclic and repetitive nature of design (innovation spiral, Norman, 2005:3). This was done at the same time as the model shown in Figure 2.3, and reflect Roberts (1992) view that design is not as organised as managers and educators wish and is a process that continually repeats itself until an outcome is reached.

Figure 2.7. Other forms of design activity model (Norman et al, 1990:21)
Pugh's plates (See Figure 2.8), gives an alternative view of the design process. This is a closer look at his total design model (Figure 2.2) and shows more of the dynamic nature of design decision-making. Based on a circus act, it describes a designer's need to keep a number of plates (specifically selected for each project) spinning. The failure of one element to 'remain spinning' will lead to the overall failure of the 'act' of designing (Norman, 2005:7). The designer must continually make judgements about which issues are most important to address.

![Figure 2.8. Pugh's Plates - the elements of a design specification (Cooke et al, 1984:9)](image)

This leads us to the use of a designer's individual product design specification (PDS) as a model of their decision-making 'intent'. A PDS can be considered as a statement of the characteristics by which a successful design can be recognised (Norman, 2005:2). Can we consider then, a PDS to be a very personalised (as they will be different for each project and probably change as the project progresses), and simplified model of design decision-making 'intent', as each element of that PDS highlights an episode of decision-making that needs to occur? The product design specification written when the design is complete could even be viewed as encapsulating the best decision-making efforts of the designer (Norman, 2005, private email).

In 1982 Hicks et al categorised the key influences for design and technological activity as knowledge, skills and values. The knowledge, skills and values model was also adopted by, Archer, Roberts and Baynes who all refer to it (1992). In 2000 Dr Eddie Norman
presented a model of designing based on these categories (see Figure 2.9). He suggests that effective design is likely to be 'bound' by the designers knowledge, skills and values, and that education or professional development should seek to address these as key issues (Norman, 1998).

![Diagram of designing process](image)

Figure 2.9. Technology as the summation of knowledge, skills and values (Norman, 2000:129)

2.2 Knowledge, skills and values

2.2.1 Values

In the late 1970s Lawson's studies of designing within architecture and scientific activity highlighted some differing strategies which could be employed:

The scientists generally adopted a strategy of systematically exploring the possible combinations of blocks, in order to discover the fundamental rule which would allow a permissible combination. The architects were more inclined to propose a series of solutions, and to have these solutions eliminated, until they found an acceptable one (Lawson 1979, cited in Cross 1982:223).
In essence the scientists 'adopted a generally problem-focused strategy and the architects a solution-focused strategy' (ibid:223) That is, in the words of Simon, designers 'satisfice' (1969, cited in Cross 1993:17) which is the view also held by Cross who explains:

A central feature of design activity, then, is its reliance on generating fairly quickly a satisfactory solution, rather than on any prolonged analysis of the problem (Cross 1982:224).

This act of 'satisficing', explaining design as a problem resolution activity also refers to design activities as being different to scientific activities by being based on 'ill-defined' (Robert's et al 1992:38) or 'wicked problems' (Rittel and Webber 1973) rather then 'tame' problems (Cross 1993:16). As Pedgley states 'a characteristic of many design problems (especially as presented formally in a brief) is that they contain a complex of missing information, inexplicit requirements and conflicting demands' (Pedgley 1999:33):

Design problems are described as 'ill-defined' because there is no way of arriving at a provision description merely by the reduction, transformation or optimisation of the data in the requirement specification. By the same token, it is rarely possible to determine whether or not the finished design is 'the correct', 'the only' or 'a necessary' answer to the requirements. It must usually be possible, of course, to establish whether or not one 'proper' answer to the requirements is better or worse than some other 'proper answer' (Roberts, 1992:38).

Dorst agrees, commenting on the indeterminate nature of design problems because '...a description in terms of needs, requirements and intentions can never be complete (there can never be enough to determine a form)' (2003:2) This approach to understanding designing is best articulated by Roberts (1992:39) who asks 'When is a (design) problem?' And responds, 'A problem consists in a state of affairs, in which we feel some unease or discrepancy or incompatibility' (ibid). This can be seen in Figure 2.10. This model was also used by Norman in 2000 (see Figure 2.9).
This suggests that the design 'problem' is really a mismatch between existing and desired states of affairs. In contrast to scientists, designers' solutions are based on an 'acceptable degree of closure of the gap' (ibid) This can be seen in Figure 2.11:

This is supported by an earlier article from Cross, who when comparing design activity to scientific based study states that 'The designer is constrained to produce a practicable result within a specific time limit, whereas the scientist and scholar are both able, and often required, to suspend their judgement until more is known... ' (1982:224). This means the designer will be '...producing any one of what might well be a large range of satisfactory solutions rather than attempting to generate the one hypothetically-optimum solution' (ibid). Therefore we can state that without scientific methods, some other 'judgement' is required.

'Intelligently reflecting how to act is, among other things, considering what is pertinent and disregarding what is not' (Polanyi, 1962:31). It is undoubted that values must play some part in designerly behaviour, as decisions must be made as to which solution is 'best'. Cross says of education: 'Deciding what is worthwhile is obviously value-laden and problematic' (1982:222). He could just as easily have been discussing design decision-making. 'In design decision-making, a marked effect of values is to direct and reduce the
various avenues of enquiry a designer explores’ (Pedgley, 1999). In a recent paper, Middleton agrees when commenting on what he called ‘good works’, he concludes that:

intelligence and creativity were not of themselves enough, and that human thought and action, even very clever thought and action, needed to be mediated by what is variously referred to as ethics or values or something connoting ‘goodness’ (2003:111)

Values will be looked at in more detail in Chapter 3.

2.2.2 Knowledge and skill

When designing products and systems, designers must employ knowledge from a wide variety of categories (Figure 2.12). Knowledge, assuming it has not been forgotten, can be communicated verbally (Ryle 1948).

![Figure 2.12. Some knowledge areas in design](image)

But what forms of knowledge do designers require? Table 2.1 below shows some of the many knowledge categories found in the literature. Designers’ are continually called upon to make decisions which require additional information from disciplines other than their own (Hicks et al, 1982). This raises many important points; Hicks’ use of the term ‘information’; this can come from many sources (e.g., books or conversation) and can be valid (e.g., a theory that has been subject to scientific testing), false (e.g., an aloof verbal remark) or a partial form of either (e.g., it may be incomplete). It is not until this information has been assimilated by the designer that it can be referred to as knowledge. De Vries also explains how many categories of technological knowledge have a
normative nature (ibid) - that is they are, for example; effective, or ineffective; good, or bad. Pavlova believes that knowledge is relative, based on a person's experience and directed by human needs and wants (2005). Consequently the use of such knowledge requires the exercise of values.
<table>
<thead>
<tr>
<th>Author</th>
<th>Type of knowledge</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hicks <em>et al</em>, 1982</td>
<td>Control knowledge</td>
<td>Knowledge of systems, static or dynamic, can be created for specific purposes</td>
</tr>
<tr>
<td></td>
<td>Energy knowledge</td>
<td>Knowledge of sources, costs and forms of energy; of methods for storing and transmitting energy; of efficiency and the</td>
</tr>
<tr>
<td></td>
<td>Materials knowledge</td>
<td>Selection, use, sources, costs, useful properties and limitations of materials, and of the appropriate methods of production.</td>
</tr>
<tr>
<td>Lawson, 2004</td>
<td>Theoretical knowledge</td>
<td>Knowledge based on theory and testing</td>
</tr>
<tr>
<td></td>
<td>Experiential knowledge</td>
<td>Knowledge based on previous experiences</td>
</tr>
<tr>
<td>Pedgley 1999</td>
<td>Product centred knowledge</td>
<td>Knowledge of products, components, manufacturing processes, materials, environments, people and market places.</td>
</tr>
<tr>
<td></td>
<td>Procedural knowledge</td>
<td>Knowledge of how to go about designing a product (meta-activities)</td>
</tr>
<tr>
<td>Dasgupta, 1996</td>
<td>Declarative [tokens] knowledge</td>
<td>Laws etc</td>
</tr>
<tr>
<td></td>
<td>Rules</td>
<td>If something needs to happen, then do something</td>
</tr>
<tr>
<td>Van Akin, 2005</td>
<td>Evolutionary knowledge</td>
<td>Knowledge that has been verbally or implicitly passed via realised designs incorporating form time to time, improvement</td>
</tr>
<tr>
<td></td>
<td>Professional design knowledge</td>
<td>Knowledge from experimentations</td>
</tr>
<tr>
<td></td>
<td>Variant knowledge</td>
<td>Knowledge based on a combination of evolutionary and professional knowledge</td>
</tr>
<tr>
<td></td>
<td>General design knowledge</td>
<td>Collected over the years</td>
</tr>
<tr>
<td></td>
<td>Specific design knowledge</td>
<td>For the task at hand</td>
</tr>
<tr>
<td></td>
<td>Object or substantive knowledge</td>
<td>Knowledge on the characteristics and properties of artefacts and their materials</td>
</tr>
<tr>
<td></td>
<td>Realisation knowledge</td>
<td>Knowledge on the various physical processes to be used to realise artefacts</td>
</tr>
<tr>
<td></td>
<td>Process or operative knowledge</td>
<td>Knowledge about the characteristics and properties of design processes</td>
</tr>
<tr>
<td></td>
<td>Prescriptive knowledge</td>
<td>If you want to achieve y, do x</td>
</tr>
<tr>
<td>Rodgers and Clarkson, 1998</td>
<td>Explicit knowledge</td>
<td>Knowledge that can be passed on to others</td>
</tr>
<tr>
<td></td>
<td>Tacit knowledge</td>
<td>Knowledge with unknown origins</td>
</tr>
<tr>
<td></td>
<td>Operative knowledge</td>
<td>Knowledge from practical experience and formal knowledge such as mathematics</td>
</tr>
<tr>
<td></td>
<td>Substantive knowledge</td>
<td>Knowledge from applied sciences such as algorithms</td>
</tr>
<tr>
<td></td>
<td>Static knowledge</td>
<td>Knowledge used by designers in a given domain</td>
</tr>
<tr>
<td></td>
<td>Inferential knowledge</td>
<td>Knowledge and experiences developed by the designer, such as brainstorming</td>
</tr>
<tr>
<td></td>
<td>Dynamic knowledge</td>
<td>Knowledge that changes as the design progresses</td>
</tr>
<tr>
<td>Vincenti, 1990</td>
<td>Descriptive knowledge</td>
<td>Statements of facts, frameworks (material properties)</td>
</tr>
<tr>
<td></td>
<td>Prescriptive knowledge</td>
<td>Generated through experimentation, trial and error</td>
</tr>
<tr>
<td></td>
<td>Tacit</td>
<td>Knowledge that cannot be made explicit</td>
</tr>
<tr>
<td></td>
<td>Dynamic knowledge</td>
<td>Knowledge that changes as the design progresses</td>
</tr>
</tbody>
</table>

Table 2.1. Different forms of knowledge (from various authors).
In her paper on the relationship between technological knowledge and values, Pavlova comments that the search for a common approach to the classification and research of knowledge is problematic due to the following factors:

- problems with finding an appropriate approach for the analysis of technological knowledge;
- problems with a technocratic interpretation of technological knowledge for the purpose of its classification;
- problems with establishing a constant approach to distinguish common features of technological knowledge;
- in many cases only one feature of technological knowledge receives special treatment in identifying the nature of technological knowledge;
- technological knowledge is identified as value-free knowledge; thus, to add values, there is a need to add a special category of knowledge;
- the concept of values is not explicitly presented, although it is embedded in putting technical values above all others. Although some non-technical values are mentioned as a part of technological knowledge (aesthetic for example), moral values are not;
- tacit knowledge is restricted to sensor-motor aspect;

It is impossible to separate the complex relationship between knowledge, skills and values. As Pavlova comments many approaches to researching knowledge attempt to separate scientific knowledge from personal knowledge, knowledge from ethical and social issues (in the sense of separating these issues from cognitive aspects) and knowledge from values. She believes this is not sufficient to develop a coherent analysis of technological knowledge as it cannot be free from interests, desires and values (2005:128 -129).

Gouvinhas and Costa, when discussing the development of a knowledge management model to support product design, mention four types of conversions for knowledge:

- from *Tacit knowledge* to *Tacit knowledge*, or Socialisation (sharing, seeing, perceiving, experiencing.). 'Without sharing experience it is difficult for anyone to know the process of other individual's reasoning';
- from *Explicit knowledge* to *Tacit knowledge* or Internalisation (Operational - reading, hearing, individual interpretation);
- from *Tacit knowledge* to *Explicit knowledge* or Externalisation (Conceptual – writing, talking, symbolism, articulation, images, models);
- from *Explicit knowledge* to *Explicit knowledge* or Combination (systemic – group, combine) (2003:3).
Knowing *that* is not only ‘that part that is held in an individual’s memory (…) but also knowledge about where to find such items’ (Rodgers and Clarkson, 1998: 252). This idea echoes Polanyi who wrote, ‘…we are interested less in the stocks of truths that they [people] acquire and retain than in their capacities to find out’ (Polanyi, 1962: 28-29) (e.g. Figure 2.13).

- I know *that* recycled plastic material can be used for interior and exterior applications.
- I know *that* I can find the typical tensile strength of the ‘origins’ range of recycled plastics by looking on their website (Web 4)

Figure 2.13. Knowing that is not only that which is held in memory (pictures from design work done at Loughborough University, www.lboro.ac.uk)

In designing, knowledge on its own may be insufficient because ‘from all this, one does not really know the product, only of it’ (Pedgley, 1999: 53) and people are more concerned with ‘operations than with the truths that they [people] learn’ (Ryle 1948: 28). That is to say, knowing how can be derived only from personal experience. For example I can be told that when sawing recycled plastics sheet that fine teeth are preferred and wavy set or skip tooth saws are recommended. I can be shown that using a relatively slow feed helps ensure swarf is rapidly removed. I can be told that HDPE boards are difficult to glue but lap joints can be glued using primers and cyanoacrylate adhesives, and that adhesives used on polystyrene can be used on the HIPS range. I can be shown that I can shape the plastic using heat bending or vacuum forming techniques, but from all this I will still not know *how* to ensure the outcomes of these methods are successful (see Figure 2.14).

Figure 2.14. Things I can know but still not know how
Richard Kimbell recently presented the term 'indigenous knowledge' (2005) which recognises the importance of cultural, local and traditional knowledge. One example he gives of indigenous knowledge is from his observations of the construction of dhows (sailing craft, see Fig 2.15). He saw how raw materials (trunks of teak) were being selected, shaped and fixed by hand, without a single drawing. The builders ‘knew’ how to shape and fix it (2005:9) He goes on to explain that many of the examples of indigenous knowledge he came across (during travels across Africa) relate to ‘practical knowledge; the kinds of know-how that make life live-able in the local situation (...) In short, indigenous knowledge is typically design and technology knowledge, which is ‘know-how’ rather than ‘know-that’ (2005:9). This also relates to tacit knowing, that is to say that some actions are not based on any explicit, or formally constructed or documented forms of knowledge.

Fig 2.15. A dhow made using indigenous knowledge? Picture from (http://www.mnstate.edu/robertsb/eastafrica/img100.JPG).

Pavlova presents two views on knowledge in education, one of the need for formal knowledge, or knowledge that develops frameworks for action, and one of the need for epistemological knowledge, or knowing that develops by doing (2005:137). Introducing the concept of skills, Polanyi states ‘... you cannot acquire a skill merely by learning to perform its fragments, but must also discover the knack of coordinating them effectively’ (1962:602) Hicks et al introduces four categories to identify skills (See Table 2.2).
Table 2.2. Identifying the skills used in design decision-making (Hicks et al, 1982: 4-5)

<table>
<thead>
<tr>
<th>Category</th>
<th>Includes the ability to:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investigation</td>
<td>▪ recognise the existence of a problem which may be amenable to solution&lt;br&gt;▪ perceive, or identify through investigation, how far a given thing or system meets the stated need&lt;br&gt;▪ look for information and resources and generate information through observation and experiment&lt;br&gt;▪ judge how relevant, sufficient and reliable are the information and resources obtained&lt;br&gt;▪ employ a balance of knowledge, analytical skills and judgement in reaching conclusions in the face of ill-defined problems</td>
</tr>
<tr>
<td>Invention</td>
<td>▪ initiate and develop ideas and images of proposed things or systems, and to manipulate, rotate and transform those images&lt;br&gt;▪ think of alternative configurations for a desired thing or system and to adapt, transform and select from these to meet given needs&lt;br&gt;▪ express these images in various ways, such as sketching, drawing, diagram making, constructing, or through the use of notation or language, and thus communicate information about them to others</td>
</tr>
<tr>
<td>Implementation</td>
<td>▪ examine the integrity and coherence of a product or system, how well it matches its requirements and how well the requirements themselves are appropriately defined&lt;br&gt;▪ plan a practical activity and see it through&lt;br&gt;▪ select from available resources the most appropriate means for gaining desired effects&lt;br&gt;▪ use tools, instruments, materials, components, appliance and appropriate energy resources&lt;br&gt;▪ monitor and measure the effects of operations and to control their outcome</td>
</tr>
<tr>
<td>Evaluation</td>
<td>▪ discern the context within which the designed product or system is to be considered, and to identify the related criteria by which it should be judged&lt;br&gt;▪ choose the measures appropriate to given criteria and to devise practical or logical tests to determine the performance of a given product or system in relation to them&lt;br&gt;▪ form judgements about the balance or merit of a given thing or system in respect to given criteria&lt;br&gt;▪ distinguish between the needs of different sorts and to assign different degrees of importance or priority to given needs in different circumstances&lt;br&gt;▪ appraise the efficacy of a given design activity</td>
</tr>
</tbody>
</table>

Although Polanyi and Hicks et al are describing skills, they could arguably be describing know how. Attempting to distinguish between these two concepts has led to much
discussion in the prior art for this complex area of design decision-making, but it remains an unresolved area.

Pedgley describes know how as ‘knowledge from acquaintance’ and claims that ‘whereas know-how can be said to exist in one’s mind at all times (as tacit knowledge), the same cannot be said of skill, skill exists only during the performance of an activity’ (1999:57). Norman, quoting Archer and Roberts, describes forming images in the mind’s eye or a designer’s use of cognitive modelling (and especially in the sense of graphic modelling to represent ideas) as a form of skill (1998). This is reiterated by Pedgley, who describes ‘seeing’, or a designers cognitive ability to see more than what is physically there (form etc) as a skill (1999:63) Polanyi describes the ‘activity’ as the ‘performance of a skill’ (1962:602). For example a pianist can be described as giving a ‘skilled performance’ at a concert. However, when they have finished, we can still describe them as ‘possessing great skill’ or being a ‘skilled’ musician. Naughton and Walker suggest a distinction between know how and skill explaining that skill is a ‘whole business’ (Naughton and Walker, 1982) or, in Norman’s words, the ‘enabling force’ (1998). Pedgley agrees when he states ‘what an observer sees in an individual’s practical action is not solely know-how, but skill, of which know-how might be one element’ (1999:56). In his book The Concept of Mind, Ryle categorises knowledge as, ‘know that’ and ‘know how’(1948). Naughton and Walker suggest that in the practice of skills, these two types of knowledge can be mutually exclusive, they actually interfere with one another (1982).

It is acknowledged that understanding ‘knowledge’ may not be enough to understand decision-making. For example Pedgely asks, ‘Aside from possessing knowledge, what is it that predisposes an individual to apply knowledge?’ (1999:50). Pring states, ‘Something learnt can be ‘impersonally packaged’ and has to become ‘personally significant” (ibid). Pedgley attributes knowledge becoming personally significant to acquiring know how and the application of values in the form of value judgments. Value judgements are expressive statements that make values explicit (Keeney, 1992:7).This suggests that one use of values in design decision-making is to make knowledge more significant for use.

Dasgupta introduces the concept of ‘bounded rationality’ (Dasgupta 1996:43). A designer's knowledge may be erroneous, they may not posses the requisite knowledge to lead to a desired goal, or knowledge may be incomplete (i.e., deciding whether or not to take an umbrella) (Dasgupta, 1996:43-44). This personal use of knowledge suggests that there is ‘some higher quality depending on some identifiable body of knowledge lying outside and beyond the problem’ (Lawson 2004:10) This allows designers to make judgements about what knowledge to bring to a project when its problems are not expressed completely. Allowing different designers to end up with quite different solutions given the same start point (Lawson, 2004:13). Lawson comments:
This knowledge is predictive but uncertain and laden with values. It is clear that the application of such knowledge is a highly selective process and therefore inevitably results in designers making their own unique interpretation of design problems (Lawson, 2004:14).

In some instances the designer may not be able to use the information in its original form and may need to deconstruct and restructure it as necessary (Layton, 1993, see Figure 2.16) because ‘...in order to be used effectively it must be transferred into designerly knowledge’ (Cross, 1982). This is especially important in our understanding of skill as Layton suggests this restructuring occurs for practical action.

![Figure 2.16. Restructuring of designerly knowledge (Layton 1993)](image)

This ‘personalised’ way in which designers use propositional knowledge is supported by Daley who states: ‘...the mind may not have a systematic way of knowing or conceiving, the schemata of which can be definitely described’ (Daley, 1982) or that designer’s may use visual rather than verbal representations of information. Daley’s term ‘schemata’ refers to organised networks of knowledge. It is considered as a dynamic entity, where the strength of links between networks varies and changes (See Fig 2.17). This network of organised schema is also attributed to our ability to perform certain skills, such as face recognition (Daley, 1982), or the tacit knowledge of procedure (Schön 1983, Pedgley 1999).
In a paper in which he attempts to clarify the meaning of the term cognition, and its use in design and technology Archer states:

'cognition' is intended to embrace all those processes of perception, attention, interpretation, pattern recognition, analysis, memory, understanding and inventiveness that go to make up human consciousness and intelligence (Archer 1992b: 5).

Archer describes cognition as a series of signals that are collected and interpreted. These can be overlaid with 'all sorts of irrelevance, interference and noise, and distorted on reception by all sorts of errors, illusory juxtapositions and omissions' (Archer 1992b: 5). He suggests that these signals can link and form associations, or deny the conception of others and are integrated to become an individual's cognitive model of external reality 'There is evidence that the human mind is predisposed to seek similarities within and between its accumulating conceptions, and to assign these to categories' (Archer, 1992b: 5). It is also from this ability to order our cognitive 'signals', that rational thought appears. The use of cognitive processes to assign symbols to represent conceptions, categories and relations. The use of symbols permits abstraction in inner thought. (Archer, 1992b: 5).

The expression 'cognitive modelling' is intended to refer to the basic process by which the human mind construes sense experience to build a coherent conception of external reality and constructs further conceptions of memory and imagination. The expression 'imaging' is intended to refer to that part of cognitive modelling which construes sense data and constructs representations spatially and presentationally, rather than discursively and sequentially (Archer 1992b: 6).
Lawson (1993) agrees with Cross (1982) that designers' do have a 'designerly way of knowing' when he suggests 'knowing by doing'. Lawson observed that he could tell a designer from a non-designer because there 'seems to be a certain kind of knowledge and understanding that is very hard to attain in any other way other than by actually designing seriously' (2004:7). He also observes that designers bring a lot to the situation that was not in the original problem, knowledge from 'outside the problem', knowledge dependant on 'having seen things' (Lawson, 2004:9).

Design solutions are characteristically holistic responses to the design problem (Lawson, 2004:13). Designers work within, and are products of their culture. They have acquired knowledge from that culture, and work with technologies which embody the accumulated knowledge of their society. They develop personal values, but are influenced by the values of all the stakeholders to a design (Norman 2005). Pedgley suggests that it is the interaction of knowing that, knowing how and values that allows designers to complete designerly activities. The example he uses is spray painting where he describes the need for:

- knowing that the principles of high quality spray painting are such and such;
- tacit knowing, or know how of the intricacies and intimacies of painting; and
- values, to direct the activity (Pedgley 1999:55).

Pavlova uses the term 'praxiology' to describe the theory of efficient action with the guidance of practical values (not aesthetic or moral) as a form of practical knowledge and presents a view that although different they are both considered as knowledge of accumulated practice (2005:133). Many authors believe that know how, know that and values do not, and cannot occur in isolation. Gouvínhas and Costa talk about knowledge being a mixture of experiences, values, contextual information and intuition, forming a framework that enables a person to evaluate and obtain new experiences and information (2003:2). Shaw and Perkins agree, presenting a model of design that relies on a system of faiths (a combination of values, knowledge and experience) working as 'lenses' through which the world is noticed and moulding their form of acting (cited ibid:5). Gouvínhas and Costa agree, commenting that the ‘...larger the individual’s knowledge the [better] will be his/her appreciation and analysis of the data and information available. As a consequence, the better is the quality of the decisions taken within the product development process’ (2003:2). This makes sense as, for example, to have propositional knowledge of how difficult a process or craft is will lead to further appreciation of a good example of an outcome of that craft or process. This strengthens the need to develop a strong understanding of values impinging on the decision-making process in order that it may be possible to isolate them from other decision-making activities that may be occurring in parallel.
2.3 Summary

Chapter two has discussed a number key models of designing from the literature and provides a justification for the choice to conduct this research programme within the established model of the influences on design decision-making being classified within a framework based on:

- knowledge;
- skills; and
- values.

The role of knowledge, skills and values within design decision-making described by the prior art is discussed. The use of values in industrial design decision-making is introduced and justified through the following:

- that designers satisfice, in that they must find an acceptable solution to a problem and decide which solution is best;
- that design problems are ill-defined;
- that design problems are not amenable to scientific solutions, and therefore some other judgement is required;
- that designers must find some way to reduce avenues of enquiry.
Overview: Chapter 3 is an in depth discussion of the role of values in design decision-making as presented in the previous literature. The broad understanding of values is explored, including those held by society (external values) and by the designer (internal values). Previous methods for assessing values and the value of products are described, as well as the embedding of values in products and visual representations. The changing role of value in relation to design expertise is discussed.

3.1 Introduction

In his paper for the Royal College of Art, Roberts states the 'pursuit of design and technology activity can rarely be entirely free from the exercise of value judgement' (Roberts, 1993:9).

At present there is no key agreed consensus of the meaning and scope of application of values and little indication of those deemed important to design decision-making. The Concise Oxford Dictionary defines value as 'the worth, desirability, or utility of a thing, or the qualities on which these depend' (1992:1356). This suggests that it is not only intrinsic value that is of interest but also the value of the resultant outcome in the sense of how it affects the user. They also retain a more traditional definition of values as being 'the amount of money or goods for which a thing can be exchanged in the open market...' (ibid:1356). Lonchampt et al define value as the result of the 'judgement related to the product on the basis of the user's expectations and motivations, expressed by a ratio which grows when, all others things being equal, the satisfaction of the user's need increases and/or that the expenditure related to the product decreases' (2003:3). They have made a connection between economic output and social values. The Concise Oxford Dictionary goes on, describing value as 'the ability of a thing to serve a purpose or cause an effect' (ibid:1357). It can also be used to imply an order by which a selection of items should be ranked. The Concise Oxford Dictionary also defines value judgements as 'a subjective estimate of quality etc' (ibid:1357). Pavlova explains values provide the basis for choice and are relative to particular situations and that value judgements are the means by which values are made explicit in decision-making (2005:142). European standard EN12973 defines value as 'the relationship between the satisfaction of many different needs and the resources used in achieving so'. Elhamdi et al provide another definition when they describe value creation as an act of 'consuming and transforming input values in order to provide clients and other stakeholders with output values' (2003:1). Keeney describes values as '...principles used for evaluation, we use them to evaluate the actual
or potential consequences of action and inaction, of proposed alternatives, and of decisions' (Keeney, 1992).

Cagan and Vogel quote Webster's dictionary describing value as the 'relative worth, utility, or importance of one item versus another; the degree of excellence'; or something 'intrinsically valuable or desirable' (2002:57). They go on to explain that these days rather than value referring to the cost of the product, it now refers to quality and the 'perception of excellence' (ibid:57), although they still acknowledge that cost is an important issue. They then present their own definition of values as 'the level of effect that people personally expect from products and services represented through lifestyle impact, enabling features, and ergonomics, which together result in a useful, usable, and desirable product' (ibid:58). Graber identifies four definitions of value in a design context:

- conception of what is ultimately good, proper or desirable in human life;
- a person's willingness to pay the price of a good in terms of cash in return for certain product benefits;
- value as a meaning and meaningful difference (or the context in which products are used and how they are made sense of); and
- value as experience (cited Boztepe, 2003).

The notion of value oscillates between concepts like economic returns and moral standards. For example, there is a general belief among designers that design can 'add value' by devising products with 'increased value' which 'embody social values' (Boztepe, 2003). These statements are more directed toward value for the consumer, rather than those values which influence a designer to take one decision over another.

One of the most common understandings of values is in relation to economic issues. It is clear that artefacts have economic values placed upon them in that they must be purchased before they can be used. During the industrial revolution what the early engineers did was to 'turn ideas into saleable products and so also into wealth. In this they set the model for all designers in subsequent years' (Baynes, 2005:17). The designer has a commitment to stay within the project budget, and must know the cost of the materials and processes required to produce the artefact in the first instance. Cost is a common constraint placed upon the designer by stakeholders and therefore it is of importance in the sense of the success of the product that it be given due consideration during design decision-making. All products are designed to perform to particular requirements. Acceptable levels of these requirements are necessary at minimum cost, and will lead to increased competitiveness. The word cost, indicates a framework within which all industry must work. Product costs originate from the designer who has a responsibility to ensure
that the product gives optimum 'value for money'. Design practice has evolved to meet the following characteristics of the modern capitalist market place:

- design is seen as contributing to profits by devising commodities that can be effectively sold;
- design seeks a 'fit' between what can be made at a profit and what the user needs or wants;
- design problem solving (or opportunity seeking) takes place within the economic constraints of the market place;
- the emergence of new technologies constantly push design activity into creating new wants (and possibly new needs) (Baynes 2005:34).

Value is often described in terms of the economic sacrifice one is willing to make in return for a good or service. Ashby and Johnson make an important point when they comment that value depends on the market and industry at which the product is aimed: a titanium bicycle (to take an example) is attractive to mountain biking enthusiasts — to them its value exceeds its cost; but it is not attractive to the average city shoppers, who perceive the cost to exceed the value (2003:13).

The success of a product relies on a balance being made between features and cost. 'The role of business is to satisfy human needs and it expects to be rewarded with profits for doing so' (EE Report, 2000:4), therefore we can conclude that the cost of a product is undoubtedly related to its value within a social group. 'A product is economically viable if its value in the market place is greater than its cost by a significant margin...' (ibid).

The political, economic and environmental power of consumption is widely recognised as a central feature of modern industrial economics. This view is taken both by those who celebrate the creativity of capitalism and those who see it as a destructive force (Baynes 2005:8-9). Design is at the heart of the consumption enterprise, captured in phrases such as 'design for profit' (Baynes 2005:9). In this case money is the fundamental index of value (Boztepe, 2003). Such a view is problematic for design as it overlooks the situation of product use. Ken Baynes points out that

Design practice sets out to serve human needs AND solve problems WITHIN the imperatives of the market economy, particularly profit, growth and productivity. And, we might want to add: it is the last of these three that is pre-requisite (2005:10).

However, it is also clear that the economic value of the product is more complexly determined than simply the price of its constituent parts and the payment wanted, or estimated for it. Marx provides a dual nature of object value when he presents use value and exchange value (see Scott, 1920). Use value encompasses the utility of the physical properties of a product, as realised during its use in terms of what this allows the product
to be worth. Exchange value refers to the labour necessary for manufacture of the product and distinguishing it from its competitors and reducing prices (Boztepe, 2003).

Champions of sustainable initiatives are potentially driven by more selfish economic agendas. For example the development of renewable energies can be attributed in part to the oil price hikes of the 1970s. Soon there may also be economic value involved in the economic gain from the recycling or reuse of the product at the end of its life.

3.2 A more general understanding of values

In education, values were identified as contributing to design decision-making in the 1980s. Hicks et al (1982) identifies four areas within which values might be assessed within education (Table 3.1).

Table 3.1. Values acting on the decision-making process (Hicks et al, 1982:6-7)

<table>
<thead>
<tr>
<th>Category</th>
<th>involve the appreciation and application of:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical values</td>
<td>efficiency, and the ways in which input is compared with the resultant output</td>
</tr>
<tr>
<td></td>
<td>Robustness, flexibility, and the ways in which the performance of a man-made object or system might be sensitive to change</td>
</tr>
<tr>
<td></td>
<td>precision, and the qualities of fit and of fitness to purpose, valued either for their own sakes or as a means to an end</td>
</tr>
<tr>
<td></td>
<td>confidence, and the ways in which possible reliability or unreliability of information is taken into account</td>
</tr>
<tr>
<td>Economic values</td>
<td>the broad distinction between the ideas of use-value, intrinsic value and value-in-exchange</td>
</tr>
<tr>
<td></td>
<td>the distinction between value, price and cost</td>
</tr>
<tr>
<td></td>
<td>the marginal value of one product or product variation over another</td>
</tr>
<tr>
<td></td>
<td>the effects of variation in supply and demand on availability and price</td>
</tr>
<tr>
<td>Aesthetic values</td>
<td>the structures, proportion and colours to be found in the natural and the man-made world</td>
</tr>
<tr>
<td></td>
<td>of the importance of aesthetic factors in all forms of human communication and self-expression</td>
</tr>
<tr>
<td></td>
<td>the inter-relationship between workmanship, tools and the aesthetic quality of the resulting environment or artefact</td>
</tr>
<tr>
<td>Moral values</td>
<td>mankind’s impact on the natural environment and his responsibility for its and his own future survival</td>
</tr>
<tr>
<td></td>
<td>the inter-relationship between the man-made world and religious, social, economic and philosophies</td>
</tr>
<tr>
<td></td>
<td>the needs of individuals in society and ways of meeting them</td>
</tr>
<tr>
<td></td>
<td>the importance of ethical values in carrying out design activity and evaluating the effects of technology</td>
</tr>
</tbody>
</table>
Roberts (1993) outlines an additional area along the dimension of values (Table 3.2) that takes into account some of the additional examples of values within designing which may have been previously neglected.

Table 3.2. Hedonic values (Roberts, 1993)

<table>
<thead>
<tr>
<th>Category</th>
<th>Involve the appreciation and application of:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hedonic values</td>
<td>the role of vision, hearing, smell, taste and touch in attaching value phenomena through their direct appeal to the senses;</td>
</tr>
<tr>
<td></td>
<td>the role of appetite, desire, pleasure, pain etc, in the evolution of products and systems;</td>
</tr>
<tr>
<td></td>
<td>the demands made on the configuration of man-made things and systems by the physiology and psychology of people;</td>
</tr>
<tr>
<td></td>
<td>the importance of hedonic factors in all forms of design activity and an ability to take them into account when designing or evaluating things in the man-made environment.</td>
</tr>
</tbody>
</table>

This area was no doubt considered in 1982 (private communication from Professor Phil Roberts to Dr Eddie Norman), but was not included in the final report at the time.

Layton contributed to the debate of values in design and technology education with his International Design and Technology Educational Review (IDATER) keynote address in 1992 along with his chapter in the book Make the Future Work (Budgett-Meakin 1992). He stated 'values and value judgements are the engine of design and technology' (Layton, 1992: 36). He outlined the following value judgments as important:

- judgements about how intentions are realised shape the activity;
- judgements about efficacy and effects of the product influence the next steps to take;
- judgements reflecting people's beliefs, concerns and preferences are ubiquitous in design. (Ibid:36).

He also highlighted some different kinds of values in design and technology (see Table 3.3)
Table 3.3. Some different kinds of values in design and technology (Layton 1992:36).

<table>
<thead>
<tr>
<th>Values</th>
<th>Examples</th>
<th>Values</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical values</td>
<td>Right materials for the job, Improved performance of an artefact, 'Neat' solution</td>
<td>Social Values</td>
<td>Equality of the sexes, Regard for the disadvantaged and handicapped</td>
</tr>
<tr>
<td>Economic values</td>
<td>Thrifty use of resources, maximising added value of product</td>
<td>Environmental values</td>
<td>Ecological benignity, Sustainable development</td>
</tr>
<tr>
<td>Aesthetic values</td>
<td>Pleasing to handle, Attractive to look at</td>
<td>Moral values</td>
<td>Sanctity of life</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Spiritual / religious values</td>
<td>Commitment to a conception of humans and their relationship to nature</td>
</tr>
</tbody>
</table>

In his 1992 address Layton identified some of the stakeholders involved in the socio-political shaping of school technology and commented on each.

- **Economic functionalists** – economic competitiveness and wealth creation as sovereign values
- **Professional technologists** – The dominant value concern reflects the need to overcome society’s limited view of, and improve the professional image of technology and to see it as a major wealth creator and provider of services and systems.
- **Sustainable developers** – A values position encapsulated in the phrase ‘global responsibility’. The diverse representatives of this category believe technology education should empower people with the knowledge, skills and values needed to achieve an acceptable quality of life not only for themselves, but for future generations.
- **Women** – value female technical initiatives and aim to reconstruct women’s place in technological developments and bring a further dimension of values to technological discussion. Also to advocate for technology that empowers women intellectually, financially and politically and that sustains the natural world.
- **Liberal educators** – In contrast to serving external goals their value position is that education should initiate children to technological epistemology. (1992:3-8)

Further contributions from education are due to the recent promotion of values issues within the field, for example *Pupils Attitudes To Technology* (PATT) held a conference on values within design and technology in 2003. One paper outlined the values issues that have recently been added to the Scottish and South Australian curricula. The South Australian board even re-named the learning area from ‘technology’ to ‘design and technology’ as a ‘reflection of the values-rich and purposive-intentional activity of design compared with the object-and-use-only connotations of technology’ (Keirl and Mclaren, 2003:38). An overview of these can be seen below (Table 3.4).
### Table 3.4. Values issues within the Scottish and South Australian curricula (ibid, p35-40)

<table>
<thead>
<tr>
<th>a. Scotland</th>
<th>b. South Australia</th>
</tr>
</thead>
<tbody>
<tr>
<td>a caring and responsible disposition which asks and reflects about social, moral, aesthetic and environmental, as well as technical and economic aspects of technological activity</td>
<td>ethical, critical, enterprising and futures dispositions towards their own and other people’s products,</td>
</tr>
<tr>
<td>an inquisitive mind to bear on the man-made world and appreciate the complexity of decisions which may involve resolution of tensions between aesthetic, cultural, economic, ethical, and functional aspects of enjoyment of practical work and of it being worth doing well, and working alone, together, and with experts, and how each can help achieve solutions to problems</td>
<td>identify and critique the values underlying the intentions, design, manufacture and consequences of any technology</td>
</tr>
<tr>
<td>The importance of other people’s views, feelings and situations, the notion that ideas and solutions, which although satisfying some, might be unacceptable to others</td>
<td>consider and respond to the needs of diverse cultures</td>
</tr>
<tr>
<td>Social and environmental responsibility</td>
<td>responsible management and duty of care towards themselves and others when designing, making and using</td>
</tr>
<tr>
<td>The way products come into existence, are bought, sold, used and discarded and the effects upon social systems and environmental quality</td>
<td>examination of the competing values embodied in products</td>
</tr>
<tr>
<td>The interplay between meeting people’s needs through the use of materials, money and time conserving and improving the quality of the natural living environment through minimising the harmful effects of action</td>
<td>clarification of the relationships amongst people, products and quality of life, ethical analyses of various possible technical futures.</td>
</tr>
<tr>
<td></td>
<td>generation and management of design strategies to create ethically defensible products</td>
</tr>
</tbody>
</table>

### 3.2.1 Additional values taxonomies

Boztepe provides an overview of different definitional approaches to value in a recent conference paper (2003, see Table 3.5). She also explains her own difficulty in selecting an overarching definition stating “it is difficult to assume one of the definitions reviewed so far as encompassing” (ibid).
<table>
<thead>
<tr>
<th>Values as Belief System</th>
<th>Values as Exchange</th>
<th>Value as Meaning and Sign</th>
<th>Value as Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deep social structures</td>
<td>Price and desire for a product</td>
<td>Social and Cultural Context</td>
<td>Interaction between user and product</td>
</tr>
<tr>
<td>Value is Durable</td>
<td>Objectively determinable in terms of price</td>
<td>Subjective, almost arbitrary</td>
<td>Both objective and subjective</td>
</tr>
<tr>
<td>Unit of analysis</td>
<td>Exchange situation</td>
<td>Communication situation</td>
<td>Any point of experience with product</td>
</tr>
<tr>
<td>Product is Mean to higher ends</td>
<td>Sacrifice made by user measured in terms of cash</td>
<td>Utility</td>
<td>Enabling an experience</td>
</tr>
<tr>
<td>Application for design in global markers</td>
<td>Need for understanding of competitive ones, activities, contexts, meanings, and beliefs which make experience possible</td>
<td>Need for understanding of needs and ways of doing things</td>
<td>Need to resonate with different local belief systems</td>
</tr>
</tbody>
</table>

Table 3.5 Different approaches to value (Bozetepe 2003).
3.3 Internal and external values

Individual and collective action is informed by values. Designers have their own personal values that will direct and control their decisions, and they must also take into account, or are influenced by (either consciously or not), the values of society. Goonatilake states;

... (t)he scientific community does not exist in a social, political and economic vacuum and is therefore not socially autonomous. It is buffeted by the social, political and economic considerations of the society in which it is embedded (1984:69).

The same can be said for design, as it can have external (societal), and also internal (personal) influences.

Designers work within, and are products of their culture. They have acquired knowledge from that culture, and work with technologies, which embody the accumulated knowledge of their society. They develop personal values, but are influenced by the values of all the stakeholders to a design (Norman, in Baynes, unpublished).

3.3.1 Personal Values

(T)he designer is to a large extent free to design according to his own taste, style and abilities (it is of course not the case that the designer would never have to defend these aspects of the design to others, but in these areas the designer is dominant in the sense that he also provides the criteria on which this aspect or part of the design is to be judged) (Dorst, 2003:2).

Designers must make a number of decisions which significantly affect the outcome of a design project. Commenting about system designers, but equally appropriate to industrial designers, Kumar and Bjorn-Anderson comment '... in the absence of explicit policies or guidelines, these choices are determined, to a large extent, by the [systems] designers' personal values' (1990:528). For example, value judgements can be made based on 'preferences, priorities, opinions, convictions and emotions' (Pedgley 1999:51, see Table 3.6).

Table 3.6 Examples of internal values

<table>
<thead>
<tr>
<th>Internal Values</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Pedgley, 1999, p51) I think that shiny plastic looks terrible. An opinion which may sway the designer in this case away from the use of shiny plastic in the new product.</td>
<td>I have a passion for creating products in which materials provide people with a tactile response. An emotional state driving this designer's approach to product design.</td>
</tr>
<tr>
<td>all about for me'. An implicit statement of priority to focus thoughts on the determinations of a product's form and materials rather than in some other product feature.</td>
<td></td>
</tr>
</tbody>
</table>
Rokeach gives the following two categories for internal values:

- **Terminal values (end states of existence)** - exciting life, sense of accomplishment, equality, freedom, inner happiness, self-respect, social recognition, friendship and wisdom;

- **Instrumental values (modes of conduct)** - ambitious, open-minded, capable, helpful, honest, imaginative, intellectual, logical, responsible, self-controlled (1973).

Daley comments that a designer’s employment of values includes ‘... not only moral consciousness in the usual sense, although certainly that is included, but also in the sense of the ordering of conceptual priorities’ (1982:293). She goes on to explain that the ‘forms of our perception are determined by the limits of our a priori conceptual framework’ (Daley 1984:294) linking design activity and the application of value judgements to our personal experiences. Dörner backs up these ideas when he describes knowledge as ‘a source of analogies’. His example was:

> ‘Do I already know machines that serve similar functions?’ If this is the case then these machines are used as models for the new machine (1999:407).

However he also states that although this approach is helpful, it can also be dangerous as it may fence in the design process, thus ‘inhibiting the formation of new ideas. Experience can be a great help, but it can also be a barrier to new developments’ (Dörner 1999:408). Dörner also introduces ‘ballistic thinking’, where designers consciously choose not to ask important questions.

Even though the need to ask (oneself such) questions sounds trivial, a ‘natural’ demand, many people seek to avoid such questions. Sometimes it seems that designers are so happy to have arrived at a solution that seems to work, that they do not want to be confronted with the uneasy experience that they have not yet arrived at an appropriate solution to the problem (Dörner 1999:412).

Gregory and Commander made a further contribution to this area with an investigation into the adoption of new materials by industry (a paper particularly apt for this thesis) in which design behaviour as a whole was investigated. They present six models of design behaviour:
• information processing model: the activity of design comprises the handling and treatment of considerable quantities of information of various kinds;

• search and evaluate model: much of design activity consists of trying to find data, directions, concepts etc and evaluate them; only after much effort of this kind is it possible to arrive at or suggest a decision;

• decision model: design is characterized by a succession of decisions (heuristics) and, in the case of important decisions, there is likely to be a change in the pattern or level of activity afterwards;

• interaction model: those engaged in design have to interact with resources or people in the course of the design: with immediate colleagues the interaction is likely to have a technical character whereas for more distant interactions, e.g. top management or client, policy becomes important;

• organizational characteristics model: design activity is affected by size of company, production method ('technology'), nature of industry sector, etc;

• adoption factors model: adoption behaviour related to new designs, e.g. by other people within the organization producing the design, or by a client, is affected by a range of factors... (1979:107).

Kaldate et al (2003) write about decision traps as a result of heuristics and the development of a decision tool for overcoming these traps within the context of sustainable design.

Designers deal with this new set of complexities through a traditional reductionist approach, breaking the problem into smaller sub-problems and hoping that if they solve each of these sub-problems in isolation, it will lead to the desired final solution (...) It can lead to the products that do not reflect the true preferences of the customers, are not sustainable, or do not achieve the best level of sustainability possible (Kaldate et al 2003:1).

The process of anchoring, where designers select a design that is readily available from which they make modifications is another common heuristic reported by Kaldate (2003).
3.3.2 Social values

The historian David Noble explains that

"technology bears the social 'imprint' of its authors... there is always a range of possibilities or alternatives that are delimited over time – as some are selected and others denied – by the social choices of those with the power to choose, choices which reflect their intentions, ideology, social positions and relations with other people in society (Noble, cited in Layton 1992a:9)."

Noble also describes technology as 'frozen fragments of human and social endeavour' (cited Layton 1992a:10). Writing with experience of technology transfer from the industrialised to the third worlds, Susantha Goonatilake describes technology as a social gene – a carrier of social relations from one society to another (1984). Values are embedded in a social context (see Table 3.5), they are practically and concretely realised in social action and organisation. The effects of values on the world of experience only become tangible, interpretable or contestable when one action framework encounters another: when more than one way of acting in and on the world is possible and a choice must be made (O'Brien and Guerrier 1995:xiii).

There is however an alternative view of the relationship between products and society. In the words of Layton 'the counter proposition in its extreme form argues for technological determinism' (Layton 1992a:10). That is technology as a force which is shaping society.

We are progressively being manoeuvred into ways of acting – both in the home and in employment – which are not of our deliberate choosing, but which are dictated by the technologies we have ourselves created. Far from our values shaping technology, technology is shaping our values (ibid).
Table 3.7 Social values in design

<table>
<thead>
<tr>
<th>(Layton, 1992a, p37-38)</th>
<th>The value of occupational hierarchies is preserved through the design of office furniture that differ in size from the large managerial desk to the smaller, more reserved work station for a secretary.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>The design of mousetraps reflecting the culture in which they are used, the French version, modelled on the guillotine and an Egyptian one which entombs the hapless mouse in a pyramidal structure.</td>
</tr>
<tr>
<td>Goonatilake (1984, p71)</td>
<td>The success of joint ownership schemes is dependant on the value placed on collectivism rather than individualism. Therefore because of the social status of owning a personal computer, in western societies the design of a central IT service would probably fail.</td>
</tr>
<tr>
<td></td>
<td>The values of certain societies can also become direct drivers of design decisions, for example the post World War II competition between the American and Soviet Union military machines, in which their science and technology both vie and mirror each other.</td>
</tr>
<tr>
<td></td>
<td>Other examples include the space race and in a modern context the competitive nature of large transnational corporations.</td>
</tr>
</tbody>
</table>

Allowing design decisions to be influenced by societal values is important and has been attributed to contributing towards the success of the product. Layton defines this as ‘technological adoption’ (Layton, 1992a:39):

...it appears that a technology becomes a successful one, in the sense of achieving widespread adoption, when values embedded in the design are congruent with those of social groups in that particular culture. (Layton, 1992a:40)

Josephine Green (Director of Trends and Strategy at Philips Design), agrees stating ‘It is still widely assumed that technology drives growth. However history shows us that technological innovation is a strategically important condition but, if it is offered to a society that is culturally, socially, and economically unprepared to accept it, its value will be lost...’ (2003a:21). Layton also states that ‘technological obsolescence or senility’ (ibid:41), or when a product is no longer desired by society, refers to the changing of values within social groups leading to a product becoming ‘dysfunctional within the culture it is placed’(ibid).

It is also clear to see that an understanding of these more emotional values is present within the commercial design industry. In fact, in some forward thinking companies such as Phillips (www.design.phillips.com), research into social, environmental and economic values has become an important part of research and development (R&D). From this they developed the ‘Living memory’ project, that used an understanding of social values to create new technologies, and ‘The Q4 plugged’, developed through a realisation that the values people place on living areas has changed and so have the activities that take place within them (See Figures 3.1 and 3.2).
Some companies are using these emotional responses to over design elements within their products to reflect the values that are embedded within them. 'The use of Allen screws to mount the machined steel filler cap of the Audi TT and the prominent welds of the mountain bike express the engineered robustness of both products' (Ashby and Johnson, 2002, see Figure 3.3)

Needs are experienced (including physical ones) within cultures (Boztepe, 2003). An example of this is provided by Boztepe who describes different bathtub designs relating to cultural use values, with western cultures opting for a design where the occupant can lay, Japanese culture opting for a seated bathtub design, and the Turkish culture opting against bathtubs altogether in the belief that washing should involve running water (Boztepe, 2003). Context and product may denote added value to certain materials. The potential for innovation, novelty value, acceptable degree of risk, value of performance against cost of failure all cause materials to take on different added value to the designer or design team. For example in sports equipment performance is key, so new materials with superior properties and performance attributes will hold more value than others. In the design of nuclear reactors, risk is high and safety is key. So materials that have increased safety performance properties, but still hold other properties in keeping with current materials are going to have added value (Ashby and Johnson, 2002:159).
Designers in a sense have to represent consumers and carry out 'thinking' on their behalf (Baynes 2005:59). This thinking is within broader agendas of their own, but may also be directly influenced by consumers, and other members of society (See Fig 3.4).

![Economic Situation Diagram](Baynes 2005:60).

Fig 3.4 Ways of influencing design activity open to the consumer (Baynes 2005:60).

The frequency to which members of society are involved in design and to what end, is at the discretion of the designer. Some members of society will only come in contact with the product when it is sold, or at the latter stages of design development. Others may become engaged earlier in the design process, either at specific stages or for prolonged periods (see Table 3.8).

<table>
<thead>
<tr>
<th>Involved</th>
<th>Those directly engaged with the activity of designing over a period of time as the design develops</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consulted</td>
<td>Those whose advice is sought on a regular basis at specific stages during the development of the design (or possibly only once at the outset)</td>
</tr>
<tr>
<td>Persuaded</td>
<td>Those who are presented with information about the design as it develops in a marketing style of presentation</td>
</tr>
<tr>
<td>Excluded</td>
<td>Those who will be involved in the product of the design activity but whose views are not sought</td>
</tr>
</tbody>
</table>
The consumer plays a role in influencing design decision-making. Goonatilake comments that technologies not only influence the shape and structure of society but that technologies are also shaped by socio-economic systems and pressures (1984:121). He goes on to explain that these socio-economic factors are specific to time, region and other limiting factors and as a result technology carries the ‘scars of the socio-economic system that gave birth to it’ (ibid:121).

Holbrook suggests that different value perspectives can be considered using the following classifications:

- **Intrinsic-extrinsic**: where a product is valued as an end itself or for its ability to help the user achieve a desired end (sculptural pieces).
- **Self orientated-other orientated**: whether the product is valued because of its value to the user or for the reaction of others.
- **Active-reactive**: whether there is a manipulation to a product by the user, or vice versa (cited in Boztepe, 2003, see figure 3.5).

![Fig 3.5 User value types (Holbrook, cited in Boztepe, 2003:5)](image)

Holbrook also suggests a classification of consumer values.

- **Social value**: a product’s ability to achieve social objectives (affirming status)
- **Emotional value**: the emotions the product provokes
- **Altruistic value**: provokes a sense of being right or good (green products) (cited in Boztepe, 2003).
3.3.3 Values embedded in design

We all use products to communicate ourselves to one another and so we can conclude that these products carry with them a huge amount of information and embedded value. They carry with them the values of the creator and the society in which they were made (Goonatilake 1984). Layton highlights the values carried within existing products by the way a new society adapts to suit them (Layton 1992a, p41). For this reason industrial designers may research prior work and use existing products as a great source of inspiration as there is '...a great wealth of knowledge carried in objects of our material culture...' (Cross 1982:225) and in many cases work from 'existing products to create new ones' (Middleton 2003:111).

Designers also have an understanding of the additional values a product holds outside of its material, tangible structure, for example.

- **Physio-pleasure**: pleasure derived from the sensory organs (i.e. the use of 'new car' smell spray in second hand automobiles).
- **Socio-pleasure**: the enjoyment derived from the company of others, (i.e., products that facilitate social interaction, such as a coffee machine. Or products that make people feel part of a social group, such as a Porsche).
- **Psycho-pleasure**: pleasure from the accomplishment of a task (i.e., a computer).
- **Ideo-pleasure**: pleasure derived from theoretical entities, such as the aesthetics of a product or the values that a product embodies (i.e., a product made from biodegradable plastic embodying the values of environmental responsibility) (Jordan and Macdonald 2002:265).

These additional values are sometimes referred to as a product's semantics. Semantics refers to the language of products and the messages that they communicate, it can employ metaphor, allusion, and historical and cultural influences for example. It can also provide visual clues for its use (Jordan and Macdonald, 2002:266). Product semantics are related to psychology, anthropology, linguistics and semiotics. It is not easy to interpret the meaning of an artefact, because the meaning is dependent on the context in which it is shown, and the personal and cultural background of the interpretant (Feils and Overbeeke (2003:1). It is the challenge of the designer to understand the meaning of things, and how their artefact may be interpreted. An even greater challenge is to create value by designing useful and meaningful products. Roughly speaking, the designer has to create value not only by creating useful functionality but also meanings that convey human values beyond functions; this is where designing engages with ethics and humanistic values (Flejs and
Overbeeke, 2003: 1). Two examples are the Karrimor ‘Condor’ rucksack buckle, which closes with a positive click, giving the physio-pleasure projecting a sense of reliability; and the NovoPen, a diabetic syringe designed to look like a pen, thus embedding more positive values than those associated with the drug abuse of medical syringes (Jordan and Macdonald 2002: 266).

It becomes clear when we look at certain products that Robert’s hedonic factors see section 3.2) and tacit emotional responses have a huge impact within design. If we compare a polystyrene cup to one made of glass, they are visually nearly identical (Figure 3.6), and it is not until we engage our tactile and acoustic senses that we notice a difference.

It is also very clear that Marx’s economic value system does not take into account the high value of a range of products (such as gifts) that were not expensive, or utilitarian, or scarce, but nevertheless are highly valued (Boztepe, 2003). People often value products for what they signify. We have already seen many examples of this (see Figure 3.7). Are the societal values that influenced the creation of these three desks now embedded within them?
Martin comments that technology cannot be value free and that the artefacts we see around us reflect the values of our society, the values of the designer, and the values of other stakeholders, as well as the perceived values of end users (1999: 56).

Layton highlights the values embedded in design by the way in which a recipient value system adapts to suit a product or technology. Transfers from the industrialised minority world to the rural minority world provide us with a clear example of this occurrence; the snowmobile was transferred from North America, where it was used predominately for winter sports, to Lapland for use in reindeer herding, and with it came profound changes to Laplanders value systems: The capital outlay and the expenses of maintenance meant that relatively few families were able to participate in herding by snowmobiles. Those who adopted the technology found it more economical to work with larger herds; as a result, small farmers, previously with their own herds were bought out, becoming waged labourers or unemployed (Layton 1992a:41). This led the previously egalitarian society to be transformed into an in egalitarian, hierarchical society. In this sense design outcomes can be viewed as having embedded within them the values of the creator and the society they were created in. They carry '...the scars of the socio-economic system that gave birth to them' (Goonatilake, 1984:121).

Previous designs furnish a vocabulary both for thinking about new designs and for describing designs to others. Often the referents of these descriptions are not present but are understood due to shared cultural experiences. These can be in the form of: comparable designs (other similar artefacts), other types of design, or objects from everyday life (Eckert and Stacey, 2000:523 - 524). They go on to explain that these images not only reveal details and carry information about manufacturing processes, but also already have some sort of interpretation attached to them in the way they have been created, interpreted and the context created by them, or by the people who own them. They also explain their use to define contexts, trigger ideas and as anchors for structuring mental representations (Ibid:524 - 525). They suggest the following ways in which they are used ( from research within the knitwear industry, see Table 3.9):

<table>
<thead>
<tr>
<th>Table 3.9 Uses of design inspiration (Eckert and Stacey, 2000:525)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Starting design</strong></td>
</tr>
<tr>
<td><strong>Precedent</strong></td>
</tr>
<tr>
<td><strong>Reuse</strong></td>
</tr>
<tr>
<td><strong>Pattern</strong></td>
</tr>
<tr>
<td><strong>Primary generator</strong></td>
</tr>
</tbody>
</table>
Marx's idea of use value, where the value of a product lies in its use, and therefore not in the product itself, is reiterated by Adam Smith who believed the value of objects is derived from their relationship with the human body. In opposition to these normalist views, Simmell's relativist theory of value believes that value is inherent to the product and is enhanced by subjective judgement (Sassatelli, 2000:210).

Products will undoubtedly have personal values imposed upon them, the internal preferences of the designer or stakeholders. But do products have attributes and associations? Can they affect social, political and religious positions and beliefs? Can they have personalities? Can values reside within products? 'At first sight no — it only acquires these when used' (Ashby and Johnson 2003:73). However, if we view value as arising purely from social context, then we leave no room for design to contribute (Boztepe, 2003:6), or indeed for products to contribute to design. She suggest that the value comes from a 'persuasiveness from design including.

- **Form, colour, texture and materials** — to make sense of products, provoke emotion and communicate utility.
- **Symbolic elements and metaphors** — to communicate aspects of object value
- **Archetypes and historical forms** — to serve to embed products into the fabric of society.
- **Affordances** — to denote what products can do.
- **Stories and myths** — to create connections with beliefs and desires (Boztepe, 2003).

If we look more closely at a material, for example wood, we can see that it achieves its character from an intricate pattern of knots, colours and rings which are present long before the designer has fashioned it into a product of sorts. We can also look at products, such as the simple table, that achieves its favour with stakeholders through the use of desirable materials and finishes, as well as its designed form. 'So there is a character hidden in a material even before it has been made into a recognisable form — a sort of embedded personality, a shy one, not always visible, easily concealed or disguised, but one that, when appropriately manipulated, can contribute to good design' (Ashby and Johnson, 2003:76).

There is already an understanding of this embedded character made apparent through literature regarding selection by synthesis. For example trendy products are fashioned with transparent, brightly coloured plastics such as polycarbonate, polypropylene and polyethylene and humorous product design can be achieved using soft, coloured elastomers (Ashby and Johnson, 2003:126). It is also clear that certain materials can be connected to eras and movements throughout history, such as wood, bronze and iron and the Art Nouveau period.
It is important at this point to mention that these concepts do not occur in isolation and that the achievement of product personality cannot be successful solely by the correct choice of material, but is the clever manipulation of a variety of methods. For example it has already been mentioned that the creation of humorous products can be done through the use of soft, coloured elastomers. But to be successful this must also be 'integrated with over-moulding, simple shapes and references to animals' (ibid:126).

Designers also use products as a great source of inspiration and studies have shown that inventors not only use mental images but also 'worked from existing objects to create new ones,' (Middleton, 2003:111). Ashby and Johnson also suggest that it is common for designers to undertake 'selection by similarity, seeking materials with selected attributes that match those of an existing material, without knowing why these have the values they do, merely that they are relevant for the success of the design' (2003:131). These objects must have therefore held some value to the designer in their original form or they had 'some meaningful relationship to the to-be-invented object' (Middleton 2003:111). This concept is important in our understanding of the influence of values on design decision-making as:

There is a great wealth of knowledge carried in the objects of our material culture.... A significant branch of designerly ways of knowing, then, is the knowledge that resides in objects. Designers are immersed in this material culture and draw upon it as the primary source of their thinking. Designers have the ability to both 'read' and 'write' in this culture... (Cross, 1982:225).

Layton comments that it is sometimes argued that technology is value-free. It is the use of that technology that determines its value. He gives the example of an axe, as an artefact, being neutral until it is used either constructively or destructively (Layton 1992a:9). However he comments that this argument does not stand up to close scrutiny (consider for example, a gas chamber) (ibid:9).

It is always difficult to isolate the material artefact from the network of human activities in which it is inextricably enmeshed – and hence from the values of people (...) Also, an artefact-such as a motor car-can reshape people's values and call new ones into play. It makes possible new kinds of actions between which people have to choose; they are inexorably driven into the realms of value judgement (Layton, 1992a:9).

His essential point is that technological innovations alter the circumstances in which our choices have to be made (Layton, 1992a:9).
This brings us to the importance of 'dispositional concepts' (Ryle, 1948:44) and their use by designers (however tacitly) to convey the correct message through their products. Designers are aware of how others perceive their products and of the values of the society they are designing for and use this to direct their decision-making. Ryle describes dispositional concepts as knowing how, but it is clear to see that their application is based on values.

...simple observation of an artefact does not usually allow us to discern the inherent values directly. Values – technical, social, political, economic, aesthetic, environmental or ethical – do not stand out on the surface of, say, a telephone hand piece, a hair drier or a torch (Layton 1992a:10).

He goes on to offer that these 'hidden' values become visible from adoption (whether a technology becomes widely used), obsolescence (when a technology is abandoned) and transfer (when a technology moves from one society to another)(Layton 1992a:10).

3.4 Methodological approaches for assessing values

Cagan and Vogel in their book *Creating Breakthrough Products* identify what they refer to as 'Value Opportunities' (VOs), a discrete set of attributes for evaluating value in products and services, suggesting that value can be 'broken down into specific attributes that contribute to a product's usefulness, usability, and desirability, and connect a product's features to that value' (2002:62).

'It used to be that the more features you could get in a product for the least price you could pay the more 'value' you were told the product had (....) For products that are highly desirable, value is not the more features you can get for the least money but rather how effectively the product or service meets personal expectation of usefulness, usability and desirability. Value is represented through impact of the product or service on the user's lifestyle, use of the product or service or service through enabling features, and meaningful ergonomics' (Cagan and Vogel, 2002:2)

These VOs consist of seven classes that present opportunities to add value (and assess the value already present) in a product or service and each product should capture a range. These seven classes are outlined in Table 3.10 below.
<table>
<thead>
<tr>
<th><strong>Class</strong></th>
<th><strong>Explanation</strong></th>
</tr>
</thead>
</table>
| **Emotion**| Emotion defines the essence of the experience as perceived by the consumer. Attributes of emotion include:  
  - Sense of adventure: promotes excitement and exploration.  
  - Independence: provides a sense of freedom.  
  - Sense of security: provides a feeling of safety and stability.  
  - Sensuality: provides a luxurious experience.  
  - Confidence: supports the user's self-assurance and promotes his or her motivation to use the product.  
  - Power: promotes authority, control, and supremacy. |
| **Aesthetics**| Aesthetics focus on sensory perception and includes:  
  - Visual: relates shape, colour and texture to the context and target market.  
  - Tactile: physical interaction must enhance the product experience.  
  - Auditory: emits appropriate sounds and eliminates undesired sounds.  
  - Olfactory: must have an agreeable smell, and eliminate undesirable odours.  
  - Gustatory: products that are designed to be eaten, used as a utensil, or may otherwise be placed in the mouth must have an optimum flavour, or no flavour at all. |
| **Identity**| Personality: the product's ability to fit among yet differentiates itself from competition and the connection that it has to the rest of the products produced by that company.  
  - Point in time: it has to capture a point in time and express it in a clear, powerful way.  
  - Sense of place: designed to fit into the context of use. |
| **Impact**| Social: may have a variety of effects on the lifestyle of a target group, from improving the social well being of the group to creating a new social setting.  
  - Environmental: minimising negative effects on the environment due to manufacturing, resource use of the product during operation, and recycling. |
| **Ergonomics**| Ease of use: must be easy to use from both a physical and cognitive perspective. Should function within the natural motion of the human body. The size and shape of components that a person interacts with should be logically organized and easy to identify, reach, grasp, and manipulate.  
  - Safety: must be safe to use. Moving parts should be covered, sharp corners eliminated, and internal components shielded from users.  
  - Comfort: should be easy to use and not create undue physical or mental stress. |
| **Core technology**| Enabling: core technology must be appropriately advanced to provide sufficient features. It must meet customer expectations in performance.  
  - Reliable: consumers expect technology in products to work consistently and at high level of performance over time. |
| **Quality**| Craftsmanship: fit and finish. Made with sufficient tolerances to meet performance expectations.  
  - Durability: performance over time. The craftsmanship must hold up over time. |
Fugita, Takagi and Nakayama present a method of adding value through the addition of functions and even refer to features as creating values: ‘Diverse kinds of features are implemented into a consumer product, some of them define its fundamental values, and some others provide supplementary values’ (2003:2). The example they provide is a fridge, with its capacity providing its fundamental values and an additional ice maker providing supplementary values. They believe that added value can be achieved with a shift from mass production to mass customisation and see value-addition in allowing room for ‘subsidiary features’ (ibid).

Their paper suggests the view that supplementary value can be achieved with little extra cost to the overall system but can yield substantial increase in the value of the product:

\[
\text{According to the nature of technical systems, larger level of performance, which relates to fundamental features, can be accomplished with less cost than one proportional to its scale. On the other hand, a customer tends to require value in a product that is proportional to or more than the cost he or she pours into. As a result, more subsidiary features must be introduced for enhancing the product integrity between features and cost as value addition for higher grades and lower grades (Fugita et al, 2003:2).}
\]

Companies are beginning to show a great interest in values ‘...companies evolve in an industrial environment influenced by large technical, economical and social mutations. In addition, they face increased competition. Therefore they are continuously in search of new methods and innovative tools helping them to control and improve the performance of their activities and to maximise the value they generate’ (Elhamdi, et al, 2003:1).

Sirisalee et al explore how already established methods of multi-criteria optimisation can be adapted to aid material choice among designer’s. They base their tool on the assumption that material choice is directed by the optimisation of a number of ‘metrics of performance’ in the product in which it is used. Common among these metrics are ‘cost, mass, volume, power-to-weight ratio and energy density, but there are many more’ (2003:1). The designer makes a choice by adding all the various objectives into a single figure of merit (although they each began as a measure using their own units such as kg or £) using complex algorithms. The minimum of this single figure of merit denotes the most appropriate solution. Each objective can also be plotted against the other individually where more apparent conflicts appear. Included in this complex array of mathematical equations is a method for the calculation of utility or value (ibid.3). This method seems highly complicated and a designer’s ability to understand and implement the calculation of these algorithms without formal mathematical training, and whether they would have the inclination or determination to do so can be doubted. If we continue to read through the methodology we can also ascertain that the figures required to calculate sections of these
equations are based on assumptions and estimations made by the designer and so it cannot be said that the outcome of such a complex task would be at all objective.

Lonchampt, Prudhomme, and Brissaud attempt to measure value using an inventory of all required functions that are then ordered by their relative importance to stakeholders. Functions are split into categories (external functions; those which allow interaction with the product, and the adaptation of the product with an environment, and internal functions, based on FAST: Function Analysis System Technique (2003:2)). These functions each then have appreciation criteria attached to them that allow assessment of the level of fulfilment from each function. They are also judged on their expected level of performance and flexibility (ibid). These functions are then weighted by concerned stakeholders (ibid:3). The designer can then make more informed design decisions by balancing the set of required functions which the knowledge they have gained.

Fugita, Takagi and Nakayama, although looking at product families, present interesting accounts of their attention to values issues and a method of assessment for value distribution within products. They believe that cost is a key feature to the success of a product and must be in balance with other product features. Their technique is an expansion of value engineering techniques, Quality Function Deployment and design for X methods and occurs in three stages: firstly customer requirements are translated into a "chained definition of required worth". The characteristics of each product are sought using value-engineering techniques. Each characteristic is then weighted using QFD. These units are then used in a correlation weight matrix and there relative values deduced using complex algebraic equations; secondly manufacturing costs are estimated, composing of material costs, fabrication cost and assembly cost. Finally, worth and cost are then contrasted using graphs (2003:1). Again due to the mathematical component of this approach and the use of rather vague assumptions, the author questions its potential use by designers.

Cagan and Vogel present a simple method of qualitatively analysing values based on their value classifications (Table 3.10). This is done through a 'value opportunity chart' (2002:69, see a section of a value opportunity chart in Figure 3.8). The value opportunity chart first evaluates each value's presence within the selected product, and secondly, helps define goals in the early product development stages and allows analysis to provide direction for the improvement of integrated value within the product.
Figure 3.8 An example of a section of a value opportunity chart.

The chart lists each value opportunity and attribute. The presence of each is then measured on a qualitative scale of high, medium or low. If that value does not appear to be present at all, no unit is given. A party that is uninvolved with the design process should undertake the qualitative analysis. This is because the design team may have misguided perceptions of the strength of each element. The qualitative analysis of each element should also be made with the target market in mind, as other markets may perceive things differently. 'Profit Impact', 'Brand impact' and 'Extendable' at the base of the chart gives indications of the overall success of the product (ibid). It is suggested that value is not just integrated into a product, but can also be created via integrating value into a company. (ibid:65) The design team can then assess where gaps are present from the graphical output and assess where value could be added to improve the marketability of the product. The designer can then convert the outcomes of the Value Opportunity Analysis (VOA) to a working specification for product development.

Elhamdi et al present value chains as a means of analysing value creation within companies using qualitative and quantitative methods. A summary of the value chain method is that it firstly decomposes a firm into sections and identifies how activities are performed; firm know how; strategies; and their constraints. Secondly it then works to coordinate these activities and optimise the cost generated. This then allows 'designers to improve and to optimise the value of products during the early phases of development' (2003:2) and to help firms 'estimate the value gap registered between stakeholders' expectations and their actual satisfaction in order to increase an aggregate value' (ibid:3).
Hallender describes a concept of life cycle value evolved within the Lean Aerospace Industry (LAI) describing the '...creation of life cycle value implies a balance between cost, performance and other attributes' (2003:2). She identifies a value creation framework that '...provides a holistic view of system, value, including life cycle considerations' (2003:3) and includes three stages.

- Value identification – this involves 'recognizing all of a system's stakeholders and articulating their needs and expectations in the form of system goals'.

- Value proposition – this is the transition from goals to concepts. It involves balancing stakeholder goals based on creating life cycle value.

- Value delivery – occurs during product development. It involves the creation of a system specification from the value proposition (ibid). Care must be taken to include considerations of the entire system and the entire life cycle (Hallender 2003:3).

From three cases studies Hallender identifies six attributes as significant contributors to a more holistic life cycle perspective: Holistic perspective, organizational factors, methods, requirements and metrics, enterprise relationships and knowledge management (2003:5).

Other methods for assessing values were also considered for this research and are presented in Table 3.11 below. They were not pursued further because of the apparent mismatch with industrial design practice.
Table 3.11 Other methods considered

<table>
<thead>
<tr>
<th>Method</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economic value added - value measurement system aiming at maximising the value created for shareholders</td>
<td>Elhamdi et al, 2003</td>
</tr>
<tr>
<td>Value engineering - methods and indicators to maximise value</td>
<td>see ref 1, Elhamdi et al, 2003</td>
</tr>
<tr>
<td>Activity based costing - determines real cost by analysing resources and activities</td>
<td>Elhamdi et al, 2003</td>
</tr>
<tr>
<td>Multi-criteria utility analysis</td>
<td>Zha, 2003</td>
</tr>
<tr>
<td>Probability analysis</td>
<td>Zha, 2003</td>
</tr>
<tr>
<td>Design analytic method</td>
<td>Zha, 2003</td>
</tr>
<tr>
<td>Info content approach</td>
<td>Zha, 2003</td>
</tr>
<tr>
<td>Quality function deployment – a method of resolving interactions between design objectives</td>
<td>Zha, 2003</td>
</tr>
<tr>
<td>Design for x</td>
<td>Zha, 2003</td>
</tr>
<tr>
<td>Concurrent function deployment</td>
<td>Zha, 2003</td>
</tr>
<tr>
<td>Conceptual selection matrix</td>
<td>Zha, 2003</td>
</tr>
<tr>
<td>Taguchi robust model</td>
<td>Zha, 2003</td>
</tr>
<tr>
<td>Neural networks</td>
<td>Zha, 2003</td>
</tr>
<tr>
<td>Data mining</td>
<td>Zha, 2003</td>
</tr>
<tr>
<td>Intelligent agents</td>
<td>Zha, 2003</td>
</tr>
<tr>
<td>Value chain – analysing value creation in companies – optimising the connection between activities</td>
<td>Elhamdi et al, 2003</td>
</tr>
<tr>
<td>Englands Personal Value Questionnaire</td>
<td>See Kumar and Anderson, 1990</td>
</tr>
</tbody>
</table>

3.5 Values embedded in a designer's visual representations

Visual representations must facilitate designer's problem solving or decision-making otherwise designers would only use them as a means of communicating their ideas to others (See Figure 3.9). Little research has been done to empirically examine how designers cognitively interact with their sketches (Suwa, Gero and Purcell, 1998a:1). 'it is one of the most tangible artefacts produced directly during the conceptual activity...The sketch also possesses the potential to act as both facilitator and recorder of creative acts' (Rodgers et al 2000:452). Asking them to draw is not asking them to do anything they would not normally do.
Designers visual representations hold evidence of considerations having been made and decisions having been taken for the purpose of documenting design activity, the products of 2D and 3D modelling can be considered external manifestations of cognitive activity (Pedgley, 1999:100). If this is true then visual representations may provide clues to the influence of values in design decision-making. Sketches serve many functions (See Suwa et al 1998a, 1999, 2000, Goldshmidt 1991, Lugt 2005), and have many forms, (see Baynes 1992, Rodgers et al 2000, Akin and Lin 1996).

3.5.1 Visual representations and design decision-making

The fact that drawings are usually accompanied by verbalisations (in case of the individual designer this would just be unspoken thought) supports the idea that sketches only partially represent ideas in the mind. In general, a drawing act in sketching is not an attempt to represent a solution as such, rather it is a notational device that helps its creator to reason with complex mental structures (Scrivner and Clark, cited Lugt, 2005:5).

'Usually as the design progresses, the drawings illustrate increasing degrees of concretisation and detailing' (Rodgers et al 2000:452). To this end sketching can be seen as the externalised form of a designer's thoughts, indeed 'diagrams and diagram making are an inherent part of the thinking process, thus a 'medium of thought' (Do et al 2000:484) and therefore it may be possible to infer what a designer was thinking by looking at their modelling activity; 'diagrams are external evidence of an internal thinking process and serve as valuable clues to reveal its function' (ibid 2000:484). Do et al describe the roles researchers ascribe to the use of visual representations as:
• generating concepts;
• externalising and visualizing problems;
• organising cognitive activity;
• facilitating problem solving and creative effort;
• facilitating perception and translation of ideas;
• representing real world artefacts that can be manipulated and reasoned with;
• revising and refining ideas (2000:484).

Many of these could also be seen to contribute to decision-making.

Lugt also presents a number of functions of sketching, which can be connected with general decision-making:

• supporting the re-interpretative cycle in the individual thinking process;
• supporting re-interpretation of each other's ideas in group activity;
• enhancing access to earlier ideas;
• means to spur creative thought (Lugt, 2005:1-2).

According to Dörner, visual representations fulfil three functions; to clarify characteristics; to form a log of the design process; and to allow self-reflective thinking (Dörner 1999)

Table 3.12 shows how these three functions can be connected to decision-making.

<table>
<thead>
<tr>
<th>Dörner</th>
<th>Decision-making</th>
</tr>
</thead>
<tbody>
<tr>
<td>To clarify characteristics, making the idea amenable to critical consideration.</td>
<td>To make ideas available for the application of value judgements</td>
</tr>
<tr>
<td>To serve the purpose of forming a log of the whole design process, allowing abandoned ideas to be revisited and having a stockpile of raw material for new approaches.</td>
<td>As an aid to the cognitive organisation of decisions</td>
</tr>
<tr>
<td>Allows insight into a designers thinking by providing a basis for reforming their strategies through self-reflective thinking</td>
<td>Reflective thinking as an aspect of decision-making</td>
</tr>
</tbody>
</table>

Suwa et al suggest that experts tendency to maintain a successive chain of related thoughts is attributed to the ability to use visual cues for association of functions (1998a:2). Zimring agrees suggesting that diagrams function as an aid in the organisation of cognitive activity' (1999:2).

When describing how a designer cognitively interacts with sketches, Suwa et al are referring to the following activities:
• drawing;
• paying attention to previously drawn depictions;
• perceiving their visuo-spatial features;
• thinking of non-visual information (Suwa et al. 1998a: 2).

They go on to explain that through cognitive interaction with sketches, designers are then able to have higher interaction at the perceptual and functional levels' (Suwa et al. 1998a: 5) within which the application of values, or value judgments may occur. They also describe the importance of sketching as a form of external memory, stating that 'externalising intermediate results of inference as visual tokens reduces memory load' (Suwa et al. 1998a: 1), thus aiding decision-making. Lugt agrees stating 'sketching may facilitate archiving and retrieval of information generated earlier in the problem solving process' (2005:6). And that 'sketches have a special set of attributes that help the human mind in translating descriptive prepositional information into depictive information' (Lugt, 2005:4) so by 'inspecting those externalised ideas, the designer finds useful clues to refine them...' (Suwa et al. 1999: 1). Many authors suggest that sketches may promote cyclical models of re-interpretation 'interactive conversations with the paper on which the designer draws' (Schön and Wiggins, 1992, cited (Lugt, 2005:3). 'Many lines drawn in a sketch are incomplete and can be interpreted in different ways (...) which enables designers to re-interpret what they have just drawn...' (Lugt, 2005:2). Sketches allow designers to make 'reflective conversation with their own ideas' (Schön and Wiggins cited Lugt). We can also see this in the APU model of designing (1991:20, see Figure 3.10).

![Fig 3.10 The APU model of designing (1991:20).](image)

There are many different types of visual representations, as shown in Fig 3.11 in section 3.5.1. A few of the types of sketching can be seen in Table 3.13, these have been included as they represent some of the decision-making actions that are aided by sketching.
Table 3.13 Types of sketching

| Rodgers et al  
| (2000:452-453) |
| Thinking Sketch | Which designers use to focus and guide non-verbal thinking |
| Prescriptive Sketch | Made by a designer to direct a draftsman in making a finished drawing |
| Talking Sketch | Which is produced during the exchanges between designers engineers in order to clarify complex and possibly confusing parts of a drawing |
| Do et al  
| (2000:501) |
| Memory Sketch | Recalls elements and organizations from previous work |
| Functional Arrangement Sketch | Explores layouts in plan or section |
| Structure Sketch | Examines layouts of a structural grid, and spatial and dimensional aspects |

When Rodgers et al were carrying out their research, they started by identifying separate sketching episodes and separate yet still connected sketching episodes, and numbering each sketch in the order they were completed, a process known as ‘individuating’ (ibid 2000:454). It was noted that the authors had some difficulty making decisions about successive sketches, as it was observed some designers jump ‘opportunistically from one idea to a second different idea and then onto an expansion of a first idea’ (ibid 2000:457). These sketches can be deemed as connected even though they are not consecutive. Could this be reflective of the disorganised way designers make decisions?

The use of freehand sketches in design is one example of the tacit-ness of design activity. However Schön and Wiggins stress their importance as an essential medium through which designers make reflective conversations with their own ideas (1992). Suwa et al (1998b) analyse the cognitive processes of designers working with freehand sketches and found the following which can be connected to decision-making.

- sketches serve as representations of external memory, so that ideas can be revisited,
- sketches play a role as a provider of visuo-spatial cues for associations of functional issues,
- that cognitive interactions with sketches (making depictions, inspecting, perceiving) enables designers to determine when to think of functional issues and how sketches serve as a physical setting in which thoughts are constructed on the fly (Suwa et al 1998b:8).
3.5.2 Values and visual representations

In the early stages of NPD quick sketches are used by the designer to better understand the problem and to externalise early ideas 'to somehow make real an imagined object' (Rodgers et al 2000:453). Therefore making a problem amenable to decision-making processes and the application of personal values. 'By sketching, temporal decisions are made which allow for evaluation and interpretation of a design solution, without excluding alternatives' (Lugt, 2005:5). Sketching also makes the application of value judgements easier as 'the act of sketching allows shapes and ideas to evolve on paper very quickly, when they are still somewhat unresolved in the designers' head...' (Storer, 2005:4) and allows designers to focus non-verbal thinking (Lugt, 2005:2-3).

Sketching also allows for reflection based on new value judgements that come to light during the design process '...when a designer has invented a design requirement during the process, the new design concept will enable the designer to view sketches from a new perspective and encourage unexpected discoveries' (Suwa et al 1999:1). This is also known as 'Emergence', or 'reinterpretation', or when unexpected discoveries are made within sketches and giving new meaning to what has already been drawn (Gero 1992, Suwa et al/1998a, Lugt 2005, Storer 2005). Values are also involved in the giving of that new meaning as attention to the existence of sketched elements belongs to the sensory level of information processing in human cognition' (Suwa et al 1999:5).

'Emergence of visuo-spatial information sometimes occurs in unexpected ways, because externalising a set of ideas forces a specific organisation of elements (Sterring and Oberlander, 1995, cited Suwa et al 1998a:1). It provides a concrete appearance to encourage attention to elements, a visual clue for 'association or reminding of abstract concepts, functional issues, relevant past experiences, or problem-solving strategies' (Suwa et al 1998a:2), or the application of value judgements.

Suwa et al found there was a delay between sketching episodes before functional actions occur. 'These suggest that sketches serve as something more than just a provider of visuo-spatial cues. Cognitive interaction with sketches, i.e making depictions, inspecting and perceiving, enables designers to determine when to think of functional issues and how. Put differently, sketches serve as a physical setting in which design thoughts are 'constructed on the fly in a situated way' (1998a:9) This personal organisation of decision-making activities must based on personal values. Neiman et al (2000) also agree with the use of spatial relationships between elements and memory sketches and mention bringing memory sketches in from previous projects stating a designer 'recalls elements and organisations from previous work' (ibid:9). This reflects the use of personal experiences and other personal values during sketching episodes.
In 1992 Roberts presented his expectations of the development of cognitive modelling skills within education. What he described could also be considered as value judgments:

- to develop the ability to present ideas in two- and three-dimensional forms and media;
- to develop the ability to make transformations between the symbolic forms in which an idea is conceived and the forms in which it might best be represented;
- to develop the ability to choose and use the symbolic form and media most appropriate to the purpose, the task, and the audience (1992:34).

3.6 Values and expertise

When assessing the effect of expertise on design activity, it is important to understand what distinguishes an expert from a novice designer and therefore enable us to choose participants for the study that fall within these categories. Most of the research papers looked at during this literature review assess expertise via experience, i.e., claiming that the more years experience a designer has, the more expert he can be considered to be (see Table 3.14).

Lawson suggest stages that a novice designer must go through in order to acquire expertise:

- acquisition of design domain schemata;
- acquisition of a pool of precedent (continuous growth);
- identification of guiding principles and structuring of precedent;
- ability to recognise situations with little or no analysis;
- building design gambits to be integrated and adapted into schemata to recognise problem situations (2004:456-457).

All of which contribute to the application of values in design decision-making as they refer to a designer's use of values embedded in design and the development of personal values.
Table 3.14 Different definitions of expertise.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Expertise</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experienced</td>
<td>7 yrs + 3rd, 4th, 5th yr student</td>
<td>7+ yrs commercial experience</td>
<td>Outstanding designer = Senior and distinguished, widely regarded, knighted, high profile clients</td>
<td>Novice ½ yr student</td>
<td>Novice 1-2.5 yrs</td>
</tr>
<tr>
<td>Advanced</td>
<td></td>
<td></td>
<td></td>
<td>Expert 3rd yr student</td>
<td>Experienced 8-32 yrs</td>
</tr>
<tr>
<td>Beginner</td>
<td>1st or 2nd yr student</td>
<td>Masters Students with 1 yr company placement</td>
<td>(Undergraduate level)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Expert Successful, experienced

Outstanding Highly successful, highly innovative within a competitive market
3.6.1 Decision-making strategies

Kavakli and Gero suggest one difference between novice and expert designers is in their level of cognitive activity, stating that experts show a much higher level of cognitive activity but lower levels of parallel cognitive activities (2001:10). This suggests that experts have more control of their cognitive actions (or their general decision-making ability) and can therefore use them more effectively and efficiently (ibid).

Experts are seen most regularly to be 'problem-focused' (Lawson, 2004:451, Cross, Christiaans and Dorst, 1994:39) or undertake 'working-forwards', 'data-driven' strategies (Ho, 2000:27-29), or 'reason-forwards' approaches (Ahmed, Wallace and Blessing, 2002:2). Whereas novices undertake 'solution-focused' (Lawson, 2004:451, Cross, Christiaans and Dorst, 1994:39), 'working-backwards' or 'goal-driven' (Ho, 2000:27-29), 'reason-backwards' and 'deductive approaches' (Ahmed et al, 2002:2). However Ahmed et al also suggest expert designers switch between the two approaches when dealing with more complex problems (ibid). This theory is also backed up by Ho (2000:29). This suggests that novices and experts vary in the way they direct their design decision-making.

It is suggested that novices 'perform unsystematically while applying rules; they solve the problem by goal-driven search' (Ho, 2000, p29) and experts 'apply rules from the initial states of the problem and to solve the problem by data-driven search...'(ibid). These rules could be in the form of personal values or design heuristics. Kavakli and Gero also suggest a difference in search strategy between novice and expert designers in that novices practice exhaustive searches and experts tend to follow an amalgamation, recognition and systematic expansion search strategy (Kavakli and Gero, 2001). Recognition being attributed to the link between schemata and values. However, they also attribute this exhaustive search strategy witnessed in novice designers to their ability to develop novel solutions and to innovate, in contrast to the expert, who can be seen to orientate their activities towards efficiency and success (ibid:11).

Ho observes that novices solve problems by depth-first searches, observing a 'cyclical pattern based on fixed and subjective perspectives' (2000:30) that leads to only generalised solutions, compared to experts who create a search 'space' by carrying out breadth-first searches to solve the problem and tackle problems from alternative perspectives in order to generate a number of more practical solutions (Ho, 2000:29-30).
Ahmed et al agree observing that novices tended toward an overall design pattern described as 'trial and error' (2000:8) in which values must play an important part in determining the appropriateness of outcomes. Generating ideas, implementing them and then evaluating the outcomes repeatedly. They describe however, that experts would evaluate their decisions prior to implementing them and avoid this timely activity (ibid). Ho agrees stating that the search strategies of a novice are to 'haul to another problem if he failed to deal with the problem at hand' (2000:37). Another striking observation between novice and expert designers is in the way in which they address and overcome conflicts, with novices tending to ignore them, and experts embracing them (Petre 2004:485). Both describe novices as ballistic thinkers (see section 3.4.1).

3.6.2 Prior experiences (personal values)

Much of the literature reviewed to date seems to focus on experience as being a main driver in the transfer from novice to expert, indeed Ahmed et al refer to the novice and experienced designer, rather than expert in the title of their paper (2002). Carkett highlights the 'experience of designers' as one of her 13 barriers to creativity (2004:464). Designers use precedent (readily retrievable solutions), gambits (a designer's use of recognition to employ a standard tactic), ploys, strategies, manoeuvres, schemes and analogy (the use of 'source' information from a previous problem-solving episode as a means to facilitate attempts at solving a current 'target' problem) to aid the development of new solutions or the use of examples, models or guides explains how 'expert designers' problem solving knowledge may be viewed as fairly 'routine' in nature, in that familiar kinds of problem will often have well established 'precedents' that are known to be effective' (Ball et al, 2004:500, Lawson, 2004:448 Ball et al 2004:495, Casakin and Goldschmidt, 1999:154). However, there appears to be no evidence that these prior experiences must be based on previous episodes of design decision-making, and so could be better explained as the 'transfer of relational information from a known situation (…), to a situation that needs explanation...' (Casakin and Goldschmidt, 1999:154), indeed Lawson states that this access to previous experience may 'relate to something from an entirely different context' (2004:454).

It appears the use of analogies differs between novices and experts in that novices tend to generate irrelevant analogies when sources and targets shared surface features and experts have greater success in generating relevant analogies where sources and targets shared structural elements (Casakin and Goldschmidt, 1999:155). Lawson agrees,
stating that a key feature in expertise is the ability to recognise design situations and retrieve 'precedent in the episodic memory' (2004:454).

Lawson also acknowledges that this expertise is also highly dependant on time in that experienced designers have 'simply seen more and made more connections already than inexperienced designers (2004:454), also agreed by Achmed et al, 2002:10) Indeed Petre also states that in her observations of engineers they had spent years collecting examples of technology and other items of interest, that some 'simply maintain' mental stores' of such possibilities, but some keep records such as 'idea diaries'... ' (2004:482).

Ball et al also link schemata, or 'abstract knowledge structure, developed through extensive domain-based experience, that can function automatically to recognise a class of problems and to afford an appropriate solution procedure' (Ball et al, 2004:496), and the use of analogy by experts when they define schema driven analogising. They describe the link as — 'the recognition-primed application of abstract experiential knowledge that could afford a design solution to a familiar problem type' (ibid 2004:495) or 'the rapid, automatic, and implicit identification and application of abstract experiential knowledge that is relevant to the task at hand' (ibid, 2004:497). They also agree that a fundamental difference between novices and experts is in their abilities to transfer abstract relations; that experts are schemata-driven, and novices case-driven in their use of prior experiences in that they 'may sometimes involve the strategic identification of a concrete prior problem whose solution can be mapped systematically onto the current problem (ibid 2004:497, See Table 3.15). Indeed experts show greater than three fold increase in the number of schemata-driven analogies compared to novices, and a three fold reduction in the use of case-driven analogies (ibid, 2004:505).
Table 3.15. Examples of schemata and case driven analogising

(ibid, 2004:503-504).

<table>
<thead>
<tr>
<th>Type of analogising</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Schemata-driven analogising</td>
<td>'I've designed outdoor terminals before, so straight away, I'm thinking about how this relates to my knowledge of what I've done before...'</td>
</tr>
<tr>
<td>Case-driven analogising</td>
<td>I'm thinking immediately back here to a ticket machine that we worked on, where an external consultant came up with the idea of a rotary wheel for scrolling through the screen options’</td>
</tr>
</tbody>
</table>

Casakin and Goldschmidt link knowledge and values when they attribute expertise to the representation of knowledge (1999:154), but they also state that as ‘expertise develops, knowledge becomes more structured and better integrated with past experiences’ (Casakin and Goldschmidt, 1999:154), that in order to be used more efficiently prior knowledge must be stored as more abstract schemata.

The Massachusetts Institute of Technology (MIT) states that for ‘appropriately challenging problems experts do not just automatically extract patterns and retrieve their response directly from memory. Instead, they select the relevant information and encode it in special representations in WORKING MEMORY that allow PLANNING, evaluation and reasoning about alternate courses of action (cited Ericsson and Lehman 1996). Hence, the difference between experts and less skilled subjects is not merely a matter of the amount and complexity of the accumulated knowledge; it also reflects qualitative differences in the organization of knowledge and its representation (Chi et al 1982, Ericsson, 1999:299), or allowing knowledge to be amendable to value judgement. The same acquired representations appear to be essential for experts’ ability to monitor and evaluate their own performance (Ericsson 1996; Glaser 1996) so that they can keep improving their own performance by designing their own training and assimilating new knowledge (Ericsson, 1999:299).
Even though Casakin and Goldschmidt are referring to the use of analogies in accessing prior experiences, they could well be describing novices as case-driven, in that they cannot transfer abstract relations from source examples (Casakin and Goldschmidt, 1999:155) and experts as schemata-driven designers in that they can successfully transfer (and from this we can infer they can also develop internally) abstract schemes from prior experiences (ibid).

It is unsurprising that novices rely more on case-driven analogies and use of prior experiences as 'novices simply will not possess much in the way of schematised domain knowledge derived from extensive prior experience' (Ball et al, p496).

Ball et al also hint on an opinion of the use of analogy as a simple form of heuristics in action (2004:498). They also explain how analogy and prior experiences can influence design decision-making as they note that exposure to problems helps build schemata that may also 'embody a procedural understanding of how best to solve problems of that particular type' (2004:499).

This notion of building schemata also suggests a notable transition from novice to expert being in schemata acquisition as well as application, bringing us back to the need to be exposed to multiple experiences within the design domain.

Ball et al also suggest the need to develop skill in accessing an appropriate schemata for the task at hand (2004:499) and that this could be a driver in the novice approach in selecting case-driven analogies and reliance on design heuristics in order to solve problems that bear relations to prior experiences, with the intention that these will slowly transcend into skills for developing and accessing schemata (ibid, 2004:507). They also noted that a 'majority of the case-driven analogising that we identified in both the expert and the novice protocols appeared to be dominated by the use of surface-level cues available in the target problem, as opposed to more abstract cues associated with the underlying structure of the target' (ibid 2004:507).

Lawson discusses experience through an exploration of 'experience in expertise focussing on the way precedent stored in the form of episodic schemata is used by experts to recognise design situations for which gambits are available' (2004:443). He also suggests that expert designers perceive drawings more readily due to schemata that
organise precedent (2004:451). He agrees that a difference between novice and expert designers is in their ability to ingest and regurgitate prior experiences, or what he refers to as precedent, suggesting that experts take a shorter time to ingest and understand drawings due to the ‘use of symbolic references to design precedent’ (2004:450) compared to novice use of geometric descriptors, suggesting better recognition of precedent by more experienced designers. Interestingly the experts lost this ability when encountering situations outside their discipline, again highlighting the domain-specific nature of expertise. For example

its is much harder to describe tartan through an explanation of its geometric make-up, than it is to evoke schemata to extract precedent evoked by the word ‘tartan’ that we may have stored through previous experience (2004:451-452).

3.6.3 The use of existing examples (values embedded in design)

Petre, (2004:487) describes the use of scenario-based reasoning to explore problems, shifting among scenarios to reveal consequences of design choices and revealing opportunities or changing perspectives from products to processes. She also suggests the development of abstract precedents, gambits, schemata can occur from product examples looked at during the project, highlighted by the need from both experts and novices to look at existing products during project work and the observation that exceptional companies encourage play allowing designers to explore ideas (ibid, 2004:489).

3.6.4 Expertise and a designer’s personal values

A key element of the transition from novice to expert seems to lie in the designer’s personal drive to do so. The ‘key is that innovative engineers are ‘hungry’ for input and work actively to maintain and update their knowledge base’ (Petre, 2004:482) and that many authors say displays of ‘internal desire to be creative, to develop innovative ideas into the design can deliver the best design...’ (Carkett, 2004:469).

Achmed et al also observed novices lacked confidence in their decisions to a greater degree than experts (2002:7). They also observed that experts more commonly asked questions of whether an avenue of enquiry or activity, or an approach was worth their while pursuing (2002:12).
Many authors also observed the use of guiding principles, or 'sets of values and priorities which on the one hand guide each project, and on the other hand are informed and refined by projects' (Lawson, 2004:448). These are also referred to as 'primary generators' (ibid, 2004:449) or 'tried and tested precedents' (ibid) (anchors if we talk in heuristic terms). Ahmed, Wallace and Blessing describe something similar when they observe 'experienced designers were also found to have developed individual approaches to a design task' (2002:17). Cross et al observed that the two 'outstanding' designers involved in their research both 'framed' the problem in a distinctive way and designed from 'first principles' (1998:141) connecting problem definition to a form of internal values.

Ahmed et al also mention expert designers being 'aware of reason' (2002:12) in that they were aware why they were using a component or manufacturing technique for example. They also observed that novices 'consider issues sequentially, and were not observed to differentiate between important and less important issues' (2002:11). This suggests novices have a lesser ability to organise their internal values effectively.

3.6.5 Expertise and a designer's use of social values

It is clear within the literature that expertise, and the observable differences between novices and experts is domain-specific (Ho, 2000; Cross, 2004; Ball et al, 2004). The way in which designers tackle problems and generate solutions has marked differences to other disciplines that have been widely researched in regard to expertise. This is particularly due to the ill-defined nature of design problems (mentioned in chapter 2).

Carkett states: 'it has been evident that design does not take place in a vacuum, but that it is a social skill developed through experiential and situated learning' (2004:473) and suggests the need for skills/expertise/experience registers, personal development plans as needed to support the transition from novice to expert. And that creativity cannot be 'separated from social relationships, culture and business...' (2004:474) suggesting that as well as expertise being domain-specific, that it is also culture-specific.
3.7 Summary

Chapter 3 has provided an in-depth discussion of the role of values presented in previous literature. The literature provides evidence of:

- societal values;
- personal values;
- values embedded in design;

Previous methods for assessing values and their limitations are discussed. Values embedded in a designer's visual representations as discussed in the previous literature are also presented along with a discussion regarding expertise and the use of values in industrial design decision-making. This review provides part of the foundation, along with the pilot studies described in the next chapter, for the methodology used in this research.
Overview: Chapter 4 describes the pilot studies which were conducted to explore methods for uncovering the role of values in design decision-making. Case studies of designing by 16+, undergraduate, postgraduate and professional designers were conducted using retrospective interviews, protocol analysis and diary methods.

4.1 Key aims for the pilot studies

The aim of the following pilot studies was to test the applicability of data collection methods in the chosen context, in this case to uncover values in design decision-making, and to improve the data collection methods for use in the main study. They also needed to ensure that what was being found was useful, as it was unknown at the outset how the use of values could be made explicit.

The literature gave no united or complete classification system for values in design decision-making and so the pilot studies provided an initial understanding of these values in order to develop a taxonomy to be used in the main study.

Due to the lack of prior art in this field the pilot studies also allowed the establishment of what could be uncovered, and the development of a robust analysis technique for the main study based on this. This thesis will also provide documentation of the process to develop, test and refine a best practice method for the collection and analysis of values within design decision-making.

4.2 Uncovering the use of values in design decision-making

There is a substantial body of data in the form of a literature review that has been collected that can provide information as to how designer's thoughts can be uncovered.

Qualitative and quantitative methods are not simply different ways of doing the same thing (Maxwell, 1996:17) Quantitative describes methods that examine and/or measure in terms of quantity, amount, intensity or frequency. However, '... in the real world a large
number of variables are found to be highly interrelated. This means that their causes and effects are hard to distangle...' (Blalock, 1970:6). Qualitative methods act to address these problems and '...stress the socially constructed nature of reality, the intimate relationship between the researcher and what is studied, and the situational constraints that shape enquiry.' (Denzin and Lincoln, 1998:8). They also do more to aid expressions of the 'value-laden nature of enquiry' (Denzin and Lincoln, 1998:8). The data required for this research fits into the qualitative paradigm because it is understanding of deeper meanings, within specific contexts, as the use of values will be unique to the circumstances in which they occur, which allows research into unexpected phenomenon and the generation of new theories. In this case the understanding of the role of values is very limited, and this is a key matter in the understanding of design decision-making. Developing causal relationships, or the discovery of what events lead to specific outcomes is an appropriate use for qualitative analysis taken from Maxwell (1996:17-20).

Three ways of uncovering designer's thoughts are from:

- what people say at the time;
- what people do;
- what people tell you afterwards.

4.2.1 What people say at the time

This requires the researcher to ask them to verbalise or 'think aloud'. Cognitive coding and symbolic representation within 'the minds eye' are not considered. In all research methods verbatim and motor activity is all that can be measured and recorded. We cannot directly delve into a designer's head.

4.2.2 What people do

Designers could be provided with initial information and then what they produce could be analysed and inferences could be made about what happens in between. Internal operations that cannot be directly observed, that we wish to gain insight into would be missed. Pedgley already commented that direct observations of designers (or video recordings with no audio) are not adequate on their own to uncover designer's thoughts (1999:106).

However Pedgley also found that analysing sketching alone was 'insufficiently externalised on sketch sheets for an outsider to gain a clear understanding of the decision-making that took place' (Pedgley, 1999:100).
4.2.3 What people tell you afterwards

This requires the researcher to ask designers to describe what they were thinking. Robson suggests to ascertain what people do in private, or in their heads, it is best to use interviews, questionnaires and diary techniques (1996:189) because without asking them, it would be impossible to make these thoughts explicit.

The use of values in design decision-making is not well understood, even by designers, and therefore it was felt surveys would yield no useful data. Attempts at the manipulation of values within design decision-making through experimentation was also discarded as this would invalidate the data and not provide useful insights. Also there was no understanding of the initial state of play from which the experiments could be derived. It was decided that case studies were the best method of data collection for this body of research as it enabled the development of detailed intensive understandings. It also allowed the analysis of the unique circumstances in which the data occurred and the identification of unanticipated phenomenon. It also allowed an understanding to be developed of the process by which events and actions took place rather than solely relying on outcomes to develop an understanding. This allowed more causal relationships to be identified (Maxwell, 1996).

4.2.4 Tacit processes

‘There are things I know but cannot tell’ (Polanyi, 1962:601) This is important in regards to understanding the depth of our ability to research design decision-making as in some instances the way designers work may be ‘inexplicable, not for some romantic or mystical reason, but simply because these processes lie outside the bounds of verbal discourse: they are literally indescribable in linguistic terms’ (Daley, 1982). In many cases ‘What designers know about their own problem-solving processes remains largely tacit knowledge’ (Cross, 1982). Their decision-making processes may have evolved to a point that the origins of them are now unknown and a drawback of any research technique is its inability to capture internalised thought, indeed ‘only by really being Plato could I really understand him’ (Ryle, 1948). It is necessary to be aware of the existence of tacit performances.
4.3 Selected methods

Pilots were conducted into retrospective interviews, concurrent verbalisation and protocol analysis and diary methods.

4.3.1 Retrospective Interviews

Retrospective interviews are a qualitative method of gaining in-depth responses to questions asked. The outcome is a wealth of information on case studies. The interviewer is also empowered with the ability to probe and explore responses that other research techniques would not allow. The analysis of designers' work folders also provides additional information on motor-based cognitive action (drawing and writing) that can also be analysed.

One of the main disadvantages of retrospective analysis is that it is not a reflection of true design activity and may therefore be unreliable. Participants are required to discuss processes and activities, both internal and external, after they have occurred and design folders may be incomplete and in a different order to the design activity that produced them. Lee and Radcliffe (1990) support this view stating the 'major weakness of this method is the difficulty of tracing how the time was spent during the actual design period'.

It must also be factored in that the participant's account of their processes and activities may not be wholly accurate due to the impregnable arena of tacit knowledge and human construction of meaning. It must also be acknowledged that the interviews may not elicit honest responses.

The pilots were done in 3 phases, which for the thesis will now be refered to as datasets. Two A-level students were chosen to take part in dataset one and will be referred to as NN and RG. A third A-level student, SG, was used as a subject in the second dataset. Between the first dataset and again after the third dataset, methods and findings were presented at conferences and feedback and developments took place. In the third and last dataset, five final year undergraduate students from Loughborough University's Department of Design and Technology were used. They will be referred to as LG, ER, RW, JP and RT (see Figure 4.1).
Each participant took part in a forty minute to one-hour interview about his or her project work. They were recorded using a Dictaphone. The interviews were transcribed immediately afterwards to ensure an accurate verbatim transcription. Questions were asked using a topic guide that was developed after each dataset in the light of the experiential new understanding gained. Each participant was also required to provide a copy of his or her design folder. The focus of the questions was on how values influence decisions about materials. This was expanded to how values influence design decision-making once data started emerging, as it was felt a more generic understanding of design decision-making was possible.

4.3.1.1 Dataset one – NN and RG

The two students were taking part in the Sustainable Design Award (SDA), an award scheme integrated into their normal work to ‘help students explore environmental, economic, social and moral issues in design and technology’ (www.sda-uk.org). The project would also be submitted as part of their A-level design and technology work. The interviews took place at the student’s schools. The projects were not finished at the time of the interview. RH was developing a cardboard desk for use in disaster areas (such as
areas recovering from an earthquake). NN was developing a recycling centre for a local school (see Table 4.1).

Table 4.1 RH and NN project information

<table>
<thead>
<tr>
<th>RH</th>
<th>Cardboard desk for disaster areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>A2 level</td>
<td></td>
</tr>
<tr>
<td>NN</td>
<td>Recycling centre for a primary school</td>
</tr>
<tr>
<td>A2 level</td>
<td></td>
</tr>
</tbody>
</table>

**Developing the initial topic guide**

An initial topic guide was developed for dataset one (see Figure 4.2). The topic guide allowed the interviews to be semi-structured to ensure comparability between case studies. It was developed as a guide that would encourage the participant to discuss their decision-making as it occurred during the project. The questions were also developed based on the literature review. Care was taken not to overload participants with the use of too many questions, and to help generate conversation by them to encourage candid, honest responses.
Background

I am interested in the points in designing when materials are considered and what drives decisions about materials. I am especially interested in values as drivers of decision making.

This interview will not affect your marks at all. Please be as honest as possible.

Introduction to the project

What is it that you are designing? Can you give me an outline of the brief, including the set brief?
Who are designing this for?
Are you following a particular strategy / model of designing (e.g. Starting with a brief then moving to concept generation, detail design etc)
Would you consider your knowledge of materials to be strong, weak or somewhere in between?
How have materials been presented to you up till now?
How important are materials and material choice to you? To this project?

Questions

I would like to look through your project now and talk about when you have considered materials. As we look through it, can you identify where issues regarding materials have been thought about (or where they definitely haven’t been considered). I would like to know how you have considered materials; this could be in many ways:

- In your head (minds eye) as a thought, an image, a sense (how you think it should feel, look)
- Diagrammatically, you have used a sketch, or a rendering, or a technical drawing or a model to convey something about materials (to yourself or others), using colour or a direct reference (written)
- Using external resources, In conversation, when have you spoken to others about materials, looking at books, the internet, reference products

Final questions

Is there a hierarchy of things you consider in a project?
Do you think you address material issues continuously, a lot, quite regularly, or as an afterthought?
Do you feel that the SDA / Study weekend had any effect on the way you considered materials?

Do you feel constrained regarding materials in any way?
What other resources do you feel would have helped in regards to making decisions about materials.
Who / what were you thinking about most when designing the object (yourself, the consumer, the client, your teacher, the mark scheme)?
Are you happy with the direction your project is going in?
You haven’t finished your project yet. Do you think this interview will have any effect on the way you consider materials?

Figure 4.2 Dataset one topic guide
It was important to ask some initial questions about the participant's backgrounds and personal experiences as this was highlighted as an issue within the literature and would probably not be discussed while going through the project. A brief overview of the sorts of information being sought was also included to ensure the participant gave a complete-as-possible account of their designing. In order to ensure the fluidity of the interview the author also used a prompt sheet to facilitate eliciting responses; these can be seen below (Table 4.2).

<table>
<thead>
<tr>
<th>Prompting Questions</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Why was this idea abandoned?</td>
<td></td>
</tr>
<tr>
<td>Why was this idea continued?</td>
<td></td>
</tr>
<tr>
<td>Can you give me details of your decisions here?</td>
<td></td>
</tr>
<tr>
<td>What was driving this decision?</td>
<td></td>
</tr>
<tr>
<td>How did you arrive at this idea?</td>
<td></td>
</tr>
<tr>
<td>What is the significance of...?</td>
<td></td>
</tr>
<tr>
<td>Did you consider...? / have any ideas on...?</td>
<td></td>
</tr>
<tr>
<td>Where did you get this idea?</td>
<td></td>
</tr>
<tr>
<td>Why is that important?</td>
<td></td>
</tr>
<tr>
<td>What media did you use?</td>
<td></td>
</tr>
<tr>
<td>How did you get from here to here?</td>
<td></td>
</tr>
</tbody>
</table>

4.3.1.2 Dataset two – SG

A review of the research method was then made and it was felt that, although no accurate analysis had occurred, the technique did appear to yield beneficial information. However the initial two interviews and the resulting review did highlight some changes that were required, these are outlined below (Table 4.3).
Table 4.3 The changes required after dataset one.

<table>
<thead>
<tr>
<th>Changes required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discontinue the use of double questions to ensure all information required is gained</td>
</tr>
<tr>
<td>The clarity of some questions needed improving</td>
</tr>
<tr>
<td>Introduce more generic questions to elicit some more general value related responses</td>
</tr>
<tr>
<td>Need to rephrase misunderstood questions during the interview instead of moving on to the next question</td>
</tr>
<tr>
<td>The interviewer needs to acquaint themselves with the project before the interview</td>
</tr>
<tr>
<td>The interviewer needs to summarise what they think the participant is saying in order to facilitate any clarifying required when statements are unclear</td>
</tr>
<tr>
<td>Need to discontinue questions that can be answered with yes or no answers and replace them with ones that require more in-depth responses</td>
</tr>
<tr>
<td>The interviewer needs to be aware of and prevent feeding responses to the participant</td>
</tr>
</tbody>
</table>

It was also decided in some cases it was needed to record how a certain phrase was said, this is done in the following way (see Table 4.4):

Table 4.4. Annotation of phrases

<table>
<thead>
<tr>
<th>Annotation</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>(underlined)</td>
<td>sarcasm</td>
</tr>
<tr>
<td>... (3 dots)</td>
<td>pause</td>
</tr>
<tr>
<td>...... (6 dots)</td>
<td>long pause</td>
</tr>
<tr>
<td><em>italics</em></td>
<td>word is stressed</td>
</tr>
</tbody>
</table>

This would also be used for the concurrent verbalisation and protocol analysis. The third dataset (SG, see Figure 4.3), was interviewed using the updated topic guide (see Figure 4.4 in section 4.3.1.3).
They were also taking part in the SDA and the interview also took place at the participants school (see Table 4.5).

Table 4.5. SG project information

<table>
<thead>
<tr>
<th>SG</th>
<th>Bag for Kenyan paravet</th>
</tr>
</thead>
<tbody>
<tr>
<td>A2 level</td>
<td></td>
</tr>
</tbody>
</table>

4.3.1.3 Dataset three - LG, ER, RW, JP and RT

It was felt that the topic guide from dataset two had improved and could be taken through to dataset three (Loughborough participants, see Figure 4.4).

As all five students were involved in the same brief the topic guide was updated to reflect this and is shown in Figure 4.5.
**Topic Guide**

**Alms**
To discover when in the process of designing materials are considered.
To ascertain what drives decisions about materials.
To discern what part values play in driving decisions about materials.
To promote honest response.

**Personal Biography and Background**
Can you briefly describe the areas you have worked in (GCSE, A-Levels, Uni, Work etc)?
Can you tell me a general hierarchy of things you consider important in a product you are designing?
How good would you consider your knowledge of materials to be?

**Project Introduction**
Did you follow a particular strategy / model of designing during the project?
Did you feel constrained regarding materials and manufacture in any way?
How important do you consider material choice to be in this project?
Do you think you addressed material issues continuously, a lot, quite regularly, or as an afterthought? Did this differ from previous projects?
Who / what were you thinking about most when designing the object?

**Project**
I would like to look through your project now and talk about when you have considered materials. As we look through it, can you identify where issues regarding materials have been thought about (or where they definitely haven't been considered). I would like to know how you have considered materials; this could be in many ways:

- In your head (minds eye) as a thought, an image, a sense (how you think it should feel, look)

- Diagrammatically, you have used a sketch, or a rendering, or a technical drawing or a model to convey something about materials (to yourself or others), using colour or a direct reference (written)

- Using external resources, In conversation, when have you spoken to others about materials, looking at books, the internet, reference products

I would also be grateful if you could highlight points during the project where you feel important decisions have been made.

**Post Project**
Do you feel that the project has had any effect on the way you consider materials?
What other resources do you feel would have helped in regards to making decisions about materials?
What do you think of the outcome of the project?
If you specified its use, do you think the use of recycled material adds or subtracts value from the product?

---

*Figure 4.5 The final topic guide*
The project they were interviewed about was the outcome of a brief set in conjunction with Recoup, a company that promotes and facilitates post-consumer plastic container recycling in the UK (www.recoup.org), and Smile Plastics, manufacturers of recycled plastic sheet (www.smile-plastics.co.uk). The brief was to propose a new product to be displayed at either the Chelsea Flower Show or Ideal Home Exhibition that exploits the use of recycled plastic sheet from Smile Plastics. The students were given one week to complete the project (for further project details see appendix i). The participants were interviewed on completion of the one week project which took place in the Department of Design and Technology at Loughborough University (see Table 4.6).

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>LG</td>
<td>'Serenity' garden bench</td>
</tr>
<tr>
<td>JP</td>
<td>'Lumina' portable lights</td>
</tr>
<tr>
<td>ER</td>
<td>'Frost lights' floating candles</td>
</tr>
<tr>
<td>RT</td>
<td>'Axis' entertainment stand</td>
</tr>
<tr>
<td>RW</td>
<td>'Flex' wine rack</td>
</tr>
</tbody>
</table>

4.3.2 Concurrent verbalisation and protocol analysis

The development of the concurrent verbalisation and protocol analysis pilot was based on prior art, mainly form the Cross et al publication 'Analysing design activity' (1996).

Protocol analysis seeks insight into design decision-making (as well as a variety of other problem solving tasks) through observing a designer’s activities as they carry out a set design task as visual aspects of the design decision-making are explored in the graphic mode. This is reflected in the drawings that are produced (Akin and Lin, 1996:37). It is important to document parallel activity (such as looking, or reading) in order to analyse different influences that are required at each stage of decision-making. It can be used with a combination of techniques to further our understanding. In this case it will be used with concurrent verbalisation, or thinking aloud, as speaking becomes the means through which internal activities can be better understood (Akin and Lin, 1996:39), and it would be difficult to 'imagine how else we might examine what is going on inside people’s heads, other then by asking them to tell us what they are thinking’ (Cross et al, 1996:1-2).
There has been much discussion regarding the inadequacy of protocol analysis. Experiments showing limitations such as: the set-up heavily influences the protocol data; the interpretations can be numerous and varied (see Cross et al, 1996). Akin and Lin have reservations that although verbalisation aids the researcher to 'access the mental processes of the designer' (1996:36) the effect of verbalisation on the designer and the design activities has not yet been determined and its obtrusive nature may also change the subject's behaviour and their cognitive performances. Dörner agrees stating:

Germinal processes exist in human thought, in which casting ideas into verbal form is premature because it would destroy the dynamics of thought. These germinal phases, which can be regarded as rapid and partially unconscious recombination's of images, may result in 'sudden insights' and shouldn't be disturbed by attempts to verbalise (Dörner, 1999).

There are also reservations about the limitations of the information being captured. Cognitive coding and symbolic representation within 'the mind's eye' are not considered in protocol analysis. There is a belief that it may change a subject's behaviour and their cognitive performance; it may give irrelevant accounts unintentionally, reporting 'parallel but independent thoughts to those that are actually being employed in the task' (Cross et al, 1996:2); its inability to capture non-verbal thought and that what is captured is a few aspects of design decision-making in great detail (Cross et al, 1996:13-14). The verbal reports may also be incomplete accounts of their cognitive activity, this may be due to tacit cognitive activity being hidden from any possible verbalisation or they may be reporting parallel but independent thoughts to those being employed in the task.

People do not necessarily know what is going on inside their own heads, let alone have the ability to verbalise it (Cross et al, 1996:2).

Cognitive coding and symbolic representation within the 'minds eye' is not considered in protocol analysis. 'There is ample evidence which supports the idea that humans process information whether it is in the form of language or other conceptual representations' (Akin and Lin, 1996:36). Concurrent verbalisation means the designer 'talks aloud thoughts' rather than 'talks aloud thoughts on a particular subject' (Pedgley, 1999:107). Relevant data may not be collected or could be mixed with other data. Pedgley has reservations about protocol analysis as he believes verbalisation merely contains an echo of actions that have been videotaped (1999:108).
The choice and set-up of the design task is a crucial element of protocol analysis, the design task should be:

- challenging;
- realistic;
- appropriate for the subjects;
- not too large;
- feasible in the time available;
- within the sphere of knowledge of the researcher (Dorst, 1996:18).

Protocol data is generated at a microscopic level. The videos produce such a huge amount of data that it would be impossible to analyse large amounts of video footage. One aim of dataset four is to determine how long this video should be.

4.3.2.1 Dataset four – KB and IS

Two professionals were chosen to take part in the concurrent verbalisation and protocol analysis pilot (Dataset four) and will be referred to as KB and IS (see Figure 4.6). They had both previously worked in design consultancies and both showed an interest in sustainable design. Prior to the pilot both took part in a training day to introduce them to sustainable design and some of the tools and strategies that could be used during sustainable product redesign. The protocol analysis would be carried out over the first hour of a project to redesign a consumer toaster. The toaster redesign and the work that produced it would then be used by KB and IS to produce posters for another research project. This ensured that the project was ‘worth their while’.

It was decided that one hour per subject would produce enough data for the pilot study but that this was too short to complete an entire project to an acceptable standard. It was also felt that this may ‘skew’ the design process, disallowing time for reflection, contemplation, restart and other processes important in design decision-making.
Therefore the concurrent verbalisation and protocol would analyse the first hour of the redesign project that could then be continued in the designers' own time.

To carry out the design task each subject was given drawing paper, the original toaster (see Figure 4.7) that could be taken apart if desired, and the results of an eco-indicator test carried out on the original toaster (see appendix ii). They were also advised to bring their own drawing equipment to ensure they had the items they were used to. They were each given a project guide that can be found in appendix iii. The concurrent verbalisation and protocol analysis took place in the Department of Design and Technology at Loughborough University.

![Figure 4.7 The current toaster](image)

To capture data a video recorder was set up that provided a view of the drawing area, the subject, and adequate space to ensure all activities (including any attention paid to the original toaster) would be captured. The video camera was set up to record audio as well as visual data but a second Dictaphone was also used to ensure all relevant data was collected. Finally a timer was placed in the room to signal the end of the hour (see Figure 4.8).
4.3.3 The diary of designing

The end-of-the-day diary method was developed by Pedgley whose aim was to design a research technique that was ‘appropriate to naturalistic, long term study of real world designing’ (1999:23) and that allowed data to be collected on very focussed elements of a designer’s work. ‘The diary of designing provides autobiographical documentary evidence of designing contained in a combination of narrative and drawings’ (1999:24). The diary does not ask too much of the diarist. Also, it does not take the time that some research methods do, requiring transcription or reordering for analysis etc. The studied designing can be done anywhere, as no equipment other than the folder of stationary and the archive folder is required. The end-of-the-day diary format works well as, in the words of Pedgley (who also tested the diary as a concurrent study) reporting at the day’s end is a ‘compromise between being too close to the activity (and upsetting it) and too distant from it (when the likelihood of providing misinformation increases)’ (1999:121) A full account of the development of the diary of designing used for the pilot studies can be found in Pedgley (1999).

A private email from Dr Owain Pedgley with updated notes for researchers can be found in appendix iv. An email was received from Owain Pedgley with suggestions for researchers wishing to use the end-of-the-day diary. Development of the diary began by using this 10 step checklist set out by Pedgley (see appendix iv). Each step was read and applied to information regarding the current research pilot.
The author decided to take the role of diarist for the pilot and main study (see Figure 4.9) as Pedgley suggests the researcher as the diarist, as it 'requires commitment of time and personal dedication and, without the lure of an incentive or a track record in collaborative research, designer's are likely not to agree to participate' (1999:294). He also found that when he asked others to complete a diary of designing the results were wholly inadequate. The diaries were so sparse of entries that it was not possible to perform any detailed analysis' (1999:274). From the outcomes of interviews with the participants he suggests some reasons behind this being:

- that it was difficult to commit to the diary and set time aside to write it due to workloads for other projects;
- that it was too time consuming;
- that they found it tedious;
- that knowing what to write was difficult even with prompts (1999).

Pedgley developed three formats of stationary that were used for the Dataset five, these were then developed for dataset six, although they were very similar. They consisted of:

- mainsheets for diary entries that had spaces for the date, sheet number and the day's main activity to be filled in and was then left blank for the diary entry;
- tracing paper that had spaces for the date, sheet number and the number of the design sheet being traced. This could be overlaid over 2D design work where notes could be written to highlight attention to materials;
• a 'no detailed entry' sheet where the days main activity could be recorded if design activity had occurred with no attention being made to materials. (1999:115-116).

At least one of the sheets must be filled in each day that work is carried out on the project under study. Out of hours designing is recorded in the next day’s diary entry as Pedgley realised that ‘thoughts can follow oneself around day and night’ (1999:113). The diary will commence on the first day’s designing and has the following features.

• It is written at the days end.
• It documents the designer’s account of working (rather than an outsiders inferences).
• The content is requested not to include elements of design activity that the researcher is not interested in.
• The content is requested to be made against a few guide questions and prompts (so that the final content is focussed but not rigid).
• The diary entries must be archived and unavailable (so as not to be available as an abnormal source of information for use in designing).
• The resultant design folio and any models made are numbered and logged (Pedgley, 1999:121).

The diary is not a real-time recording method and, as such, cannot be used to record a ‘designer’s skill, connoisseurship, know-how, intuitive decision-making and precise trains of thought’ (Pedgley 1999:290) So it has to be seen to compliment rather than replace existing methods. Pedgley also noted the following disadvantages; it requires the production of documents which are not normally expected of a designer and which may be considered obtrusive; diaries are subject to the same limitations of reliability and validity as other methods of collecting data on designers’ thoughts; they rely on the designer being verbally articulate about what they have covered in their work; they rely on honesty (Pedgley, 1999:121-122).

4.3.3.1 Dataset five - Table/chair project

In order to ensure the pilot for this prospective research method was carried out under the best conditions it was decided that a small initial dataset would be gathered for the researcher to become acquainted with the technique and highlight any issues that
needed addressing. The brief was selected as a table or chair that could be made from the different plastics in the Smile Plastic range (www.smile-plastics.co.uk). The design of this object would be used for the trial. Dataset five occurred over the first 6 days of the design task.

4.3.3.2 Dataset six - Recoup lectern project

The table/chair project highlighted an issue that some ideas were written in the diary as a documentation of 'hidden thinking' that would otherwise not have been documented. This may have the unnatural effect of making those ideas more concrete than they otherwise would be, thus interrupting the natural design process. It was also found that the act of filling in the diary acted to rethink, rephrase and redefine parts of the project that had already been addressed. In some cases the act of verbalising (in word form) the day's activities acted to clarify some issues. Pedgley agrees that it may be an aid stating that he found 'the process of diary-writing (or more precisely, the process of reflection inherent in diary writing) eased the grasping and comprehension of design issues, thereby aiding further decision-making' (1999:292). In these cases it was hard to tell whether to document these ideas (at the time or as 'out of hours designing') or whether to ignore them as unnatural occurrences. One approach would be to specify design episodes (through annotating design work) that were initiated by the diary entries, thus acknowledging the diary as a design resource, but then one produces another problem in contemplating the origins of subsequent chains of thought. It was decided that this would be noted as a problem but changes would not be made to the diary. Minor changes were made including organising a folder for diary stationary with prompts and plentiful supplies of sheets (see Figure 4.10).

Figure 4.10 Diary folder (left) and Diary archive (right)
The researcher agrees with Pedgley when he states that the quality of entries see an improvement as the project progresses due to the diarist becoming more competent in his/her ability to narrate their activities. However the initial table/chair project allowed the author to become competent and reflect on the ability to be a diarist and therefore this disadvantage should be disregarded for dataset six.

For dataset six a design project was accepted from Recoup (www.recoup.org). The project entailed the design and production of a lectern for the company to use at conferences and displays that was made from and promoted the use of recycled plastics. Dataset six was a more longitudinal study (see Fig 4.11).

Figure 4.11 The outcome of dataset six.
4.4 Summary

The following pilot studies were conducted to explore methods for uncovering the role of values in industrial design decision-making (see Figure 4.12).

Figure 4.12 Overview of the pilot studies
Overview: Chapter 5 describes the key findings from the pilot studies. It was clear that evidence of the role of values in design decision-making could be identified, and that value judgements are used by designers to make decisions at every stage of the project. This chapter provides examples from the pilot studies of many of the value categories which have been highlighted by the literature (as described in chapter 3). It also demonstrates new understanding of the role of values, particularly in relation to the designer’s internal values and meta-values and the need for a new taxonomy.

5.1 Knowledge, skills and values as a model of decision-making

The data presented below, provided by the pilot studies, shows the knowledge, skills and values models applicability for this study. Below (Table 5.1) shows two examples from the retrospective interviews of knowledge being used by the designers. NN has learnt about materials from information he has been given by his teacher that will affect his decisions. LG’s decisions are influenced by thinking she does not possess enough knowledge about water features to include one in her design.

Table 5.1 Examples of the use of knowledge in design decision-making

<table>
<thead>
<tr>
<th>Dataset</th>
<th>Exert from transcript</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dataset One</td>
<td>RC - How have you learnt about materials so far?</td>
</tr>
<tr>
<td></td>
<td>NN – um, well our teachers have obviously given us information packs and stuff...</td>
</tr>
<tr>
<td>Dataset Three</td>
<td>RC - What sparked the whole decision to move it on from a water feature to a seat?</td>
</tr>
<tr>
<td></td>
<td>LG – The whole technical design thing. I didn’t know enough about water features; the technical side of putting electrical stuff into water in a week was too much to find out about...</td>
</tr>
<tr>
<td>Dataset Three</td>
<td>RC – More maths. What decisions was this leading to?</td>
</tr>
<tr>
<td></td>
<td>RW – This was looking at the stability along the main axis and the bottles and also trying to see how far along the bottle from the neck would the rubber have to go so the bottle wouldn’t topple.</td>
</tr>
<tr>
<td></td>
<td>RC – Ok, so what did doing this achieve?</td>
</tr>
<tr>
<td></td>
<td>RW – It lead to the overall sizing.</td>
</tr>
</tbody>
</table>
However, it is also clear that decisions based on knowledge are still the subject of value judgements (see Table 5.2 below):

Table 5.2 Knowledge as the subject of value judgements.

<table>
<thead>
<tr>
<th>Dataset Three</th>
<th>Excerpt from transcript</th>
</tr>
</thead>
<tbody>
<tr>
<td>RC – Did actually knowing what the materials were made from change your ideas about any of the materials at all?</td>
<td>LG – I am slightly dubious about the toothbrush one... I know the smell is put on afterwards, but the fact that they're toothbrushes, I know they're factory rejects but it still didn't seem right... I know that sounds strange but I just thought it was a bit peculiar.</td>
</tr>
</tbody>
</table>

The subject of this thesis is the use of values in design decision-making, but this example clearly shows how decisions can be based on both knowledge and values, with the latter carrying ascendancy. So here, although the use of knowledge is undoubtedly present, LG is applying a personal value judgment to her decision not to use the material.

Table 5.3 below shows skill influencing the designer’s decisions. NN has chosen MDF because he has worked with it previously and SG has made models of her veterinary bag in order to increase her skill for making the real thing. RT has realised that he can transfer his skills from wood-working, onto the recycled materials.
Table 5.3 Examples of the use of skill in design decision-making.

<table>
<thead>
<tr>
<th>Dataset</th>
<th>Exert from transcript</th>
</tr>
</thead>
</table>
| One     | RC – oh right ok, so how come you chose MDF?  
NN – because I perceive it to be very strong and I've worked with it a few times  
RC – so is it because you're quite used to it?  
NN – yeah, yeah, I think that's it |
| Two     | RC – This is another model...  
SG – yeah, a model for the main bag  
RC – how did this help?  
SG – well it helped me to realise how I was going to put the actual bag together |
| Three   | RT – This is looking at the usability of the materials, how I could use them, any restrictions in the way I could use them.  
RC – Did this lead to any decisions?  
RT – Yeah, it did really, yeah, it told me what I could and couldn’t do. It made me realise I could think of it as wood really. |

5.2 Findings from the literature

Participants from dataset Three all had the same brief, however all five outcomes were very different. There was not deemed to be one correct outcome and four incorrect outcomes (although some were deemed to be better than others through the award of higher grades by academic staff to some students over others). This shows that designers satisfice (see chapter 2), and therefore value judgments must come into play. Numerous examples are provided below where values described in the literature review found in chapter 3 have influenced design-decision-making.

It is clear that many value judgments made by designers are made on the basis of traditional economic values. In the following example IS believes that using glass would be too expensive for the context, in this case, a toaster. He later decides on aluminium, among other reasons, for its cost.

- Dataset 4. IS: "...I don't think glass is...it would be nicer in quality and look really expensive...but it probably would be really expensive...".
- Dataset 4. IS: "...we've got our aluminium extrusion which is pretty cheap,..."
Cost seems to have big links with societal and stakeholder values e.g. paying more for something that brings with it an increased social status or returning a larger profit for investors. Economic value judgements can also be based on personal values (making more from sales or wanting to price a product fairly.

Examples for all of Hicks et al's four value categories, along with Robert's hedonic values (see chapter 3) can be found within the pilot studies, even within one dataset (e.g. Table 5.4 below). However the pilot studies also showed that these categories were insufficient, as can be seen by the additional findings in this thesis. Many of these categories are also mentioned by other authors in the literature review (see chapter 3).
<table>
<thead>
<tr>
<th>Category</th>
<th>Involve the appreciation and application of:</th>
<th>Evidence:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Technical values</strong></td>
<td>Efficiency, and the ways in which input is compared with the resultant output</td>
<td>Dataset 4. KB: &quot;So, wouldn’t it be more efficient to use less electricity for the heating...&quot;</td>
</tr>
<tr>
<td></td>
<td>Robustness, flexibility, and the ways in which the performance of a man-made object may be sensitive to change</td>
<td>Dataset 4. KB: &quot;Could you actually get rid of this side mechanism?&quot;</td>
</tr>
<tr>
<td></td>
<td>Precision, and the qualities of fit and of fitness to purpose, valued either for their own sakes or as a means to an end</td>
<td>Dataset 4. KB: &quot;You could have, slide in slide out, but you’d want the whole thing angled&quot;</td>
</tr>
<tr>
<td></td>
<td>Confidence, and the ways in which possible reliability and unreliability of information is taken into account</td>
<td>Dataset 4. KB: &quot;PVC...surprised that it’s PVC...but I guess that’s true&quot;</td>
</tr>
<tr>
<td><strong>Economic values</strong></td>
<td>The structures. Proportion and colours to be found in the natural and the man-made world</td>
<td>See above</td>
</tr>
<tr>
<td></td>
<td>Of the importance of aesthetic factors in all forms of human communication and self-expression</td>
<td>Dataset 4. IS: &quot;Um...maybe its almost like a wave rolling down&quot;</td>
</tr>
<tr>
<td></td>
<td>The inter-relationship between workmanship, tools and the aesthetic quality of the resulting environment or artefact</td>
<td>Dataset 4. IS: &quot;, ..., and then some end caps which are nice and curvy and styled that go on,...&quot;</td>
</tr>
<tr>
<td></td>
<td>Mankind’s impact on the natural environment and his responsibility for its and his own future survival</td>
<td>Dataset 4. IS: &quot;,...some kind of clear polyprop...nice clear striation...clear cap things that go in your extrusion head,...&quot;</td>
</tr>
<tr>
<td></td>
<td>The inter-relationship between the man-made world and religious, social, economic and philosophies</td>
<td>Dataset 4. IS: &quot;I would have thought you could get away with some polyprop or something in there which might be a little healthier&quot;</td>
</tr>
<tr>
<td></td>
<td>The needs of individuals in society and ways of meeting them</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The importance of ethical values in carrying out design activity and evaluating the effects of technology</td>
<td></td>
</tr>
<tr>
<td><strong>Hedonic values</strong></td>
<td>The role of vision, hearing, smell, taste and touch in attaching value phenomena through their direct appeal to the senses;</td>
<td>Dataset 4. KB: &quot;So, uh...that looks very ugly...&quot;</td>
</tr>
<tr>
<td></td>
<td>The role of appetite, desire, pleasure, pain etc, in the evolution of products and systems</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The demands made on the configuration of man-made things and systems by the physiology and psychology of people</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The importance of hedonic factors in all forms of design activity and an ability to take them into account when designing or evaluating things in the man-made environment</td>
<td>Dataset 4. IS: &quot;The problem is with this your bound to burn the toast which is why they invented the popping mechanism...&quot;</td>
</tr>
</tbody>
</table>
In the next sections the discussion shows evidence related to both internal and external values. We can see many examples of the categories from the literature within the pilot study transcripts, that show design decision-making is influenced by:

- personal values;
- social values;
- values embedded in design.

5.2.1 Personal values

Table 5.5 below shows decisions being swayed by personal values. Personal values, such as personal preference (or 'gut instinct') and comfort (in SG's case of working with a particular material) can lead to important decisions about what materials to use. A designer’s personal interests seem to influence design decisions to a high degree. RH is personally interested in sustainable issues and is therefore more active in applying them.

<table>
<thead>
<tr>
<th>Examples of personal values influencing design decision-making.</th>
<th>Dataset Three</th>
<th>Dataset Two</th>
<th>Dataset One</th>
</tr>
</thead>
<tbody>
<tr>
<td>RC – Why is it that you have immediately gone for these materials?</td>
<td>ER – They were just gut instincts</td>
<td>RC – So it was from personal preference?</td>
<td>ER – yes, personal preference completely</td>
</tr>
<tr>
<td>RC – And here you’ve got the...what are these inners made out of?</td>
<td>SG – I was sort of thinking you could have a thick material, a thick bag, but I wasn’t sure whether that would work or not</td>
<td>RC – So you weren’t specifying a particular material</td>
<td>SG – No, I think I did eventually think of foam but its not a very good material and I’m not very happy about working with it to be honest.</td>
</tr>
<tr>
<td>RC – Did you reject that idea</td>
<td>SG – Yes</td>
<td>RC – Is there anywhere you were thinking (reads) oh here we go you’ve got some...educate about the product, the recycled materials, what do you mean by that?</td>
<td>RH – Cos its sustainable design, I want to use materials that can be recycled, used again in some way, maybe in another project, or product</td>
</tr>
</tbody>
</table>
The example below shows NN has no personal interest in sustainability but understands that dealing with sustainability additionally within his project will gain him increased marks and an extra award:

- RC: "So, is the environment quite important to you then or is it just for this project that you have focused on it?"

Dataset 1. NN: "Um, its for the project (laughs)".

His value judgement to include sustainable issues is based on personal values. It is clear that personal values can have a profound effect on other decisions.

We can also see the use of heuristics in the pilot studies. SG has seen many examples of bags which use a cross-over stitch to connect the straps to the main body. She has extracted these examples and used this information to form a rule upon which she bases her designs. As explained by Dörner (1999) this is the use of RULES based on previous experiences, design episodes or built up from observations of previous projects - not the direct use of these previous ideas or available products. Ballistic thinking also occurs in the pilot studies, for example ER does not know whether her final idea will actually work, but proceeds with it anyway. Anchoring (Kaldate 2003, see chapter 3) also seems to be evident in design decision-making. This seems mainly to be in the form of the designer's previous projects (see Table 5.6).
Table 5.6. The use of heuristics in the pilot studies.

<table>
<thead>
<tr>
<th>Heuristic</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rules</td>
<td>Dataset 2. SG: &quot;Um… from my development I sort of decided how I was going to make it, and looking at examples, like looking at the straps, doing this little criss-cross stitch. RC: &quot;Do you know why they do that? Dataset 3. SG: &quot;No but they all do it so it must be important, strength I guess.&quot;</td>
</tr>
<tr>
<td>Ballistic thinking</td>
<td>Dataset 3. ER: &quot;On my feedback I did get a comment back that they weren’t sure that that would work. But because the candle is lower down it should in theory be O.K. I like theory! (laughs)&quot;</td>
</tr>
<tr>
<td>Anchoring</td>
<td>Dataset 3. LG: &quot;My GCSE project, I made a unit for the TV and hi-fi and I used steam bent wood to create it and I realised it looked quite organic and I thought maybe I could apply that here.&quot;</td>
</tr>
</tbody>
</table>

5.2.2 Social values

The examples from the pilots, shown below (Table 5.7) illustrate the designer’s decisions being influenced by the values of the society they are designing for. Both SG and RH were designing for a developing country and thinking about how their designs would affect the people living there.
Table 5.7 Examples of societal values from the pilot studies.

<table>
<thead>
<tr>
<th>Examples of the use of social values in design decision-making</th>
<th>Dataset Two</th>
<th>Dataset One</th>
</tr>
</thead>
<tbody>
<tr>
<td>RC – You have some moral issues here, what sort of things... how were you connecting this to your project?</td>
<td>RC – were you making any design decisions when you were thinking of these?</td>
<td>SG – yeah, I was thinking about how it would be made, and the working conditions of the people. So it’s mainly about people and how it would affect them.</td>
</tr>
<tr>
<td>SG – um...</td>
<td>RC – and what sort of design changes did you make to your product?</td>
<td>RC – were you making any design decisions when you were thinking of these?</td>
</tr>
<tr>
<td>SG – One of the things was about not making the product so that it wouldn’t overtake the whole market because there will be other companies making similar products so I didn’t think I would make a product like that... I was thinking I could make a product that could be made by those companies rather than set up a new company.</td>
<td>SG – yeah, I was thinking about how it would be made, and the working conditions of the people. So it’s mainly about people and how it would affect them.</td>
<td>RC – were you making any design decisions when you were thinking of these?</td>
</tr>
<tr>
<td>RC – One of the things was about not making the product so that it wouldn’t overtake the whole market because there will be other companies making similar products so I didn’t think I would make a product like that... I was thinking I could make a product that could be made by those companies rather than set up a new company.</td>
<td>SG – yeah, I was thinking about how it would be made, and the working conditions of the people. So it’s mainly about people and how it would affect them.</td>
<td>RC – were you making any design decisions when you were thinking of these?</td>
</tr>
<tr>
<td>RH – money’s quite limited in underdeveloped countries, so they’re not going to want to spend a lot of money on anything they make</td>
<td>RH – probably cardboard, canvas, things that are actually available to them, wood, but then they would probably use wood to burn rather than in production.</td>
<td>SG – yeah, I was thinking about how it would be made, and the working conditions of the people. So it’s mainly about people and how it would affect them.</td>
</tr>
</tbody>
</table>

5.2.3 Values embedded in design

We can also see how information is gained and values are transferred through existing products (see Table 5.8).
Table 5.8 Information is gained and values are transferred through existing products.

<table>
<thead>
<tr>
<th>Examples of the use of existing products in design decision-making.</th>
<th>Dataset Three</th>
<th>Dataset One</th>
</tr>
</thead>
<tbody>
<tr>
<td>LG – They had some pieces of plastic that were curved and bent, and that was what sparked my ideas</td>
<td>RC – What other resources do you think would have helped in making decisions about materials?</td>
<td>LG – Perhaps, products that had already been made out of these materials, seeing how they look once they have been produced, that might have helped</td>
</tr>
<tr>
<td></td>
<td>RH – Yes .... this bit’s (page 3) about looking at what products people already have in their schools and what materials they also actually use, the items that they have</td>
<td>RC- why is it that you were looking at the materials they already use?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>RH - well I had to find out what’s actually available in the different countries, also to see how effective the materials are for manufacturing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>RC – did you get any ideas from looking at that? What sorts of thoughts did you come up with when you were looking at that?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>RH – it made me aware that their resources are actually quite limited</td>
</tr>
<tr>
<td></td>
<td>Dataset One</td>
<td>Dataset Two</td>
</tr>
<tr>
<td></td>
<td>RC – Here you’re looking at some existing products, did these provoke any thoughts when you were looking at these</td>
<td>SG – yeah, most of it used polyester and things for the main material, some of it is canvas materials, it made me think of the different qualities of each material and why they had been used.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>RC – when you say qualities...</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SG – I was thinking about waterproofing, and how durable they are, things like that.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>RC – Ok – so your looking at this one in more detail</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SG – yeah</td>
</tr>
<tr>
<td></td>
<td></td>
<td>RC – How did that help you?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SG – I think it made me sort of think how the product was put together, and the range of materials that were used, they’ve used polyester and different nylons and things and mixed them together</td>
</tr>
<tr>
<td></td>
<td></td>
<td>RC – Were you looking at the way they were joining the materials together?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SG – yeah, thinking about how to fix it all and stuff</td>
</tr>
</tbody>
</table>
5.3 Values and expertise

From the pilot studies it would be hard to make any confident statements of the effect of expertise on design decision-making, due to the use of different research methods (i.e., the experts were used to pilot concurrent verbalisation and protocol analysis and the others retrospective interviews). However, a few observations were made and it was decided to continue this investigation into the main study where both novices and experts could be researched using the same methods.

Much as Ho suggests novices appear to 'haul' to another problem when failing to deal with the one at hand. The experts tended to address the problem until a solution was found (Chapter 3). The use of ballistic thinking is also more prevalent in less expert designers, we have already seen one example of ballistic thinking above (section 5.2.1), we can see again in Dataset 1, NN appears to overlook elements that may be troublesome.

- Dataset 1. NN: "yeah, yeah, because this is a recycling centre you want the materials to be recycled as well..."

  RC response: "but you chose MDF?"

  NN response: "(laughs nervously) cut that out, lets not go into that! But that was the easiest material"

Another difference observed was in decision-making strategies. The experts seem to be more efficient in developing complete solutions whereas less expert designers appear to practice exhaustive searches for ideas, much like Kavakli and Gero suggest (see chapter 3). This could however be due to the nature of the different briefs and the required outputs.

There were also some surprising similarities between the work of the two experts. They did not know what the brief was prior to the research study and were not in contact with each other between. It is not known whether this was coincidence or an indication of the way experts carry out design decision-making. This could also reflect the domain specific nature of design decision-making (Ho 2000, Cross 2004, Ball, Ormerod and Morley 2004).
5.4 Findings from visual representations

Project work that has been done for submission, i.e. for presentation (Datasets 1, 2 and 3) cannot really give us a complete insight into the designer's thinking as the scruffier drawings will have been discarded in favour of neater versions for assessment. In the main study it is important that all design sheets are collected at the end of the study. There is however, evidence that we can gain insights into design decision-making via a designer's visual representations.

Dataset 4 (Protocol analysis) not only recorded the designer's chain of thought, but also the visual representations that they made. It was observed that they 'thought aloud' while using hand gestures and pointing to specific parts of sketches. They appeared to be having interactive conversations with their visual representations. It was also observed that designers interacted with their sketches in the retrospective interviews:

- 
  RC: "Right, how did you come to your decision about materials here?

  Dataset 3.LG: "I was just going purely on aesthetics, what I like and what would look good

  RC: "So how did you decide, were you thinking in your head?

  Dataset 3.LG: "Each material against the drawing"

The use of CAD as another form of visual representation was also observed as a decision-making tool:

- Dataset 3.JP: "CAD also makes you think exactly, you cannot guess. You must think of exactly which bolt, which hole, which size, how they will join, it tidies it up for you."

It was also clear that the use of 3D modelling during design episodes helped to clarify many decisions that needed making, and to establish subsequent judgments that needed to be made (see Figure 5.1).
5.5 New understandings from the pilot studies

5.5.1 Stakeholder values as different from societal values

In his 1992 address (see chapter 3) Layton had already identified some stakeholders as having a large influence on the shaping of school technology. A similar increase in influence can be seen in design decision-making. This is also touched on by Baynes's levels of engagement (see chapter 3) and can be seen in the following examples. The first example shows how the brief can be considered as a list of identified stakeholder values. In the following example NN is actively seeking the value judgements of his client, in this case, a local school.

- *Dataset 1. NN:* "No I had to follow the brief this time because it gave me things to consider such as space, the school isn't that big, and also they wanted..."

- *Dataset 1. NN:* "Yeah, this is a questionnaire I gave to them for the research"

JP explains that he believes his success as a designer will make his parents proud. He is perceiving a value judgement on their behalf. Below ER describes how she has taken on
board a value judgment from one of her peers. Finally RT expresses his view that undergraduates sometimes make the decision to reject an idea as a result of stakeholder advice.

- Dataset 3 JP: "I am trying to think of the user and of course for the marks! (laughs) And about making my parents proud!"
- Dataset 3. ER: "...actually someone pointed out to me that if you have a shelf there and that one above it no light will be able to get through and I thought 'yes, that's a very good point!'"
- Dataset 4. RT: "...tutorials, lecturers almost dictate which ideas to reject don't they. It's not great when they do that but you have to follow their ideas for the marks don't you"

5.5.2 Internal perception of external values

It is clear from the literature that both internal values and external values influence design decision-making. What has also become apparent is that designers have an internal perception of these external values that they use to make value judgments 'on behalf' of external influences. In the following examples (see Table 5.9) RT is making an internal value judgement of what he perceives the values of the society he is designing for to be, and RG is making an internal decision about the values of the society that she is designing for, in this case a developing country.

Table 5.9 Internal perception of social values.

<table>
<thead>
<tr>
<th>Dataset</th>
<th>Exert from transcript</th>
</tr>
</thead>
</table>
| Dataset Three | RC – Why is it that you were focussing on the high-end 'couples' market?
RT – Because the brief wanted a striking, bold and... inspirational, and I thought that meant money and where the wealth would be, and I assumed couples would have more money than families and be able to splash out on products like that. It's the practicality of it as well, families have to be very practical, and couples don't. |
| Dataset one | RG – money's quite limited in underdeveloped countries, so they're not going to want to spend a lot of money on anything they make
RC- so when you were thinking of materials that were cheap were you thinking of any particular material while you were writing that?
RG – probably cardboard, canvas, things that are actually available to them, wood, but then they would probably use wood to burn rather than in production. |
5.5.3 Designers use of meta-values

As well as personal values such as personal taste, and personal opinion, to name only two, designers also appear to have an internal, value based organisational system. Essentially the thinking behind designers' actions does not just look backwards, as suggested by Schön's reflective practice but also looks forward to plan ahead. This is hinted at by Layton who suggests the use of organisation values when he mentions 'judgements about how intentions are realised shape the activity' (1992:36). Daley (1982) commented on a designer's use of values as an ordering mechanism. It is also clear that designers must make value judgements as to what extent an idea satisfies the overall need or whether alternatives should be sought. This is apparent in the pilot study outcomes, the following examples are taken from Dataset five:

- Dataset 5. RC: "Realised the need to discover the properties of materials" A value judgment of what needs to happen next based on an earlier decision that there would be of great benefit from the design requiring only simple changes to the original material.

- Dataset 5. RC: "Today I also decided to make some small models of some of the ideas and thought I could print out the examples of the plastics from Smile Plastics.co.uk to use for the models – more realistic idea of designs, assembly etc (models not made yet though)", A decision about later activity based on not knowing exactly how the design will be assembled.

Designers also appear to have an internal hierarchy of values. RH places more importance on certain value judgments than others. She basis her decisions on personal values of aesthetics before she decides on the most appropriate material for the design:

- Dataset 1. RH: "We kind of design the ideas of how we want it to look, then take a range of materials, try to analyse them – which one is best"

This group of values was initially referred to as 'organisational values'. However these early observations suggest a concept that is an abstraction from values, used to analyse and determine their use. In epistemology the prefix 'meta' is used to mean 'about', so here it is used as 'about values' as a more appropriate descriptor of this subset.

5.5.4 The importance of value judgements

The pilot studies provide evidence of many value judgements being made, but not all leading to decisions. Value judgements made during design activity appear to 'build up' before they are used to make a decision. This is hinted at by Gregory and Commander's
search and evaluate model where much time is spent on many activities before decisions are made (see chapter 3). RH's decision to use cardboard shows the influence of many different value judgements including:

- realising she needed a cheap material through the perception of social values;
- the association she made between cardboard and wood which led to the judgements that it would be a) strong; b) would use the same production techniques and c) that it would be easy to use;
- finding out that it was a waste product, which she specified as personally important;
- finding previous examples of the use of cardboard, Values embedded in design, for a) an English school b) a degree student's work and d) examples from Italy;
- testing its appropriateness through the creation of a model (this would be considered more as gaining know how but has been included as it shows the use of visual representations to aid decision-making).

5.6 Summary

Chapter 5 describes the key findings from the pilot studies. It provides evidence that the influence of values in industrial design decision-making can be identified and distinguished from the influences of knowledge and skill.

This chapter provides examples of the value categories identified by the literature (as described in chapter 3) i.e:

- societal values;
- personal values;
- values embedded in design.

It also presents the following new understandings from the pilot studies:

- that stakeholder values are different from societal values;
- that the designer has an internal perception of external values;
- that designers use meta-values to organise their activity;
- that different value judgements are deemed more or less important;
- values have different influences at different stages.
Due to these findings it was felt that a new classification system for values in design decision-making was required. The new values taxonomy and its development are described in chapter 6.
6.1 Development

It would be impossible to create an exhaustive list of values influencing design decision-making, but there is a need to develop a clear guideline system for the classification of all of these many values. The development of the new classification system occurred in three stages:

- by looking at the prior art;
- by making observations during the pilot studies;
- through the use of focus groups.

6.1.1 Looking at the prior art

It is clear from the prior art that there are both external values and internal values influencing design decision-making. It is also clear that designers have personal values that they bring to design decision-making, but that they are also influenced by societal values. The literature also provided evidence of values being embedded in design.

How the prior art fits into the new classification system is summarised in section 6.2.

6.1.2 Observations during the pilot studies

The pilot studies confirmed the influence of personal and societal values and values embedded in design suggested in the prior art described in section 6.1.1 above. The following were also observed (in relation to the creation of a new values taxonomy):

- stakeholder values are different from societal values (see section 5.5.1);
- the designer has an internal perception of external values (see section 5.5.2);
- designers use meta-values to organise their activity (see section 5.5.3).
6.1.3 The use of focus groups

The studies using focus groups were done in three phases:

- looking at the separation of internal and external values;
- looking at possible sub-categories for both the internal and external sets of values created in phase 1;
- assessment of the new values taxonomy developed in phases 1 and 2.

Many different people participated in the focus groups including postgraduate researchers, design and technology undergraduates and lecturers. The author also participated as well as having organised the activities. The focus groups took place in the postgraduate research office at Loughborough University's Department of Design and Technology.

6.1.3.1 Phase 1 – separating internal and external values

All initial members participating in the focus group sessions were invited and the task was explained. It was important to invite a number of people to this initial stage to ensure there were a number of participants. Two large pieces of paper were pinned to a wall, one with the heading internal decisions, and one with the heading external decisions. Participants were then asked to add values which they felt belonged on each piece of paper (see Figure. 6.1).

![Figure 6.1. A section of an outcome sheet from the focus groups](image)
The prior art was then introduced and participants were asked to decide whether these were internal or external values. Extracts about which there was uncertainty were pinned to a blank section of wall. These sheets of paper were then left up for a period of 10 days for people to add to them as and when they wished. The author felt it was important to keep the focus group activities as open as possible to ensure that those who wished to contribute could do so as they wished even if they had not been present at the initial briefing. No log was kept of the number of people who contributed during the 10 day period.

6.1.3.2 Phase 2 – developing possible sub-categories

During phase 1 a poster was placed next to the sheet inviting participants to take part in phase 2. From the internal and external sub-sets created in phase one, attempts were made to group them into possible sub-categories, with these sub-categories being recorded as the activity developed. This was achieved using what the author referred to as the 'Blue Peter' method. Each value was cut out and participants were able to physically move them into possible sub-categories. This was combined with free discussion and included the addition of new values if they came up during the activity. The initial categories identified by the prior art, and the new understandings developed after the pilot studies (see section 5.6 for a summary of these) were also discussed during this phase and became the basis for the new taxonomy. The categories were then trialled against extracts from the pilot study transcripts. At the end of the phase 2 focus group participants were invited to take part in the third and final focus group.

6.1.3.3 Phase 3 – assessing the new values taxonomy

The new values taxonomy was discussed during the third and final focus group session for applicability and completeness. The values documented in phases 1 and 2, which were cut out and reclassified in phase 2, were each placed within a category of the new values taxonomy on a large sheet of paper. This was presented to those taking part prior to the final focus group and it was deemed to be appropriate by all participants.
6.2 The new values taxonomy

From the prior art, pilot studies and series of focus groups it was possible to create a new values classification system which is seen below (Table 6.1)

Table 6.1. The new values taxonomy

<table>
<thead>
<tr>
<th>External values</th>
<th>Internal values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Societal values</td>
<td>Perceived societal values</td>
</tr>
<tr>
<td>Identified stakeholder values</td>
<td>Perceived identified stakeholder values</td>
</tr>
<tr>
<td>Economic system values</td>
<td>Perceived economic system values</td>
</tr>
<tr>
<td>Values embedded in design</td>
<td>Designer's personal values</td>
</tr>
<tr>
<td>meta-values</td>
<td></td>
</tr>
</tbody>
</table>

6.2.1 External values

External values influencing design decision-making are:

- societal values;
- identified stakeholder values;
- economic system values;
- values embedded in design;

6.2.1.1 Societal values

Societal values are the values of those from the designer's own or another society that have been readily sought by the designer (See the involved and consulted levels of Baynes’s levels of engagement in chapter 3). There must be evidence that these values have been sought, for example the designer has questioned members of the society where the interest lies:

Dataset 2.NN: “Yeah, this is a questionnaire I gave them for the research”

These values could be in the form of ‘...preferences, priorities, convictions and emotions’ (Pedgley 1999:33). The acceptability of a design within the selected society could be based on market desire, current fashion, aesthetic appeal and extends to the less tangible effects of the society’s political climate and religious, cultural, social and ethical positions (for example the value of occupational hierarchies preserved through the design of office furniture that differs in size from managerial desk to secretarial work stations; the
design of mousetraps that reflect the culture in which they are used, from the French version, modelled on the guillotine, to the Egyptian one based on a pyramid, and the success of joint ownership schemes being based on the value of collectivism or individualism within the selected society (Layton 1992a:37-38). It is of interest to the designer to be aware of the values of others and Hicks et al acknowledges this as he defines ‘...the appreciation and application of the needs of individuals in society and ways of meeting them’ (1982:7) as a moral value. Layton (1992a:39) also suggests that a technology will only be successful if the values embedded within it are congruent with those of the society for which it is intended.

Societal values sought by the designer will still have the personal values of the designer imposed upon them, in his or her value judgment to seek those values, to use those values once they are sought or in attaching meaning to the values that he or she is presented with, but this is still different from an internal perception of societal values.

Much of the prior art refers to societal values, a brief overview is supplied below (Table 6.2).
Table 6.2. Summary of societal values referred to in the prior art.

<table>
<thead>
<tr>
<th>Author</th>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concise Oxford Dictionary, 1992</td>
<td>How the outcome effects the user</td>
</tr>
</tbody>
</table>
| Hicks et al.                   | Responsibilities to mankind's future survival  
Inter-relationship between the man-made world and religious social and philosophies  
The needs of individuals in society and ways of meeting them  
The importance of ethical values in carrying out design activity and evaluating the effects of technology. |
| Elhamdi et al, 2003            | Level of effect that people personally expect from products and services                                                                                                                                 |
| Baynes, 2005                   | Designers addressing socially important problems. Social worth of products.                                                                                                                                 |
| Layton, 1992a                  | Technology bears social imprints. Technology shapes society. Design preserving social hierarchies. Design reflects cultures Societal values allow technological adoption or technological obsolescence. |
| Goonatilake, 1984              | Technology as a social gene Social values drive design decisions Technology carries the scars of the socio-economic system that gave birth to them                                                                        |
| O'Brien and Guerrier, 1995     | Values are embedded in a social context                                                                                                                                                                 |
| Green, 2003a                   | Design must be socially and culturally acceptable                                                                                                                                                       |
| Boztepe 2003                   | Needs are experienced within cultures Social values determining how we view products. Classification of consumer values                                                                               |

6.2.1.2 Identified stakeholder values

Identified stakeholder values are the sought values of those identified as having a greater influence or importance on the designer's decisions, see for example, Table 6.3 below.

Table 6.3. Some examples of stakeholders.

<table>
<thead>
<tr>
<th>Boss</th>
<th>Investor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher</td>
<td>Named client</td>
</tr>
<tr>
<td>Lecturer</td>
<td>Known user</td>
</tr>
<tr>
<td>Parent</td>
<td>Peers</td>
</tr>
<tr>
<td></td>
<td>Experts</td>
</tr>
</tbody>
</table>
Stakeholder values can be in the form of, for example, suggestions, opinions, comments, advice or answers to questions (it is not feedback from members of the society for which the designer is working except in the case of a known client or user) that have come directly from the stakeholder. An example from the pilot studies shows that RH has sought the advice of an expert during her project to design a desk from cardboard:

Dataset 1.RH: "...There's this guy who did some research to find out how good cardboard actually was, I spoke to someone who did a degree project on cardboard furniture"

There is not a great deal of prior art from chapter three for this category (Layton's identification of stakeholders and their value positions, (1992) and Baynes's levels of engagement (2005), but this category was observed as important in the pilot studies (see section 5.5.1).

6.2.1.3 Economic system values

These are values that have been sought by the designer regarding the economics of the product or system they are designing. For example it includes how the designer's time relates to the overall cost of the product and how the cost of the product relates to its price. For example SG looks at the cost of manufacture and its relationship to the overall cost of the product:

RC: "...you've got research into manufacture and cost, do you find those important to your design?"

Dataset 2.SG: "yeah, it's obviously important because it determines the cost of the product at the end as well and they put a limit on the cost they wanted for the bag"

There is a lot of prior art relating to economic values, a summary of which can be found below (Table 6.4).
Table 6.4 Summary of prior art regarding economic values.

<table>
<thead>
<tr>
<th>Author</th>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concise Oxford Dictionary, 1992</td>
<td>The amount of money or goods for which a thing can be exchanged in the open market</td>
</tr>
<tr>
<td>Baynes, 2005</td>
<td>Turning products into wealth Contributing to profits Seeking a fit between profit and needs and wants Economic constraints of the market place Relationship between economics and the political and environmental power of consumption Solving problems within the imperatives of the market economy Consideration of the project budget, cost of materials and processes Acceptable levels of performance in relation to cost Understanding of economic competition</td>
</tr>
<tr>
<td>Ashby and Johnson, 2003</td>
<td>Relationship between cost and the market place</td>
</tr>
<tr>
<td>Boztepe, 2003</td>
<td>Use value Exchange value</td>
</tr>
<tr>
<td>Hicks et al,</td>
<td>Use value Intrinsic value Value in exchange Marginal value of one product over another Supply and demand vs. availability and price</td>
</tr>
</tbody>
</table>

6.2.1.4 Values embedded in design

Values embedded in design are those values a designer takes from existing products or those the designer acts to embed within their own product. In dataset 3, LG uses an existing product as a starting point for her ideas:

D*ataset 3. LG: “I think this one [idea] came from... I've got a book rack in my room, on the floor and it's a cross-over one and I guess it could have come from that because I did look at that quite a lot...”

Whereas JP sees the embedded values of particular materials and makes his decisions to use or reject them based on this:

Dataset 3. JP: “The materials that are really nice are the coffee cups and the yoghurt pots because I think these materials are [better] for more sophisticated products”

There is extensive prior art on values embedded in design, a summary is shown below (Table 6.5).
Table 6.5 Summary of the prior art regarding values embedded in design.

<table>
<thead>
<tr>
<th>Author</th>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goonatilake, 1984</td>
<td>Products carry embedded value</td>
</tr>
</tbody>
</table>
| Layton, 1992a                 | Value in products highlighted by how they’re used  
Technology cannot be value free  
Portraying a sense within a design  
Conveying messages through design  
Embedding other values within design  
Values embedded in design affect their success |
| Cross, 1982                   | Existing products as a great source of inspiration  
Designers can both read and write in material culture                                                                                   |
| Middleton, 2003               | Designers work from existing products to create new ones  
Designers use products as inspiration                                                                                                     |
| Jordan and Macdonald, 2002    | Designers have an understanding of the additional values a product holds including physio-pleasure, socio-pleasure, psycho-pleasure and ideo-pleasure  
Designers have an understanding of product semantics                                                                                     |
| Feils and Overbeeke, 2003     | How an artefact can be interpreted  
Creating meaningful products                                                                                                               |
| Boztepe 2003                  | People value products for what they signify                                                                                             |
| Martin, 1999                  | Products reflecting other values (societal etc)                                                                                           |
| Eckert and Martin, 2000       | Previous designs furnish a vocabulary for new designs, processes and interpretations  
Products are used in the following ways; precedent; reuse; pattern and primary generator                                                 |
| Sassatelli, 2000              | Value is inherent to the product  
Value is enhanced by subjective judgement                                                                                                  |
| Boztepe, 2003                 | Value comes from a persuasiveness from design                                                                                                |
| Ashby and Johnson, 2003       | Materials have embedded personalities and characters  
Selection by similarity  
Some objects have a meaningful relationship to the to-be-invented object                                                                     |
| Ryle, 1948                    | Dispositional concepts                                                                                                                  |
| Rompay et al, 2004            | Values embedded in design are connected to image schemas                                                                               |
6.2.2 Internal values

Internal values influencing design decision-making are:

- perceived societal values;
- perceived identified stakeholder values;
- perceived economic system values;
- designer's personal values;
- meta-values;

6.2.2.1 Perceived societal values

Perceived societal values are the values of those from the designers' own or another society that are perceived by the designer. For example SG explains that she is mainly thinking about the end user during design decision-making, however, she makes no attempt to actively seek their values:

RC: "Who and...or what were you thinking about most when you were designing?"

Dataset 2. SG: "I think about the end user most of the time..."

Perceived societal values could be, for example, inferred through the collection of unrelated information or the designer's belief that his or her values are congruent with the society for which they are designing (for example they could be designing for their own society). They have not been readily sought, but rather assumed as the values of the selected society. This could also be referred to as internal moral judgements. This could be the perceived acceptability of the product, system or service, the perceived desired qualities it should possess, its perceived aesthetic appeal to the members of that society and its perceived market desire. It also includes the designer's perception of the current fashion and political status of the intended society and a perception of its religious, ethical or social beliefs.

The references that are summarised in section 6.2.1.1 are also relevant here as are the words of Baynes who comments that designer's in a sense have to represent consumers and carry out thinking on their behalf (Baynes 2005:59).
6.2.2.2 Perceived identified stakeholder values

These are the same as identified stakeholder values except that they have not been readily sought but are instead perceived by the designer (much like the differences between societal and perceived societal values). For example, in dataset 3, RW bases his decision to design a cup holder on the perception that his peers will design tables and chairs.

Dataset 3.RW: "...I had a feeling there would be a lot of chairs and tables and such like so it was a structural project that was a bit different"

6.2.2.3 Perceived economic system values

These are the same as economic system values except that they have not been readily sought by the designer but are instead perceived (much like the differences between societal and perceived societal values). For example, in dataset 1, RH has not readily sought information about how much her target audience would spend on what they make, instead she has made her own assumptions that will influence her decision-making:

Dataset 1.RH: "Money's quite limited in underdeveloped countries, so they're not going to want to spend a lot of money on anything they make"

6.2.2.4 Designer's personal values

These are the designer's own values that affect the design decisions they make during design activity. For example, JP's choice to reject certain materials is purely based on his own personal aesthetic taste:

Dataset 3.JP: "Yes, the bottles, I don't like the colours. It's not a kind of material that I would use. I really don't like it..."

Examples from the prior art are shown below (Table 6.6).
Table 6.6 Summary of the prior art regarding designer’s personal values.

<table>
<thead>
<tr>
<th>Author</th>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dorst, 2003</td>
<td>The designer can design according to his own taste, style and abilities.</td>
</tr>
<tr>
<td>Kumar and Bjorn-Anderson, 1990</td>
<td>Choices are determined, to a large extent, by the designer’s personal values</td>
</tr>
<tr>
<td>Pedgley, 1999</td>
<td>Designer’s make decisions based on, for example, their preferences, priorities, opinions, passions, convictions and emotions.</td>
</tr>
<tr>
<td>Rokeach, 1973</td>
<td>Terminal values and instrumental values</td>
</tr>
<tr>
<td>Daley, 1984</td>
<td>Perception and personal experiences</td>
</tr>
<tr>
<td>Dorner, 1999</td>
<td>Use of personal analogies, Ballistic thinking, Heuristics</td>
</tr>
<tr>
<td>Gregory and Commander, 1979</td>
<td>Models of design behaviour, Heuristics</td>
</tr>
<tr>
<td>Kaldate et al, 2003</td>
<td>Decision traps, Heuristics</td>
</tr>
</tbody>
</table>

This category provoked the highest response during focus group phase one, where additional values were mentioned (see Table 6.7 below).

Table 6.7 Additional values recognised in focus group phase one.

<table>
<thead>
<tr>
<th>Personal experiences</th>
<th>Personal taste</th>
<th>Embedded values of their own society</th>
</tr>
</thead>
<tbody>
<tr>
<td>Symbolic</td>
<td>Showing personality</td>
<td>Frame of mind / mood</td>
</tr>
<tr>
<td>Personal significance</td>
<td>Likes and dislikes</td>
<td>Need to do well</td>
</tr>
<tr>
<td>Personal preference</td>
<td>Personal concerns for issues</td>
<td>Personal responsibilities</td>
</tr>
<tr>
<td>Dedication</td>
<td>Reputation</td>
<td>Personality</td>
</tr>
<tr>
<td>Acceptability</td>
<td>Personal drive</td>
<td>Aspirations</td>
</tr>
</tbody>
</table>

6.2.2.5 Meta-values

These could be considered as a designer’s personal values, however they are slightly different and worth separating. Meta-values describe value judgements that go beyond the levels already described in this chapter to a more abstract level of judgement about the art of decision-making as a whole. It is not only decisions regarding the physical form, manufacture and intended use (to name a few) that must be considered by the designer, but also to what extent each step towards the conclusion satisfies the overall need, or a
designer's ability to satisfice. The following is an example from dataset 4 where IS makes a value judgement regarding the most appropriate start for his design activities:

Dataset 4.IS: “So, I guess just looking at it, whenever you switch it on all the heat's just going to come straight out the top. Probably the best place to start looking”

There is little prior art regarding meta-values, a summary is shown below (Table 6.8).

Table 6.8 A summary of the prior art regarding meta-values.

<table>
<thead>
<tr>
<th>Author</th>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Layton, 1992</td>
<td>Judgements about how intentions are realised shape the activity</td>
</tr>
<tr>
<td>Daley 1982</td>
<td>Designers use of values as an ordering mechanism</td>
</tr>
<tr>
<td></td>
<td>Designer's employment of values for ordering conceptual priorities</td>
</tr>
<tr>
<td>Keeney, value focussed thinking</td>
<td>Values as principles used for evaluation and to determine potential consequences</td>
</tr>
</tbody>
</table>

The designer must initially identify areas where discrepancies lie. They must then decide on the degree of satisfaction required and provide criteria for measuring how far that given thing meets the stated need and judge the acceptability of the resolution. This may also include the designer's response to modelling activities and must include the decision (or not) to look for alternatives.

Values of satisfaction identify the designers ability to choose between alternatives and identify the acceptability of the resolution (for example see Table 6.9).

Table 6.9. Meta-values as values of satisfaction

| Identification of areas where discrepancies lie | Responding to modelling activities |
| Deciding degree of satisfaction required       | Perceiving the quality of outcomes |
| Providing criteria for measuring how far a given thing meets the stated need | Deciding to look for alternatives |
| Judging the acceptability of the resolution   | Implying an order by which ideas are ranked |
It is important to understand that in order to make decisions a designer must first assign some sort of order to their conceptual priorities. This could be in the application of different degrees of importance to elements of the design such as its function, durability, aesthetic appearance, cost, manufacturing process etc. It also includes the perception of the truth and prioritising of information gained throughout the project and making assumptions in order to move on (for example see Table 6.10).

Table 6.10 Additional meta-values

<table>
<thead>
<tr>
<th>Prioritising</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application of different degrees of importance</td>
</tr>
<tr>
<td>Perception of truth of information</td>
</tr>
<tr>
<td>Ordering of conceptual priorities</td>
</tr>
<tr>
<td>Making assumptions in order to move on</td>
</tr>
</tbody>
</table>

Although there is no evidence for the use of prescribed, linear, design process models as a method of describing design decision-making it is clear that meta-values can be observed as the means by which a designer establishes a personal design process. Each meta-value judgement is intended to move the designer towards the completion of a satisfactory outcome and thus can form a log of the process used by the designer to move from start to finish.

6.3 Values as the sole influence in design decision-making

It is clear from the prior art and from the pilot studies that in many cases values do not act alone, and a value influence can come from more than one category at any given time. Many authors agree that economic values do not often appear in isolation from social, personal or stakeholder values (Lonchampt et al, 2003, Boztepe, 2003, Baynes, 2005 among others), and that a designer's personal values are influenced by the society in which they grew up, live, or work. Many of the examples given in this chapter and in chapter five, although used to highlight particular values, also contain influences from other value categories.
### 6.4 Summary

Chapter 6 describes the development of the following taxonomy of values (for a summary see Table 6.11 below).

**Table 6.11 Summary overview of the new values taxonomy.**

<table>
<thead>
<tr>
<th>External values</th>
<th>Summary description</th>
<th>Internal values</th>
<th>Summary description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Societal values</td>
<td>Values from the designer’s own or another society that have been readily sought by the designer. There must be evidence that these values have been sought through research, for example the designer has question members of the society where the interest lies.</td>
<td>Perceived societal values</td>
<td>Values from the designer’s own or another society that have not been sought but are instead perceived by the designer.</td>
</tr>
<tr>
<td>Identified stakeholder values</td>
<td>Values that are sought from those identified as having greater influence or importance to the designer</td>
<td>Perceived identified stakeholder values</td>
<td>Values perceived by the designer regarding those identified as having greater influence or importance to the designer.</td>
</tr>
<tr>
<td>Economic system values</td>
<td>Values sought by the designer regarding the economics affecting the product or system</td>
<td>Perceived economic system values</td>
<td>Values perceived by the designer regarding the economics affecting the product or system.</td>
</tr>
<tr>
<td>Values embedded in design</td>
<td>Values found in existing products and, or values the designer wishes to embed within their own product or system</td>
<td>Designer’s personal values</td>
<td>The designer’s own values.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Meta-values</td>
<td>Values used as principles for evaluation, organising activity and determining potential consequences.</td>
</tr>
</tbody>
</table>
Overview: Chapter seven provides an overview of the research methods adopted for the analysis of the nine case studies on which the main data collection was carried out. Retrospective interviews and concurrent verbalisation were adopted as the most appropriate methods and a one-day event designed in order to gather the necessary data. Eight of the case studies were during the one day event. The data from these was designed to be triangulated against the ninth case study, a natural design situation, as well as previous literature, in order to check the validity. The case studies again spanned 16+, undergraduates, postgraduates and professional designers. The longitudinal case study was of a professional designer in order to provide the most rigorous comparison. The same professional designer also undertook the one day event (a different brief) in order to provide a direct comparison.

7.1 Data collection methods

A number of different data collection methods were trialled during the pilot studies, an overview is shown in Table 7.1 below:

<table>
<thead>
<tr>
<th>Expertise / method</th>
<th>Protocol analysis</th>
<th>Retrospective</th>
<th>Diary method</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-level</td>
<td>Datasets 1 +2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Undergraduate</td>
<td>Dataset 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Postgraduate</td>
<td></td>
<td>Datasets 5 + 6</td>
<td></td>
</tr>
<tr>
<td>Professional</td>
<td>Dataset 4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

These pilots showed that it was most appropriate to use a combination of data collection methods, these are, as discussed below:

- retrospective interviews; and
- concurrent verbalisation and protocol analysis (see Table 7.2).

<table>
<thead>
<tr>
<th>Expertise / method</th>
<th>Protocol analysis</th>
<th>Retrospective</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-level</td>
<td>AL and KC</td>
<td>AL and KC</td>
</tr>
<tr>
<td>Undergraduate</td>
<td>MLC and SP</td>
<td>MLC and SP</td>
</tr>
<tr>
<td>Postgraduate</td>
<td>CA and JM</td>
<td>CA and JM</td>
</tr>
<tr>
<td>Professional</td>
<td>AD and DL</td>
<td>AD and DL</td>
</tr>
</tbody>
</table>
Multiple methods were chosen as it was felt that no technique used independently can represent a complete description of design decision-making but together they build a sufficient profile of a designer's use of values in design decision-making. Multiple methods were also selected in order to reduce the risk that the conclusion would reflect any limitations of a specific method. This enabled triangulation at the level of data collection as well as triangulation at the level of data analysis.

It is clear from the pilot study results that data on design decision-making can be collected and that subjects can make their decision-making activities explicit. For this body of research it is clear that it is most effective to use a combination of both retrospective interviews and concurrent verbalisation and protocol analysis. Protocol analysis allows microscopic data to be collected. However, it was decided that a 1 hour protocol created more data than could be analysed in the time available and so a 20 minute protocol was used. Its drawback was that it was sometimes difficult to tell what some decisions were based on as it relies on what they chose to make explicit. In the retrospective interviews subjects can be asked to explain their thoughts further. The retrospective interviews also allow data to be collected over the entire project, and therefore gives a more macroscopic, and complete picture of decision-making, but it lacks the in-depth insight that protocol analysis offers. It was felt that the diary of design did not produce data worth pursuing.

7.1.1 Retrospective interviews

Retrospective interviews facilitate macroscopic data to be collected regarding design decisions. The technique allows data to be collected on the entire project. Retrospective interviews took place as follows:

- each participant was asked to take part in a 40 minute interview;
- the interviews commenced as soon as possible after the completion of each project;
- the interviews were recorded using a Dictaphone;
- the interviews were transcribed as soon as possible to aid any clarification.

The interviews were semi-structured using a topic guide with the following questions (See Table 7.3):
Table 7.3 Retrospective interview topic guide.

**Personal Biography and Background**
- Can you briefly describe the areas you have worked in (GCSE, A-Levels, Degree etc)?
- How many years have you been a professional designer? (only for professionals).
- Can you tell me a general hierarchy of things you consider important in a product you are designing?
- How good would you consider your knowledge of materials to be?

**Project Introduction**
- Did you follow a particular strategy / model of designing during the project?
- Did you feel constrained regarding materials and manufacture in any way?
- How important do you consider material choice to be in this project?
- Do you think you addressed material issues continuously, a lot, quite regularly, or as an afterthought? Did this differ from previous projects?
- Who / what were you thinking about most when designing the object?

**Project**
- I would like to look through your project now and talk about your general decision-making. As we look through it, can you identify where issues have been thought about (or where they definitely haven't been considered). This could be in many ways, for example:
  - In your head (minds eye) as a thought, an image, a sense (how you think it should feel, look)
  - Diagrammatically, you have used a sketch, or a rendering, or a technical drawing or a model to convey something (to yourself or others), using colour or a direct reference (written)
  - Using external resources; in conversation, when have you spoken to others, looking at books, the internet, reference products
- I would also be grateful if you could highlight points during the project where you feel important decisions have been made.

**Post Project**
- Do you feel that the project has had any effect on the way you consider materials?
- What other resources do you feel would have helped in regards to making decisions?
- What do you think of the outcome of the project?
- If you specified its use, do you think the use of recycled material adds or subtracts value from the product?
It was felt that asking questions before going through the project had many benefits. It allowed the participant to relax before being asked to describe their decision-making. Pedgley mentions that an element of learning is involved in the process of making explicit design decision-making as it is not a process that is normally undertaken (1999), so asking each participant to begin by making specific elements explicit, allows them to practice. Finally asking about their previous experiences was felt to have some importance regarding how expertise affects design decision-making, and also allows the researcher greater understanding from which to infer the influence of certain values on subsequent verbatim during analysis.

The following prompting questions were also available to the researcher to aid the elicitation of appropriate responses (see Table 7.4):

<table>
<thead>
<tr>
<th>Prompting questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Why was this idea abandoned?</td>
</tr>
<tr>
<td>Why was this idea continued?</td>
</tr>
<tr>
<td>Can you give me details of your decisions here?</td>
</tr>
<tr>
<td>What was driving this decision?</td>
</tr>
<tr>
<td>How did you arrive at this idea?</td>
</tr>
<tr>
<td>What is the significance of...?</td>
</tr>
<tr>
<td>Did you consider...? / have any ideas on...?</td>
</tr>
<tr>
<td>Where did you get this idea?</td>
</tr>
<tr>
<td>Why is that important?</td>
</tr>
<tr>
<td>What media did you use?</td>
</tr>
<tr>
<td>How did you get from here to here?</td>
</tr>
</tbody>
</table>

Data was also collected in the form of the participants tangible work. The participants drawing folio, 2D and 3D modelling and any CAD work was requested (see deliverables section 7.4 for information on each participant).

7.1.2 Concurrent verbalisation and protocol analysis

Concurrent verbalisation and protocol analysis allows more microscopic data to be collected but only on a small section of design activity (otherwise there would be too much data to analyse). It not only allows the collection of more in-depth verbatim but also videos of concurrent visual representations. This allows more insight into a designer’s decision-making and how this corresponds with their visual representations and other observable activity.
From the data collected during the pilot studies it was clear that a short segment of protocol data yielded enough data to carry out in-depth analysis of design decision-making (Appendix vi shows the extent and depth of data captured from a 20 minute concurrent verbalisation and protocol analysis). It was concluded that the data collected during a 20 minute concurrent verbalisation and protocol analysis was more than sufficient to allow insight into a designer's decision-making. Each participant was videoed for 20 minutes during the design project. The participant was videoed as they continued with their design activity. During this time they were asked to 'think aloud'. They were given an explanation sheet with the following:

Protocol analysis seeks insight into a designer's method of making decisions through observing a designer's activities as they carry out a set task. In this case the set task is to design a lectern.

It is used with concurrent verbalisation so that the designer can describe what is happening. This allows the other activities to become better understood as it is impossible to tell what is going on inside a designer's head without being told.

Please try to 'think aloud' during the 20-minute session. Try to describe what is going through your mind at each stage of designing (and during periods of no activity).

The video was not made available to the participant during the rest of the project. The verbatim from the video was transcribed as soon as possible to aid any clarification required.

7.1.3 Rejection of the diary of designing

The diary method was tested by the author through the designing of a lectern. This was done for similar reasons to Pedgley (1999) that the author wanted to continue designing through the PhD. It was found that it was difficult to keep up with entries and the other work that was being done at the time made the development of the lectern very slow and disjointed. It was decided from this to take the route of analysing other people's design activities. Another problem that matched that found by Pedgley (1999) was in finding the commitment to a practical element difficult due to the commitment of time involved in a design project. Pedgley (1999) did suggest that the project be undertaken within an allocated time as a sole activity but other PhD commitments made this impossible a) because the initial trial project was part of another section of the thesis and therefore other work had to be done in parallel and b) due to the nature of the second project being semi-reliant on others (meetings with clients, trialling and ordering of materials etc)
meaning that if sole attention was paid to the project, a lot of time might may have been spent doing nothing at all and c) the pilot occurring at the early stages of the PhD where other work was essential.

7.2 Participants

It was not possible to make any conclusive judgments regarding the effects of expertise on design decision-making from the pilot studies as different research methods were trialled on participants of varying levels of expertise (see Table 7.1). This meant that accurate comparison between participants could not occur. However, there was enough observational evidence to interest the author to look at the effect of expertise on design decision-making within the main study (see Table 7.2).

Four levels of expertise were selected for the main trial. They were selected by levels of experience, these were:

- A-level;
- undergraduate Industrial Design and Technology students;
- postgraduate students studying for PhDs in Industrial design fields;
- professionals working within industrial design.

Two participants were selected for each level of expertise (see Table 7.5). Participants were recruited by advertising for participants who were interested in taking part in the research, and who wanted to undertake a project using sustainable materials.

<table>
<thead>
<tr>
<th>Level of expertise</th>
<th>Participant initials</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-level</td>
<td>KC, AL</td>
</tr>
<tr>
<td>Undergraduate</td>
<td>M- LC, SP</td>
</tr>
<tr>
<td>Postgraduate</td>
<td>CA, JM</td>
</tr>
<tr>
<td>Professional</td>
<td>AD, DL</td>
</tr>
</tbody>
</table>

Table 7.5 List of selected participants for the main trial

Each participant was required to fill out a consent form (altered from Robson 1996:298).
7.3 Project briefs

The data for the main study was collected from two briefs:

- one day events – lectern brief;
- longitudinal study – polymer guitar brief.

7.3.1. One day events – lectern brief

All eight participants took part in the one day events which took place in Loughborough University's Department of Design and Technology. A room was set up for the trials and was not emptied until all participants had taken part in the study. Between each study the room was re-arranged back to its original layout using photographs taken before commencement of the trials.

Each participant worked on the same brief for the one day projects to enable cross-case comparisons to be made. The brief was developed in conjunction with Smile Plastics Ltd (www.smile-plastics.co.uk) and Recoup (www.recoup.org). The participants were required to propose a new lectern design made from recycled plastics for Recoup to use at conferences and trade shows (for the full brief please see Figure 7.2). Participants did not know the exact brief before commencement of the project. The brief was chosen for many reasons including:

- its appropriateness for all four levels of expertise;
- its appropriateness for the time scale;
- its sustainable design element.

Each participant was given one day to complete the project. An example timetable is shown below (start times were moved forwards or backwards to accommodate participants other commitments):

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>9:00</td>
<td>Welcome and Introduction</td>
</tr>
<tr>
<td></td>
<td>Design work</td>
</tr>
<tr>
<td>12:30</td>
<td>Lunch</td>
</tr>
<tr>
<td>1:30</td>
<td>Protocol analysis video</td>
</tr>
<tr>
<td></td>
<td>Design work</td>
</tr>
<tr>
<td>2:45</td>
<td>Interview</td>
</tr>
<tr>
<td>3:30</td>
<td>Finish</td>
</tr>
</tbody>
</table>
7.3.1.1 Resources supplied

As well as the brief, participants were supplied with many other resources that they could use during the project. They were also given access to computers and were able to bring with them, or go and get, anything they wanted during the project (to make it as realistic as possible).

A list of additional resources is given in Table 7.6, see also Figure 7.1

Table 7.6 Additional resources

<table>
<thead>
<tr>
<th>Pamphlet draft</th>
<th>Recoup logo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smile Plastics price list and hasaw information</td>
<td>Deliverables sheet</td>
</tr>
<tr>
<td>Recycled sheet explanation list</td>
<td>Smile plastic and Yemm Hart example pieces</td>
</tr>
<tr>
<td>The authors plastic bottle top trial outcomes</td>
<td>Examples of processed plastics</td>
</tr>
<tr>
<td>Drawing and measurements of old lectern</td>
<td>Drawing resources (paper, pens etc)</td>
</tr>
<tr>
<td>Inspirational poster of products made from recycled plastic</td>
<td>Inspirational poster of lectern examples</td>
</tr>
</tbody>
</table>

Participants were also advised that they were not confined to materials and resources in the room.
Figure 7.1 Some of the resources made available to participants.
Recoup

Recoup (Recycling of Used Plastics Ltd) was established in 1989 to promote and facilitate post consumer plastic container recycling in the UK.

When Recoup was established there was little knowledge of plastic bottle recycling in the UK. Today 49% of local authorities operate a plastic bottle collection scheme. At the end of 2000, there were over 4,115 plastic bottle collection banks and more than 3.6 million households had a kerbside collection for recyclables including plastic bottles. Since Recoup was established more than 1.129 million plastic bottles have been collected in the UK for recycling.

However, there is a need to broaden awareness of the range of products that use recycled material as well as potential new applications. Those designs that are currently available tend to be rather conservative in nature and targeted towards low added value products.

Smile Plastics

Smile plastics are a company that recycles waste plastic into new plastic sheet. They launched their first product range in 1994 and have continued to develop new ways of recycling plastic waste. Recycled plastics sheets have been used extensively all over the world including the i-lde showroom and golf driving range roofing in Japan (Klein Dytham), Body Shop and Bianco fashion shops throughout Spain (Fern Green). The Science Museum, Design Museum, V & A and the Tate Gallery have all used it in different capacities.

As part of Recoup’s aims to promote the use of recycled plastics they regularly take part in trade shows, speak at conferences, and hold numerous events alongside their many members. Today’s project is to propose a new lectern for Recoup to use at these events.

Measurements

Height of top 1000mm
Height of top of screen 1200mm

Lectern requirements

Used 6-10 times a year
Multiuse (laptop, speaking, display)
Easily dismantled
Light and Portable
Back of van
Durable - it is also lent on
Incorporates the Recoup logo
Advertises the use of recycled plastics

Desirable attributes

Perceived high quality
Innovative and inspiring use of recycled plastics
Conveys a modern approach to sustainable design
Appropriate styling that considers the environments they will be used in
Aesthetically desirable

Optional attributes

Lighting, aesthetic and functional
Microphone
Cup recess
Wiring

Figure 7.2 One-day event lectern project brief
7.3.2. Longitudinal study – guitar brief

The one-day event can be considered as an artificially controlled event and therefore may come under scrutiny for being unrealistic. Because of this a longitudinal project was undertaken by one participant (AD) to see if there is any effect on the data. This project ran over ten days and the participant was left to design as he would normally.

A different brief for the longitudinal project was also chosen to see if the results were similar to the lectern brief (and therefore more generic comments could be made) and to ensure it was 'worth' doing both economically (as AD was a professional and was paid his standard rate) and personally for both the Department of Design and Technology (the brief was for one of their commercial ventures) and for the professional.

The client who developed this brief was Dr Eddie Norman, on behalf of Cool Acoustics Ltd (www.coolacoustics.com), a Loughborough University venture resulting from the polymer guitar developed by Dr Owain Pedgley as part of his PhD thesis (Pedgley 1999). He supplied AD with two possible briefs for him to choose from:

7.3.2.1 Longitudinal study brief one

Develop a new and exciting concept for a solid body or semi-acoustic electric guitar that benefits from the opportunities made available through the use of recycled plastics.

The designer must assume that all plastics manufacturing technology can be used during the project including in-mould finishing.

7.3.2.2 Longitudinal study brief two

As an industrial designer you should possess an expertise in moulded polymers. Apply this knowledge to the creation of a new concept to innovate guitar making. The new product can be either an acoustic or combination acoustic/electric guitar that benefits from the opportunities made available through polymer moulding technology. In-mould finishing and other polymer technologies can be used.
7.4 Deliverables

As well as the retrospective interview transcript and the protocol analysis tape each participant was asked to submit all folio pages (even those they would normally reject), CAD files, 2D and 3D modelling and any additional items they used (or photos of) were also collected (see Figure 7.3).

Figure 7.3 Models made during the one day events.

7.5 Developing an analysis method

Some people think qualitative data should be presented as it comes - allowing readers to make their own conclusions and minimise researcher bias (Fontana and Frey, 1998:69). Robson agrees, stating that it can make contact with reader’s own tacit knowledge and human instinct (Robson, 1996:61). However in order to facilitate an understanding of the data and to assist in the development of conclusions for the body of research, it is usually necessary to undertake many forms of analysis of the research data, an outline of possible analysis methods is shown below (Table 7.7).
Table 7.7 Some data analysis methods (Robson, 1996, Maxwell, 1996 Denzin and Lincoln, 1998)

<table>
<thead>
<tr>
<th>Method</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time-series analysis</td>
<td>Patterning of data over time</td>
</tr>
<tr>
<td>Key or focal events</td>
<td>Forming a focus for analysis</td>
</tr>
<tr>
<td>Coding / fracturing</td>
<td>Classifies and categorizing groups of words</td>
</tr>
<tr>
<td>Memoing</td>
<td>Theorizing write-up of ideas as they strike</td>
</tr>
<tr>
<td>Software</td>
<td>Computer driven analysis</td>
</tr>
<tr>
<td>Matrices</td>
<td>Rows and columns representing data</td>
</tr>
<tr>
<td>Maps and charts</td>
<td>Visual representation of data</td>
</tr>
<tr>
<td>Scatterplots</td>
<td>Cases are plotted on two or more dimensions</td>
</tr>
<tr>
<td>Causal networks</td>
<td>Shows dependant and independent variables</td>
</tr>
<tr>
<td>Counting</td>
<td>Measures frequency of occurrences</td>
</tr>
<tr>
<td>Patterning</td>
<td>Noting of recurring patterns or themes</td>
</tr>
<tr>
<td>Clustering</td>
<td>Grouping of similar characteristics</td>
</tr>
<tr>
<td>Factoring</td>
<td>Grouping variables into hypothetical factors</td>
</tr>
<tr>
<td>Relating variables</td>
<td>Relationships between variables</td>
</tr>
<tr>
<td>Themes and issues</td>
<td>Can be counted and assessed</td>
</tr>
<tr>
<td>Recurring motifs</td>
<td>Frequency of occurrence</td>
</tr>
<tr>
<td>Interpretation</td>
<td>Searching for linguistic structures in text</td>
</tr>
</tbody>
</table>

There are three types of data that require analysis in the main study:

- transcript data (retrospective and protocol);
- video data (protocol);
- data from visual representations.

The transcript data is the documentation of the participants' verbatim from both the retrospective interview and the concurrent verbalisation from the protocol data collection. The video data that requires analysis is from the 20 minute video taken during concurrent verbalisation and protocol analysis. The data from visual representations comes both from the concurrent verbalisation and protocol analysis, and from the participants drawing folios submitted at the end of the projects.

Each transcript (and subsequent sections of transcript used during the discussion part of this thesis in Chapter 8, and during clustering activities, see below), was given a code. This code indicates whether the transcript is from the one day event (ODE) or the Longitudinal event (LE), who the participant was (initials) and if the transcript is from the concurrent verbalisation and protocol analysis (P), or the retrospective interviews (I) (See Table 7.8 for overview).
Table 7.8 Participant coding for analysis.

<table>
<thead>
<tr>
<th>Participant code</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>ODE - ADP</td>
<td>One day event – AD protocol</td>
</tr>
<tr>
<td>ODE - ADI</td>
<td>One day event – AD interview</td>
</tr>
<tr>
<td>ODE - DLP</td>
<td>One day event – DL protocol</td>
</tr>
<tr>
<td>ODE - DLI</td>
<td>One day event – DL interview</td>
</tr>
<tr>
<td>ODE - JMP</td>
<td>One day event – JM protocol</td>
</tr>
<tr>
<td>ODE - JMI</td>
<td>One day event – JM interview</td>
</tr>
<tr>
<td>ODE - CAP</td>
<td>One day event – CA protocol</td>
</tr>
<tr>
<td>ODE - CAI</td>
<td>One day event – CA interview</td>
</tr>
<tr>
<td>ODE - MLCP</td>
<td>One day event – MLC protocol</td>
</tr>
<tr>
<td>ODE - MLCI</td>
<td>One day event – MLC interview</td>
</tr>
<tr>
<td>ODE - SPP</td>
<td>One day event – SP protocol</td>
</tr>
<tr>
<td>ODE - SPI</td>
<td>One day event – SP interview</td>
</tr>
<tr>
<td>ODE - ALP</td>
<td>One day event – AL protocol</td>
</tr>
<tr>
<td>ODE - ALI</td>
<td>One day event – AL interview</td>
</tr>
<tr>
<td>ODE - KCP</td>
<td>One day event – KC protocol</td>
</tr>
<tr>
<td>ODE - KCI</td>
<td>One day event – KC interview</td>
</tr>
<tr>
<td>LE - ADI</td>
<td>Longitudinal event – AD interview</td>
</tr>
</tbody>
</table>

7.5.1 Retrospective interview transcripts

The transcripts from the retrospective interviews were coded against the new values taxonomy, shown below in Table 7.9.

Table 7.9 Coding for the values categories for analysis.

<table>
<thead>
<tr>
<th>External values</th>
<th>Code</th>
<th>Internal values</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Societal values</td>
<td>SV</td>
<td>Perceived societal values</td>
<td>PSV</td>
</tr>
<tr>
<td>Identified</td>
<td>ISV</td>
<td>Perceived identified</td>
<td>PISV</td>
</tr>
<tr>
<td>stakeholder values</td>
<td></td>
<td>stakeholder values</td>
<td></td>
</tr>
<tr>
<td>Economic system</td>
<td>ESV</td>
<td>Perceived economic</td>
<td>PESV</td>
</tr>
<tr>
<td>values</td>
<td></td>
<td>system values</td>
<td></td>
</tr>
<tr>
<td>Values embedded</td>
<td>VED</td>
<td>Designer’s personal</td>
<td>DPV</td>
</tr>
<tr>
<td>in design</td>
<td></td>
<td>values</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Meta-values</td>
<td>M-V</td>
</tr>
</tbody>
</table>

This was done using coding and clustering (see Lofthouse, 2001) The transcripts were broken into sections, or ‘data threads’ that could then be analysed against the new taxonomy and the coding recorded. These data threads were then clustered according to the values observed. Data threads where more than one value judgement was observed were put into all appropriate clusters. These were then used as the basis for the discussions in Chapter 8. An example of a values cluster is shown in appendix v.
7.5.2 Concurrent verbalisation and protocol analysis transcripts

The transcripts from the concurrent verbalisations made during the protocol analysis were also coded against the new values taxonomy shown in Table 7.9. This was also done using data threads using the same method as for the retrospective interviews. The outcomes were then compared to the appropriate section of the retrospective interview (see Figure 7.4) in order to discuss similarities and differences and any anomalies.

Figure 7.4 Comparing the concurrent verbalisation and retrospective transcripts.

7.5.3 Video data

The data threads and coding from the concurrent verbalisation transcripts were updated for subsequent discussion through the use of the video data. Actions made during the protocol analysis were recorded in parallel with concurrent verbalisations. Where no verbalisation was recorded, actions were documented in a new column. An example is presented in appendix vi.

7.5.4 Data from visual representations

The visual representations made during the projects were also coded using the new values taxonomy shown in Table 7.9. These were then discussed independently, and against the other available data.

7.5.5 Validity

The longitudinal project was carried out in order to validate the results from the one day events against a natural design setting. The outcomes of this comparison are discussed in Chapter 8. In order to test the validity of the coding process, one transcript was coded twice on independent occasions. Steps were taken during the pilot testing, development
of the main study and analysis to ensure validity of data, using suggestions from many authors (see for example Robson 1996:70-73/ 374-375, Maxwell 1996:89-91).

7.6 Summary

Table 7.10 provides an overview of the briefs, participants and research methods used in the main study. Figure 7.5 provides an overview of the data analysis methods.

Table 7.10 An overview of the main study

<table>
<thead>
<tr>
<th>Project Brief</th>
<th>6th form / 1st year under graduates</th>
<th>3rd year under graduates</th>
<th>Post graduates</th>
<th>Professionals</th>
<th>Research method(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recoup / Smile Plastics Lectern Brief</td>
<td>A.L</td>
<td>S.P</td>
<td>J.M</td>
<td>A.D</td>
<td>Retrospective interviews and Concurrent Verbalisation and Protocol analysis</td>
</tr>
<tr>
<td>Cool Acoustics Guitar Brief</td>
<td>A.D</td>
<td>Longitudinal validity case study</td>
<td>Retrospective interview</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 7.5 An overview of the data analysis method.
Overview: Chapter eight discusses the key findings from the main study. It was clear that the role of values in industrial design decision-making could be described using the new taxonomy. This chapter provides evidence for each value category. The evidence from the concurrent verbalisation and protocol analysis is also discussed in relation to the evidence from the retrospective interviews and similarities and differences are discussed. It also demonstrates new understanding of the use of visual representations to highlight the influence of values in industrial design decision-making.

8.1 Retrospective interviews

All eight participants were required to hand in all tangible outputs from the one day event. All participants produced 2D sketch work ranging from 3 A3 folio sheets to 20 folio sheets. Two participants, DL and CA, made 3D models from cardboard (shown in Figure 7.3). Three Participants, CA, MLC and SP, used computer aided design (CAD) to represent their final outcome (see Figure 8.1 for an example). No participants used CAD to develop their ideas. Copies of the interview transcripts are available on request.

![Figure 8.1 MLC's CAD output](image)

8.1.1 External values

8.1.1.1 Societal values

There was no evidence of the use of societal values from the one day events. None of the participants readily sought the values of the society for which they were designing. No discussion can be made in regards to societal values in design decision-making based on the empirical evidence.
8.1.1.2 Identified Stakeholder values

There was empirical evidence, shown below, where identified stakeholder values were highlighted as having influenced design decisions. All apart from one occasion mentioned by CA were from the brief:

ODE-ALI (page two): "And I just wrote down a few points from the brief".

ODE-JMI (page one): "I suppose one point is I decided to ditch the adjustability because there was already a set height in the brief".

Internal values are also present here in that they are making value judgments regarding what to consider from the brief and what to reject (based on many of the other categories) and assigning hierarchies (Meta-values) to what they find in the brief.

ODE – KCI (page one): "Yeah I tried to get down some of the main points that I thought I should perhaps think about as I went through the project. And some of the things which may influence the actual final product at the end. Things I should bear in mind as I went along.

ODE-DLI (Page two) "One of the must haves I pulled out was that it had to incorporate the recoup logo"

The brief was developed by the author, who can be considered as a stakeholder. The one other example came when CA reports that she asked the author questions regarding the recycled materials.

ODE – CAI (page four): "And I think I was asking how the materials were when they were in their very basic form"

8.1.1.3 Economic system values

Attention to economic system values was only reported by AD, DL (the two professionals) and KC. AD mentioned that lots of forming of the flat sheet would be expensive, he also mentioned the conflict between this and the need for some form in order to increase the strength of the product (page one). DL acknowledges that cost issues are not mentioned in the brief but still believes the difference in cost between different materials is an important question to ask (page three). His decision to try and use the same component for all fixings is also influenced by the desire to minimise the cost of manufacture (page six). KC explains how cost was one of the many things she thought about during the project (page two – although she does not go into detail and does not mention cost when explaining the basis of any subsequent decisions).
Values embedded in design

There was a lot of empirical evidence as shown below, of values embedded in design during the retrospective interviews of the one day events. There were many different ways in which values embedded in design influenced design decision-making. One clear distinction observed was evidence of the influence of values embedded in existing design, existing products and materials and then evidence of values embedded in design as a concept the participants were trying to achieve, all of which are discussed below.

Values embedded in existing design

There were a great number of instances where participants discussed the use of existing products and materials as a source of inspiration. This provides evidence that designers see value embedded in existing products and materials. Existing products and materials were also used to inform about design much as Middleton (2003) and Eckert and Martin (2000) suggest (see Table 6.5 in chapter 6). For example one participant discussed the use of a laptop to inform them about the size of the working platform of the lectern and a balsawood jigsaw to suggest how the product could be manufactured and assembled (DL). A drawing board in the foyer of the Design and Technology building where the one day event took place inspired one participant to produce a concept in which the lectern top was multifunctional, rising when papers were being read, and flattening out for the use of a laptop (KC). Existing products and materials were also used to reject ideas or to reduce avenues of enquiry. For example CA decides to reject all ideas that look similar to the existing lecterns seen in the inspirational poster displayed in the room. This decision was made through wanting to be different (also DPV). The existing products and materials used by each participant are shown in Table 8.1. The existing lectern was also used by AL as a starting point, or ‘anchor’, in the words of Eckert and Martin (2000, see chapter 3).
Table 8.1 Products and materials used by participants in
the one day event.

<table>
<thead>
<tr>
<th>Participant</th>
<th>Products and materials used in the one-day event</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADI</td>
<td>Material samples (in room)</td>
</tr>
<tr>
<td></td>
<td>Pictures of lecterns (in room)</td>
</tr>
<tr>
<td></td>
<td>Old lectern picture (in room)</td>
</tr>
<tr>
<td>SPI</td>
<td>Old lectern picture (in room)</td>
</tr>
<tr>
<td>ALI</td>
<td>Tripod (in room)</td>
</tr>
<tr>
<td></td>
<td>Material samples (in room)</td>
</tr>
<tr>
<td></td>
<td>Old lectern picture (in room)</td>
</tr>
<tr>
<td>CAI</td>
<td>Pictures of lecterns (in room)</td>
</tr>
<tr>
<td></td>
<td>Material samples (in room)</td>
</tr>
<tr>
<td></td>
<td>Fish tank tubes</td>
</tr>
<tr>
<td></td>
<td>Ellula Sounds speakers</td>
</tr>
<tr>
<td>DLI</td>
<td>Folding chairs</td>
</tr>
<tr>
<td></td>
<td>3D balsawood dinosaur jigsaw</td>
</tr>
<tr>
<td></td>
<td>Drawing board</td>
</tr>
<tr>
<td></td>
<td>Tripod (in room)</td>
</tr>
<tr>
<td></td>
<td>Material Samples (in the room)</td>
</tr>
<tr>
<td></td>
<td>Laptop</td>
</tr>
<tr>
<td>JMI</td>
<td>Pictures of lecterns (in room)</td>
</tr>
<tr>
<td></td>
<td>Original lectern (in room)</td>
</tr>
<tr>
<td></td>
<td>Material samples (in room)</td>
</tr>
<tr>
<td></td>
<td>Periscope</td>
</tr>
<tr>
<td></td>
<td>Architecture</td>
</tr>
<tr>
<td></td>
<td>Parasol bases</td>
</tr>
<tr>
<td></td>
<td>Bicycles</td>
</tr>
<tr>
<td>KCI</td>
<td>Material samples (in room)</td>
</tr>
<tr>
<td></td>
<td>Flat pack boxes</td>
</tr>
<tr>
<td></td>
<td>Bottle tops</td>
</tr>
<tr>
<td></td>
<td>Corkscrew</td>
</tr>
<tr>
<td></td>
<td>Display board</td>
</tr>
<tr>
<td></td>
<td>Drawing board</td>
</tr>
<tr>
<td></td>
<td>Spiral staircase</td>
</tr>
<tr>
<td></td>
<td>Drawers</td>
</tr>
<tr>
<td>MLCI</td>
<td>Seat in a magazine</td>
</tr>
<tr>
<td></td>
<td>Lectern pictures (in room)</td>
</tr>
</tbody>
</table>

There was also evidence that designers associate values with materials before they are made into products. This echoes Ashby and Johnson's observation that materials have embedded personalities (see Table 6.5 in chapter 6).

ODE-ADI (page one): "The steel is giving it the strength, and it's polished stainless steel, to some extent it goes away because it's reflecting what's around it. And then you concentrate on this bit [recycled plastic]."

ODE-ADI (Page three) [about using more than one recycled plastic]: "But really the values are so different for all of them that I'm not sure that you'd find it worked very well like that. Maybe if you had a progression".
New materials (in this case the recycled plastics) are also associated with materials of similar value, and this association is used to help drive decisions about, for example manufacturing processes. This selection by similarity is also observed by Ashby and Johnson (ibid, see Table 6.5 in chapter 6).

ODE-ADI (page two) "I made assumptions and based them on how that material is like other plastic sheet material except that it comes apart rather more easily ...".

Materials also hold embedded value through what can be done with them. Many of the participants discussed using plastic in ways that wood cannot be manipulated to highlight this embedded value. Layton (1992a) also explains how designers work to highlight the value in products by how those products are used (see Table 6.5 in chapter 6).

ODE-ALI (page 4): "...it's like a selling point for recycled plastics isn't it? It's a selling point that you can't do it with wood but you can do it with this".

ODE-SPI "You could do that with any material really and that's a shame. If you've got a material with flex in it you might as well use it"

In the example above SP sees a material's natural flex as a positive embedded value, DL also see this flex as a possible positive embedded value, but he highlights the idea that the values embedded in design, and in this case embedded in a material's natural properties, may not be congruent with other values that must be considered during design decision-making.

ODE-DLI (page 2): "You would probably want to do some mock ups and stuff to understand how it sort of buckles and flexes and can we sort of use that in a positive way, because obviously a flexible stand is not going to give the right impression".

This connection between VED and other value categories was made explicit by many participants. Decisions were also based on whether the embedded values held by the materials were congruent with the perceived values of identified stakeholders (PISV).

ODE-JMI (page 2): "So that's why I moved away from some of these materials that which were um...sort of quite garish and bright and colourful because I thought actually from a distance it would just look, it would look horrible and it wouldn't do the company any favours".

Layton (1992a) comments that values embedded in design affect their success and Martin (1999) observes that products can also reflect other values. DLI discusses the connection between values embedded in design and societal values. He reports that he looked at many of the material samples and made judgements about which ones have the appropriate embedded values for the context. For example he decided the recycled sheet made from multicoloured plastic bottle flakes (based on the plastic used by Jane
Atfield, see chapter 3) gave the wrong impression. Eventually he decides the judgment should be left to Recoup (ISV), making different choices dependant on the audience to which they are presenting. His final idea was made from separate panels, that could be made from different examples of the recycled plastic sheet and interchanged dependant on the audience.

Different materials hold different values to the different participants, this provides evidence of the connection between the values embedded in design and a designer's personal values. This reflects Sassatelli's view that value is enhanced by subjective judgement (2000, see Table 6.5 in chapter 6). To KC, materials that look obviously recycled hold more value but ADI believes the materials that don't look recycled hold more value. These are two examples of how internal values influence how designers respond to a materials embedded value.

It is clear that values are also connected to knowledge. DL knows that it is difficult to recycle plastic bottle tops as they delaminate, so re-using them in his design holds more value. This also presents another use of existing products, and that is directly using them in a new design. In this case DL uses bottle tops as the fixing mechanism for his new lectern design. JM also uses an existing product in his lectern design, using a periscope to transfer light from the base to the top surface of the lectern.

Achieving values embedded in design

The retrospective interviews also produced a lot of evidence of designers being involved in decision-making to try and embed certain values within their design, or making decisions that highlight, or increase a product's embedded value. This idea is reflected in much of the prior art (see Table 6.5 in chapter 6). Layton's (1992a) idea that designers work to portray a sense in design can be seen in the following examples:

ODE-ADI (page one): "At the same time I was trying to make this look like it floats, it's light, it's got...it's forward looking, it's moving. So some curves, and direction, and cantilevers"

ODE-SPI: "And then I was looking at putting some lines in it, just to make it look more dynamic"

ODE-KCI (page three): "Something that changed as you went around, Because obviously as you twist the bottle top it either, you either tighten it or you loosen it, so that sort of essence".
Table 8.2 below shows some of the words used to convey the 'sense' the participants were trying to achieve (or trying to avoid) within their product.

Table 8.2 Words used by participants to describe the sense they were trying to portray, or avoid in their designs.

<table>
<thead>
<tr>
<th>Participant</th>
<th>Sense</th>
<th>Participant</th>
<th>Sense</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADI</td>
<td>Forward thinking</td>
<td>DLI</td>
<td>Recoup's ethos</td>
</tr>
<tr>
<td></td>
<td>Light</td>
<td></td>
<td>Broadening awareness</td>
</tr>
<tr>
<td></td>
<td>Cool</td>
<td></td>
<td>Novel</td>
</tr>
<tr>
<td></td>
<td>Floating</td>
<td></td>
<td>Stereotypical (negative)</td>
</tr>
<tr>
<td></td>
<td>Bland (negative)</td>
<td></td>
<td>Wobbly (negative)</td>
</tr>
<tr>
<td></td>
<td>Striking</td>
<td></td>
<td>Creaky (negative)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Flex (positive or negative</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>depending on the intention)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Challenging preconceptions</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Innovative</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Inspiring</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Refined</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Obvious (negative)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Blocky (negative)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Unimaginative (negative)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Curvy</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Distracting (negative)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Subdued</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>High quality</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Corporate</td>
</tr>
<tr>
<td>JMI</td>
<td>Garish (negative)</td>
<td>CAI</td>
<td>Modern</td>
</tr>
<tr>
<td></td>
<td>Subtle</td>
<td></td>
<td>Professional</td>
</tr>
<tr>
<td></td>
<td>Elegance</td>
<td></td>
<td>Smooth</td>
</tr>
<tr>
<td></td>
<td>Camping (as a sense – negative)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Home salesman (negative)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dell boy on a stall (negative)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Shield</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Flimsy (negative)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ALI</td>
<td>Slick</td>
<td>KCI</td>
<td>Simple but attractive</td>
</tr>
<tr>
<td></td>
<td>Simple</td>
<td></td>
<td>Different</td>
</tr>
<tr>
<td></td>
<td>Modern</td>
<td></td>
<td>Intrigue</td>
</tr>
<tr>
<td></td>
<td>Blocky (negative)</td>
<td></td>
<td>Normal (negative)</td>
</tr>
<tr>
<td></td>
<td>Streamlined</td>
<td></td>
<td>Undoing a bottle</td>
</tr>
<tr>
<td></td>
<td>Fast</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dramatic</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Floating</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MLCI</td>
<td>Cool</td>
<td>SPI</td>
<td>Alive</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Elegant</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Active</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Dynamic</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Blocky (negative)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Chunky (negative)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Oscars (sense)</td>
</tr>
</tbody>
</table>
There is also a lot of evidence of the participants choosing to incorporate the functions of other plastic, or those functions that cannot be achieved with other materials, to show the material either holds the same, or superior value.

**ODE-DLI (page 2):** "So I was thinking about those big over-centring folds like you get with plastic stuff, So you’re incorporating a function you get with plastic mouldings and devices you see around you’re, but your doing it to show this material does exactly the same as that, if it does! I’m assuming it probably does".

The decisions a designer makes can also be influenced by the embedded values of materials. For instance AL explains that the recycled material is new, therefore he made the decision that his design had to have the same associated value of ‘newness’ and not look old-fashioned. Again this echoes Ashby and Johnson’s idea that materials have embedded value (2003).

**ODE-ALI (page 1):** "I mean recycled plastics are quite a new technology so it has to be new. It can’t be old fashioned in this kind of thing".

Layton (1992a) explains how values within a product can be highlighted by how that product is used. Participants were observed trying to embed value into their products by highlighting the embedded value of the material through how it is used.

**ODE-ADI (page one) [about using steel] "But I felt there was a bit of a contradiction in that, in that what we’re saying is that this material isn’t able to stand up on its own therefore it needs steel structures".**

It has already been mentioned that both DL and SP looked at using the flex of the product, using the example as evidence that designers are aware that materials have embedded values. This flex was also used by SP as a means by which the product could be assembled. Embedding further value in the product.

There was evidence of participants associating shapes and styles with values they wished to embed in their new lectern designs, also referred to as selection by synthesis (Ashby and Johnson 2003, see chapter 3). Evidence of designs being rejected because the designer had embedded values that were not desired was also evident in the retrospective interviews.

**ODE-ALI (page 2):** "When I think about modern...I think of curves and circles and that so...".

**ODE-JMI (page 3):** "But I just thought it lacks elegance. It’s too camping...it’s too...it just lacks...it’s just too home salesman sort of ish. You know it’s sort of dell boy on a stalk!".

The decisions designers make that are influenced by the wish to embed value in their designs are also connected to other value categories, again reflecting Martin who
explains that products reflect other values (1999). For example JM's decision to use plastic welding and make the lectern recyclable at the end of its life is influenced by perceived identified stake-holder values. He wants the lectern to be congruent with Recoup's environmental ethos (page 2). The influence of other value categories also guides the designer to embed appropriate value. DL explains it was important that the lectern did not detract from the person speaking behind it (page 3, PISV). The perception of appropriate value is, however, subject to many internal value judgements based on the designer's personal values. For example DL, as stated above, believes the lectern should not detract attention away from the speaker. JM feels that the lectern should also have the added value of acting as a shield for the user, as he associates his own nervousness of presenting with the value he wishes to embed in the product.

ODE-DLI (page 3): "...so it was 'well ok then' appropriate styling in this sort of arena is something that doesn't detract from the person who's speaker, so it needs to be fairly refined".

ODE-JM1 (page 3): "then went onto thinking of a lectern and I know when I've stood at a lectern at a conference it's...it's almost your little point of safety, it's almost your little shield from the audience".

Although it is clear that the values embedded in existing design are external values, it is also clear that a designer's decisions to embed values in their design are influenced by internal values, and an internal understanding of values embedded in design, therefore this category of values must be both internal and external.

Combination

There were occasions when these two sub-sections of values (values embedded in design and embedding values in design) combine. Existing products and materials were selected to be combined with the product that is being designed in order to associate their value with the new artefact. New designs are also developed to resemble an existing item in order to take on similar values. These selected products can also be from previous projects, the outcomes of which must hold some value for the participant. The above concepts are also used to reject concepts. Table 8.3 below shows materials that were used either to accompany the recycled plastic or from which the recycled plastic was chosen for its resemblance. It also presents products and concepts used in the new design in order for it to take on the same value.
Table 8.3 Existing materials and design used to combine with new designs to transfer embedded value.

<table>
<thead>
<tr>
<th>Bar chairs</th>
<th>Steel (3 people)</th>
<th>Surfboard (negative)</th>
<th>Kite</th>
<th>Flower petals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Swan</td>
<td>Glass (4 people)</td>
<td>Bird tables (negative)</td>
<td>Snake</td>
<td>Virgin plastic</td>
</tr>
<tr>
<td>Dyson vacuum cleaner</td>
<td>Marble (3 people)</td>
<td>Tree (negative)</td>
<td>Martini glass (negative)</td>
<td>Polyprop integral hinges</td>
</tr>
<tr>
<td>Coke bottle (in room) (4 people, 1 negative)</td>
<td>Slate</td>
<td>Sharks fin (2 people)</td>
<td>Other bottles (3 people)</td>
<td>Holly leaf chair (previous project)</td>
</tr>
<tr>
<td>Modern art</td>
<td>Leatherette</td>
<td>Clear tubing (previous project)</td>
<td>Exhibition stands</td>
<td>Carpet</td>
</tr>
</tbody>
</table>

A previous example showed that stainless steel was selected to be incorporated with the recycled plastic sheet for its ability to disappear (an embedded value of the material). It was also selected by a number of participants because it was believed to be of high value, and may therefore associate high value to the new lectern.

ODE-ADI (page 3): “People can look at it and say 'gosh is that really recycled material', cos they all have the same value as stainless steel …”

There is also evidence of designers wishing to change what they presume to be a material or an object's embedded value.

ODE-DLI (page 1): “…it needs to be obvious that it’s recycled plastic, but used in maybe a novel way, rather than in the stereotypical well it’s a plastic recycled material so let’s make it three times thicker because it’s weak”

There is also an idea that they want to convey a message or a story within the product, much like Ryle’s dispositional concepts (1948, see chapter 3), which uses a combination of existing values and values they wish to embed.

ODE-KCI (page 6): “Yes, almost like a history. You know this is how it goes from one point to another. This is the outcome of it. So you can say then this is the product which will then be used”.
8.1.2 Internal values

8.1.2.1 Perceived societal values

The designer's perception of societal values was observed to be a driver of many decisions during the one-day event. Some of these decisions considered what they believed the audience response would be to the aesthetics of the product. For example JM based some aesthetic considerations, and particularly rejected certain materials, on how the lectern would look from a distance, as this is how a member of the audience might view it.

ODE-JMI (page 2): "So that's why I moved away from some of these materials [which] were...um sort of garish and bright and colourful because I thought actually from a distance it would just look, it would look horrible..."

These aesthetic considerations were also used to conceptually organise aesthetic priorities (meta-values). For example AD pays more attention to the upper half of the lectern, observing that the lower half will not be seen by many members of the audience. CA however, acknowledges that the whole lectern will be seen if it is used as a display stand. The example above show how different perceptions of societal values (along with other values) can effect conceptual priorities. Perceived societal values are also seen to influence aesthetics through the participants desire (DPV) to draw attention to the lectern.

ODE-CAI (page 4): "...if it's going to be a lectern or if it's going to be a display unit, regardless of which one of those it is going to be used for, you want people to look at it".

ODE-KCI (page 2): "...so that people might walk past and think ohhhh what's that?"

It was also clear that the participants were aware of appropriate aesthetics for the particular social context in which the lectern would be used. CA comments that the lectern must 'fit in' within the surroundings of a conference facility or a trade show (page 6). Participant's perceptions of societal values were made with three distinct drivers;

- assuming a society's values were congruent with their own (PSV through DPV);
- acknowledging that different groups of people will hold different values (PSV through PSV); and
- perceiving the values of society through their perceived value understanding of identified stakeholders (PSV through PISV, for examples see Table 8.4).
Table 8.4 Perception of societal values made with three distinct drivers.

<table>
<thead>
<tr>
<th>Driver</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assuming a society’s values were congruent with their own (PSV through DPV)</td>
<td>• AD explains that a decision was ‘largely a personal point of view but then I’m imposing my perceptions.’</td>
</tr>
<tr>
<td></td>
<td>• CA assumes that because she doesn’t understand other people wouldn’t get it.</td>
</tr>
<tr>
<td></td>
<td>• DL wants to challenge negative preconceptions about recycled plastic, assuming that they are the same as his.</td>
</tr>
<tr>
<td>Acknowledging that different groups of people will hold different values. (PSV through PSV)</td>
<td>• DL selects different materials for different audiences.</td>
</tr>
<tr>
<td></td>
<td>• AL explains that different people will like different things.</td>
</tr>
<tr>
<td></td>
<td>• KC uses of lots of colours to attract different people.</td>
</tr>
<tr>
<td>Perceiving the values of society through their perceived value understanding of identified stakeholders. (PSV through (PISV).)</td>
<td>• CA and KC believe it to be important that the audience does not see the user shuffling papers.</td>
</tr>
<tr>
<td></td>
<td>• MLC integrates a light to keep people focussed on the speaker.</td>
</tr>
</tbody>
</table>

8.1.2.2 Perceived Identified stakeholder values

The data presented below shows the use of perceived identified stakeholder values was similar from the participants and was focussed on the person using the lectern, and the company (Recoup or Smile Plastics).

Decisions based on the perceived values of the user included how they would use it. CA listed what she believed would be the lectern’s primary and secondary uses. Other participants also highlighted what they believed the user would need in order to use the lectern effectively, including where they would lean on it and what size the top surface would need to be (DL), where they would put their papers (MLC and JM), and where they could rest their hands (CA) among others.

DL considered how an employee who was new to Recoup would intuitively assemble the lectern. This links Perceived identified stakeholder values (the stakeholder being the
user), with a designer's understanding of semantics described by Jordan and Macdonald (2002) in chapter 3.

We have already seen in section 8.1.1.4 that participants perceived differently how the stakeholder sees the lectern (with JM seeing it as a shield and DL believing that the user should not hide behind it). This reflects O'Brien and Guerrier's (1995) opinion that values are embedded in a social context, with the embedded value of the lectern being a shield for JM, only being realised within a particular social context, in this case giving a lecture. It also provides evidence that perceived identified stakeholder values are internal values, and therefore subject to many other internal value judgements including those based on the designer's personal values and prior experiences.

Considerations were also made regarding how the user was observed by others (PISV through PSV). KC ensured her lectern obscured any possible fiddling with papers that the user may do in the course of the presentation. CA made decisions based on her desire to ensure the user looked professional while interacting with the lectern.

Decisions regarding Recoup or Smile Plastics were either driven by the perception of what the company wants (e.g. to promote itself, promote the materials, promote recycling etc) or how they could achieve what they want (e.g. by attracting a variety of different audiences – KC), or through how it is believed they want to be viewed (ethos, or ideopleasure in the words of Jordan and Macdonald, 2002, see chapter 3). JM made the decision not to create a project that was ironic to the company’s values but instead to develop a concept that was not only made from recycled plastics, but also used minimal materials and was itself recyclable, in keeping with the ethos of both companies.
8.1.3 Perceived economic system values

There was only one example of PESV during the retrospective interviews:

ODE-DLI (page eight): "Yeah, and although cost isn’t the sort of be all and end all it was. It should be something that is simple to produce. Otherwise people will think well yeah it looks like it does but, its really complicated to make, so trying to think along those lines a bit more. Um...then how do you make the bits and pieces, how do they all fit together?"

Here DL is discussing how the cost of the product as far as number of processes will have a result on how it is then perceived (connection with PSV). This echoes Ashby and Johnson’s perception that economic value is dependent on the market industry to which the product is aimed (2003), also reiterated in the 2000 EE report. DL understands this connection between economic values and the perceptions and internal values of the market for which he is designing, and makes decisions accordingly.

8.1.4 Designer’s personal values

Many authors reported that designer’s make decisions based on their own personal values (see section 3.4.1, chapter 3). The designer’s personal preferences and tastes as well as their personal wishes were observed to have a strong influence over decisions regarding the aesthetics of the lectern, and the selection of materials.

ODE-ALI (page 3): "I had already chosen those two cos they look nice".

ODE-CAI (page 9): "I wanted it all smooth".

ODE-DLI (page 4): "I’m not happy with that, too blocky".

ODE-JMI (page 2): "I really like this one".

Personal rules of thumb, or heuristics that the designer has built up, either through previous design projects or from other personal experiences appear to have a high level of influence over decisions. For example AD has a personal rule of thumb to avoid symmetry in his product design outcomes. He also dislikes making any ideas public that he is not sure can be realised. DL explains that he always follows a set project strategy by first organising a framework on which to work, then addressing 'tricky' issues first. Only the two experts seem to have built up rules to inform their actions suggesting the development of rules may be one element of expertise.

Past experiences also appear to drive many decisions, as suggested by Daley (1984), Dorner (1999), Gregory and Commander (1979) and Kaldate et al (2003). For example CA chooses to use clear tubing for the supporting mechanism of the lectern, this is based
on a previous successful project in which she also used clear tubing. An example of Kaldate et al’s (2003) anchoring was also observed when AL uses the existing Recoup lectern as an ‘anchor’ on which he makes truncations to develop a new lectern concept.

It is observed that all internal value judgements can be considered as a designer’s personal values. As distinctions can be made within a designer’s internal value judgements, they have been divided into the categories presented in this section (section 8.1.2 as well as embedding value in design, see section 8.1.1.4) in order to further our understanding, and for clarity.

8.1.2.5 Meta-values

There was a great deal of evidence of Meta-values working to, in a sense, manage the project, much as Daley (1984, 1982) and Keeney (1992) suggest. Many of the ideas below reflect what Layton was suggesting in his 1992 keynote (see chapter 3), that we also make judgements to guide activity and decide what steps to take next. Initially we can see all participants taking key points from the brief which they wish to address. This ‘wish list’ they produce is also influenced by many other values and immediately reduces the avenues of enquiry.

ODE-CAI (page 0): “So at the beginning I was looking at the brief and I was taking some notes from that”.

ODE-KCI (page 1): “Yeah I tried to get down some of the main points that I thought I should perhaps think about as I went through the project”.

This internal ‘project manager’ continues during the project, with time-keeping and controlling conceptual priorities that can be addressed within the time allocated. For example JM describes how he made the conscious decision to stay within his ‘safe zone’ as a designer and to keep things standard due to the constricted time limits. This suggests designers are able to change their conceptual priorities according to a number of variables, one of which is time. There was also evidence of Meta-values through participants evaluating their ideas (much of which was done through other values). For example MLC explains how she put all of her ideas onto one sheet in order to analyse them effectively.
Meta-values also appear to organise future work. Participants described mentally noting questions that needed addressing, and elements that needed consideration as the project progressed. KC, JM and DL all explained that they had many occasions where they stopped to reflect on what they had done, in order to consider where to go next. There was also evidence of assumptions being made in order for the project to continue. This links to Dorner's ballistic thinking (see chapter 3), as some participants were observed to avoid asking questions to which they depend on a positive answer.

ODE-DLI (page 2): "... what's it got to display? Um... I wasn't sure about that but I thought ok, well maybe you need some way of connecting bits and pieces to it".

It became clear that although the use of Meta-values were made explicit at certain times during the retrospective interviews, their use was continuous. Every decision requires guidance to look in one direction rather than another, to consider economic values at a particular stage rather than the values of an identified stakeholder. Even the decision to base a decision on the result from a mathematical equation rather than from some other judgment must involve some internal value influenced judgement. It could also be said then that meta-values influence the process by which a hierarchy of values is prescribed, those being deemed more important being considered by the designer and others remaining with the tacit processes of the designer's internal thinking.

8.1.3 The occurrence of value judgements

Table 8.5 and Figure 8.2, both shown below, show the total number of value judgements for each of the eight participants. The total number of value judgements made explicit during the retrospective interviews ranged from 62 to 137. Three participants all made 102 values explicit, with AD very similar at 94. The total number of judgements made explicit for each of the values categories ranged from 0 to 169. The total number of external value judgements made explicit was 242. The total number of internal value judgements made explicit was 504. All participants made more internal values explicit that external values.
Table 8.5 The total number of value judgements for each of the eight participants.

<table>
<thead>
<tr>
<th>Participant / Value</th>
<th>ADI</th>
<th>DLI</th>
<th>JMI</th>
<th>CAI</th>
<th>MLCI</th>
<th>SPI</th>
<th>ALI</th>
<th>KCI</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Internal values</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SV</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>ISV</td>
<td>9</td>
<td>14</td>
<td>15</td>
<td>11</td>
<td>8</td>
<td>0</td>
<td>7</td>
<td>6</td>
<td>70</td>
</tr>
<tr>
<td>ESV</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>VED</td>
<td>21</td>
<td>25</td>
<td>20</td>
<td>15</td>
<td>12</td>
<td>17</td>
<td>34</td>
<td>25</td>
<td>169</td>
</tr>
<tr>
<td>Total internal</td>
<td>31</td>
<td>41</td>
<td>35</td>
<td>26</td>
<td>20</td>
<td>17</td>
<td>41</td>
<td>31</td>
<td>242</td>
</tr>
<tr>
<td><strong>External values</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PSV</td>
<td>9</td>
<td>17</td>
<td>4</td>
<td>13</td>
<td>3</td>
<td>5</td>
<td>12</td>
<td>28</td>
<td>91</td>
</tr>
<tr>
<td>PISV</td>
<td>9</td>
<td>20</td>
<td>30</td>
<td>23</td>
<td>18</td>
<td>8</td>
<td>23</td>
<td>29</td>
<td>160</td>
</tr>
<tr>
<td>PESV</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>DPV</td>
<td>31</td>
<td>20</td>
<td>22</td>
<td>17</td>
<td>27</td>
<td>22</td>
<td>20</td>
<td>9</td>
<td>168</td>
</tr>
<tr>
<td>MV</td>
<td>14</td>
<td>28</td>
<td>11</td>
<td>6</td>
<td>5</td>
<td>9</td>
<td>6</td>
<td>5</td>
<td>84</td>
</tr>
<tr>
<td>Total external</td>
<td>63</td>
<td>96</td>
<td>67</td>
<td>59</td>
<td>53</td>
<td>44</td>
<td>61</td>
<td>71</td>
<td>504</td>
</tr>
<tr>
<td>Total</td>
<td>94</td>
<td>137</td>
<td>102</td>
<td>85</td>
<td>73</td>
<td>62</td>
<td>102</td>
<td>102</td>
<td>102</td>
</tr>
</tbody>
</table>

Fig 8.2 Graph showing the total number of value judgements for each of the eight participants.

High levels across all levels of expertise in DPV and VED were observed. Use of other values had no apparent pattern.
8.1.3.1 Analysing the retrospective interviews

The page the participant was discussing was also recorded during the retrospective interviews. All participants discussed their work in the order in which it was done except the two undergraduates, whose attention moved from one page to another, from old pages and new pages in their folio. These two participants (MLC and SP) have not been included in the discussion held within this section (they are included in later discussions).
The graphs above (Figures 8.3 to 8.8) show ‘bursts’ where the participant has made explicit the use of many values in decision-making. It could be explained that the lulls provide evidence of periods of design were decisions are based on knowledge and/or skill, or no decisions are being made at all. These bursts suggest that many decisions are made within particular value groups at any one time, for example, when discussing page four of her folio, KC makes many value judgements based on perceived identified stakeholder values explicit.

KCI (page 4): ...I had to think the stand should be able to be flat packed as well.

KCI (page 4): ...so maybe two smaller pieces that can be carried

KCI (page 4): ...how can you put two hard materials together without a proper fastening as such so you don’t have to fiddle around with nuts and bolts and screwing things in here and there.

KCI (page four): ...if it’s a bit more simple that can just be fitted together and easily moved and put in different areas

The graphs also show that more than one value is considered at any given time, this reflects the prior art. Keirl and McLaren (2005) reported the appreciation of the tensions between conflicting values and the interplay between values. Martin (1999) described that products are developed using a myriad of different value based decisions.

There were no judgements based on societal values made explicit during the retrospective interviews. All participants showed evidence of the use of identified
stakeholder values at the beginning and end of the project. This is congruent with the findings in section 8.1.1.2 that show this corresponds to attention being paid to the brief. At the beginning of the project this allows the designer to become acquainted to the requirements of the brief, and at the end analyse there final design in terms of whether it has satisfied the brief set by the identified stakeholder. There was also evidence of identified stake-holder values throughout the project, where again attention was paid to the brief, either to reject ideas for not satisfying requirements, or to check those requirements. There was not enough evidence of economic system values for discussion. There was constant evidence of the use of values embedded in design throughout the retrospective interviews. There is no obvious pattern in the use of perceived societal values found in the evidence from the retrospective interviews. As there was evidence of only one occurrence of perceived economic values during the retrospective interviews there is not enough evidence for discussion. There is no obvious pattern of the use of designer's personal values during design decision-making. ADI and ALI showed evidence of continuous use of designer's personal values through the retrospective interviews. CAI and KCI showed evidence of designer's personal values being used in the later 2/3rds of their folios. JMI and DLI showed sporadic use of designer's personal values throughout. There was evidence in the retrospective interviews of meta-values being used continuously during the one day event. This is congruent with the findings in section 8.1.2.5 that show meta-values as project management values, which continuously guide, shape and direct activity.

8.2 Concurrent verbalisation and protocol analysis

There were many similarities between the retrospective interview accounts and the concurrent verbalisation and protocol analysis transcripts. There were also some differences. A summary of the key findings is shown below.

The main difference observed between the two accounts is the frequency at which participants made certain values explicit. During the concurrent verbalisation and protocol analysis video, particular value judgements were mentioned at a higher frequency than during the retrospective interview account of the same period of design activity. All participants also recorded higher overall numbers of value judgements during the concurrent verbalisation and protocol analysis than recorded during the retrospective interviews.
This could be due to many reasons:

- repetitions being omitted from the retrospective interview accounts due the imposed time limit;
- limitations to what can be made explicit retrospectively;
- that the participant did not deem them to be important.

This could also be due to a secondary hierarchy of values (the primary being the hierarchy imposed cognitively by meta-values, see section 8.1.2.5). A hypothesis would be that what we are observing during the retrospective account is evidence of a value judgement in itself on a meta-level, and that the values made explicit during the retrospective interviews are those considered to be of greater importance by the participant (see Figure 8.9). Figure 8.9 shows the values observed during the retrospective interviews (shown in the left hand column), and the values observed in the concurrent verbalisation and protocol analysis transcripts (shown in the five columns on the right). The values which are highlighted and numbered correspond to one another.

For example PSV 1, the first value shown in the retrospective interview analysis column (left) indicates a value judgement also observed in column 3 of the concurrent verbalisation and protocol analysis observations.

<table>
<thead>
<tr>
<th>Retrospective</th>
<th>VED 6</th>
<th>VED 3</th>
<th>Protocol</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSV 1</td>
<td>DPV</td>
<td>DPV</td>
<td>M.V</td>
</tr>
<tr>
<td>PSV 1</td>
<td>VED</td>
<td>PISV</td>
<td>M.V</td>
</tr>
<tr>
<td>DPV 2</td>
<td>VED</td>
<td>PISV</td>
<td>M.V</td>
</tr>
<tr>
<td>VED 3</td>
<td>DPV</td>
<td>PISV</td>
<td>M.V</td>
</tr>
<tr>
<td>ISV 1</td>
<td>ISV</td>
<td>ISV</td>
<td>M.V</td>
</tr>
<tr>
<td>PISV 4</td>
<td>M.V</td>
<td>M.V</td>
<td>ISV 5</td>
</tr>
<tr>
<td>PISV 4</td>
<td>M.V</td>
<td>M.V</td>
<td>PISV 5</td>
</tr>
<tr>
<td>ISV 5</td>
<td>PISV</td>
<td>M.V</td>
<td>PISV 4</td>
</tr>
<tr>
<td>PISV 5</td>
<td>M.V</td>
<td>PISV</td>
<td>M.V</td>
</tr>
<tr>
<td>VED 6</td>
<td>PISV</td>
<td>M.V</td>
<td>PISV 1</td>
</tr>
<tr>
<td>DPV 7</td>
<td>VED</td>
<td>M.V</td>
<td>PSV 1</td>
</tr>
</tbody>
</table>

Fig 8.9 The values observed in both the retrospective interview and concurrent verbalisation and protocol analysis transcripts.
Another observed difference was the way in which participants reported the use of meta-values in the two accounts. The protocol analysis reported a greater frequency of meta-values. This again could possibly be due to the reasons listed above. The manner of meta-values recorded also differed between the two accounts. Many judgements based on meta-values were recorded in the retrospective accounts that were not observed during the concurrent verbalisation and protocol analysis. These were value judgements regarding future work. For example:

"I then thought I should look at this";

"this posed some questions I addressed later".

This could be a result of the retrospective interviews occurring after the event, and eliciting a more report-based account of activities, compared to the real time accounts from the concurrent verbalisation and protocol analysis.

DL's accounts were very different between the retrospective interview and the protocol analysis but a lot of evidence could be found to support the position that what was being made explicit during the retrospective was being considered during the protocol analysis, just not being verbalised to an extent that made it possible to apply coding. For example in the retrospective interview DL explains his desire to engineer out as many steps as possible. This decision was made not only through personal desire, and the desire to reduce costs, but also from the view that the audience would not appreciate a design that was over-complicated (M-V, DPV, PESV, PSV). Although it was not clear that this was considered during the protocol analysis DL does verbalise the importance of efficient manufacture, which could encompass the same decisions. Again this could be a reflection of the different reporting styles adopted for the two methods.

8.3 Triangulation – A comparison between the one day event and the longitudinal study

As well as being a participant in the one day event, AD also took part in a longitudinal study in order to verify the data. During the longitudinal study AD produced eight folio pages, provided 2 pages of images he had downloaded of existing guitars and many CAD outputs. Table 8.6 shows the totals observed for each value during the retrospective interviews of the one day event and the retrospective analysis of the longitudinal study (AD only).
Table 8.6 Totals observed for each value during the two retrospective interviews

<table>
<thead>
<tr>
<th></th>
<th>ODE</th>
<th></th>
<th>LE</th>
</tr>
</thead>
<tbody>
<tr>
<td>SV</td>
<td>0</td>
<td>SV</td>
<td>4</td>
</tr>
<tr>
<td>ISV</td>
<td>9</td>
<td>ISV</td>
<td>18</td>
</tr>
<tr>
<td>ESV</td>
<td>1</td>
<td>ESV</td>
<td>14</td>
</tr>
<tr>
<td>VED</td>
<td>21</td>
<td>VED</td>
<td>44</td>
</tr>
<tr>
<td>PSV</td>
<td>9</td>
<td>PSV</td>
<td>32</td>
</tr>
<tr>
<td>PISV</td>
<td>9</td>
<td>PISV</td>
<td>5</td>
</tr>
<tr>
<td>PESV</td>
<td>0</td>
<td>PESV</td>
<td>3</td>
</tr>
<tr>
<td>DPV</td>
<td>31</td>
<td>DPV</td>
<td>53</td>
</tr>
<tr>
<td>MV</td>
<td>14</td>
<td>MV</td>
<td>35</td>
</tr>
<tr>
<td>Total</td>
<td>94</td>
<td>Total</td>
<td>208</td>
</tr>
</tbody>
</table>

The total number of values recorded also increased from 94 in the one day event to 208 in the longitudinal study. This contradicts the earlier hypotheses that suggests participants can only make a certain number of values explicit during retrospective interviews. It may suggest that the number of incidents where values influence decisions increase as the duration of a design project increases, however, there is not enough evidence for this statement to be conclusive.

8.3.1 External values

There was no mention of the influence of values sought from the society (SV) during the one-day event. In the longitudinal event AD gains information from his sons, who are both in a band, who are considered as representing societal values. Interestingly AD also puts this information into context, and comments on a realisation that the information he is getting is based on the personal values of the member of society.

LE-ADI (page 1): “Um... my sons are in a pop group and they know quite a bit so they were able to feed me with a couple of bits... but that’s very personal of course, to what they feel about it”.

This highlights a grey area between SV and PSV. Another difference we can see between AD’s use of values to influence his design decisions is in the movement from PISV to ISV from the one day lectern project to the longer guitar project. Although the one day event shows 9 examples of value judgements being made from identified stakeholder values, these were all evidence of AD paying attention to the brief. In the longer design project 18 incidents were made explicit, many of which recounted conversations with experts from Cool Acoustics and other stakeholders (such as manufacturers). We can also see that fewer incidents of perceived identified stakeholder values were recorded during AD’s account of the guitar project.
In both accounts AD made initial comments on how he addressed each project. The main difference focused on values embedded in design (VED). During the lectern project AD's attention focused on how to embed value into his design. He describes the lectern as being highly functional and an important part of his attention was to embed value into it. During the guitar project he describes an awareness of the enormous embedded value already held by a guitar and how this must be considered in order for the new designs to be successful.

LE-ADI (page 1): "Well it's got cultural constraints because people expect certain things of it. When they go to look for one they have certain expectations of what a guitar is like, but those are in the way a little bit"

This suggests that differences of the influence of values may be project specific. AD later mentions an awareness of these differences during the longitudinal retrospective interview.

LE-ADI (page 3): "There are differences, in that, if you were designing a walkman, it's a very different electronic device than a piece of equipment that say you were using in a recording studio, because it's...so the appearance becomes very much more important perhaps in the consumer product. So, you get those changes in emphasis...".

An awareness of these differences also appears to drive the search for VED in the form of inspirational products, or materials that have the required embedded value. For example in the one-day event AD considers materials with embedded values that he wants to associate with his lectern in order to embed value into it. In the longitudinal study AD considers historical examples where products have made a successful transition from traditional materials to plastic (without negatively effecting people's perception of the embedded value of the product, for example the transition kettles made from metal to plastic).

AD also uses values embedded in design, or looking at prior examples, to validate decisions that may be made from other value holders (ISV). During the longitudinal guitar project he asks the advice of Cool Acoustics (who supplied the brief) on the importance of certain measurements. He then validates this information by looking at previous examples of guitars.
LE-ADI (page 3): "I went to find out what was really important, which of these dimensions were important, and it seems that the relationship between the first fret, this end of the fret and the position of the bridge are fixed, although having said that, when I looked at various designs, there were differences, so none the less they are a back bone, so those were the important things to start with".

This also occurs later on in the transcript where information is not believed until a sample is seen.

LE-ADI (page 8): "...I found at least one company who had had an idea, or who had a system that they were using which reduces that swirl. The extent to which that's true I'm not sure, because I haven't seen a sample".

During the longitudinal guitar project AD makes use of looking at previous examples of guitars (VED). Most were sought in order to answer functional questions, such as the need for certain shapes, the volume of the guitar, and the position of the frets. In the one-day event the examples AD considers reflect the use of the material rather than the function of the lectern itself. This suggests that VED (in the sense of looking at existing examples) is important in developing our understanding of elements of which we have no expertise, or are not easily understood.

8.3.2 Internal values

AD remarks on the similarities between the two briefs in the influence of Perceived societal values and Values embedded in design and how these influence decisions regarding the aesthetics (also DPV) of the product.

LE-ADI (page 2): "Yes, and when you... the problem that you set me before, with the lectern, is very similar, that because it was performing to somebody else, performing to an audience type of product... although a personal guitar is not performing to an audience... yet. The people who buy them are aspiring to perform to an audience, so it still needs to have that outward looking aspect so I think that's in the nature of the guitar, it's a performing thing. So it needs to look good from the front... so that was very influential".

AD also acknowledges the barrier between other stakeholders and their values toward one another, and how they can affect his work. And how this affects other values, in this case economic.

LE-ADI (page 11): "...you have that problem of until you have a manufacturer on board, people can't actually see the pound signs and therefore... [RC: "So a big economic barrier?"] of course, you will always have until the right people are interested..."
AD also pays more attention to economic system values in the longitudinal event. For example, on page 1 he considers that the product may be bought by newcomers who do not have much money, and that the use of plastic to produce cheaper guitars may provide commercial advantage for his designs.

AD makes many decisions based on his knowledge of plastic mouldings which has been developed through his experiences (DPV).

LE-ADI (page 5): “That was again my knowledge of moulding, and this particular process which gives you much more flexibility in thickness than you can get with ordinary injection moulding where you do have uniform thickness”.

In both the one-day event and the longitudinal event AD reduced his focus of attention for the aesthetics (Designers personal values) of the product by considering which part of the product would be viewed most often (Meta-values).

ODE – ADI (page 6): “And actually most peoples’ vision is blotted by heads at the bottom end, by people in front of them. So what goes on down here is sort of important but nothing like as important as what happens here and above”.

LE-ADI (page 2): “And the guitar again is very visual from the front... so I was determined that all my efforts, visual efforts would go on the front”.

The use of meta-values also appears to be very dependent on the time of the project, the designer tweaks the use of meta-values to reflect the length of time and therefore for what, and to what depth things can be considered during a project. It also affects the number and level of assumptions that are made and what is readily sought.

AD also highlights that although a particular value (in this case ISV from his sons mentioned earlier) is not influencing any immediate decisions, he has taken the decision to ‘store’ this information for possible later use.

LE-ADI (page 1): “...so it was just something I put in a pocket and left to think about”.

184
This highlights further difficulties in researching the influence of values in design decision-making. Decisions may be influenced by values sought much earlier in the project, or even during previous projects or the designer's experiences. These influences may not be made explicit during the account of the decisions that were based on them. No mention was made by AD of this influence being used as a basis for further decisions.

In his account of the longitudinal guitar project AD makes reference to his strategy for accomplishing a project more than he does in the one day event. This description of the influence of meta-values in guiding his design activity could be a reflection of the increased complexity of the project in the longitudinal study, or the increased time period during which he had to guide his decision-making. It could also be a simple difference in the values he chooses to make explicit in one interview, compared to another.

LE-ADI (page 2): "I do believe in designing from the inside out, and not putting the styling together and then trying to make everything else work around that (laughs)."

He goes onto to explain that these guiding principles are based on experience (DPV).

8.4 Uncovering values through visual representations

The discussion regarding visual representations uses examples from the concurrent verbalisation and protocol analysis in which visual representations have been analysed alongside accompanying verbatim. Examples from the participants' project portfolios and retrospective interviews are also used.
8.4.1 From the participants portfolios

The influence of values in design decision-making was very difficult to analyse using the participants’ folios alone. The influence of meta-values during the initial stages of the project were visible as every participant provided visual evidence of selecting elements from the brief that they would subsequently address. This was done either visually, via schematics such as the one drawn by CA in Figure 8.10 or through annotation, such as written by DL, and shown in Figure 8.11 The use of sketches during the early stages of designing, in order to better understand the problem was also observed by Rogers, Green and Mcgown (2000, see chapter 3).

Figure 8.10 Visual representation of the influence of meta-values (CA).
The influence of perceived identified stakeholder values was also made clear by every participant within their folios. This was mainly through drawing a figure (representing the user), standing next to or behind a drawing of a lectern concept. In Figure 8.12, CA annotates a representation of the user with comments on how they will interact with the lectern. This is also connected to meta-values, as she splits these into primary and secondary uses. JM and KC consider the perceived identified stakeholder values through their visual representations by drawing a bag that the user can transport the lectern in (for example see Figure 8.13).
It was also observed that SP depicted the user standing behind the lectern a long time after he drew the lectern, and he drew many other concepts in between. This suggests visual representations allow the designer to externalise ideas, and then revisit them and make decisions about them in relation to additional value judgements.
In a similar way the audience is also depicted to be interacting with the lectern, visually representing the influence of perceived societal values. This was only done by one participant (JM). This also shows the interaction of the influence of perceived societal values and perceived identified stakeholder values, as he also depicts the user, standing behind the lectern.

CA annotates one of her drawings with “audience can see laptop”. Above it she annotates “impractical”, providing evidence that she is making a judgement based on perceived societal values. We can also see the use of meta-values in her analysis of the concept and its subsequent rejection (see Figure 8.14).

![Figure 8.14 The use of meta-values (CA).](image)

The only other value category for which the folios provide evidence is values embedded in design. There are lots of visual representations of existing products influencing design decision-making. In DL’s folio we can see how he is using the form of a plastic drinks bottle to directly inform the shape of his lectern, providing evidence of both values embedded in design and effort from the designer to embed those values in a product (see Figure 8.15). He also draws a laptop to inform the size of the lecterns working platform.
JM's folio also provides evidence of the influence of VED. He draws a picture of a bird table, but it is unclear whether this is positive or negative. DL also provides visual evidence of the use of existing products directly during design decision-making, depicting the use of a bottle top as the fixing mechanism for the lectern (see Figure 8.16).
AL annotates one drawing with "using properties of plastic" showing that he sees value embedded in materials before they are made into products. The image that accompanies this comment shows the use of heat to move the height of the lectern. However, it would be difficult to say this was evidence of VED without this annotation (see figure 8.17).

![Figure 8.17 Using properties of plastic (AL).](image)

8.4.2 Analysing the transcripts

There was also evidence of the influence of values through the use of visual representations when the designer's sketches were analysed alongside the verbatim from the retrospective interview and concurrent verbalisation and protocol analysis transcripts.

It is clear, much as Scrivener and Clark (2005), and Yi Luen and Do (2000) suggest, that visual representations help their creator reason with complex mental structures and organise cognitive activity (the application of meta-values). Many of the visual representations made appear to facilitate a discussion between designer and sketch, many involving the application of value judgements.

During the protocol analysis it was clear that on many occasions talking and the use of visual representations occurred concurrently and that often reflection occurred at the same time as amendments or developments were made (this is also referred to as having an interactive conversation by Schön and Wiggins, 1992). There were also many occasions where folio sketches were re-visited by the participant, either to be analysed
against a new value judgement, or to clarify issues. This suggests that visual representations form a log of cognitive activity and help with its organisation. This matches Suwa and Tversky's (1997), claim that visual representations provide visual clues in order to maintain chains of thought, or to link to non-visual information (Suwa et al, 1998b) and Dörner's (1999) claim that visual representations allow for critical consideration (or the application of Meta-values). We could also state that the act of designing appears to be the act of concurrent thinking, drawing and reflection (see chapter 3), within which the application of value judgements can occur (see figure 8.18).

![Figure 8.18 Concurrent thinking, drawing and reflection](image)

Many of the participants discussed the use of 'warm-up' sketches at the beginning of the project. These initial sketches could be a result of a value judgement influenced by meta-values that in order for effective design decision-making to occur, initial ideas must be externalised in order to make way for subsequent, better ideas. The designer's choice to participate in warm-up sketches may also be based on past experience and the designer's personal values, SP comments 'the first ones are always terrible'. Suwa, Purcell and Gero (1998a) comment that these initial visual representations reduce cognitive load.

Finally there was also evidence of the use of Rodgers et al's memory sketch (2000). Both SP and CA were observed to use previous sketches as a start point for new concepts. SP mentioned that many of his sketches bore relation to the 'holly leaf' chair he designed at school. CA discussed the use of round tubes in her sketch work relating to previous design episodes. The use of DPV observed in the association of new visual representations to previous design work would not have been made explicit without the accompanying transcripts.
8.4.3 Triangulation – The use of visual representations in the longitudinal event

The main difference between the one day event and the longitudinal study was that AD did not present me with a significant folio of drawings from the longitudinal event. It is important to consider that visual representations may not have been made by all participants during the one day event had their use not been prescribed. By putting paper and pens in front of participants and by asking their permission to video their sketching activity, the use of visual representations may have been imposed upon them.

AD also used a lot of CAD during the longitudinal event, and although it was made available to him, CAD was not used during the one-day event. AD explained that the choice of media to work with was also very dependent on the needs of the project.

LE-ADI (page 5): "...I did very little sketching and the reason I did very little sketching was I wanted this to be dimensionally correct and I had preconceived notions about where things came, when I did a sketch they were very wrong, this bit here might be ... might look as though it's in the right place, that's the saddle shape, but actually there's a great deal of land behind the saddle shape, and when I'm just sketching I'm not really feeling that's the case, you know, it's this kind of thing here, you can see a large amount of space behind it. And until you do it to scale, these shapes don't mean very much, so I wanted to get into CAD and do it all to scale very quickly so that I had the right feel and the form and knew where everything was going to be, and that the proportions were going to be right".

This suggests the choice of media through which work occurs could reflect the types of decisions being made. This could also reflect that meta-values also include making the choice of which design media is most appropriate for the task. Later in the transcript AD also mentions the use of media.

LE-ADI (page 5): "... when I was sketching I was just trying. I was thinking what kind of approach can I have to the form that I'm going to start with, and then into CAD to try and turn it into something I can actually make, and see how that works with the material that I've got and the kind of processes I'm using".
8.5 The Influence of values in novice and expert design decision-making

Participants who were selected to take part in the main study came from four levels of experience; 2 A-level students; 2 undergraduate students; 2 postgraduate students and 2 professionals (see section 7.2). This allowed accurate comparison between levels of expertise to occur.

Kavlak! and Gero (2001) suggest one difference between novice and expert designers is in their level of cognitive activity, stating that experts show much higher levels of cognitive activity but lower levels of parallel cognitive activity (see section 3.6.1). Table 8.5 shows the total number of value judgments made explicit (an indication of cognitive activity) to be similar among all participants. Figures 8.3 to 8.8 also show that expertise does not affect a designer's ability to make parallel value judgements, with all participants making explicit bursts of cognitive activity influenced by values (see section 8.1.3.1).

Petre (2004) highlights the need for both experts and novices to consider existing design examples during project work (see section 3.6.3). The extracts shown in Tables 8.8 and 8.9 show both the professional (AD, Table 8.8) and the A-level student (Table 8.9) using existing products to inform their decisions (see also section 8.1.1.4). Within the short passage shown in Table 8.8, the professional designer's decisions are based on many existing design examples; he recalls a visit to the Eden project, where recycled plastic sheeting was used as an insert within a bookshelf. This influences his decision to show that recycled materials have more potential; he comments on observations made of other designers using recycled materials and how this has informed him of the need to use large fixings to hold the lectern in place; finally his decision to include a light on his lectern is justified by having seen many lecterns that incorporate a light. The extract presented in Table 8.9 shows the A-level student's design decisions being inspired by a green chair, and the Dyson vacuum cleaner which respectively influence his decisions to include cut out sections and large circular wheels within his own design.
"I am trying to do something with the form to show that you can do things with it and create structures".

"So are you using the form of the structure as a way of showing off what the material can do"?

"The fact that you can do things with it, and these are the kinds of things you can do with it and it will generate interesting forms. I saw some at the Eden project, I saw some recycled materials like this being used in the book shop, and it was just being used in the wooden frames as though it had no strength and that it was just the surfaces that were then framed to form the end of book cases or whatever it was. And although it was quite colourful it was being used for the sake of using it. As if to say, and it had a sticker on it saying 'this is recycled'. But I was thinking you know, you can link it, you can bend it, you can cut it. And all my bends are on one dimension so you can do it very easily and then you can put it together in various ways. And you can put strength into it by bending it. So those are the sorts of thoughts I was thinking. And also you can get great detail out of... by using big fixings, by making one bit pass through another, making it large. And you need to because I think you need to because if you use small fixings it comes apart. Is a lot more likely to come apart".

"And what's that based on"?

"That's based on seeing what other people have done with it. I've never actually cut it, done anything with it myself, but I've seen all these projects where people have. So that's what I've been doing there".

"So, as a difference from earlier you seem to be taking ideas from earlier, you seem to be taking ideas through".

"I am".

"Have you come to something you are interested in"?
"Yes I am, and I'm beginning to think that this will give me a structure that is interesting enough to look at. It's showing lots of detail of how it's being put together and it's probably strong enough and probably could be done with the thinner materials because it's got some sort of form to each of the materials. But it's still got a problem of how you make it stable and get it up. So then I was getting into some detail and thinking about lights. I was also thinking about where the logo's going to go. You need to present a surface for the logo and I've to a large extent got rid of flat front surfaces so that's perhaps a little more difficult. So perhaps by lifting the front edge of the lectern desk you can offer a little bit of privacy, because privacy's quite nice when your getting your notes confused and things like that. I had though about dropping it but privacy adds that privacy and perhaps if you want to put a light on it you can lift it off that surface.

So your decision to put a light on, what was that based on?

"It stems from the fact that I don't really know what the lectures they [do] are actually like. Whether they involve slides, films. But if you are talking to slides and films then you need light on your notes in a darkened room so it's something that's useful and an awful lot of lecterns have it. But it may well be that they don't do that and that's superfluous, I don't know. But it's a possibility, that you've got something to base that on. I was looking at was again staying still and fixing it. I thought about using wood and natural materials but actually I think it wants to be quite cool and especially with these here I think I thought that was something that would help".

"But I am also beginning, this is the point at which I think we started filming and I put all that behind me and said 'ok, that's getting very symmetrical and I want to investigate'. I do have a thing about this symmetry".

"Is that something you bring into quite a few of your projects"?

"It is. I think symmetry can be stolid and very static, whereas if you remove it things start to have direction and then you get a bit more lively forms".
"I carried on with the shark idea because you can have a light. Light would shine down. And at this stage I was thinking about... at this stage I was thinking about logos as well and I was thinking about having the recycling logo at the front. And the company name at the front as well. That would look quite nice. This [idea] is just another...

"Is that why you took that idea forward, because it works well with the functions and the logos"?

"Yeah. Yeah. And I was trying to fit the logo here because it would roll to the floor and it would have hidden it so it doesn't really work. That's what I would imagine anyway. This is just ideas carried on. And here's an idea of... it just popped into my head. It wouldn't really work but it was just an idea thinking that because the plastic deforms when you heat it up so then people can heat this up and push it down and push it up. Through the heat".

"To make it transportable"?

"Yeah. Yeah and it just..."

"Do you know where that [idea] came from"

"It cam from here [HASAW information] where it says it will change physical properties at 95 degrees and I was thinking it must bend and you would be able to make it flat and..."

"At this stage I looked at the green..."[points to poster]

"The green chair"?

"Yeah, because when I looked at that I was inspired. And I thought it would be quite good to have that shape but with..."

"with sections cut out"?

"with sections cut out"

"what was driving the decision to cut sections out"?
AL
"Firstly it looked nicer, because it's all plain and boring and then you add some patterns. But more importantly it takes some of the weight out really. And here are some other ideas".

RC
"and here is a flower idea which seems to be being developed"?

AL
"yeah"

RC
"is that just trying different shapes"?

AL
"Yeah"

RC
"What's driving your ideas"?

AL
"Well this one is like so people look at it and think this thing is not being held up by anything"

RC
"Floating"

AL
"Floating. Give it a sense of floating. Because these are far apart you won't see them. Won't see it all in one go. And then I developed this [idea] because I overdid this one a bit too many, so I did this one with just a few [cut outs]. And I got this idea from the Dyson vacuum cleaner, with the circle bits and the wheels".

Much of the literature reviewed in chapter 3 suggests the key driver in the transfer from novice to expert is experience (see section 3.6.2). This is justified through a designers use of precedent, gambits and well developed schemes that can only come from prior experiences (see section 3.6.2). In the main study the two professional designers, AD and DL, were observed using rules of thumb, or personal heuristics (see section 8.1.2.4) to guide their design activity. None of the other participants made using rules of thumb explicit. Lawson's third stage of becoming an expert describes the identification of guiding principles (2004). The prior art also describes the use of primary generators, tried and trusted precedent and individual approaches as key distinguishing features between novices and experts (see section 3.6.2). Table 8.8 shows AD describing his need to remove symmetry from his design ideas, explaining that he believes this to make ideas stolid and static. He refers to this personal rule on many occasions during the interview.
8.6 Summary

Chapter 8 discusses the key findings from the main study. It is clear that the role of values in industrial design decision-making can be described using the new values taxonomy (as developed in chapter 6). The evidence provided by the main study for each category is summarised below (table 8.7).

Table 8.9 A summary of the evidence provided by the main study.

<table>
<thead>
<tr>
<th>Internal/External</th>
<th>Value</th>
<th>Evidence from main study</th>
</tr>
</thead>
<tbody>
<tr>
<td>External values</td>
<td>Societal values</td>
<td>• No evidence</td>
</tr>
<tr>
<td></td>
<td>Identified stakeholder values</td>
<td>• Paying attention to the brief</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Asking questions to identified stakeholders</td>
</tr>
<tr>
<td></td>
<td>Economic system values</td>
<td>• The importance of minimising cost</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• The importance of the cost of processes</td>
</tr>
<tr>
<td></td>
<td>Values embedded in design</td>
<td>• Using values embedded in existing design - as a source of inspiration (aesthetics, function etc) - to inform decisions (sizes, manufacturing techniques etc)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• The desire to embed values into their designs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• The values materials already hold</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Using existing products directly in the new design</td>
</tr>
<tr>
<td>Internal values</td>
<td>Perceived societal values</td>
<td>• Perceived response to their design</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Perceived opinion of what is most important to society</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Drawing attention to their design</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Perceived societal needs and wants</td>
</tr>
<tr>
<td></td>
<td>Perceived identified stakeholder values</td>
<td>• Perceived use of their design</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Assumptions of the identified stakeholders' personal values</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Perceived identified stakeholder needs and wants</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• How they perceive their design will interact and affect the identified stakeholder</td>
</tr>
<tr>
<td></td>
<td>Perceived economic system values</td>
<td>• How the cost of the product will affect how it is perceived</td>
</tr>
<tr>
<td></td>
<td>Designer's personal values</td>
<td>• Personal preference and taste</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Past experiences</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Personal rules/ heuristics</td>
</tr>
<tr>
<td></td>
<td>Meta-values</td>
<td>• Prioritising</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Developing frameworks</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Project management</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Set ways of working</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Organising conceptual priorities</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Organising future work</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Making assumptions in order to continue</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Evaluating ideas</td>
</tr>
</tbody>
</table>
This chapter also demonstrates evidence of the use of visual representations to highlight the use of values in industrial design decision-making. The participant's portfolios provide evidence that visual representations allow the designer to:

- visually represent the products perceived interactions with society or identified stakeholders;
- better understand the problem and visually organise conceptual priorities early on in the design activity, often using the application of value judgements;
- externalise ideas in order to revisit them in the light of new value judgements;
- visually represent the use of existing products (VED) and how they can interact with/or be developed into, new concepts.

From an analysis of the participant's portfolios and the transcripts made during the concurrent verbalisation and protocol analysis it is also clear that visual representations appear to facilitate discussions between the designer and his/her ideas, which may involve the application, or consideration of value judgments.
Chapter Nine
Conclusions and Suggestions for Further Work

Introduction: This chapter discusses the key research questions presented in Chapter 1. The theses has provided many additional findings which can be found in Chapters 1 to 8. Chapter nine also presents some suggestions for further work, including the implications of this research for design education.

9.1 Conclusions

9.1.1 The collection and analysis of data regarding the use of values in design decision-making

This research presented an opportunity to add to the development of best practice for the analysis of design activity. Three methods were initially selected; retrospective interviews; concurrent verbalisation and protocol analysis; and a diary of designing (see chapter 4). The diary of designing was later rejected (see section 7.1.3).

One-to-one retrospective interviews are a qualitative method of gaining in-depth responses to questions asked. The outcome is a wealth of information on case studies. The interviewer is also empowered with the ability to probe and explore responses that other research techniques would not allow. The submission of their work folders also provides an additional wealth of information on motor-based cognitive action (drawing and writing) that can also be analysed.

One of the main disadvantages of retrospective analysis is that it is not a reflection of true design activity and may therefore be unreliable. Participants are required to discuss processes and activities, both internal and external, after they have occurred and design folders may be incomplete. They may also be in a different order to the design activity that produced them. Lee and Radcliffe (1990) agree stating, "The major weakness of this method is the difficulty of tracing how the time was spent during the actual design period". Two of the participants that took part in the main study discussed their work in an order different to that in which it was done (see section 8.1.3.1). It must also be factored in that the participant's account of their processes and activities may not be wholly accurate due to the impregnable arena of tacit knowledge. It must also be acknowledged that the interviews may not elicit honest responses. Other disadvantages of the method include its time consuming nature, especially on transcription and analysis. Another disadvantage of discussing design work retrospectively was discovered during the pilot studies. The
drawing folios presented by both the A-level and undergraduate students were
presentation folios, in which many pages had been 're-done' to look more designerly, and
some had been disposed of if the student felt they would not contribute to their marks.
This has the effect that the interview reflects the design work that is presented to the
interviewer, and does not completely reflect the design activity that occurred. This
disadvantage was overcome during the main study, as participants were asked to
complete the design activity within an allotted time, and all work produced in that time
was collected. Had a third stage of studies occurred participants would have been asked
to number drawings as they are produced.

Concurrent verbalisation and protocol analysis allows the researcher to document parallel
activities in order to analyse different influences and interactions that are required at each
stage of decision-making. The outcome of the ability to do this for this thesis was in
providing evidence for the use of visual representations in decision-making (see section
8.4.2).

There has been much discussion regarding the inadequacy of protocol analysis,
experiments showing limitations such as:

1. The set-up: The set-up heavily influences the protocol data, the interpretations can
be numerous and varied. Its obtrusive nature may change the subject's behaviour
and their cognitive performances. The author did comment that the act of videoing a
participant's design activity may encourage them to produce more visual
representations than it would do otherwise (see section 8.4.3).

2. Concurrent verbalisation: Akin and Lin have reservations that although verbalisation
aids the researcher to "access the mental processes of the designer" (1996:36) the
effect of verbalisation on the designer and the design activities has not yet been
determined. Dörner believes that any attempt to verbalise cognitive processes is
detrimental, stating "Germinal processes exist in human thought, in which casting
ideas into verbal form is premature because it would destroy the dynamics of
thought. These germinal phases, which can be regarded as rapid and partially
unconscious recombination's of images, may result in 'sudden insights' and
shouldn't be disturbed by attempts to verbalise" (1999:38).

3. The limitation of the data being captured: "People do not necessarily know what is
going on inside their own heads, let alone have the ability to verbalise it" (Cross et
al,1996:2). Indeed KB made two comments to the researcher at the end of the pilot
study.
a) That he often found himself ‘thinking one thing and saying another’, this suggest he was reporting parallel but independent thoughts to those being employed in the task.

b) That in periods of deep thought he would find he had not said anything at all.

However, all current research techniques are limited to collecting information on audio, visual or tangible data and that through all these methods it is impossible to do anything but make inferences about internal tacit processes. The use of both retrospective interviews and concurrent verbalisation and protocol analysis during the main study was advantageous in that it allowed a deeper understanding of the complex nature of values and the difficulties in their analysis. It also allowed us to suspend judgement on certain results (such as the frequency of the use of certain values, see section 8.2) due to conflicting data.

The analysis of visual representations to uncover the influence of values in design decision-making was not as successful as hoped (although it did yield some interesting results). Although it was obvious that some values had been considered through analysing a participant’s sketches (see section 8.4), the data was minimal. The analysis of visual representations to develop an understanding of design decision-making is not considered as an appropriate method on its own.

It is clear from the rich data collected during both the pilot and the main studies that the context of sustainable design, and more specifically, the use of recycled plastics provides an excellent vehicle for research in values.

9.1.2 Identifying and describing the values influencing industrial design decision-making

This thesis provides further understanding of what influences a designer’s decision-making. It is clear that a designer’s decisions are governed by values, as much as by rationality. Chapter 5 provides evidence for the applicability of the use of knowledge, skills and values as a model of decision-making. In order for values influencing design decision-making to be identified and described we must be able to distinguish values from knowledge and skill. Section 5.1 presents examples of the use of knowledge and skill in design decision-making. There are many examples throughout this thesis where the use of values in design decision-making has been made explicit. The examples shown in section 5.1 also show that although we can distinguish values from other
influences, we cannot separate decisions based solely on values from those based on knowledge and/or skill. Many decisions can be influenced by a combination of all three.

During the pilot studies, decisions influenced by values were shown to be a common element throughout participant's design activity. Chapter 5 presents findings from the pilot studies that correspond to those presented in the literature (see chapter 3). Examples are provided of the influence of economic values (see section 5.2), personal values (see section 5.2.1), social values (see section 5.2.2) and values embedded in design (see section 5.2.3).

One major finding was that the values highlighted by the literature did not accurately reflect those observed during the pilot studies (see chapter 5). New understandings were provided by the pilot studies. There was evidence that the influence of stakeholder values differed from those of society (see section 5.5.1), that designers used internal perceptions of external values (see section 5.5.2) and that designers were influenced by meta-values (see section 5.5.3).

As a result a new values taxonomy was developed (see chapter 6). The main study provided evidence of the effectiveness of the new taxonomy in categorising the values influencing industrial design decision-making. One finding was that values embedded in design, initially considered as an external value, could also be an internal value, as designers use these principles to embed value into their designs.
Figure 9.1 shows the final taxonomy of the values involved in an industrial designer's decision-making. It presents an outline of the types of values influencing design decision-making, many examples of which can be found in this thesis. Much as we cannot separate decisions based on values from decisions based on knowledge and/or skill, we cannot separate decisions based on one value and not on another. The evidence from the main study does suggest that certain values influence certain types of decisions more than others, and these are summarised in table 8.7 at the end of chapter 8. Figure 9.2 shows how the final taxonomy fits within Norman's model of designing.
9.1.3 The influence of values during design decision-making

Within the framework presented in Figure 9.1 designers are free to be influenced by few, or all values at different stages of a design project. They are also free to be influenced by values to a lesser or greater degree. For some design projects, the values influencing the designer's decisions can be simple and straightforward. For other projects decisions may be based on complex interactions and trade-offs between a number of different values. The purposeful avoidance of certain values may well simplify the decisions a designer must make in order to complete a task, but, ultimately, this approach will not lead to an appropriate outcome.

The pilot studies showed evidence of the designers having an internal hierarchy of values (considered as an output of meta-values, see section 5.5.3). The main study data backed up this claim that meta-values act as an internal project manager to organise design decision-making and prescribe which values to be influenced by (see section 8.1.2.5). The main study data also suggests that the choice to be influenced by one set of values and not another may also differ from project to project (see section 8.3.1).
Section 8.2 describes discrepancies between the frequency at which certain values were made explicit. Therefore we cannot make any conclusions about the timings and sequence and frequency at which particular values influence design decision-making.

9.1.4 Identifying any similarities or differences in the Influence of values in novice and expert design decision-making

In contradiction to much of the prior art (see chapter 3) there was little evidence that distinguished the influence of values and the application of value judgements between novices and experts. In fact only one difference was observed. The empirical evidence suggests that the two experts had built up, and were observed using rules of thumb, or personal heuristics (see section 8.5), to guide their design activity. Lawson's (2004) 3rd stage of becoming an expert describes the 'identification of guiding principles and structuring of precedent'. The prior art also describes the use of 'primary generators' (Lawson 2004), 'tried and tested precedents' (Achmed, Wallace and Blessing, 2002), and the use of individual approaches (Cross, Christians and Dorst, 1998) as key distinguishing features between novices and experts.

9.2 Contributions to knowledge

Contributions to knowledge have been made through the completion of all objectives set out in chapter 1 (section 1.5.2):

- the analysis and development of a fit-for-purpose model of design decision-making being made up of knowledge, skills and values (see section 9.1.2);
- the development of a categorisation system of values within this model of design decision-making (see section 9.1.2);
- the exploration, analysis and development of methods for the analysis of design decision-making and a review their effectiveness within this body of research (see section 9.1.1);
- the development of a clear understanding based on evidence from multiple sources of how values affect the design decision-making process (see section 9.1.3);
- the development of an initial understanding of how expertise affects the role of values in design decision-making (see section 9.1.4).
Table 8.7 summarises the empirical evidence found during the main study for each of the value categories. During the course of the study many sources of evidence (such as the literature review, pilot studies and focus groups) highlighted numerous examples of the ten values categories. These sources of evidence have been combined with the results from the main study to develop the summaries presented in Tables 9.1 to 9.10. The summaries also indicate the sources of evidence used to develop each category during the course of this body of research.

Although no evidence was collected regarding societal values during the one-day events, the longitudinal project, undertaken as part of the main study showed values being sought from members of society. It was also observed that the participant made internal judgements about these societal values, highlighting the relationship between internal and external values (see section 8.3.1). The prior art and pilot studies also provide data from which this external sub-set has been populated. The literature provides many examples of societal values including extensive contributions from Hicks (1982) and Layton (1992a) who both discuss the interplay between the man-made world and society (for a summary of all the literature please see Table 6.2). The pilot studies illustrate design decisions that are influenced by the values of the society for which the participant intends the final product (see section 5.2.2 and section 6.2.1.1). Participants discussed using information sought from members of society to understand how the outcome will effect that society and gain information about their needs and wants (also discussed by Pedgley, see Table 6.2). A summary of societal values based on both the prior art and data collected during the pilot studies and the longitudinal study is presented in Table 9.1.

Identified stakeholder values were highlighted as important during the pilot studies. Participants discussed actively seeking the value judgments of clients, teachers, peers and family members (see section 5.5.1). Having observed that stakeholder values appear to have a unique influence on design decision-making the prior art reviewed in chapter 3 was re-visited. There was little mention of stakeholder values (see section 6.2.1.2) however many of the findings from societal values were applicable to stakeholders (for example gaining information from a stakeholder about for instance their preferences, priorities, convictions and emotions). Empirical evidence from the main study showed participants paying attention to the brief and asking questions to clients (see section 8.1.1.2). A comparison between the one-day event and the longitudinal study showed that there were fewer incidents of identified stakeholder values recorded in the one-day event. This suggests the influence of stakeholder values is project specific (see section
8.3.1). A summary of identified stakeholder values based on all sources of evidence is presented in Table 9.2.

The traditional view of value relating to economics is well reflected in the prior art. The relationship between a designed object and the economic gain that can be achieved is documented by authors such as Baynes (2005) and Boztepe (2003, for a full summary please refer to Table 6.4). The pilot studies provided initial evidence of design decisions being based on economic system values and also highlighted the relationship between these and other values (see section 5.2). The main study provided fewer examples where judgements were made on the basis of economic system values and were related to the importance of the cost of materials and processes (see section 8.1.1.3). A summary of economic system values based on all sources of evidence is presented in Table 9.3.

Values embedded in design, alongside its internal counterpart embedding values in design yielded by far the most data during the research project. Initially the evidence provided by the literature review (see Table 6.5) and the pilot studies (see section 5.2.5) was used to build one external category. The main study, however, showed a clear distinction within this category. Evidence was collected regarding the influence of values embedded in existing design, existing products and materials, but evidence was also collected regarding participants making decisions to embed value in their designs, a more internal value judgement based activity (for a detailed discussion of the main study data please see section 8.1.1.4). Having made this observation the Initial literature review regarding values embedded in design was re-visited. It was clear that the literature related to both categories with the distinction being most eloquently put by Cross who describes the difference being a designer's desire and ability to 'read or write In material culture' (1982). For a summary of values embedded in design based on all sources of evidence please see Table 9.4 For a summary of embedding values in design based on all source of evidence please see Table 9.8.

A significant finding from the pilot studies was that designers have an internal perception of external values that they use to make value judgements 'on behalf of external influences (see section 5.5.2). This includes perceived societal values, perceived identified stakeholder values, and perceived economic system values. Literature related to the external categories from which perceptions are made are relevant here as designers are 'representing' societal, identified stakeholder and economic values (see sections 6.2.2.1, 6.2.2.2 and 6.2.2.3).
Participants' perception of societal values was observed as a key driver of many decisions during the main study. These perceptions were made with 3 distinct drivers; assuming a society's values were congruent with their own; acknowledging that different groups of people will hold different values; and perceiving the values of society through their perceived understanding of identified stakeholder values (see section 8.1.2.1). For a summary of perceived societal values based on all sources of evidence see Table 9.5.

Design decisions influenced by perceived stakeholder values were similar for all participants that took part in the main study and focused on the user and the company who set the brief. The data also provides evidence that perceived values are internal values and therefore subject to many other internal value judgements (see section 8.1.2.2). For a summary of perceived stakeholder values based on all sources of evidence see Table 9.6.

The main study only provided one example of perceived economic system values when one participant discusses how the cost of the product will affect how it is perceived (see section 8.1.2.3). For a summary of perceived economic system values based on all sources of evidence see Table 9.7.

The idea of a designer's decision-making being influenced by their personal values is not new. Literature regarding designers' personal values can be found from the 1970s (Rokeach 1973, Gregory and Commander 1979) to more recent publications (for example Dorst, 2003. For a summary see Table 6.6). The pilot studies provided examples of many instances where a designer's decisions were swayed by personal values such as personal preference, interest and previous experiences (see section 5.2.1). The focus group activities also yielded additional personal values during the development of the initial taxonomy (see Table 6.7). The main study, although not presenting any new findings, gave rise to many additional examples of decisions being influenced by a designer's personal values (see section 8.1.2.4). For a summary of designer's personal values based on all sources of evidence see Table 9.9.

Evidence from the pilot studies suggested that designers have an internal, values based organisational system. These early observations gave rise to the term 'meta-values' to describe this concept of values being used to analyse and determine design activity. (see section 5.5.3). There is little prior art regarding meta-values, a summary is shown in Table 6.8. The pilot study data, literature and additional comments made during the focus
groups were used to develop an initial understanding of meta-values (see section 6.2.2.5). The main study provided a great deal of evidence that reflects that designers make judgements that guide activity and project manage (see section 8.1.2.5). The main study also provides evidence that meta-values are used continuously to impose a hierarchy of other values (see section 8.2). This use of meta-values to highlight what is pertinent and disregard what is not was especially apparent during the comparison between the one-day event and the longitudinal study where the use of meta-values reflected the length of time available in which design activity could occur (see section 8.3.2). For a summary of meta-values based on all sources of evidence see Table 9.10.
<table>
<thead>
<tr>
<th>Value category</th>
<th>Decisions based on:</th>
<th>Includes:</th>
<th>Sources of evidence</th>
</tr>
</thead>
</table>
| External Values | Societal Values   | • information from members of society about for instance their preferences, priorities, convictions and emotions;  
• information from members of society about the acceptability of a design for instance regarding market desire, current fashion, aesthetic appeal and less tangible political, religious, cultural social and ethical positions;  
• information from society to gain an appreciation of their needs and expectations;  
• information from members of society to understand how the outcome will affect that society;  
• information from members of society in order to address socially important problems;  
• understanding that design can be used to reflect the values of society using information from its members;  
• design that can be used to shape the values of society using information from its members;  
• the social context within which a product is placed in order to embed additional value;  
• how other values interact with societal values. | • Prior art (see section 6.2.1.1)Pilot studies (see section 5.2.2)  
• Main study (see section 8.3.1). |
Table 9.2 A summary of the identified stakeholder values based on all sources of evidence

<table>
<thead>
<tr>
<th>Value category</th>
<th>Decisions based on:</th>
<th>Includes:</th>
<th>Sources of evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identified Stakeholder Values</td>
<td></td>
<td></td>
<td>Prior art (see section 6.2.1.2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Pilot studies (see section 5.5.1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Main study (see section 8.1.1.2 and Table 8.7)</td>
</tr>
<tr>
<td></td>
<td>• a brief that has been written by an identified stakeholder;</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• information from identified stakeholders about for instance their preferences, priorities, convictions and emotions;</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• information from identified stakeholders about the acceptability of a design;</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• information from identified stakeholders to gain an appreciation of their needs and expectations;</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• information from identified stakeholders to understand how the outcome will affect that identified stakeholder;</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• design that can be used to reflect the values of an identified stakeholder using information from that identified stakeholder;</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• information and/or advice from particular stakeholders such as clients, peers, lecturers and bosses;</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• how other values interact with identified stakeholder values.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 9.3 A summary of the economic values based on all sources of evidence

<table>
<thead>
<tr>
<th>Value category</th>
<th>Decisions based on:</th>
<th>Includes:</th>
<th>Sources of evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economic values</td>
<td></td>
<td>• minimising cost and of knowing the cost of materials, processes, and designer’s time; • economic competition; • the economic constraints of the market place and the need to solve problems within the imperatives of the market economy; • the fit between profit, needs and wants; • the relationship between supply and demand and availability and price; • the relationship between cost and other attributes such as strength and performance; • the relationship between cost and context; • how the cost of a product relates to its price and an the difference between use value, intrinsic value and value in exchange; • the relationship between economics and the political and environmental power of consumption; • the marginal value of one product over another; • how other values interact with economic values.</td>
<td>• Prior art (see section 6.2.1.3) • Pilot studies (see section 5.2) • Main study (see section 8.1.1.3 and Table 8.7)</td>
</tr>
</tbody>
</table>
Table 9.4 A summary of values embedded in design based on all sources of evidence

<table>
<thead>
<tr>
<th>Value category</th>
<th>Decisions based on:</th>
<th>Includes:</th>
<th>Sources of evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Values embedded in design</td>
<td></td>
<td>- existing design as a source of inspiration and/or to inform decisions;</td>
<td>- Prior art (see section 6.2.1.4)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- existing design as a start point for new designs;</td>
<td>- Pilot studies (see section 5.2.3)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- materials and/or existing products used directly in the new design due to the value they hold;</td>
<td>- Main study (see section 8.1.1.4 and Table 8.7)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- the embedded value existing products carry;</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- existing materials and products used to gain an understanding and appreciation of how values embedded in design affect their success;</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- existing materials and products used to gain an understanding and appreciation of the additional value a product holds, such as physio-pleasure, socio-pleasure, psycho-pleasure and ideo-pleasure and of product semantics;</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- existing materials and products used to gain an understanding and appreciation that people value products for what they signify;</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- existing materials used to understand the embedded value of similar new materials;</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- existing products used to gain an understanding that materials hold value through what can be done with them and how they are used;</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- existing products used to gain an understanding of the need to embed values that are appropriate for the context in which the new design will be used;</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- existing products used to gain an understanding of the use of shapes and styles to embed particular values (selection by synthesis);</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- how other values interact with values embedded in design.</td>
<td></td>
</tr>
<tr>
<td>Value category</td>
<td>Decisions based on:</td>
<td>Includes:</td>
<td>Sources of evidence</td>
</tr>
<tr>
<td>----------------</td>
<td>---------------------</td>
<td>-----------</td>
<td>---------------------</td>
</tr>
<tr>
<td>Internal Values</td>
<td>Perceived societal values</td>
<td>• the perception of for instance the preferences, priorities, convictions and emotions of society; • the perception of the acceptability of a design for instance regarding market desire, current fashion, aesthetic appeal and less tangible political, religious, cultural social and ethical positions of a society; • the perception of the needs and expectations of society; • the perception of how the outcome will affect that society; • the perception of socially important problems within society; • design that can be used to reflect the perceived values of society; • design that can be used to shape the perceived values of society; • a perceived understanding of the social context within which a product is placed in order to embed additional value; • how other values interact with perceived societal values.</td>
<td>• Prior art (see section 6.2.2.1) • Pilot studies (see section 5.5.2) • Main study (see section 8.1.2.1 and Table 8.7)</td>
</tr>
</tbody>
</table>
Table 9.6 A summary of perceived identified stakeholder values based on all sources of evidence

<table>
<thead>
<tr>
<th>Value category</th>
<th>Decisions based on:</th>
<th>Includes:</th>
<th>Sources of evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perceived identified stakeholder values</td>
<td></td>
<td>• the perception of for instance the preferences, priorities, convictions and emotions of identified stakeholders; • the perceived acceptability of a design for identified stakeholders; • a perception of the needs and expectations of identified stakeholders; • a perception of how the outcome will affect that identified stakeholder; • design that can be used to reflect the perceived values of an identified stakeholder; • how other values interact with perceived identified stakeholder values.</td>
<td>• Prior art (see section 6.2.2.2) • Main study (see section 8.1.2.2 and Table 8.7)</td>
</tr>
</tbody>
</table>
Table 9.7 A summary of perceived economic systems values based on all sources of evidence

<table>
<thead>
<tr>
<th>Value category</th>
<th>Decisions based on:</th>
<th>Includes:</th>
<th>Sources of evidence</th>
</tr>
</thead>
</table>
| Perceived economic      |                                                                                    | • a perception of the cost of materials, processes, and designer's time;  
| system values            |                                                                                    | • a perception of economic competition;  
|                         |                                                                                    | • a perception of the economic constraints of the market place and the need to solve problems within the imperatives of the market economy;  
|                         |                                                                                    | • a perception of the fit between profit, needs and wants;  
|                         |                                                                                    | • a perception of the relationship between supply and demand an availability and price;  
|                         |                                                                                    | • a perception of the relationship between cost and other attributes such as strength and performance;  
|                         |                                                                                    | • a perception of the relationship between cost and context;  
|                         |                                                                                    | • a perception of how the cost of a product relates to its price and a perception of the difference between use value, intrinsic value and value in exchange;  
|                         |                                                                                    | • a perception of the relationship between economics and the political and environmental power of consumption;  
|                         |                                                                                    | • a perception of the marginal value of one product over another;  
|                         |                                                                                    | how the cost of a product will affect how it is perceived;  
|                         |                                                                                    | • a perception of how much people will be willing to pay;  
|                         |                                                                                    | • how other values interact with perceived economic values.                                                                                     | Prior art (see section 6.2.2.3)  
|                         |                                                                                    | Main study (see section 8.1.2.3 and Table 8.7)                                                                                                  |
Table 9.8 A summary of embedding values in design based on all sources of evidence

<table>
<thead>
<tr>
<th>Value category</th>
<th>Decisions based on:</th>
<th>Includes:</th>
<th>Sources of evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Embedding values in design</td>
<td></td>
<td>• existing design as a start point for new designs in order to embed their value in the new design; • materials and/or existing products used directly in the new design in order to embed their value in the new design; • how the value of a product can be highlighted by how it is used; • the desire to portray a sense within a design; • the desire to convey a message through design; • the use of an understanding and appreciation of how values embedded in design affect their success to embed appropriate value in new designs; • the additional value a product holds, such as physio-pleasure, socio-pleasure, psycho-pleasure and ideo-pleasure and of product semantics; • that people value products for what they signify; • new materials selected because of their similarity to old materials with appropriate embedded values; • materials that hold value through what can be done with them and how they are used; • the need to embed values that are appropriate for the context in which the new design will be used; • shapes and styles used to embed value (selection by synthesis); • the desire to change a material or products embedded value; • how other values interact with embedding values in design;</td>
<td>• Prior art (see section 6.2.1.4) • Main study (see section 8.1.1.4 and Table 8.7)</td>
</tr>
</tbody>
</table>
Table 9.9 A summary of designer’s personal values based on all sources of evidence

<table>
<thead>
<tr>
<th>Value category</th>
<th>Decisions based on:</th>
<th>Includes:</th>
<th>Sources of evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Designer's personal values</td>
<td></td>
<td>• the designer’s personal preferences, conviction, priorities and emotions; • the past experiences/projects of the designer; • the designer’s personal rules and heuristics; • the terminal and instrumental values of the designer; • personal analogies used by the designer; • ballistic thinking; • the need to show for instance dedication, passion, concern for issues, personality and the values of the designer’s own society; • gut instinct; • the designer’s personal aspirations and personal drive; • how other values interact with the designer’s personal values.</td>
<td>• Prior art (see section 6.2.2.4) • Pilot studies (see section 5.2.1) • Focus groups (see Table 6.7) • Main study (see section 8.1.2.4 and Table 8.7)</td>
</tr>
<tr>
<td>Value category</td>
<td>Decisions based on:</td>
<td>Includes:</td>
<td>Sources of evidence</td>
</tr>
<tr>
<td>----------------</td>
<td>---------------------</td>
<td>-----------</td>
<td>---------------------</td>
</tr>
<tr>
<td>Meta-value</td>
<td>judgement made in order to guide the activity and decide what steps to take next;</td>
<td>• conceptual priorities that can be addressed within the time allocated; • the evaluation of ideas, making decisions as to what extent each step towards the conclusion satisfies the overall need, values of satisfaction; • the organisation of future work; • assumptions made in order to continue; • the decision to consider one value over another, influencing the process by which a hierarchy of values is prescribed; • judgements made as to how intentions can be realised; • values for ordering conceptual priorities; • principles used to determine potential consequences; • the perception of the truth of information; • different degrees of importance; • a designer's set ways of working; • how other values interact with meta-values;</td>
<td>• Prior art (see section 6.2.2.5) • Pilot studies (see section 5.5.3) • Main study (see section 8.1.2.5 and Table 8.7)</td>
</tr>
</tbody>
</table>
This thesis represents an extensive contribution to knowledge as it expands on the value-based explorations done by Hicks et al. in the 1980s and includes the contributions made by key authors in the field as well as evidence collected during the course of the study.

9.3 Suggestions for further work

9.3.1 Design education

The findings in this thesis present many opportunities for the development of resources to improve design decision-making. A taxonomy of the values influencing design decision-making has been added to a model of design decision-making as a summation of knowledge, skills, and values (see figure 9.2). We have seen in chapter two that design models are useful in that they support education. By furthering our understanding of design decision-making, it is possible to develop more effective teaching practices and resources. This enables students to improve their design capability and essentially become better designers.

It is the author's opinion that the use of values in design decision-making needs to be included in course curricula and presented in a framework of knowledge, skills, and values. It is also the author's opinion that the use of visual representations as a vehicle through which effective discourse between a designer and value judgements can occur (and not just for communication) needs to be a key part of design education.

An understanding of values is also helpful to professional designers in increasing their awareness of what constitutes design decision-making, therefore allowing them to apply effective and more informed strategies to their activities (see section 2.1). Many of the findings presented in this thesis could be transferred into a resource for professional designers.

Finally, the development of educational courses and resources for both students and professionals needs to involve the understanding of how the role of values can drive the sustainability agenda forward.
9.3.2 The importance of value judgements

Section 5.5.4 suggest key decisions are made from multiple value judgements, which build up into a value chain upon which a decision is made. This observation was not within the scope of this thesis but provides the basis for further work. It would also be interesting to isolate key decisions (or NDDs, see Akin and Lin, 1996) and to research what values were involved.

9.3.3 Management decision-making

The literature found in this thesis, which provided a basis on which this research is developed lies within the design disciplines. There is scope for further understanding by broadening this prior art to other disciplines, namely research into management decision-making. For example, although talking from a managerial perspective Bazerman could easily be referring to designers when he expands Simon's judgement and states 'decision makers satisfice. Rather than examining all possible alternatives, they simply search until they find a solution that meets a certain acceptable level of performance' (2000:5). He mentions six steps when applying a rational decision-making process:

1. define the problem;
2. identify the criteria;
3. weight the criteria;
4. generate alternatives;
5. rate each alternative on each criteria;
6. compute the optimal decision (2000:3-4).

The process he is describing in these six steps is similar to that attributed to the application of meta-values by designers. Bazerman also presents three general heuristics used in management decision-making, Evidence of similar heuristics being employed by designers can be seen in both the pilot studies (see section 5.2.1) and during the main study (see section 8.1.2.4).

- The availability heuristic – an event that evokes more vivid emotions and is more readily available in memory will outweigh an event that evokes no emotion or is difficult to imagine. For example, a person's assessment of a product's success will be based on that person's recollections of the successes or failures of similar products.

- The representative heuristic – people make judgements about objects (people or places) by looking for traits that may correspond with previously
formed stereotypes. For example they predict a product's success based on
the similarity of that product to past product types.

- Anchoring and adjustment — the 'anchor' is an initial value which is adjusted
to yield a final decision. For example managers make salary decisions
based on an employee's past years salary (2000).

9.3.4 *Contexts for researching the designer's use of values*

The briefs used to collect the data for this body of research were all set within a context of
sustainability, and this was felt to be currently the most important context for industrial
design. This context was focussed further to include the use of recycled materials as it
was felt that these would evoke more value driven responses. An appropriate 'next step'
for researching values would be to look at more 'normal' materials and other design
contexts to ensure the same issues and taxonomy would apply.
References


Archer B (1965) 'Systematic Method for Designers' in Cross N (Ed) Developments in Design Methodology, John Wiley and Sons


Baynes K (2005) *Design and Democracy: Speculations on the radical potential of design, design practice and design education*, draft copy, private correspondence, Department of Design and Technology, Loughborough University.


Cavanagh-downs, G (1997) The waste Challenge: Return to Sender, Centre for Design at the Royal Melbourne Institute of Technology, Melbourne

Charter M And Tischner U (2001) Sustainable Solutions, Sheffield, Greenleaf Publishing Limited


Cross N (1984) Developments in Design Methodology, John Wiley and Sons Ltd.


Coles, R. (2002) An inquiry into whether Recent Developments in Thinking Concerning Sustainable Design have Provided a Sufficient Basis for Changes in the Industrial Design and Technology Course at Loughborough University, and Whether these Changes have led to the Development of a Successful 'Education for Sustainability' Programme, unpublished dissertation, Loughborough University


Coles R (2003b) 'An exploration of the role values play in design decision-making' in J R Dakars and M J deVries (eds) PATT13 (Pupils' Attitudes to Technology), University of Glasgow, 211-219

Cooper T (2003) 'Durable consumption: reflections on product life cycles and the throwaway society', in T Cooper (Ed) Product Life and the Throwaway Society, Centre for Sustainable Consumption, Sheffield Hallam University


Datchefski E (2001) The Total Beauty of Sustainable Products, Rotovision

Do E Y, Gross M, Nelman B and Zimring C (2000) Intentions and relations among design drawings, in Design Studies 21, 483-503


Gero J S (1998) 'Toward a model of designing which includes its situatedness' in Grabowski H, Rude S and Grein G (Eds) Universal Design Theory, Shaker Verlag, Aachen, 47-56


Goldschmidt G (1996) 'The Designer as a Team of One' in Cross N Christiaans H and Dorst K (Eds) Analysing Design Activity, John Wiley and Sons


232


Jones J C (1963) 'A method of Systematic Design' in Cross N (Ed) Developments In Design Methodology, John Wiley and Sons Ltd


Keeney R L (1992) Value-focused thinking: A path to creative decision-making, Harvard University press, USA

233


Layton D (1992a) Values and Design and Technology – Design Curriculum Matters: 2, Department of Design and Technology, Loughborough University of Technology


Layton D (?) ‘Science Education and Praxis: the Relationship of School Science to Practical Action’, 11-23

Lee T Y and Radcliffe D F (1990) 'Innate design abilities of first year engineering and industrial design students', Design Studies, Vol 2, April 1990, 96-106

Lewis and Gertsakis (2001). Design and Environment, Greenleaf publishing


Lugt v-d R (2005) 'How sketching can affect the idea generation process in design group meetings', Design Studies, Vol 26, No 2, 101-122


Neiman B, Gross MD and Do E Y-L (2000) *Sketches and their functions in early design – a retrospective analysis of a pavilion house*, Publisher unknown


Norman E (2001) *Creating markets through designing with recycled polymers*, Department of design and Technology, Loughborough University


Polanyi M (1962) 'Tacit Knowing: Its Bearing on Some Problems of Philosophy' in *Reviews of modern Physics*, vol 34 no 4, 601-616


Ryle G (1948) The Concept of Mind, Hutchinson


Storer I (2005) *Reflecting on professional practice: capturing an industrial designer's expertise to support the development of the sketching capabilities of novices*, unfinished, Loughborough University


Suwa M, Gero J and Purcell T (1998a) 'The role of sketches in early conceptual design processes', publisher unknown


Appendix I: Project details – pilot studies, dataset three

Loughborough Design Week 2003 / Recoup brief

Recoup

Company statement

Recoup (Recycling of Used Plastics Ltd) was established in 1989 to promote and facilitate post consumer plastic container recycling in the UK.

When Recoup was established there was little knowledge of plastic bottle recycling in the UK. Today 49% of local authorities operate a plastic bottle collection scheme. At the end of 2000, there were over 4,115 plastic bottle collection banks and more than 3.6 million households had a kerbside collection for recyclables including plastic bottles. Since Recoup was established more than 1129 million plastic bottles have been collected in the UK for recycling.

Since 1989 Recoup has assisted over 130 collection schemes by providing advice and sponsoring equipment; targeted over £3m of industry support to develop plastic bottle recycling; informed and educated with newsletters, fact sheets, instruction notices and posters; actively investigated and developed new market opportunities for collected plastic bottles; highlighted plastic bottle recycling successes through national and local TV, radio and press; introduced polymer sorting schemes and trained operators to provide high quality, high value material ... and much more.
However, there is a need to broaden awareness of the range of products that use recycled material as well as potential new applications. Those designs that are currently available tend to be rather conservative in nature and targeted towards low added value products.

Smile Plastics

Smile plastics launched their first product range in 1994 and have continued to develop news ways of recycling plastic waste. Recycled plastics sheets have been used extensively all over the world including the Idée showroom and golf driving range roofing in Japan (Klein Dytham), Body Shop and Blanco fashion shops throughout Spain (Fern Green). The Science Museum, Design Museum, V & A and the Tate Gallery have all used it in different capacities.

Product backgrounds

The Chelsea Flower Show is the world's most popular and renowned flower show. This year Recoup is looking to enter the small gardens competition. The aim is to inspire and they have chosen the following category:

Chic Gardens-These gardens should incorporate new ideas, modern materials, and imaginative and innovative design. Stylish and possibly controversial, these spaces will be striking and bold.

The Ideal Home Show, held at Earls court in London is officially Ireland's biggest, best attended and most successful exhibition for homeowners. No other consumer exhibition in Ireland attracts such a large number of high quality visitors who are genuinely interested in sourcing new products for their home and lifestyle.

This year RECOUP is looking to exhibit a selection of products that illustrate modern, stylish and striking design solutions for household living environments.
Brief

To propose a new product to be displayed at either the Chelsea Flower Show or Ideal Home Show that exploits the use of recycled plastic sheet from Smile Plastics.

Desirable attributes:

- Perceived high quality and value
- Innovative and inspiring use of recycled plastics
- Conveys a modern approach to sustainable design
- Appropriate styling that considers the environments they will be used in

Reference

www.recoup.org


http://www.idealhomeshow.co.uk

Inspirational and useful websites

Materials

http://www.smile-plastics.com

http://www.yemmhart.com

Design Ideas

http://www.biothinking.com

http://www.designresource.com

Books


Students must NOT make direct contact with the company or any associated companies during the Design Week assignment.
### Appendix ii: Eco-indicator test results – pilot studies, dataset four

<table>
<thead>
<tr>
<th>Production</th>
<th>material or process</th>
<th>amount (kg)</th>
<th>indicator</th>
<th>result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Packaging</td>
<td>Cardboard</td>
<td>0.39</td>
<td>69</td>
<td>26.91</td>
</tr>
<tr>
<td></td>
<td>Paper</td>
<td>0.02</td>
<td>96</td>
<td>1.92</td>
</tr>
<tr>
<td></td>
<td>PP Plug cover</td>
<td>0.002</td>
<td>330</td>
<td>0.66</td>
</tr>
<tr>
<td>Toaster</td>
<td>UPVC Black plastic parts</td>
<td>0.25</td>
<td>270</td>
<td>67.5</td>
</tr>
<tr>
<td></td>
<td>Steel</td>
<td>0.78</td>
<td>86</td>
<td>67.08</td>
</tr>
<tr>
<td></td>
<td>Frames and bread lifter</td>
<td>0.04</td>
<td>86</td>
<td>3.44</td>
</tr>
<tr>
<td></td>
<td>Nichrome wire</td>
<td>0.0012</td>
<td>3085</td>
<td>3.702</td>
</tr>
<tr>
<td></td>
<td>Mica sheets</td>
<td>0.037</td>
<td>2500</td>
<td>925</td>
</tr>
<tr>
<td></td>
<td>PET circuit board parts (white + clear)</td>
<td>0.031</td>
<td>380</td>
<td>11.78</td>
</tr>
<tr>
<td>Processes</td>
<td>Injection moulding 1</td>
<td>0.033</td>
<td>21</td>
<td>0.693</td>
</tr>
<tr>
<td></td>
<td>Injection moulding 2</td>
<td>0.25</td>
<td>44</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>bending steel</td>
<td>0.78</td>
<td>0.00008</td>
<td>0.0000624</td>
</tr>
<tr>
<td></td>
<td>TOTAL</td>
<td></td>
<td></td>
<td>127.6050 no mica</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1052.61 with mica</td>
</tr>
<tr>
<td>Use</td>
<td>electricity (kwh) (850/1000)x(1/60)x365x10</td>
<td>518.1176</td>
<td>33</td>
<td>17097.9</td>
</tr>
<tr>
<td></td>
<td>Distribution 1.6/1000x150km</td>
<td>0.24</td>
<td>15</td>
<td>3.6</td>
</tr>
<tr>
<td></td>
<td>TOTAL</td>
<td></td>
<td></td>
<td>17101.5</td>
</tr>
</tbody>
</table>

### Disposal

<table>
<thead>
<tr>
<th>material or process</th>
<th>amount (kg)</th>
<th>indicator</th>
<th>result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landfill</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PP Plug cover</td>
<td>0.002</td>
<td>3.5</td>
<td>0.007</td>
</tr>
<tr>
<td>Toaster</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UPVC Black plastic parts</td>
<td>0.25</td>
<td>2.8</td>
<td>0.7</td>
</tr>
<tr>
<td>Steel</td>
<td>0.78</td>
<td>1.4</td>
<td>1.092</td>
</tr>
<tr>
<td>Frames and bread lifter</td>
<td>0.04</td>
<td>1.4</td>
<td>0.056</td>
</tr>
<tr>
<td>Nichrome wire</td>
<td>0.0012</td>
<td>no ind</td>
<td></td>
</tr>
<tr>
<td>Mica sheets</td>
<td>0.037</td>
<td>no ind</td>
<td></td>
</tr>
<tr>
<td>Recycling</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardboard</td>
<td>0.39</td>
<td>-8.3</td>
<td>-3.237</td>
</tr>
<tr>
<td>Paper</td>
<td>0.02</td>
<td>-0.02</td>
<td>-0.024</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td></td>
<td>0.449</td>
</tr>
</tbody>
</table>
Appendix III: Project guide – pilot studies, dataset four

Guide for participants

PROTOCOL ANALYSIS PILOT

K.B and I.S

Brief:
Toaster re-design incorporating sustainable issues

Background Information:
Eco-design training day held 25/07/03
Eco-indicator outcomes for an existing toaster.

Task:
Spend one hour designing a new toaster that incorporates sustainable design.

Thinking aloud – please try to verbalise what is ‘going through your mind’ at each stage of designing.

Thank you
Appendix IV: Private email from Dr Pedgley

Email received 2\(^{nd}\) January 2002

Notes relating to new 'diary of designing' studies

© September 2000 Owain Pedgley

1. Procedural notes for the diarist

- If you normally use a log book to record thoughts and decisions, avoid using the diary as a log book substitute. This is at risk of happening on occasions when out-of-hours designing takes place (in which case externalised design thoughts end up in the 'wrong' place).
- Diary-writing will generally benefit from the use of a quiet area with no interruptions.

2. Improvements to the pre-formatted stationery

Some re-design of the diary stationery will help in alerting diarists to the main subject areas to respond to. Rather than loose sheets, those questioned would have preferred a self-contained (spiral bound?) version. Perhaps provide a waterproof case? The new self-contained format, completed at the day's end, will be comprised of:

- a first section (Section 1) containing essential daily information (i.e. each day's main activity, to be completed on all days when work was carried out on the designated project);
- a second section (Section 2) containing plentiful supplies of tracing and plain paper sheets for the detailed diary entries.

It is still probably best to start diary-writing on a new sheet for each new day of the designated project. Although this uses extra stationery, it helps keep things neat and tidy. Consider inclusion of 'headed' blank areas (or simply words as reminders) for key subject matter (e.g. information use, non-externalised cognitive modelling, 2D modelling, 3D modelling etc.).

3. Scope of application

It should be noted that as a non-real-time recording method, diaries cannot be used to capture a designer's skill, connoisseurship, know-how or intuitive decision-making. All of these can be identified only in some practical response or action (e.g. through a protocol analysis study). The diary is able to capture a result, a manifestation or an account of what was involved in skilled activity and intuitive decision-making (as reported by the designer) but it cannot capture the actual skilled activity in motion.
4. Procedural notes for the researcher

Diary studies need to be better managed if they are to be effective for third-party use. The ten stages described below form a recommended procedure for a naturalistic, longitudinal diary study of designing.

Stage 1: The subject matter

Limit and define the subject matter to be investigated. This process will involve a thorough literature review to identify gaps in current knowledge and understanding.

Stage 2: The participants and the diary format

Decide upon the population that will be approached to participate (practising designers? students? oneself?). How many individual cases will be studied? When seeking agreements to participate, provide clear information on the background to the research, the purposes of the diary and the expectations on the diarist. Once agreements have been secured, obtain the participants' biographical details and find out what media the participants normally use to externalise their thinking (e.g., A2 marker pad, A5 spiral ring pad, computer software). From this information, tweak the diary stationery (or diary software) so that it fits with the participants' work practices.

Stage 3: The project

Decide upon the design project that the participants will work on. If detailed cross-case comparisons are to be made, it is recommended that all the participants work towards the same brief. Negotiate with the participants the kinds of 'deliverables' that will be expected at the end of the design work and the time scale for producing these. The completed diary and copies of any by-products to which entries refer (e.g., sketch sheets, models) will of course form one of the deliverables. Projects that are not subject to confidentiality agreements are preferred, since results can be published without having to disguise sensitive data. The participants should be referred to with anonymity.

Stage 4: The briefing and the trial runs

A well-structured briefing session will need to be held before asking the participants to commence their diary-writing. This briefing will involve the participants in several trial-run design exercises to become accustomed to the diary method. Ensure that the questions posed to the diarists are easily comprehended. It will be necessary to present example entries (based on the specialised subject under study) and to discuss the following points.

- The recommended procedure for writing an end-of-the-day diary.
- The need to make entries as intelligible, accurate and precise as possible.
- The need to pay special attention to describing work in the same sequence that it was covered. (Consider 'bullet point' accounts of designing.)
- That the participants' entries will not be scrutinised for 'good' or 'bad' practice; the aim of the exercise is simply that participants give an honest account of their practice.

Diary entries that refer to otherwise hidden thinking should be encouraged. The main focus of the diary should be on describing what the day's designing has involved, not on what tomorrow's designing might involve. The exceptions are philosophical entries that reveal long-term intentions (e.g., 'my approach to this phase of work is now to...'). Such descriptions are useful for constructing a macroscopic view of design activity. By the end of the briefing, it is most important that the participants fully understand what is expected of them and that they are happy with the general technique of diary-writing. The participants should be handed clear written instructions covering all the salient points of the briefing.
Stage 5: Production of the diary
Diary-writing should commence on a day negotiated with each participant. It may be helpful to stagger multiple studies, in order not to become overburdened with administration. This stage requires exemplary management. It is essential that, whilst the participants are involved in diary-writing, regular contact is maintained to rectify practical problems and to check that diaries are indeed progressing.

Stage 6: Creation of an archive
On completion of the diary, collect all the paperwork, models and (if appropriate) computer data and store these as an archive. Take photographs of 2D and 3D design work.

Stage 7: An initial review
Make an initial assessment of the diary content and note any points that need clarifying or expanding upon in the post-diary interview. Produce:

- a glossary of terms;
- a catalogue of each day's main activity;
- a catalogue of each day's entries.

Stage 8: The post-diary interview
Conduct a post-diary interview with each participant. In the case of documenting own practice, a reflective review of the designing and of the diary entries forms a suitable substitute for a post-diary interview (which in effect becomes self-administered).

Stage 9: Analysis
Undertake the main analyses of the data. Assign codes and piece together diarists' narratives into a subject-by-subject description of their design activity.

Stage 10: Dissemination
Triangulate the results with other sources, as appropriate. Make copies of the findings available to all the participants.

5. Participants
'Researcher-as-designer'
Assuming that one's design skills are considered suitable for scrutiny in a research programme, an option is to make oneself a diarist. This way, attracting participants is, by definition, not an issue and the benefits of incorporating a practical element into a research programme (i.e. making use of one's expertise) can be realised. Commitment to the task of diary-writing will need to be solid because the success of the research programme will hinge on the diary creation.

As a methodological point, it might also be a good approach to be ignorant of the exact longitudinal design exercise that will be set (assuming this is acceptable within the research methodology), leaving it to a research supervisor to secure or decide upon a small portfolio of suitable projects (within a general area of interest). With this approach, design ideas would not be generated before data collection methods were in place.

Students
Students might be motivated to participate in a diary study under two circumstances. First, if diary-writing were set as an additional requirement of a compulsory project (i.e., if it formed an essential part of an assessed piece of coursework). Second, if a financial incentive were offered to work on a diary study outside of term time. For the latter, the student could tackle
a design project that would be of direct benefit to the research institution. One pressing limitation of using students as research subjects is that they are still in training. They may not have developed design processes that lead to manufacturable products and could be tempted to adjust their normal work practices (or simply their diary entries) in order to be 'seen in a good light'. This kind of distortion is of course applicable to all diarists.

Practitioners
The participation of professional design consultants is more likely to be secured if the work is conducted on the same terms as typical commissioned work. That is to say, with a negotiated brief, timeplan, 'deliverables' and a fee. This approach could prove expensive if a number of different designers were to be studied, so a modest design project (perhaps lasting no more than two weeks) should be considered. The choice of project would depend in part on the number of phases of designing that are to be studied. For instance, a new chair design might be taken from a brief to a detailed design in just two weeks, but this may not be sufficient time to complete the concept development of a new laptop computer. As with student participants, the chosen brief might be one for which the outcomes are directly useful to the research institution. Confidentiality issues are likely to make diary studies of third-party commissioned consultancy work unsuitable. The same is the case for in-house practices.
Appendix v: Example values cluster

**External – ISV**

| ODE-ADI Page one | My first feeling was that the material is flat as it comes in sheet material form and so that's the starting point, and lots of forming is going to be expensive and... but, at the same time flatness is something that you want to get away from a little bit. And flatness isn't very strong either, and the original design, as you say, is 18mm, I hadn't realised they had used quite such thick material. You know if you don't put any form into it, then you don't get any strength out of it. So in order to get any strength and to reduce the weight some form is necessary. | ESV ISV M-V |
| ODE-ADI Page one | No I don't think so, I think it was just the idea that it needs to be... you've got some height and you've got function here – you have to support something, pieces of paper or a laptop, or whatever it is at a particular height. And the focus of the audience is on the person's face, which is up here somewhere, so you want to get up to that height in an interesting way, without it looking heavy and stolid, and being to heavy. At the same time you need to get the strength back into it. So, I was thinking here lets move up with these curves, with a single bend at this point in a big arc, and then perhaps and then perhaps bring in some thinner steel, tubular structures through it to try and give it... to make that actually stable, and again something on the ground to try and give it some stability. | ISV ISV DPV M-V |
| ODE-ADI Page two | And then I was looking at how other structures of how you might get up to this level in an interesting ways, because this is very bland. And turning the sheet material sideways instead of forwards, so you see through it, so it becomes a bit lighter visually, but maybe its not actually lighter because there's more material in it. And again splaying it outwards from the base so that it has an elevation to it, pulling it up. And that was one or two on here that I saw that had that direction going upwards which I think is almost more expected of a... this type of product. But its fairly repetitive and symmetrical. I have a thing... I guess I... you tend to work symmetrically and I guess I tend to work symmetrically when there's no reason for it not to be. And I was trying to get away from that and break the symmetry is something I look at trying to do and that's what I was trying to do there and also trying... Well partly because I think that symmetry can be very boring, and repetitive things can get really boring cos you know what's going to happen. So trying to do something which you didn't expect can break that. | DPV PSV + DPV ISV VED DPV NDD |
| ODE-ADI Page two | Yes, I am, and I'm beginning to think that this will give me a structure that is interesting enough to look at. It's | DPV ISV |

252
<table>
<thead>
<tr>
<th>Page</th>
<th>showing lots of detail of how its being put together and its probably strong enough and probably could be done with the thinner materials because its got some sort of form to each of the materials. But its still got a problem of how you make it stable and get it up. So then I was getting into some detail and thinking about lights. I was also thinking about where the logos going to go, I you need to present a surface for the logo and I've to a large extent got rid of flat front surfaces so that's perhaps a little more difficult. So perhaps by lifting the front edge of the lector desk you can offer a little bit of privacy, because privacy's quite nice when your getting your notes confused and things like that. I had thought about dropping it but privacy adds that privacy and perhaps if you want to put a light on it you can lift it off that surface.</th>
</tr>
</thead>
<tbody>
<tr>
<td>ODE-ADI Page six</td>
<td>It is, I think symmetry can be stolid and very static, whereas if you remove it things start to have direction and then you get a bit more lively forms, I don't like any of these but I was beginning to think about doing that and lifting it off the surface. I had actually thought about using clear material here which wouldn't be recycled material obviously, it might even be glass toughened glass, but lifting this piece of material up here so that its floating, so this you wouldn't see. And actually most peoples vision is blotted by heads this bottom end, by people in front of them. So what goes on down here is sort of important but nothing like as important as what happens here and above. So putting the material further up could lead the attention further up, and offering a surface again for the logo I though that could be interesting. Keeping it nice and simple. And then I've been looking here again, how we might get it up in the air. I think I started of with these and thinking about this curve and whether I could actually introduce some corrugation to get some strength into it in an interesting way. And then an asymmetric corrugation, a single one, so that once again not symmetrical, does one thing on one side and something else on the other. And here tubular steel to lift it. So the tubular steel goes away and is not, you sort of take note of it then forget about it. And then you think about what this material is. And you could perhaps use two different types of material, then lift it up. If I do that this structures got a cantilever in it and that arrow there and this one there tell you what's going to happen when you lean on it. And its going to do that, because of all the bending moments around that corner, so structurally its not wonderful, although you could do it with stiff enough steel, although you'd always get some vibrations on that surface and it could be irritating. So perhaps it needs to have more legs and so on. And what happened after that,</td>
</tr>
<tr>
<td>ODE-ADI Page seven</td>
<td>I started, going back to these forms here...if I took...because really the form that I thinks most logical is this one. Structurally its very logical its two formed sheets which can lock together link together, and they get all there strength by this once fitting into a slot and then locking down these top surfaces. Fixings at two points there and there and you might want a rail across here</td>
</tr>
</tbody>
</table>
which you step on and off. And this rail was quite nice too as it acts to stabilise the whole thing. And then it slots together in two pieces, and when it comes apart one bit fits inside the other, and it doesn’t exactly pack flat, but its more compact than these in the middle. You could break it up further and it gets more interesting, but you could probably pack it up a bit smaller.

ODE-ADI Page seven

I was thinking... I was trying to move ahead, but again I am becoming very symmetrical. I don’t think that’s a big problem as long as its interesting enough, but it is something I am always conscious of, and I did try with these structures to break it down into smaller pieces to make it more transportable and I do think that that is the direction I would start in, to work very simple, and that was my next stepping off point, to start modelling in three dimensions, and I would start from there and then again start moving off in other directions to look at other possibilities. It says a lot about the materials, ways it works well, and also its very easy to think of, and resolve the problems off. And here I was beginning to take some of the things and put bends into them. And then I though well if you get rid of the things between the bends and just use these pieces and begin to put them together and then you can start to do some things... but really, doing this in sketch for is really a waste of time, I need to start making things.

ODE-ALI Page one

Well first is this. (A4 sheet) I read the brief and wrote some points. And it said it had to be recycled plastic so I wrote this here. And then I looked at the original, old plinth and it is actually quite dull, quite boring and not very nice. And then I did some measurements, you gave some measurements so I wrote them down. And I just wrote down a few points from the brief. It needs to be light and durable and modern and things like that.

ODE-ALI Page two

Yeah I was thinking about the lecturer using it and things like that, and it needs to be safe and you need to hold it... and its written on the brief as well. Because I always have in mind the brief and how the company is wanting to do it.

ODE-ALI Page five

This one (bottom left) I didn’t reject it totally but I think its too big. The area of its too big and this one (2nd in bottom left) is just too blocky and is just... I was thinking it could be hollow so its lighter but I didn’t go for it. This (2nd up left) is just too complicated because I need mechanics and stuff to lift it up and... and it doesn’t work well for plastics because its crap (laughs). And the streamlines I was thinking about... that the lecturer doesn’t have to stand behind it, he could actually stand on the side.

ODE-ALI Page seven

Yeah. And I think it looks different. I haven’t seen it before. And I carried on with the shark idea because here you can have a light. Light would shine down. And at this stage I was thinking about... at this stage I was thinking about logos as well. And I was thinking about having the recycling logo at the front. And the company name at the front as well. That would look quite nice. This (top centre) is just another...
| ODE- ALI | Yeah. Yeah. And I was trying to fit the logo here but because it would roll to the floor it would have hidden it so it doesn't really work. That's what I would imagine anyway. This is just ideas carried on. And here's is an idea of ... it just popped into my head. It wouldn't really work but it was just an idea thinking that because the plastic deforms when you heat it up. So then people can heat this up and push it down and push it up. Through the heat. | ISV |
| Page seven | | VED |
| ODE- ALI | Yes, here (far left) I was looking at the shapes here (central trunk) nicer shapes, I think. And this ones not actually free standing. So its nice but it doesn't actually match the brief. So I was developing this idea from a swan. | ISV |
| Page ten | | VED |
| ODE- CAI | So at the beginning I was looking at the brief and I was taking some notes from that. And I just had a random sketch (laughs) really. I don't really know why I did that, just as a start really. | ISV |
| Page zero | | |
| ODE- CAI | The person who would be speaking behind it. And thinking about the primary uses of this thing, of this lectern. And also the secondary uses, so um...sort of the consideration that their going to be using it, going to be leaning on it so it needs to be quite sturdy, I thought that was quite sturdy. It needs to be able to operate a laptop on it so there's got to be some sort of ledge, I guess preferably sort of horizontal...um it needs to be a display unit as well. You know all these sorts of things, you need to be able to lean on it as well. So they were the primary things. | PISV |
| Page zero | | M-V |
| ODE- CAI | Well yeah, I guess the fact that it needed to operate a laptop I thought its got to have some sort of shelf. To rest your hands on it I thought the base has got to be um...sort of as big as the top of the part, so that it was going to be sturdy. The display not really, that didn't really lead to any ideas as such. The secondary sort of bits and pieces. The lighting, there needs to be some sort of light on it. So it needs to maybe attract attention. Microphone I thought that the top of the product somewhere there needs to be a microphone. Cup recess, yes. This was really just stuff taken from the brief. The wiring, that led me onto think that there has to be some sort of wiring system so that you can power your laptop and you can power the microphone and the lighting. So that was that really. | PISV |
| Page zero | | M-V +ISV |
| ODE- CAI | Mirror, yeah, that was going back to this and thinking well how could you possibly display, how could it be used as a display stand as well. And then I thought well maybe if you had a mirror around the back of the product as well, then you would be able to see all angles of the product that was being displayed on it as well. Um...microphone. Yeah. Maybe some sort of smooth area to rest your hands on. And I also thought the ... because I hadn't had any ideas for the display I was thinking that maybe there could be a swivel under the shelf so maybe you could twist the product that's being displayed on it around. So that's pretty much everything on that page | ISV |
| Page one | | PSV |
| ODE- CAI | I was trying to! Then I realised that it looked a bit rubbish...and it didn't really work. | DPV + |
| Page three | | ISV |
| ODE-CAI Page three | No I wasn't thinking about materials at this stage really. I was just trying to get a form out really. Um... I mean these are really really rough at the moment. I was thinking in the back of my mind that it has to be portable and light and dismantle-able... is that a word? I don't know (laughs) so that's what I was thinking about. And these... I was just playing around with forms. And here I was actually was thinking about materials here because I was thinking about this frosted glass issue or frosted plastic of some sort. So that was that page. | DPV ISV + M-V

| ODE-CAI Page four | I think at this point I had a wonder over to the materials, had a look at them and brought some materials over. And I think I was asking how the materials were when they are four in there very basic form. | VED ISV

| ODE-CAI Page four | Ohhhh, um... I think I was actually thinking of those fish tank tube things, not in that sort of way. But then I was thinking before I've seen some sort of heavy liquid... not heavy liquid but very dense liquid that I think I've you put some plastic shavings into could have quite a good effect. Certainly very eye catching. But then I was thinking again this has got to be portable, that's not very practical if its got liquid in it. And because its just got these small shaving in it you could just empty them out and put a different colours in every time, or... and it would be very light weight. And obviously you wouldn't have the risk of having liquid in there and electronics in the base. Which is not ideal! (laughs). Um... so yeah. I was also sort of thinking obviously there's got to be a fan then um... in the base and a power supply. And then with this I went on from this idea and had a think about the different ways that a leg could be incorporated... | VED ISV

| ODE-CAI Page eight | Yeah. I was thinking that... if there's a microphone, you would assume that there would be speakers on it somewhere and I um... and I thought about having small holes (materials sample falls) that's going to really hurt your ears when you come to transcribe this (laughs). And, having small holes or maybe... but I thought that would detract from the design, because I want it all smooth and so then the I was thinking of the Ellula technology which goes behind the plastic. Then that got me onto thinking that the fact that this has to be light and portable and does that work through thick materials or not? And I thought if this was really thin sort of flexible material then you could clip it together somehow and then... you know with tags or whatever and then it would be really easy to dismantle and carry. So that's what I was thinking there. And also that the base part and the fan would be created as one, so you wouldn't dismantle those, you would carry them \ around and then you would have a tube that would go on top of the fan. Which you could put on and take off, filled with different coloured shards or whatever. And it would have a lid on each end so that you would... so to transport it around you would have the lid on, and then you would take the lid off to place it on top of the fan. And have the lid on the top so the shards don't go everywhere, and then put the lid back on. And then you would construct this and clip it all together. | DPV VED ISV PISV PISV PISV
<table>
<thead>
<tr>
<th>Page</th>
<th>Content</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>eight</td>
<td>roll it up and stuff so. So yeah. That’s really when I started thinking about how portable its got to be and what materials... not what materials its going to be made out of but what the materials are really going to be like. And I was also thinking if there was a light, which I think I have written all over the model, if there was a light there as well as a fan then that would have a really great effect. That would light up the shards that were floating around. And also if this was really thin then you would get some...</td>
<td>VED DPV</td>
</tr>
<tr>
<td>one</td>
<td>Oh ok (laughs) first sheet we’ve already been through and that was sort of ... this was a slightly different brief to what I am used to doing because the client was also the manufacturer of the material... well, not the manufacturer really but certainly part and parcel of the whole sourcing of it, so it was wanting to try and demonstrate the whole sort of ethos and what have you that had come from Recoup in this particular project so that was like ok, was there any sort of clues there. Anything we wanted to pull out. Erm… most important thing on the first sheet was about broadening awareness. Um… and it was, you know. They wanted to broaden the awareness that they were products out there using recycled material so my conclusions from that were that it needs to be obvious that its recycled material, but, used in maybe in a novel way, rather in the stereotypical well it’s a plastic recycled material so lets make it three times thicker because its weak. Etc etc, so trying to show that it can be used in new novel ways, which is what they wanted to do, sort out new applications for it. And no, a lectern is not a new application but …uh… it was trying to show that you could use it in clever ways and it didn’t have to be seen as a secondary material.</td>
<td>PISV VED M-V DPV ISV VED</td>
</tr>
<tr>
<td>two</td>
<td>So, um… one of the must have I pulled out was that it had to incorporated the Recoup logo, that was a definite link to be made between the product and them. Um… and I just sort of went through all the different bits. So usage we’ve got 3 to six times a year, we’ve got um... its not really a regular thing so its not really something that you would do every day. Um… you could be new to Recoup and be given this thing and be told to go away and give a presentation, so it should be easy to set up and use, and intuitive. So I said to myself, ok I’ll give myself a secondary aim of that, so I gave myself three… at that point it was three assembly sequence steps to get it up and ready, and then to use the same for dismantling, cos your obviously going to need to take it apart as well. And try to make that as absolutely as intuitive as possible. Um… the multiuse, sort of what’s going to go on it, so a laptop, ok, how much does a laptop weigh? How big is it? That sort of stuff, because that defines some parameters. Um… I’ve put that you don’t… you really don’t want any sort of flex visible to other people, because it indicates, or it shows that’s it’s under engineered. But then i...</td>
<td>ISV PISV M-V PSV + VED</td>
</tr>
<tr>
<td>two</td>
<td>Yeah! (laughs) so true. Erm… and then it was that it had to display things, so it was, well, what’s it got to display? Um… I wasn’t sure what that was but I thought ok, well maybe you need some way of maybe connecting bits</td>
<td>M-V ISV</td>
</tr>
</tbody>
</table>
and pieces to it. And that set of the idea that... you know its got to unfold in some way, because you know... your going to have to be able to pack it up. So maybe in that whole unfolding and clipping together process you can then trap things in between the clips or whatever features you've got, and then use those bits to hold what you've got, whether its posters or whatever. So they were just some thoughts about what does multiuse entail as you go through it.

<table>
<thead>
<tr>
<th>ODE- DLI</th>
<th>Um obviously the recoup logo, and then I've also highlighted to myself you know if you lean on this thing, that's the worse case loading condition... if you deal with that one you've dealt with the other. So it was then... and that was a function of where I've put some of the functions in this, why its laid out in the way it is. The models not a very good example of this, it would have been better if it had been done on CAD. But um... but just trying to look, right, if your going to lean on it, where are you going to lean on it? There were certain points... the front your more likely too... sorry, the front nearest to the speaker, rather than the furthest point away. Um... light and portable, I put ok it ideally needs to be foldable in some way because you've got quite a big bulky thing. So I was thinking about those big over centring fold like you get with plastic stuff. So your incorporating a function you get with plastic mouldings and devices you see around you, but your doing it to show this material does exactly the same as that, if it does! I'm assuming it probably does.</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISV</td>
<td>M-V</td>
</tr>
<tr>
<td>PISV</td>
<td>ISV</td>
</tr>
<tr>
<td>VED</td>
<td>VED</td>
</tr>
<tr>
<td>+</td>
<td>PSV</td>
</tr>
<tr>
<td>M-V</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ODE- DLI</th>
<th>Ok, next thing was ok its an environmental... or an environmentally sensitive design. The sheets come in a certain size. It would be great if we could make one of these out of one sheet, so that if anyone asks about this lectern we can say well it was produced out of one of these sheets, minimal waste and what have you, so that was, ok, well how big is it, what else do they do, how much is it going to be, cost weren't indicated on this but it was well ok, are there some thicker than others, are there some more expensive than others, errr, I also picked out that smile over a cnc routing service so it was ok, that would make a lot of sense for the production, so it was ok, rather than doing just, putting hinges and stuff... you know, on it... can we actually use CNC routing to actually form more of a jigsaw. So the product I had in my head at this point was you know those 3-D sort of balsawood jigsaws of sort of dinosaurs and stuff, well, can we actually use that, so you actually just clip it all together. So smile produce the material and they do all that. So they know... they know how to machine it because, well its there material! And what have you. So I've put another aim here, produce the device from one sheet with all parts being CNC'd together. That was just a, ok, that seems to make sense, where can we go with it? Because obviously I only had a day to do it, so it was a case of lets make some decisions and see where</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISV</td>
<td>DPV</td>
</tr>
<tr>
<td>PSV</td>
<td>ESV</td>
</tr>
<tr>
<td>ESV</td>
<td>VED</td>
</tr>
<tr>
<td>M-V</td>
<td>DPV +</td>
</tr>
<tr>
<td></td>
<td>M-V</td>
</tr>
<tr>
<td></td>
<td>PISV +</td>
</tr>
<tr>
<td></td>
<td>DPV</td>
</tr>
</tbody>
</table>
we end up. Because otherwise you could end up doing concepts all the time, but I tend to focus in on ok, how can we produce it, what are the tricky bits? Um... again I've put a note to myself to make sure it's innovative and inspiring, err... then there was this thing of modern or... and appropriate style, so it was well ok then appropriate styling in this sort of arena is something that doesn't detract from the person who's speaker, so it needs to be fairly refined.

ODE- yeah, just having a play with that, and looking at the samples you've got there and there buckled and there and you just get the feeling well its going to be variable input, its going to be variable tolerances from the input. The plastics we deal with have got very very good tolerances, but we know that there are other ones that not, I don't work with them but you think, well ok if I've got to consider them in pharmaceutical context and there tight tolerances, than this is going to be variable. So started to think well how can I use this, and because you had that form there, It was kind of, well can I do something telescopic with that which is along the lines of this sliding idea. But I thought well you still need to, you need to pin it in some way shape or form... umm, so started thinking well, ok you could emboss the Recoup logo, is that going to be strong enough visually? Are you going to be able to see it from the back of the room? That sort of stuff. So yeah, lots of different sorts of thoughts going on....

ode- At that point, at that point I got up and had a play with the material, and I had a play with your bottle tops, and twisted it and they fragmented and I thought it's a real shame and they, and I've heard that bottles tops are, I've heard, next to impossible to recycle. So I thought well, hang on, there must be... there's got to be something we can do with them. So I suddenly thought well hang on, what if we had a little hole there, and we used that profile, so little sort of plugs, that profile and passed this through the hole and then, that's how you tighten them. You know, every one knows how to tighten a bottle, it's a clear demonstration of reuse, direct reuse, reuses something we cant do, and it gets round this issue of wanting to collapse this thing down and, but still have the inherent strength. So it was well ok, you know that sort of triangulation form is the kind of form that is probable going to be best, so I made a decision quite early on about that. Um...just having the side panel, having these vertical is not going to give you any support in this direction, so I thought well, ok, if we've got the curve which you're going to have with the bottle then these are going to be offset to each other, so your going to get natural sort, of beam moment if you like, so its going to be sturdy. I thought actually that's great, you'd have to injection mould that, so you probably wouldn't be bale to do that from recycled material, but these can be directly reused and that does mean that the rest of the panels are going to be pretty well flat or a very simple one piece bending...
operation, whilst still giving you something that looks a
curvy. So, stared looking around this and thought well,
the problem with curving into a triangle is that its
going to want to open back out again. So why not
design it so that the lectern piece actually sits over the
top and forms a framework, and that natural bend is
trapping it

ODE-DLI Page five

So you design it so that the bit that's going over is
always wider than the bit that's going over the top of
it, so you have to flex it in, put the top on so it holds
itself and then you put those bits through. Because its
CNC milled, you're going to have the accuracy of this.
My next question which I come on to a little bit later on
is well how much overlap have I got on this because
there's not a lot of difference between the size of the
thread its got to pass through and the size of the cap
on the other side. So it was like lets think this
through... but anyway I haven't got that far yet! I
wanted to, I wanted to somehow support this triangle
somehow whilst also giving the function of, it will be
nice to have somewhere for a cup and all that other
stuff. Well I thought you always have sorts of
paraphernalia with you, and you don't want it on top of
the... it would be nice to have a little shelf underneath,
right lets use that shelf to support the structure. And
then I actually went the other way with this and
thought well if we had the flex so that's always sort of
tugging in, then you could slide the shelf in and you'd
have a CNC milled holed there with a sort of pip
sticking out, then you would actually flex the base out
and put the shelf in and it would hold, its natural
tendency of clam shelling, of closing up, well that's
what, well that's going to want to open out the other
way but at the time I was thinking well mouldings they
want to clam shell together, and you have the stress
of the curve, of the curved part, could we use that to
trap a shelf. Plus I was thinking about feet and you
don't want, you don't want a completely flat bottom
because nothing you ever put it on is completely flat
so would you have some feet. And then well put the
lectern on the top, and that's a triangle, then put that
in, and could one battle the other to keep it together,
so that one holds it together and that ones trying to
force it apart. Therefore that ones held in by the fact
that that ones trapping it, yeah? So starting to think of
the sort of engineering function. And then the lectern
bit, well you want a screen, so you form that by
bending a bit, don't form that by a secondary thing,
and add some handle loops and what have you.
Um... right and then I've got this a plan view of it. On
this one. And I've got the angle here and said well
actually you want to minimise the distance here
between that point at the base and the edge of the
lectern, because that's where your going to lean on it

ODE-DLI Page

So it was an assumption, yeah, needs to be clarified
and worked through on CAD as well, if that was the
next stage. So this was working out the six of that, this

M-V
ISV
PISV
M-V
ISV
PISV
| ODE-DLI Page ten | CNC machined out there, there's a dotted line down there which I'm going to put back in, which is to show that that panel there is just a square edge and you just push it in align the holes and there. I haven't shown you assembly sequence, but that would have been the next thing probably. And then this is just showing the cap idea, clearly, how it works. And then just a 3-d one showing, you glue those bits to that, and then those bits come in and you put the widgety things through. So that's just a side profile, again, removal of the material to make it lighter to carry, but then you do have the option of doing other fancy things and that these are interchangeable. And then looking at the plastic materials. So, I sort of thought what's going to convey the right sort of ethos? Yes you could do it out of the goddy day glow 1970's stuff but its going to give the wrong impression, its too distracting, you want something that is subdued and gives the right sort of message. And recoup a blue logo, whether it is. So that's the one that I went for there, which actually looks like a nice high quality. I like the matt on it, I like the fact that there's subtle detailing in there, its, its , its corporate, it gives the right sort of feel and look. | ISV VED |
| ODE-DLI Page eleven | And then the last thing I did was a bill of materials and what's what but that was more for you if you wanted to take this on um...to the next stage, and to convey the basic concept of it all. But basically that's what I came up with in that time. | ISV |
| ODE-DLI Page one | Got these the wrong way round, this one should be there, so this was trying to give you some detail, because obviously one of the deliverables was to give you the information that you need so that you can CAD model it up without me being here. So it was ok lets show, lets capture some of the thoughts in there and tell what it would look like, yeah? | ISV |

seven was just a one to five scale plan view of what this top piece would look like to see what sort of angle are we talking about here? How feasible is it to do that? How tight a radius is that nose? I mean it could be much bigger than that with these almost forming more of a u shape than a v, but again I hadn't really gone...I thought well I'll leave it at that. Looking at it now, that probably should be larger if your going to have the recoup logo down the front. But you know, this was down to the manufacturability of it.

Ok, page one was..i was literally starting. I had read the brief and I was considering what a lectern does. Um...the sort of first words that I put down was forces. I think that is a main consideration. The last thing that you want is for the lectern to break while your using it. That wouldn't do any good for Recoup or anybody who is presenting. I was thinking then about what would go on it and issues and how it would be used. So it was coming at it perhaps from a user perspective and the sort of issues that the lectern would have to deal with. So the forces, um...at first I thought of...
adjustable height sort of ergonomic perspectives. I suppose one point is I decided to ditch the adjustability because there was already a set height in the brief.

<table>
<thead>
<tr>
<th>ODE-JMI Page</th>
<th>It was the brief it was. I probably would have had it as adjustable. My final design I think could be adjustable with a few weeks. I was just considering other things like, um... the sort of use of the wires, where the wires could go. Sort of lighting, um....where the logo... how you could put the logo on. So this is sort of a bit of a brainstorm page.</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISV</td>
<td>DPV M-V ISV</td>
</tr>
</tbody>
</table>

ODE-JMI Page

I looked behind me and I thought well there all lecterns. So I actually put a few birds on top cos I thought if I want to get anymore ideas I mustn't get sort of transfixed on that. So I've started coming up with a few more ideas. I've started thinking sort of cantilever designs, one that supports itself from the ceiling um...and then sketched out the...the original ways and just saw different ways of doing that. Um...then just started messing about with shapes and thought how you could perhaps put a light on it.

<table>
<thead>
<tr>
<th>ODE-JMI Page</th>
<th>Urr...most of this page actually consists of incorporating a light because I looked at the possibilities of including a light.</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISV</td>
<td></td>
</tr>
</tbody>
</table>

ODE-JMI Page

This is a light for the user, but then..it's..it started with the SF with me thinking if I have a certain thickness, this ones 10mil but if you had 5 mil you could actually engrave into it the recoup logo on the inside. And where its actually thinner the light could pass through more easily. So if you then shine a light at the back, what would initially appear to be just a plain front would actually suddenly light up the logo from the inside. And this is actually ... picture 5 because this was actually a bit of a turning point because that changed my way of thinking, because that's actually a great idea. It plays with the material. It pushes the material to the new limit I think. So when the lights of you wouldn't actually see anything at all and it acts as a bit of a surprise to the audience when you turn it on. Up comes there logo, it glows, I'm ready to present now. Err...I then had a look at...these little laptops here. This was an idea... this is actually the lectern platform, table and I thought if you already have a light down there, it would be useful to also have a light at the top, so these were...I thought the best way to get the light from the bottom to the top was using a periscope. So just reflect the light onto there work um...so therefore id only need one light...I don't know if this is the page I thought ...yeah...you just periscope

<table>
<thead>
<tr>
<th>ODE-JMI Page</th>
<th>I've brought the tube thing back so I could now focus the light. So I have the recoup...the light at the bottom, it lights the recoup logo, up to the top and then you would have some light onto your page. Um...at the very top you've got...I was having a read thought the brief for the 3&quot; of 4&quot; time and I looked through the must be portable and I had a play around with using the SF material but actually turning it into a</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISV</td>
<td></td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th>Name</th>
<th>Text</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>ODE-JMI</td>
<td>Well this was the grit or the sand idea, which I quite liked but it doesn't work with the portability aspect of the brief so that was abandoned quite quickly. Um... this was working on how I could fit this together. So if I just had a simple pole I could start slotting... slot the tops and the bottom on. Um... this was a first idea here of the um... the supporting cross at the bottom. Where you have almost a y... shape so a t shape and you just slot the base through and that would then support it. And then once you've finished you could just pull the top out and they would then collapse. Um... there you have the portability. I was a bit concerned about the top and how to make it secure enough so just coming up then with ideas for the support, how I could get them to fit on and...</td>
<td>five</td>
</tr>
<tr>
<td>ODE-JMI</td>
<td>It is purely aesthetics and thinking about the forces because I didn't want them to ... it was mostly aesthetics, forces and portability because I've got things like the hinge there. Also things like the mesh protector for the light cos I ... I knew how a light would go in the bottom, so all of these have got lights in. Um... that's how I was going to get my logo to light up and that's how I was going to get light to the top. So the light was just standard feature now.</td>
<td>five</td>
</tr>
<tr>
<td>ODE-JMI</td>
<td>Um... still on structure but thinking more about the size of things and whether if we had this huge tube thing coming up, possibly how large would the platform have to be to support laptops and also where could the tower come up. Could it come in centre or to the left or... um... I think one of my designs... which is not actually on this page actually, is just going of the edge. I've actually got a cup holder there. I was just thinking about other things I could do, uh... shapes of the supports coming out of the tower to support the platform um...</td>
<td>six</td>
</tr>
<tr>
<td>ODE-JMI</td>
<td>Yes that's where I was thinking I initially thought should I joint these braces together. So should you actually lift these off and if you actually lifted these for you would end up with a y shaped oddity there, a t shaped oddity there and this big tower. And I thought well that's not very portable. So then I thought well its best to go back to this idea where there all separate and they all just literally wedge in together and if that was the case I could actually end up, if you look at this little drawing here.</td>
<td>nine</td>
</tr>
<tr>
<td>ODE-JMI</td>
<td>That's the final idea, that was it. So this is just going through telling you little bits. I mean I've actually thought.</td>
<td>ten</td>
</tr>
<tr>
<td>ODE-KCI</td>
<td>Yeah I tried to get down some of the main point that I thought I should perhaps think about as I went through the project. And some things which may influence the actual final product at the end. Things I should bear in mind as I went along.</td>
<td>one</td>
</tr>
<tr>
<td>ODE-KCI</td>
<td>Page one</td>
<td>ISV</td>
</tr>
<tr>
<td>--------------</td>
<td>--------------------------------------------------------------------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td></td>
<td>Um... Not really. I think um... mainly it's got to be able light weight and portable because obviously its got to be carried around but also it has to serve the function that its going to be used for. So there's no point having something that's really small if your going to need lots of space. And its got to last because obviously its going to be lent on and it has to be able to stand on its own without being lent against a wall or anything. Its got to be fairly sturdy.</td>
<td>PISV</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PSV</td>
</tr>
<tr>
<td></td>
<td></td>
<td>VED +</td>
</tr>
<tr>
<td>ODE-KCI</td>
<td>Page three</td>
<td>ISV</td>
</tr>
<tr>
<td></td>
<td>Yeah, yeah and as I see people around they often have a plastic bottle with them. So I thought about the bottle shapes, just the different shapes that are around and how they catch peoples eye. And then I went through a process of trying to put across, almost thinking of the base of the bottle and then how can it be turned almost like a story tell into another material that could be used. It wasn't...quite so successful with the portable idea cos I tried to think of some whirlwind ideas and I went into the colours that were used. If you look at say a coke bottle it's a clear bottle with a red top. Whereas if you look at a Fanta or a sprite bottle its slightly coloured with a coloured top. So trying to think of the way people look at it and say oh yes that's coke because its red and it catches everyone's eye. Or whether they see a different colour almost and say oh I wonder what that is, and are intrigued by it.</td>
<td>PISV</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PSV</td>
</tr>
<tr>
<td></td>
<td></td>
<td>VED +</td>
</tr>
<tr>
<td>ODE-KCI</td>
<td>Page four</td>
<td>ISV</td>
</tr>
<tr>
<td></td>
<td>Well I realised that you couldn't just have a lectern without having a purpose behind it, so you couldn't for example just have a flat board because you'd ... if you were going to use it as a lectern, to put forward your ideas and your thoughts then you needed a place to put your laptop or your notes or actually be able to use it as a fundamental lectern so then I was thinking about just really the way it could be laid out inside the lecterns so it's all compact, so you don't have just like a plain board and I was thinking about obviously if you talking, if your giving a speech or something you might want a drink and you have wires coming out for laptops or you need somewhere to put your notes clearly um... um... and you don't want them to get fuddled up or people will just thing what are you going on about! When you try and tell them something. So I was just trying to think or more compact ways of how it could be on one board.</td>
<td>PISV</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PSV</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PISV +</td>
</tr>
<tr>
<td>ODE-KCI</td>
<td>Page five</td>
<td>ISV</td>
</tr>
<tr>
<td></td>
<td>I just basically cos I just had one with me and I just looked at them and I thought well that ones got a square base but then when you look at some they have a round base. So then I thought the shape of its important because obviously not everything's the same. So I then looked at does a circle go into a square easily of does a square go into a circle? I it came up that actually a circle fits into a square a bit more easily than the other way around. And then that led me onto the design of the actual cup or bottle holder and thinking you don't want to have</td>
<td>PISV</td>
</tr>
<tr>
<td></td>
<td></td>
<td>VED</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ISV</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PISV</td>
</tr>
</tbody>
</table>
to spill it or knock it so much. So if you just have a little recess and you can just place your cup or something in there its subtle and if you don't want to use it then its not something that's in the way its, its just there if you want it.

ODE-KCI Page six

One slots into the other so it can just be fitted together. And that way because I was thinking of a triangle, it would slot in and be quite sturdy. So it would keep two wings together instead of letting them splay away and possibly be broken. And then I went through some of the finer detail and had a ...microphone and light sand those sorts of things added to it which...

ODE-MLCI Page one

MLC – oh ok, yeah those two I thought it would be quite good like in terms of flat pack furniture where they all fit together and I thought well if its going to be a plinth then its going to be moved about a bit, so flat pack furniture would be quite a good thing to think of. And then that base I quite like the shape of that all the way through and I kept coming back to that.

ODE-MLCI Page six

With the glass that slips down on top because I thought you could take all the parts apart and it would be quite easy to put together. And then that was going to be a way that you could have the logo across the top of these ones so...

ODE-MLCI Page five

I used the idea of having the logo on the front and sort of having the bent front and its I guess... its similar sort of shapes as the end one as the end one ... its just a sort of cone but a bent cone, with a cut out.

ODE-MLCI Page ten

Just cos it would use less plastic... and just make it lighter because it had to be portable. But I wasn't really thinking a lot. And I also thought you could have like recoup cut out.

ODE-MLCI Page eleven

I was thinking of like the audience really. But then I was thinking about where the user would put his feet and stuff, when he's standing. And I started thinking about it more later on, like in the brief and stuff. Which is quite soon. And then I thought well maybe that one could like clip together down oner side and just it would just stand up and have recoup down the side there and a shelf there. But it just looked to much like a surfboard.

ODE-MLCI Page thirteen

Whether it would stand up or not. And I thought I could if that base could fold up so you would just have quite a thin thing to take away with you. But then it didn't quite have enough to have a decent label on it. So this has to have something on the front, like a big area, and this sort of circle on it. Having that... I don't like that, but I just saw something conical like that.

ODE-MLCI Page eighteen

And then I thought there could be lights and...

ODE-MLCI And then looking at these, because his eyes would
be looking down. Sort of what height this would be which I know is written in the brief but... so his arms would be bent. And then his feet, so I had a cut away on here so he could get his feet in, so it wasn’t such a long way away. Or this ([trunk]) could be ebnt further round so he could get his feet under.
<table>
<thead>
<tr>
<th>PARTICIPANT</th>
<th>TRANSCRIPT</th>
<th>ACTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>So, I'm not too happy that this is on a slant but that's just the way it seems to have been modelled with my cardboard modelling skills, um, I'm just going to draw on the back because I've had an idea about how the plastic is going to look.</td>
<td>Holding model (A) (main model) in one hand</td>
</tr>
<tr>
<td></td>
<td>so, just thinking that if I had this, one of these white materials</td>
<td>Draws two lines down model (A) (main model)</td>
</tr>
<tr>
<td></td>
<td>around the side of it then that would look very smart and would be quite strong...</td>
<td>Picks up 2 plastic samples – 'snowflake' and 'yy'</td>
</tr>
<tr>
<td></td>
<td>quite sturdy.</td>
<td>Holds both plastic samples up to model (A) (main model)</td>
</tr>
<tr>
<td></td>
<td>Although I'm just thinking of how its actually going to be taken apart, from show to show... um... because the neck goes into the bottom, which is going to have a fan in, so that's going to be quite heavy, so that should support it. I need to see what it looks like with some sort of base,</td>
<td>Puts plastic samples and model (A) (main model) down</td>
</tr>
<tr>
<td></td>
<td>so there's going to be a fan there, and it needs some sort of base I guess</td>
<td>Gestures to model (A) (main model)</td>
</tr>
<tr>
<td></td>
<td>With this white material and then the stand is about there, and that's all going to be little bits of plastic shards which are going to be blowing around in the tube.</td>
<td>Draws profile of (46)</td>
</tr>
<tr>
<td></td>
<td>Powered by this fan and obviously going to have to have a power supply,</td>
<td>Draws lines for fan on (46)</td>
</tr>
<tr>
<td></td>
<td>and this bit here is obviously going to have to be glass, well... plastic. Hmmm.</td>
<td>Draws faint circle base on (46)</td>
</tr>
<tr>
<td></td>
<td>And obviously your going to be able to see the person behind there, so... and the laptop.</td>
<td>Draws lines down (46) then matching lines on model (A)</td>
</tr>
<tr>
<td></td>
<td>Might actually just model the laptop so I can see what that's going to look like. Really need some clear plastic so I can see what its really going to look like, but I think when I model it on CAD then that will give me an idea. This is the laptop... oops,</td>
<td>Points to front section on model (A) (main model)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Draws faint circle base on (46)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Draws lines for fan on (46)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Draws profile of (46)</td>
</tr>
</tbody>
</table>

267
<table>
<thead>
<tr>
<th>Action</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Places visual representation (cardboard laptop) on top of model (A)</td>
<td>so that's going to sit there</td>
</tr>
<tr>
<td>Cuts out visual representation (B) (cardboard circle)</td>
<td>and there's going to be some sort of base, and again. If I use good CAD modelling strategies ill be able to change this really easily on CAD, so I'm not to worried about the shape of this at the moment.</td>
</tr>
<tr>
<td>Holds visual representation (A) (main model) above visual representation (B) (cardboard circle)</td>
<td>Its going to be something like that.</td>
</tr>
<tr>
<td>Gesturing to model (A) (main model)</td>
<td>Microphone I guess could go somewhere at the top. Probable say the power supply will be somewhere on the side here and through the base which is also going to have a fan. Which is going to be here and some sort of external power supply. I wonder if I, I don't know...</td>
</tr>
<tr>
<td>Reads brief</td>
<td>I'm just wondering how easy its going to be for someone to stand here... because obviously this part felt a bit too low for me to chop it of, or maybe make it flat here so you can stand like flush to the lectern, or maybe make some sort of drinks holders here.</td>
</tr>
<tr>
<td>Points to side of model (A) (main model)</td>
<td>I think that was something on the brief (reads brief) cup recess, maybe have a cup recess, although that's quite near to the laptop so maybe that's not such a good idea, if it gets knocked over or something.</td>
</tr>
<tr>
<td>Gestures to model (A) (main model)</td>
<td>Or there could be a cup recess coming out from the side although I think that would subtract from the overall shape of the design so...</td>
</tr>
<tr>
<td>Gestures to visual representation (46)</td>
<td>um........ trying to imagine what this is going to look like.</td>
</tr>
<tr>
<td>Gestures to model (A) (main model)</td>
<td>and the whole in relation to the average sized person, and whether or not to make this frosted.</td>
</tr>
<tr>
<td>Gestures to model (A) (main model)</td>
<td>I think it would have to be clear because if the person is slightly shorter than there not going to be able to see who there talking to which is not good.</td>
</tr>
<tr>
<td>Picks up plastic sample 'snowflake'</td>
<td>I think it would be quite nice if we could use this colour plastic shard.</td>
</tr>
<tr>
<td>Points to cable of visual representation (46)</td>
<td>The other thing that's slightly worrying me is whether a normal power supply would power a fan that will be able to blow these shards around in here, and a laptop, obviously, and a</td>
</tr>
</tbody>
</table>
microphone and possible some speakers,

I mean there could be some speakers there and there maybe I don’t know.

I don’t know, maybe that could possibly detract from the shape because I wanted it to be quite streamlined. And just wondering if I put some holes there for some speakers maybe that’s going to look a bit strange.

Unless there were two speakers sort of ipod style, maybe that would look a bit better. And maybe they could have the same shards in them being powered in the same way?

Maybe? I’m not sure speakers, speakers is not one of the things on the list, microphone is and obviously if there going to be a microphone there’s obviously going to be some speakers but.

so my next thing really is how this is going to be taken apart, maybe there needs to be some bands?

I don’t know. This could be lifted from the base

part and the fan could be attached to the base, and it literally just slotted on, then that would be ideal,

but I’m not sure if this is then too bulky to then be portable…. (reads) light and portable you see…. ahh errr…..

This is quite, I’m not sure how heavy this is going to be, you see that’s another thing I need to think about, you see if this was quite thin… maybe even flexible then that would be good, then there’s no reason, yeah, there’s no real reason why the outside of this cant then be flat, the actual outside of this cant be flexible in fact. And clipped together, maybe manufactured from a sheet and then you bend it and clip it together to form it maybe.

That way maybe the fan and the tube could be more… oohhh I don’t know…

errr… the fan and the tubing…. no no… ok

this was very light weight,
<table>
<thead>
<tr>
<th>Action</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>tells how to make the unit</td>
<td>suggests using visual representations of the cardboard circle, tubing, and plastic shavings for the basic components.</td>
</tr>
<tr>
<td>describes the structure of the unit</td>
<td>emphasizes the need for a fan and a base to support the tubing.</td>
</tr>
<tr>
<td>suggests using a tube with a lid</td>
<td>recommends using a lid to enclose the plastic shavings.</td>
</tr>
<tr>
<td>explains the purpose of the tubing</td>
<td>highlights the importance of the tubing in supporting the shavings and providing structure.</td>
</tr>
<tr>
<td>describes the need for a strong fixing</td>
<td>stresses the need for a strong fixing to support the weight of the tubing.</td>
</tr>
<tr>
<td>suggests using a cable path with pen</td>
<td>recommends using a cable path with a pen to guide the laptop cable.</td>
</tr>
<tr>
<td>emphasizes the need for cable clipping</td>
<td>stresses the importance of cable clipping to prevent the cable from getting tangled.</td>
</tr>
<tr>
<td>suggests using a clearing on both sides</td>
<td>recommends using a clearing on both sides to allow visibility of the tubing.</td>
</tr>
<tr>
<td>mentions the possibility of incorporating the technology</td>
<td>discusses the potential of using the technology from the Ellula speaker system for producing sound.</td>
</tr>
<tr>
<td>concludes with a summary</td>
<td>summarizes the points and suggests incorporating the technology for producing sound.</td>
</tr>
</tbody>
</table>
yeah, that would be good, because they could be possibly placed on the inside of this, and then possibly to the outside when this is a display.

So cup recess, I mean there could be a cup recess on the top, but I'm just thinking I wouldn't put my cup right next to my laptop.

Also when you're doing a presentation, there also needs to be another set of wires leading to the projector, so, I'm not sure, maybe there could be, yeah could take the front of, so maybe the person could stand here and look this way, so maybe there needs to be a small recess here, some small clips, errr... I'm just not sure how good that's going to look when its turned round and used as a display. I think certainly as I was saying if the main body of this is made using very flexible very light plastic, when there's a light shone here there's a reasonable bright light into this fan and bright plastic shavings, then that's also going to shine through this plastic and that's going to look quite good I think, and again when its turned round its going to be the same effect and that's going to look quite good.

And the other thing I was thinking earlier was, was it... rotating... swivel or something here to rotate around so if your were display something you could turn it around, and maybe possible a mirror there, although that's not possibly going to be quite so possible as I'm using clear plastic, so we'll scrap that idea as that possibly would work better if it had been a solid unit, this a shelf to rest pens on maybe, although again if it... ohhhh... I'm just wary that any recess, any pen recess or anything like that is going to detract from this is if it going to be used as a display. Because its all very well and good, and it would be good to have that of it was just going to be used as a lectern, but if its going to be used as a display then that's going to look quite strange I think, so I'll, I'll not use that.
<table>
<thead>
<tr>
<th>Microphone at the top.</th>
<th>Points to top of visual representation (A) (main model)</th>
</tr>
</thead>
<tbody>
<tr>
<td>That's going to have to go to the power supply again that's there, wiring would run, no it wouldn't run up the product would it as its being powered from the base to give it some support, so its heavy.</td>
<td>Points to visual representation (B) (cardboard circle)</td>
</tr>
<tr>
<td>So how's the microphone going to be powered? And the speaker system?</td>
<td>Picks up visual representation (A) (main model)</td>
</tr>
<tr>
<td>Or maybe there is some sort of power supply here, really that's the only solution, as the laptop needs to be powered, the speaker system needs to be powered and the laptop needs to be powered, unless, the microphone is obviously incorporated into the laptop, although you might not have a laptop and you may still need power, which is a good point really for it to be powered as I'm assuming that at that height</td>
<td>Points repeatedly at the top of visual representation (A) (main model)</td>
</tr>
<tr>
<td>that's presumably where you would be standing so maybe a little bit height than that, but when your projecting your voice it will be picked up by that microphone so that's fine. (silence)</td>
<td>Gestures with visual representation (A) (main model)</td>
</tr>
<tr>
<td>this is obviously a bit thick, so this obviously needs to be a lot thinner, a lot lot thinner in fact, just wondering when you lean on it however its going to be strong enough if its flimsy material on the outside, I think it should be ok though, so.</td>
<td>Draws line repeatedly across visual representation (A) (main model) then puts it down</td>
</tr>
<tr>
<td>This get the materials... yeah I think this is the one to be used, although this has got some twinkle in it, but I think that when you've got the tubing and the stuff that that will be enough, I think that's quite nice as that wont detract from what's going on in the middle quite so much, so I just need to find out whether that can be manufactured as a thinner sheeting and whether that's going be strong enough to hold this, although this has a lot of strength to it even as cardboard so that's quite good. (silence)</td>
<td>Picks up plastic sample 'snowflake' then puts it down</td>
</tr>
<tr>
<td>just wondering what are the best ways to model this on CAD, I'm thinking of a revolve... I think ill be able to get a much better idea of the dimensions with reference to these here and the size of a laptop which I think</td>
<td>Turns visual representation (A) (main model) in hand, then puts it down</td>
</tr>
</tbody>
</table>

272
I work out as about 40 cm by about 30 cm's, well 30 ish cm so, its fine for a laptop, its fine for a display, its fine for speaking, its light and portable, the main body of it is light and portable, obviously the base needs to be a bit heavier in itself, ahh... the recoup logo...

hmmm... maybe that could be incorporated on the bottom, that would look quite good.

Re-coup, with the crazy arrow thing. There. Just on the base, so I was thinking of having it like some sort of.......