Core Design Aspects

A thesis submitted to the University of Manchester for the degree of Doctor of Philosophy (PhD) in the Faculty of Engineering and Physical Sciences

2010

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Table of Contents

Contents                                   page
List of figures                             ........................................ 4
Abstract                                    ..................................................... 5
Declaration                                 ..................................................... 7
Copyright statement                        .................................................. 9
Acknowledgements                           .................................................. 10
The author                                 ...................................................... 11
The publications presented                .................................................. 13
1. The statement – introduction            .................................................. 15
   1.1 Aims                                    ..................................................... 15
   1.2 Objectives                             ..................................................... 16
   1.3 Overview                               ..................................................... 17
2. Part 1 – the publications               .................................................. 17
   2.1 Overview                               ..................................................... 17
   2.2 Publication 1                         ..................................................... 18
   2.3 Publication 2                         ..................................................... 19
   2.4 Publication 3                         ..................................................... 20
   2.5 Publication 4                         ..................................................... 21
   2.6 Publication 5                         ..................................................... 22
   2.7 Publication 6                         ..................................................... 23
   2.8 Publication 7                         ..................................................... 24
   2.9 Publication 8                         ..................................................... 25
   2.10 Publication 9                        ..................................................... 26
   2.11 Publication 10                       ..................................................... 26
   2.12 Publication 11                       ..................................................... 27
   2.13 Publication 12                       ..................................................... 28
3. Part 2 – contextual review               .................................................. 30
   3.1 Design                                 ...................................................... 31
      3.1.1 Defining design                   .................................................. 31
      3.1.2 What design is                    .................................................. 32
      3.1.3 The design process at its simplest ........................................ 33
      3.1.4 Design as the management of constraints ................................... 33
      3.1.5 What design involves              .................................................. 35
      3.1.6 Different types of design        .................................................. 35
      3.1.7 Good design                       ...................................................... 39
   3.2 Design elements and principles        .................................................. 39
      3.2.1 The elements and principles      .................................................. 39
      3.2.2 Design principles                 .................................................. 32
      3.2.3 Design rules                      ...................................................... 40
      3.2.4 Repetition                        ...................................................... 40
      3.2.5 Elements and principles as part of the design process ............... 42
   3.3 Design activities and process         .................................................. 43
      3.3.1 Design activities                 ...................................................... 43
## List of figures

<table>
<thead>
<tr>
<th>Figures</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 2.1</td>
<td>Publications links</td>
<td>18</td>
</tr>
<tr>
<td>Figure 3.1</td>
<td>The design process at its simplest</td>
<td>33</td>
</tr>
<tr>
<td>Figure 3.2</td>
<td>Design integrity</td>
<td>34</td>
</tr>
<tr>
<td>Figure 3.3</td>
<td>What design involves</td>
<td>35</td>
</tr>
<tr>
<td>Figure 3.4</td>
<td>Repetition and variation</td>
<td>41</td>
</tr>
<tr>
<td>Figure 3.5</td>
<td>Lots of variation</td>
<td>42</td>
</tr>
<tr>
<td>Figure 3.6</td>
<td>The main activities in design</td>
<td>44</td>
</tr>
<tr>
<td>Figure 3.7</td>
<td>The creative problem-solving process</td>
<td>46 &amp; 59</td>
</tr>
<tr>
<td>Figure 3.8</td>
<td>Aspects of real-world problem-solving</td>
<td>54</td>
</tr>
<tr>
<td>Figure 3.9</td>
<td>A developed design-process model</td>
<td>58</td>
</tr>
<tr>
<td>Figure 3.10</td>
<td>Aspects of design/creative problem-solving</td>
<td>60</td>
</tr>
<tr>
<td>Figure 3.11</td>
<td>A model for performance and aesthetics</td>
<td>61</td>
</tr>
<tr>
<td>Figure A1</td>
<td>The four leaf shapes</td>
<td>83</td>
</tr>
<tr>
<td>Figure A2</td>
<td>Observer preferences as a bar chart</td>
<td>83</td>
</tr>
<tr>
<td>Figure A3</td>
<td>The 21 pairs of leaves in Exp. 1 with observer preferences</td>
<td>84</td>
</tr>
<tr>
<td>Figure A4</td>
<td>Two views of the experiment at the Whitworth Art Gallery</td>
<td>86</td>
</tr>
<tr>
<td>Figure A5</td>
<td>Leaf pairs in Experiment 2</td>
<td>86</td>
</tr>
<tr>
<td>Figure A6</td>
<td>Spot pairs in Experiment 2</td>
<td>87</td>
</tr>
<tr>
<td>Figure A7</td>
<td>Square pairs in Experiment 2</td>
<td>88</td>
</tr>
</tbody>
</table>

Word count of statement: 13,666
Abstract
This statement gives an overall summary of the aims and achievements of the research work and scholarship carried out by the author during her time at The University of Manchester (and UMIST – now part of The University of Manchester) for which the publications presented give evidence. The research has been about exploring the design process, the activities and issues, and elements involved – from both an industry and student point of view. The publications explore design pedagogy, the skills required by designers and how these might fit into a curriculum for design today.

In three parts it summarises the publications presented, reviews the main aspects of design and the current state of knowledge and research in design and summarises the core aspects as distilled from over 36 years practice, research and scholarship.

The driver for much of the research undertaken has been to gain a better understanding of the core aspects of design – what key knowledge and skills are required by designers to allow the consistent design of better products and services which enhance the experiences of users.

The work presented investigates design and design methods: the activities and processes and the elements involved. It considers responses to designs, the emotional aspect of design - why some designs are preferred over others, why some colour combinations are more desirable, and why repetition is so important to the human psyche. Underpinning the work presented are three research questions.

• Are design rules and processes generic for whatever is being designed?
• Can a better understanding of design theory and the emotional response to designs ensure a more effective process and thus lead to stronger designs?
• Can students be educated to be better design thinkers and ultimately better designers?

It concludes that:
• ‘design’ is a process;
• design is a problem-solving process and problem-solving is a design process;
• for the most effective outcomes a creative and structured approach is required;
• this process is based on generic rules and principles which are applicable across all discipline areas;
• collaborative/cross disciplinary elements reinforce the concept that there are processes involved that are not unique to individuals or discipline specific;
• a greater understanding of the process is of benefit to all individuals and organisations;
• any design/problem solving activity will normally result in more than one solution option.

The results of the research have informed the author’s teaching practice and have been disseminated through publications to benefit the wider education arena. The work presented aims to inform students and design education practitioners.

**Key words:** design; design theory; design process; design methods; emotional aspects of design; responses to design; design education.
The University of Manchester
PhD by published work
Candidate declaration

Candidate name: Jacqueline Anne Wilson
Faculty: Engineering and Physical Sciences
Thesis title: Core Design Aspects

i. There are 12 publications presented for this PhD. The nature and extent of my own contribution and the contribution of co-authors and other collaborators to each of the publications presented is given below.

Publications 1: *Handbook of textile design; principle, process and practice*. Sole author.

Publication 2: *Creative connections*. The author was lead editor for the exhibition catalogue. She also was instigator and lead curator of the exhibition.

Publication 3: ‘Seamless knitwear – the design skills gap’ in *The Design Journal*. A co-author of this peer reviewed paper - the author’s contribution was with regard to knitwear design, design process and design education.

Publication 4: ‘Problem based learning in constructed textile design’ in the *International Journal of Art and Design Education*. Co-author of this peer reviewed paper, the author’s expertise was with regard to knitwear design, design process and design education.

Publication 5: ‘Optimising product colour’ in the *Review of Progress in Colouration*, Society of Dyers and Colourists. Co-author of this peer reviewed paper, the author’s contribution came from her experience in industry with regard to forecasting and the design process.

Publication 6: ‘Predicting the future: an overview of the colour forecasting industry’ in *The Design Journal*. The author was principal author of this peer reviewed paper.

contribution came from her experience in industry with regard to forecasting and the design process.

**Publication 8:** ‘Underpinning the design process - teaching textile design for a global market’ at the *New Silk Route: Design Education and Research Conference*. Sole author of this invited conference paper.


**Publication 10:** ‘Colour, design and emotion’, presented at *Design and Emotion Society International Conference*. Principal author and presenter of the paper.

**Paper 11:** ‘Through the wardrobe: a generic platform to foster the evolution of creative problem solving skills’ presented at *Creativity or Conformity? Building Cultures of Creativity in Higher Education* – Co-author of this conference paper; all three authors made equal contributions.

**Publication 12:** ‘The development of a module to equip students with real-world problem-solving skills’ presented at *EE2008 – the International Conference on Innovation, Good Practice and Research in Engineering Education conference*. Co-author of this peer-reviewed conference paper - all three authors made equal contributions.

ii. All the work presented has been completed whilst the candidate has been a member of staff of this University.

iii. None of the work presented has been submitted in support of a successful or pending application for any other degree or qualification of this or any other University or of any professional or learned body.

I confirm that this is a true statement ad that, subject to any comments made above, the submission is my own original work.

Signed: [Signature]

Date: 15th December 2010
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Acknowledgements

I would like to express my sincere gratitude to all those I have worked with over the years, particularly the students who have always been a source of inspiration. I would like to especially thank Anna Hiley and Aileen Collis who are always a delight to work with and whose support and enthusiasm is boundless and, of course, my family.
The author

Jacqueline Wilson graduated from the Scottish College of Textiles (now part of Heriot Watt University) in 1974 with an Honours Associateship in Textile Design. After graduation she spent ten years in industry as a practising designer in a variety of positions working with designers such as Mary Quant, Jeff Banks and Margaret Howell and for a number of companies including John Smedley and Viyella. She came to Manchester to the Department of Textiles at UMIST (now part of the School of Materials at The University of Manchester) in 1984 to teach knit design. During her 26½ years in higher education she has made significant contributions to teaching, research and the pastoral care of students. She has taught knitted, printed and woven textile design and a number of related subjects and undertaken research into design and design processes. In 1992 she was awarded an MSc by research in Textile Technology for 'A Creative CAD System for the Representation of Knitted Fabrics'. She has received commendations and awards for art and design work and in 2004 she won UMIST's annual teaching award of £20,000.

Professional status and membership of professional bodies

- FHEA; Fellow Higher Education Academy – awarded 2004
- MCSD; Member Chartered Society of Designers – awarded 1984
- CText ATI; Associateship of the Textile Institute – awarded 1979
- Member of Textile Institute Council 1984 – 1991 and local Section Committee Member 1984 - 1990

Research

Research areas cover the emotional aspects of design and drawing, repetition, the design process and design pedagogy. Current projects include research into the delivery of digital print in HE and open-ended problem-solving. Much of the research undertaken has been in collaborative research groups and since 2006 much of the author’s research has been done with two colleagues - Aileen Collis, a digital print designer and Anna Hiley, an architect who is currently a lecturer in The University of Manchester’s School of Mechanical, Aerospace and Civil Engineering. This small cross-disciplinary research group has worked closely together on a number of projects which have involved text mining as well as more traditional data-analysis research methods. A real-world problem-solving module has been developed which is now taught across the University. This module is essentially
about the process of design and aims to equip students with a framework for creative open-ended problem-solving.

**Grant applications funded**

The author has been successful in a number of grant applications (£108,376) including being a co-investigator for an EPSRC Consortium Network: *A language for emergence and design* (GR/T25521).

**Publications**

As well as writing a number of papers for refereed journals (the author has publications in a number of respected journals including two papers in the Design Journal) the author has regularly presented at national and international conferences. There have also been invitations to talk on design and the future of design at international events; at one the invitation to make a keynote presentation included a request to chair the opening session which was televised.

The author has written one book that has also been published in China and as an e-book. She has co-authored another book and two invited book chapters have been written and are due to be published in 2011.

**Professional practice**

Consultancy work has been undertaken for a number of companies and organisations including Le Coq Sportif, Lifeguard Knitwear Ltd, Powell Knitwear Ltd, The Scottish Development Agency and William Patons Ltd.

**Exhibitions and art commissions**

The author instigated and curated the exhibition *Creative Connections*. She has been invited to exhibit artwork and has also undertaken a number of commissions. Design work undertaken for Powell Knitwear was featured in a 1985 Design Council touring exhibition *Profit by Design* and an interview with the author regarding the work showcased was featured on the BBC’s Look North West.
Publications presented

This section lists the work presented for this PhD by published work.

Book

Exhibition catalogue

Refereed journal papers


Conference papers - invited

Conference paper and book chapter


Conference paper


Refereed conference paper

1. The statement - introduction

1.1 Aims
This statement gives an overall summary of the aims and achievements of the research work and scholarship carried out by the author during her time at The University of Manchester (and UMIST – now part of The University of Manchester) for which the publications presented give evidence.

Underpinning the work presented are three research questions.

• Are design rules and processes generic for whatever is being designed?
• Can a better understanding of design theory and the emotional response to designs ensure a more effective process and thus lead to stronger designs?
• Can students be educated to be better design thinkers and ultimately better designers?

The aim of the statement is to identify the ‘core aspects of design’ and the generic design process to ensure greater success for design students, design educators and professional designers alike.

The statement is divided into three parts. The first gives summaries of the publications presented with the standard of the journals and the reception of the publications as indicated by citations and reviews as appropriate. It also outlines the research methods used and the author’s contribution.

The second part reviews the current state of knowledge and research in the area of design methods and references key works in this area. It links these to the author’s work.

The final part summarises the findings from the research and scholarship with recommendations for future work.

1.2 Objectives
The driver for much of the research undertaken has been to gain a better understanding of the core aspects of design – the knowledge and skills that are really needed by designers to allow the design of better products and services.
1.3 Overview
The work presented for this PhD by published work investigates design and design methods: the activities and processes and the elements involved. A thread throughout much of the work has been the emotional aspect of design – why some designs are preferred over others, why some colour combinations are more desirable and why repetition is so important to the human psyche. Underpinning all the research presented are the questions - can design skills be improved, and can students be educated to be better design thinkers and therefore designers?

While the author’s background is in textiles and textile design, she considers herself to be first and foremost a designer and a textile designer second. With ten years spent in industry working with designers such as Mary Quant, Jeff Banks and Margaret Howell and more than 26 years in higher education teaching design and design-related topics, such as the professional practice of design and design history, and from her research into the design process the author’s experiences and research have led to the view that design rules and the process followed are essentially the same for whatever is being designed.

Design is investigated throughout much of the published work presented in this statement as something that everyone does on a daily basis either consciously or subconsciously, an activity that, to be successful, requires consideration and reflection and a knowledge, implicit or otherwise, of core design rules and guidelines.
2. Part 1 - the publications

2.1 Overview
Over 36 years in industry and education the author has a range of outputs. These include:

- commercial textile and knitwear designs;
- book chapters;
- books;
- conference papers;
- refereed journal papers;
- paintings;
- exhibitions.

The publications presented have been selected for inclusion as they provide a representative overview of the work undertaken by the author investigating design and the design process. The publications are summarised in this section along with information on the outputs including the standard of journals. The reception of the publications as indicated by citations and reviews is also given as are the research methods and author contribution. All have been published in the last 10 years.

- The book is the culmination of 36 years spent in industry and academia.
- The exhibition catalogue explores design theory and process and combines this with design practice.
- The journal papers demonstrate work that has been rigorously peer reviewed.
- The invited conference papers are evidence of international recognition.
- The refereed conference papers show recent research and scholarship developing a taught module which aims to give students a framework for a generic design/problem-solving process.

The following diagram Figure 2.1 shows how the publication themes are linked.
2.2 **Publication 1 - book**


*A handbook of textile design; principle, process and practice* (Wilson, 2001) took four years to write and is the result of the author’s 10 years industrial practice as a textile and knitwear designer, design consultant and design director, and 16 years scholarship as an academic teaching knit, print and weave and researching aspects of design and the design process.

Written in response to the lack of academic textbooks in this area it aims to provide a comprehensive overview of the role of the textile designer within the textile industry and brings together all aspects of design and the design process including design elements and principles and the great variety of activities that a textile designer can be involved in: from how to go about attracting clients, through range planning and development, to making presentations of work and passing production runs. Commercial considerations are also covered, together with trend forecasting and an overview of the factors influencing purchasing decisions. It is aimed at anyone requiring an understanding of the textile design process including buyers and merchandisers of textile products as well as students of textile design.

Woodhead Publishing is the recognised publisher for scientific and technical books in Textiles. It publishes on behalf of The Textile Institute, the world-wide organisation for textiles, clothing and footwear.
A *Handbook of textile design* is now widely recommended to textile students both nationally and internationally. Universities that have it on their reading lists include in the UK - Huddersfield and Leeds, and internationally - The Textile Institute Pakistan (TIP) in Karachi and National Institute of Technology Jalandhar in India. In September 2004 a version of the *Handbook of textile design* was published for the Chinese market (Wilson 2004). It is now also available as an e-book. Citations 4.

The research for this book was undertaken by the Author through:

- observation and practice in industry, in a variety of design positions (both as in-house designer and as a consultant);
- research via literature reviews;
- case-studies.

Literature reviews and case-studies were undertaken in the areas of:

- fashion history;
- marketing;
- design management;
- design processes and methodology;

to inform the Author’s lectures and tutorials to textile design students at Manchester.

Practical design work was undertaken in and for a number of companies including:

- John Smedley Ltd., William Hollins Ltd. (Viyella), Le Coq Sportif and Selectus.
- And with designers including: Mary Quant, Margaret Howell and Jeff Banks.

### 2.3 Publication 2 – exhibition catalogue


*Creative Connections – Art meets Science* was an exhibition which was initially curated for Manchester Science Festival 2009 and was exhibited at MOSI (Museum of Science and Industry). The exhibition illustrated how two traditionally separate cultures can find joint inspiration and innovative solutions, and how the same source material will be interpreted and developed in very different ways to produce quite distinct designs. The author, with two other textile designers and a jeweller, produced pieces of work in response to a selection of images from a Spring 2009
photography competition to encourage students in the School of Materials to promote their work and the Materials discipline in an exciting way. This exhibition demonstrated that design problems which use the same sources as a platform for solutions to be developed can provide different ‘solution options’.

The research developed from a concept from the author. This was based on:

- an interest in the design process and the variety of designs that can result from a similar source;
- and after viewing an exhibition of photographs from entries to a student School of Materials photography competition.

- Appropriate fellow researchers/participants (Aileen Collis, Vicki Wheeler and Sarah O’Hana) were identified by the Author.

- The Author and AC made initial trial designs to identify a range of suitable source photographs.

- With AC the Author planned the work schedule; managed the project; organised the printing and framing of the designs and photographs; compiled and designed the catalogue; prepared the catalogue for print; and planned the exhibition layout.

The exhibition at MOSI was well received. After the exhibition in Manchester the work from the exhibition was displayed in January at IOM3 (The Institute of Materials) offices in Grantham, Lincolnshire and in March at their headquarters in London.

2.4 Publication 3 – refereed journal paper

Seamless knitwear – the design skills gap looks at the teaching of a relatively new technology - 3D seamless knitwear manufacture. The new electronic machinery allows the creation of whole garments, garments which are knitted in one piece and require little to no make-up. The introduction of this technology impacts on the design process with a conceptual shift in the way knitted garments are both designed and created.

The study surveyed UK Higher Education Institutions, which were currently teaching knitwear design within their curricula. It discusses what was being taught at the time of writing with regard to seamless knitwear design and compares this
with the views of a number of industrialists. It offers some suggestions as to how to teach seamless concepts.

The research for publication 3 gathered both quantitative and qualitative data via:

- a literature review by the Author and the other researchers of the knit design process and new knit technologies;
- a survey of UK Higher Education Institutions in the UK through email, post and telephone as to what was taught with regard to seamless knitting technology and what should be taught. The survey was undertaken by KS and SC;
- case studies compiled by the Author, KS and SC with information gathered through email, telephone and face to face interviews with four knitwear manufacturers.

The Design Journal is a highly regarded journal in the area of design which has been rated an 'A' in the European Reference Index for the Humanities (ERIH).

Citations 1.

2.5 Publication 4 – refereed journal paper

*Problem-based learning in constructed textiles* looks at design education, and specifically how constructed textile design is taught. Staff observing undergraduate students enrolled on the BSc Hons. Textile Design and Design Management programme in the School of Materials at The University of Manchester identified difficulties with knowledge retention in the area of constructed textile design. Rather than the traditional lecture-based module as a means of learning, an experimental approach using problem-based learning for seamless knitwear design was undertaken.

The research was to see if PBL could be used to help with knowledge retention in the area of constructed textile design.
The research methodology involved:

- the observation of students and analysis of examination results had shown that students were adopting a surface rather than deep approach to learning (author, KS and SC);
- the identification of learning styles of textile design students by using learning style tests (Honey and Mumford’s ‘Learning styles Questionnaire’ and Fleming’s ‘How do I learn best’);
- the analysis of a series of tasks to see if these would be appropriate for the practical approach being studied; this was done by KS with the Author and SC;
- students working through the PBL tasks in small groups;
- groups working through the tasks were observed (Author, KS and SC);
- the analysis of feedback forms from the students to get their reactions to the learning experience (Author, KS and SC).

The paper investigates the effects of the trial on the student volunteers and documents the shift of focus from teacher to student-centred learning. This approach is now in place in a module teaching knitting and knit structures and is proving effective. The approach has also been extended to a module teaching weaving.

The International Journal of Art and Design Education in which publication 4 was published is highly regarded in the area of art and design with an SI Journal Citation Reports® Ranking: 2009: Education & Educational Research: 125 / 139 Impact Factor: 0.19. Citations 4.

Publications 5, 6 and 7 look at colour and how colour decisions are made. The emotional aspects of colour are very important with colour being a huge influence on all aspects of life, from the clothes worn and food eaten to the environment in which people work (Cooper, 1996). The final colour of a product on sale to the customer is the end result of a complex interaction of knowledge, guesswork, practical constraint, and marketing skill (Benson et al., 1999).

2.6 Publication 5 – refereed journal paper
Optimising product colour presents an overview of research efforts in the field of colour optimisation in products; highlighting advances in consumer research, colour definition and communication.

Research was undertaken via:

- a literature review looking at colour and colour psychology by the Author and LB.

It was published in *Review of Progress in Colouration* (RPC) which is an annual journal of the Society of Dyers and Colourists with specially commissioned papers critically reviewing a wide range of colouration and technology themes. Citations 4.

### 2.7 Publication 6 – refereed journal paper


*Predicting the future: an overview of the colour forecasting industry* also explores the importance of colour in design and marketing and investigates how colour trends for apparel can be forecasted. Consumers are extremely sensitive to colour when choosing apparel goods as the colour choices made have an impact on how the wearer perceives him or herself and is perceived by others. The factors that influence colour choice are considered as there are very important implications for those making colour decisions. Colours that are chosen and do not sell can have a huge financial impact, with garments not being sold and purchases missed. Getting a colour range wrong, with colours too bright or too dull, can lead to loss of sales and profit and may lead to market share being lost to competitors who have got their colours right.

The paper aims to contribute towards a greater understanding of colour decision-making by considering some of the factors that influence colour selection, by looking at the services that are available to those making decisions about colour and by analysing the processes involved. An attempt is also made to develop a strategic framework to assist in the management of colour selection.
Research was undertaken via:

- a literature review looking at colour and colour psychology by the Author and LB;
- the Author’s industrial experience of the colour selection and forecasting processes.

The Design Journal is a highly regarded journal in the area of design. The Design Journal has been rated an 'A' in the European Reference Index for the Humanities (ERIH). Citations 1.

2.8 Publication 7 – refereed journal paper

Colour is one of the most complex and difficult variables which marketers have to contend with when forecasting, planning, presenting and managing ranges of fashion goods. The art of colour forecasting aims to contribute towards a greater understanding of some of the factors that influence decisions about colour forecasting within the textile and clothing industry.

A variety of colour forecasting services are available to aid colour selection. However the earlier the colours are predicted, the more expensive the service is. In the case of a leading mail order company, how useful are these services? Do they aid colour selection or are they an unnecessary expense? What are the risks of selecting the wrong colour? These questions and many more are addressed by looking at how a leading mail order company selects their colour palette for a season.

Research was undertaken via:

- a literature review looking at colour and colour psychology by the Author and LB;
- the Author’s industrial experience of the colour selection and forecasting processes;
- interviews with staff at a mail order company by the Author and LB;
- analysis of sales and other records at the mail order company by LB.

Citations 1.
2.9  Publication 8 – invited conference paper


Underpinning the design process: teaching design for a global market looks at design and what is involved in the design process, It considers design to be something everyone does – arranging elements to give a whole that is greater than the sum of its parts – and it argues that there is a visceral response to design that is frequently shared by many. It discusses how the skills involved in design can be developed and how the learning experience for design students can be enhanced. The language of design, the elements and principles that are commonly identified are briefly discussed and a number of guidelines towards better design are proposed. It introduces research being done at the time of writing in the area of design and emotion.

The work presented was work by the Author on design and the design process.

The work was via literature reviews by the Author on:
- the emotional response to design;
- the elements and principles.

And experiments by the Author which looked at:
- reactions to drawing quality;
- repetition.

The premise that the best design is design that is functional and has a positive emotional impact is put forward by the Author.

The conference was part of a two-year British Council project involving expertise from the UK to promote creativity and design in countries in central and south east Asia including Bangladesh, Iran, Kazakhstan, Pakistan and Uzbekistan. The author’s paper was presented as part of the inaugural ceremony which was televised.
2.10 Publication 9 – invited conference paper


The paper ‘Designing for the future’ was presented at the *3rd International Conference on Advanced Fiber/Textile Materials 2005*. It looked at the reactions evoked by a design referencing Don Norman’s work on the emotional aspects of design (Norman, 2004) and the work by Kurosu and Kashmira (1995) and Tractinsky et al. (2000) on the effect attractiveness has on perceptions of usability.

The work presented was work by the Author on emotional aspects of design and usability in the design process.

The work was via literature reviews by the Author on:
- the emotional response to design;
- attractiveness and usability.

And experiments by the Author (with SC) which looked at:
- reactions to drawing quality;
- repetition.

The model illustrating the premise that the best design is design that is functional and has a positive emotional impact is by the Author.

The paper was well received and one outcome from the conference was the invitation to host a conference in Manchester in 2007. *Textile Futures - an international forum setting the agenda for higher education and research in the 21st century* was organised by the author in conjunction with North Carolina State University, USA and Shinshu, Japan.

2.11 Publication 10 – conference paper


‘Colour, design and emotion’, was a paper presented to the 3rd *Design and Emotion Society International Conference* in 2002. It looked at the elements that make up
a textile design and rules and theories for constructing designs. In particular it discussed the importance of variation in repetition and colour. The way people perceive and react to designs is discussed and what it is that impacts on perceptions.

The work presented was research on design and the design process and was via literature reviews by the Author on:

- colour;
- design rules;
- the elements and principles.

After the conference the paper was published as a chapter in *Design and emotion, the experience of everyday things* - an edited collection of papers given at the conference. Citations 15.

Publications 11 and 12 present work done by the author (with Collis and Hiley) to develop a module to help students across all disciplines acquire creative problem-solving skills.

### 2.12 Publication 11 – peer-reviewed conference paper


‘Through the wardrobe: a generic platform to foster the evolution of creative problem solving skills’ was presented to the conference *Creativity or Conformity? Building Cultures of Creativity in Higher Education*. The paper describes how a learning strategy to develop design or creative problem-solving was implemented and how evaluation of the students’ responses to the module was used to develop a generic framework, through which creative problem-solving and design skills can be fostered at undergraduate level. The initial aim was to provide engineering
students with the creative problem-solving skills they will need as future practitioners.

This project looked at the appropriateness and impact of a framework previously developed by the Author with AH and AC.

- An assessment strategy was developed which would give data that could be used for research (Author, AC and AH).
- Key words and phrases in student reflective reports were identified and analysed via a manual text-mining process (Author AC and AH).

It was found that transferable design skills can be developed. Through the reflective reports of students there was evidence that transferable design skills can be developed with students giving evidence as to how the skills they have acquired can be applied to other activities, both academic and non-academic.

The paper was well received and several requests for more information about the work presented have been and are still being received.

2.13 Publication 12 – peer-reviewed conference paper

Recognising that engineers work in multidisciplinary environments a second generation of sessions on problem-solving was developed for students from all disciplines and it is the development of this module that is described in the peer reviewed paper ‘The development of a module to equip students with real-world problem-solving skills’ which was presented to the *EE2008 – the International Conference on Innovation, Good Practice and Research in Engineering Education conference*. Delivered as a ten-credit module entitled “Real-world problem-solving” over a twelve week period the approach is process-oriented rather than task-oriented and is based on seven interactive sessions, each of which deal with an aspect of the design process. The word design was deliberately not used as many
students had perceptions of design as being something that only designers did and most would not have described themselves as designers.

The paper describes the rationale behind the further development of the real-world problem-solving module in paper 11.

The framework that had been initially developed, and was the basis of a module taught in 2008 and 2009, was developed and refined through observation of students in class and their responses in reflective reports.

The Author, AC and AH developed the presentations and practical coursework in the light of their observations and student responses.

The primary aim of the module is to provide students with the problem-solving skills they will need as future practitioners working in cross-disciplinary teams.

The paper presents the module structure and the thinking behind its development. With both individual and group coursework, a reflective report and oral and poster presentations, the module is now offered to all students across the University. In addition the content has been adapted to be delivered as a three day course for Engineering Doctoral students and as a one day course for students sponsored by the Saudi oil company Aramco.

Comments from the reviewers included “This was an interesting and innovative approach that was clearly and successfully presented.” The paper was well received at the conference.
3. **Part 2 - Contextual review**

This review covers literature on design, the design process and design activities, the emotional aspects of design and design education and links these with work by the author. While initially discussed under the separate headings of design, design elements and principles, design activities and process, emotional aspects of design and design education these areas are considered to be inextricably linked as evidenced by the references cited. The summary in part 3 attempts to pull everything together under an umbrella heading of ‘core design aspects’. 
3.1 Design

3.1.1 Defining design

Design has many different definitions and while everyone will have an understanding of what they mean by design one individual’s understanding may not always be shared by others.

Design can be a noun or a verb. It can be a plan of action or implicitly infer a process that has an element of making or creation. Jones gives a range of definitions in his book Design methods (Jones, 1981, pp.3,4) from a variety of different authors and a number of these are given below with the original reference.

- “A goal-directed problem-solving activity” (Archer, 1965).
- “Decision making, in the face of uncertainty, with high penalties for error (Asimow, 1962).
- “The optimum solution to the sum of the true needs of a particular set of circumstances” (Matchett, 1968).
- “The imaginative jump from present facts to future possibilities” (Page, 1966).
- “Relating product with situation to give satisfaction” (Gregory, 1966)
- “A creative activity – it involves bringing into being something new and useful that has not existed previously” (Reswick, 1965).


“Design:

v. to mark out; to plan, purpose, intend ...

n. a plan conceived in the mind, of something to be done ...

n. adaption of means to end …”

Oakley (1980, p.13) also says that “in practice the word is also applied to the product of ‘a plan conceived in the mind’, not only as a set of drawings or instructions, but as the ultimate outcome from manufacture.”

There are several definitions of design both as a noun and a verb given in The Oxford dictionary online (accessed 18 October 2010) and these are as follows.

As a noun definitions include:

“a plan or drawing produced to show the look and function or workings of a building, garment, or other object before it is made”;

“the art or action of conceiving of and producing a plan or drawing of something before it is made”;

“the arrangement of the features of an artefact, as produced from following a plan or drawing”;

“a decorative pattern”;
“purpose or planning that exists behind an action, fact, or object”.

As a verb [with object] definitions include:

“decide upon the look and functioning of (a building, garment, or other object), by making a detailed drawing of it”;
“do or plan (something) with a specific purpose in mind”.

The Oxford dictionary online gives the origin of the word design as being late Middle English “(as a verb in the sense 'to designate'): from Latin designare 'to designate', reinforced by French désigner. The noun is via French from Italian.”

Pipes (2003, p.9) in his book *Foundations of art and design* considers the roots of the word design to be found in the Italian word ‘disegnare’, to create. In its broadest sense Pipes considers design to be about “preparing for action: planning and organising” (Pipes, 2003, p.9).

In the *Handbook of textile design* (publication 1 presented for this PhD) the author considers one definition of design to be “relating and visually arranging components or elements to create effects” (Wilson, 2001, p32). Malcolm (1972, p.7) talks about “visual unity” and about shapes, forms, colours and textures combing to become “a unified whole which is commonly called ‘a design’ ” (Malcolm, 1972, p.7).

A more accurate definition may be created by adding to the author’s definition above “in response to a problem”; so a more accurate definition of design as an activity may be: relating and visually arranging components or elements to create effects in response to a problem. And for design as a noun an effective definition may be that a design is something which, in response to a problem, is created to address the issues by relating and arranging components or elements. However as Buchanan (1992) says “no single definition of design … adequately covers the diversity of ideas and methods gathered together under the label.”

### 3.1.2 What design is

For the work covered in this statement design is considered to apply both to a service as well as a product. As such, where applicable, when product is referred to a service is also implied.

The author in a *Handbook of textile design* (Wilson, 2001, p.20) talks about design being:

- an investigative process – one that involves research;
- a creative process - one that involves innovation and research;
• a rational process – one that involves logical reasoning, evaluation and testing;
• a decision-making process – one that involves value judgements.

3.1.3 The design process at its simplest
In a *Handbook of Textile Design* the author gives the design process at its simplest in Figure 3.1. A developed process is given in the summary as Figure 3.9.

![Diagram of the design process at its simplest](The Author)

3.1.4 Design as the management of constraints
Dino Dini is a computer game designer and musician who teaches design and who has presented at many conferences. He has said that if you ask a roomful of designers for a definition of design you will get as many answers as there are designers in the room (Dini, 2009). He talks about the activity of designing being about negotiable and non-negotiable constraints. He suggests that at the start of any design exercise there are infinite possibilities and all are negotiable. At the start of any design project the time available for the project, the budget and the product requirements are all negotiable. As key decisions are made these become non-negotiable constraints. The timescale and the available budget will normally become non-negotiable first. As the designer goes through the process of designing with every decision he or she makes come non-negotiable constraints. Dini talks about designers using these constraints to design. He also talks about the ultimate quality of a design being directly attributable to the quality of the constraints and that for a design to be more likely to succeed it must have integrity (Dini, 2009).
Dini considers design (as a product) to be "a collection of decisions that creates a set of constraints which give a concept [something which is to be made or achieved] its identity" (Dini, 2009). He defines 'concept identity' as "the true nature of a concept which may, or may not, match the intention of its designer".

Dini defines 'constraint' as "a rule that reduces the possible outcomes of the concept and contributes to its identity"; a 'non-negotiable constraint' to be "a constraint which, if broken, would cause a significant change to the identity of a design"; and a 'negotiable constraint' to be "a constraint which may be applied or not depending on circumstances, but which is not crucial to the identity of the concept". He considers rules and integrity to be very important in designing as these combine to give products a strong identity: something which he considers the most successful designs to have (Dini, 2009).

In a presentation to the Game Developers Conference in Cologne in 2009 Dini showed an example of how a design loses integrity. Taking straight lines he added line after line until he had a pattern as shown in the left-hand image of Figure 3.2. He then removed one line which changed the pattern – now, in the middle image, the lines no longer only make triangles. Back to the original and this time Dini moved a line down to give the right-hand image in Figure 3.2. This significantly changes the pattern. Dini considers it now to be visually jarring having completely lost its identity and thus its integrity.

Dini says that integrity is about how well something maintains its identity that is how it maintains its form. He considers successful designs to always have integrity and that a lack of integrity results in a loss of identity and that in turn leads to an unsuccessful design.
3.1.5 What design involves

The management of constraints as described by Dini involves knowledge, research, planning, problem-solving, creativity, decision-making reflection, context and risk-taking. If design is considered to be the management of constraints then design involves: knowledge; research; planning; problem-solving; creativity; decision-making; constraints; context; reflection; risk-taking (Figure 3.3).

![Diagram of design process]

Figure 3.3 What design involves
(The Author)

Different design problems will require different levels or aspects of the above. Design in different disciplines will require specialist discipline-specific skills and design can be incremental, building on previous designs, or it can be highly innovative – completely new and different to what has gone before.

3.1.6 Different types of design

There are many different adjectives appended to the word design. The following are all terms that are used and all have subtly different meanings – or do they? Many of the adjectives used are interchangeable, describing the same ideals.

Co-design

Co-design attempts to deal with the different ideals and perspectives that individuals have. The stakeholders work together to determine the best outcome. The journal CoDesign, the International Journal of CoCreation in Design and the Arts, considers it to be “inclusive, encompassing collaborative, co-operative, concurrent, human-centred, participatory, socio-technical and community design” (Taylor and Francis, accessed 5 December 2010).
Participatory design (originally known as co-operative design)
This is considered to be design that attempts to involve all stakeholders in the process of design to help make sure that whatever is designed (a product or service) meets the needs of the stakeholders and is usable. Essentially it is co-design by another name (Schuler and Namioka, 1993).

Inclusive design
Inclusive Design is “a general approach to designing in which designers ensure that their products and services address the needs of the widest possible audience, irrespective of age or ability” (The Design Council, 2010).

Universal design (also known as Design for All or DfA)
This is about producing designs for products and services which meet the needs of and are accessible by both the able-bodied and the physically disabled (Herwig, 2008). Essentially it is the same as inclusive design.

Affective design
Affective design considers the emotional relationships between consumers and products and explores the affective properties that products communicate through their physical attributes. Consideration of such emotional aspects aims to help the designer produce products and services that users connect to on an emotional level; products and services that elicit the maximum pleasure (Surhone et al. 2010).

Kansei design
Kansei design is a design approach rooted in Japanese culture and developed from Kansei Engineering (Lévy et al., 2007; Lee et al., 2002) that is “first and foremost a product development methodology, which translates customer’s impressions, feelings and demands on existing products or concepts to design solutions and concrete design parameters” (Schütte, 2005).

User-centred design
User-centred design (UCD) is an approach to design that “grounds the process in information about the people who will use the product. UCD processes focus on users through the planning, design and development of a product” (Usability Professionals’ Association, 2010). ISO 9241-210:2010 is an international standard which gives guidance on the process of user-centred design. User-centred design is a multi-stage problem-solving process where, as well as designers analysing and
predicting how users are likely to use a product or service, they test their assumptions in real world tests with actual users.

**Human-centred design**
This is essentially another name for user-centred design as is interaction design.

**Interaction design**
Derived from Human Factors Design for computers "Interaction design is a user-interface design methodology that was first proposed by Bill Moggridge and fully developed by Alan Cooper. The interaction design focus is on the end users to drive user-interface design" (Fioretti and Carbone, 2007).

Fioretti and Carbone go on to suggest that interaction design is design from the perspective of understanding "how and why people desire to use products." They talk about it being based on "creating personas" which are the "archetypal users of products with their goals, backgrounds, and mental models"; "describing scenarios the personas will be involved in"; and creating "storyboards of the product interface derived from persona scenarios and mental models, which then drive the rest of the product design" (2007). Designers and marketers have been using similar strategies since the late 70s with consumer, lifestyle and mood boards all being an important part of the marketing and design processes.

Verplank (2009) in his on-line *Interactive design sketchbook* considers that “the central concern [of interaction design] is how to design for people – for their physical and emotional needs and increasingly for their intellect” and that “successful interaction design involves balancing a variety of concerns using a variety of methods or representations.”

### 3.1.7 Good design
From the definitions and descriptions given if design is about fulfilling needs and requirements then good design must be design that fulfils these needs and requirements well. To fulfil these well in addition to considering people’s physical requirements, there must also be consideration of their emotional needs.

Perceptions of design involve responses in terms of functionality and usability and in terms of emotional response – visceral (gut reaction) and reflective (more considered feelings after experiencing a product) (Norman, 1998). While people will usually know what they like, they will often find it difficult to articulate why. In
many areas of design where aesthetics are more important, such as surface pattern design, once basic function is satisfied responses are considered to be subjective with little objectivity involved. What is considered good design might be expected to mean different things to different people however, from observing people’s reactions, it is quite clear that responses are not merely subjective. Frequently there is consensus in what is considered to be good and the author argues in publications 8, 9 and 10 that work that has universal appeal to a group will often follow one or more of the many rules and theories as to how best designs should be created; it will demonstrate good use of design elements and principles.
3.2 Design elements and principles

3.2.1 The elements and principles
What might be termed as design elements and principles are frequently referred to in discussions about design. Different people may categorise and refer to these in different ways but essentially they are talking about the same things.

Alan Pipes in his book *Foundations of art and design* (2003) gives the elements as: points and lines; shape; texture; space; time and motion; value; and colour and the rules as: unity and harmony; balance; scale and proportion; contrast and emphasis; and rhythm, while William Justema talks about creating patterns under the four headings of line, shape, texture and colour (Justema, 1982). In their book *The elements of design* Oei and Kegel (2002) talk about elements under the headings: colours; textures; dots; dot and line; lines; crossing; planes; and circles. Malcolm (1972) arranges the elements and principles slightly differently yet again in her book *Design: elements and principles* with the elements as: space, line, shape, form, colour, value and texture and the principles as: balance, movement, repetition, emphasis, contrast and unity.

Bringing all these together in a *Handbook of textile design* (publication 1) the author (Wilson, 2001, pp. 32-43) classed the elements as Malcolm (1972), but reordered the list with space coming after line, shape and form as it is essentially something that "flows in, around and between forms and shapes" (Wilson, 2001, p.34). The author considered the principles to be what was done with the elements to create an art form or design.

3.2.2 Design principles
In every design there are some or all of the design elements - varieties of line, positive and negative shape, three-dimensional form, occupied and unoccupied space, colour, value and texture. The way in which these elements are used and combined determine the quality of a design. The author in publication 1 gives the design principles as balance, movement, repetition, emphasis/contrast and unity (Wilson 2001, p.37); by thoughtfully balancing, moving repeating, emphasising and contrasting the design elements a sense of unity can be achieved. Unity exists when all the elements in a design work together harmoniously. In a unified design each element plays an important part.
Mark Getlein (2008) suggests the principles of design are "almost instinctive", "built-in", "natural", and part of "our sense of rightness".

### 3.2.3 Design rules

In publications 8 and 10 the author considers the importance of design rules with a series of key design rules being outlined in publication 8. These design rules are considered an important aspect of a designer's toolkit and while Getlein (Geitlein, 2008) may well be right in his view that these are almost instinctive the author believes that professional designers should have some understanding of these. In publication 8 which was presented to the *New Silk Route: Design Education and Research Conference* the author argues that designers need to know about the basic rules and theories as to how designs are constructed. She says,

> To play jazz piano successfully in a jam session usually requires the player to have learnt music notation, scales and harmonies before they can break these rules. So it is with colour and design, to break the rules and have success there has first to be an understanding of these.” (Wilson, 2007)

### 3.2.4 Repetition

Repeating pattern is an important aspect of much design work. Repetition is something done with the design elements and there are many different types of repeat structures. The importance of variation in repetition is considered in publication 10.

> Repetition occurs when elements which have something in common are repeated regularly or irregularly, sometimes creating a rhythm. Rhythm is a vital part of our universe and is represented in the movement of the heavenly bodies, the seasonal changes, the motion of ocean waves and even by the heartbeat. (Malcolm, 1972)

The author considers that humans are comfortable with the familiar - repetition is important, but there seems to be a need for visual imperfection too. When a design consists of shapes that are exactly alike, repeated in a uniform and regular manner, then that design tends to become very rigid and formal. By varying the shapes and the spaces between them more interest is created that seems to have a greater appeal. Hand-crafting, or at least the appearance of hand-crafting, seems to be important to the human psyche - patterns that repeat are comfortable, but if they are too exact they can feel overly formal, clinical or cold.
Figure 3.4 shows two patterns of repeated leaf silhouettes. The left one is the same leaf repeated while the right one consists of two different leaves.

William Justema (1968) analyses pattern and the appeal of pattern. In his book *The Pleasures of Pattern* he states,

> Although repetition is what makes a pattern, variation is what makes it rewarding to look at ... Variation is that principle of design that relieves the ... mechanical regularity of a pattern. (Justema, 1968)

In many publications that look at the design elements it is stated that repetition with variation is interesting while repetition without variation can become monotonous. There does not however appear to be any empirical evidence for this. And there is no indication as to just how much variation is required for optimum effect.

With the aid of a small grant from the Arts and Humanities Research Council an initial empirical study by the author explores the emotional aspects of repeating pattern with regard to variation. The objectives were to bring about a better understanding of repetition in artwork and design and the emotional responses to repeated elements in terms of numbers and the level of formality/variation. Responses to a variety of repeated themes and elements were elicited from a wide range of observers by means of questionnaires. The results of this study were presented in a paper at the 2006 Seoul Costume Culture Association and Ars Textrina Joint International Conference and these are presented in Appendix I.
3.2.5 **Elements and principles as part of the design process**

While consideration and an understanding of the design elements and principles are crucial for designers there are many more activities involved in the design process as identified in the author’s Handbook of Textile Design - from how to go about attracting clients, through range planning and development and fashion forecasting to making presentations of work and passing production runs (Wilson, 2001 pp. 19).

Figure 3.5  Lots of variation
(The Author)
### 3.3 Design activities and process

#### 3.3.1 Design activities
Using the definitions given previously the creation of a design will involve a number of different activities. These activities will change to a degree given the nature of the design work being undertaken and while not all designers will be involved in all of them, all designers will be involved in some of them. The processes by which these activities result in a new product or service will also vary according to the nature of the design work being undertaken. The activities that a textile designer can be involved in are given by the author in publication 1 and outlined on page 40 (Wilson, 2001 pp.19).

#### 3.3.2 Design methods research
The methods used for design undertakings first became a focus for research in the 1950s when the importance of problem-definition in any design exercise was recognised. It was increasingly realised that the bigger and more complex ‘wicked’ problems that were being faced by society in the period just after the Second World War could no longer be solved by individuals but rather required inter-disciplinary teams using a more systematic and rational approach to design. Significant publications in this area of design methodology are those by Archer (1965), Jones (1970) and Cross (1975). Simon also took the view that design methodology was primarily about problem-solving (Simon, 1996).

#### 3.3.3 A common process
In Lawson’s book *How designers think: the design process demystified* (2005, p4) he considers what at first appear to be two quite different types of designer; the structural engineer whose process is frequently precise, measured and systematic and the fashion designer whose process appears to be more imaginative, unpredictable and spontaneous. Lawson however argues that good engineering design also requires imagination as well as precision and its outcome can be unpredictable while good fashion design also requires technical skills and knowledge as well as imagination and flair. The reason that there are perceptions that the process is different for different disciplines is because although each process is based on a generic framework there is a ‘layer’ of discipline specific considerations, activities and terminology.
3.3.4 The main activities
In any consideration of the design process the main activities are generally agreed to be requirements capture, research, design development, design realisation and evaluation although these may, in different disciplines be given different terms. These are frequently shown as being part of a fairly linear process and Figure 3.6 shows this very simply with the provision for all elements to feed backwards to any stage in the process as well as forwards.

![Diagram of design activities]

**Figure 3.6** The main activities in design
(The Author)

**Requirements capture** – this usually takes place at a briefing where the designer gets information about what it is that is required. The outcome from a briefing meeting should be that the designer has sufficient information to proceed. The requirements can be sub divided into business, user and functional requirements.

**Business requirements** – these are what is required in terms of fulfilling the business plan.

**User requirements** – these are what is required of the product or service being designed by the persons who will be using the product or service.

**Functional requirements** – these are what the product or service is required to do.
Research – this is where the designer gathers the information they need to design a product or service to meet the requirements identified at the briefing meeting.

Design development – this is where initial design ideas are developed and considered and then adapted, further developed or shelved as considered appropriate. A design may be developed from a new and original idea or it may be incremental – a further development of an existing design.

Design realisation – where an appropriately developed design goes into production or a service is launched.

Evaluation – evaluation should be taking place at all stages of any design process; this may involve testing and trialling; it is not only undertaken by the designer but will also be undertaken by the end-user.

Lawson discusses several such maps of the design process (Lawson, 2005, pp. 33-39) but cautions that as much design work is done inside the designer’s head it is necessary to gather hard evidence rather than just using logical thought to give maps of the design process.

3.3.5 Individual processes
McDonagh-Philp and Lebbon (2000) suggest that practicing designers do not usually have a formal model for their design process, rather individual designers will put together a process that suits them and meets the requirements of a design brief.

In his later book How designers think Lawson (2005) again recognises the generic nature of design but acknowledges that there are different specific skill requirements for different types of design.

It is more likely that design involves some skills that are so generic that we could reasonably say they apply to all forms of design practice, but it also seems likely that some skills are quite specific to certain types of design. (Lawson, 2005, pp.33).

3.3.6 Something everyone does
In publications 11 and 12 the author, along with her fellow researchers considers design to be something everyone does. Lawson (2005, p.5) and Dini (2010) both also regard design as an everyday activity, something that everyone does. This reinforces the idea that design may be considered overall to be a problem-solving
activity. If it is, as with most problem-solving activities, there is no one definitive right answer. Instead the design, or problem-solving activity could result in a number of ‘solutions’ or ‘solution options’, some of which may be better than others.

3.3.7 A common problem
It is the author’s belief that the process involved in design or problem-solving is frequently not given the full deliberation deserved, rather most people, on being given a problem or brief, will often jump to suggesting solutions before all the factors concerned (including context and constraints, and testing and evaluation) are fully considered.

3.3.8 A creative problem-solving model
The creative problem-solving/design process diagram that the author has developed along with Collis and Hiley is given in Figure 3.7 below.

![Figure 3.7 The creative problem-solving process](Collis, Hiley and Wilson)

The process is shown within a context and time frame with a deadline where solution options are required. The process starts with a trigger; this may be a problem, need or want. There is a problem-definition stage which comes out of consideration of requirements, criteria and constraints which, in turn, are identified by questioning, consulting and discussing. Decisions are made throughout the process to develop ideas. Here iteration is often an important aspect. Ongoing
evaluation of the decisions made and ideas is crucial as is reflection. Donald Schön (1983) described the design process as a reflective conversation. He considered that the implicit knowledge that was vital for professions such as design could only be achieved from experience and that this required reflection. Alongside all these aspects project planning is necessary to keep the whole process on track.

This creative problem-solving/design model is presented in a way that aims to show the process is frequently not straightforward and could even be termed ‘messy’. As already stated McDonagh-Philp and Lebon (2000) suggest that practicing designers will put together a process that suits them and this process will often change depending on the requirements of the design brief being worked on. They suggest that most designers do not follow a formal design process. However whatever the actual process a designer might follow they will more than likely undertake the main activities as given in Figure 3.6.
3.4 Emotional aspects of design

3.4.1 Responses to artwork and designs

Publication 10 (Wilson and Challis, 2002) considers the emotional response to artwork and design which, while extremely difficult to articulate, is very often shared. It also considers the relationship between colours and emotion.

There is considerable interest in and growing recognition of the emotional domain in product development. The relationship between the user and the product is paramount in industry, which has led to major research investments in this area. Traditional ergonomic approaches to design have concentrated on the user's physical and cognitive abilities. However, new approaches also take into consideration the user's emotional relationship with their belongings. (Wilson and Challis, 2002)

McDonagh-Philp and Lebbon (2000) talk about products not just performing tasks but also satisfying aspirations, cultural, social and emotional needs. They believe it is therefore very important for designers to empathise with their users, that their designs create appropriate emotional relationships.

Design has always stirred the emotions however it is only fairly recently that the emotional aspects or 'affective' design as it is now frequently termed has become the subject of rigorous academic research (Helander and Tham, 2003).

In the introduction to the book Design and emotion: the experience of everyday things McDonagh (2002) says “We can no longer ignore the important role that emotions play in the generation, development, production, purchase and final use of products that we surround ourselves with.” The emotional response to products and services is now being recognised as a key driver in choice of products and services. As such it is hugely important to designers and manufacturers alike. Since 2000 work published on the emotional response to design includes Jordan’s book Designing pleasurable products (2000) and Norman’s book Emotional design (2004). Jordan explains how good design can appeal to the user holistically, leading to products that are a joy to own and use, while Norman talks of three levels of response to a design - visceral, behavioural and reflective.

Demerbilok and Sener (2003) state, in their paper on product design, semiotics and emotional response, that intentionally or otherwise “all manufactured products make a statement through shape, form, colour, texture etc.” They say that however designers might use the design elements of colour, shape, form and texture the products they design will send out messages, informing users and observers about them and the people they belong to. Products will give signals as
to how they work or should be handled, express their values and qualities, elicit specific reactions and identify themselves with other products.

Publication 2, the catalogue to the Creative connections exhibition, demonstrates how different designers will respond very differently to the same source of inspiration. The messages the final designs send out are indeed very different.

### 3.4.2 The importance of sensory appeal

It is generally agreed that it is becoming more difficult to give added value to products in an increasingly competitive marketplace where it is becoming more and more difficult to distinguish products on the basis of price, quality and technology (Postrel, 2004; Maclachlan et al., 2009). Postrel (2004) in her book The substance of style: how the rise of aesthetic value is remaking commerce, culture, & consciousness talks about the importance of sensory appeal becoming more prominent in western culture. She argues that sensory pleasure and meaning are fundamental to humans and that styling of products has become an accepted unique selling point (USP). While functionality still matters Postrel says that in a crowded marketplace it is aesthetics and a product’s appeal to fundamental human emotions make a product stand out. Machlachlan et al. (2009) advocate designing products that that consumers will want to take care of, cherish and repair rather than products that will be disposed of after a relatively short time and replaced. Norman (2004) says that products can be more than the sum of the functions they perform and that their real value can be in fulfilling people’s emotional needs.

The author in a keynote presentation to the New Silk Route: Design Education and Research Conference in Karachi (Wilson, 2007) argues that there is frequently a collective emotional response to designs.

> Perceptions of design involve an emotional response. Although people know what they like, they often find it difficult to articulate why. The response to aesthetic design is often considered subjective with little objectivity involved. However, from observing people's reactions [to artwork and designs] it is quite clear that responses are not purely subjective. Work that has universal appeal to the group will often follow one or more of the many rules and theories as to how designs should best be created; it can be considered to demonstrate good use of design elements and principles. (Wilson, 2007)

Since 1990 there has been a shift towards products that enhance ‘quality of life’ (McDonagh-Philp and Lebbon, 2000).
### 3.4.3 Attractive things work better

Publications 8, 9 and 10 explore the premise that attractive things work better. While it is perhaps no surprise that objects and products that look good are preferred over ones that do not, research has shown that attractive things really are perceived to work better. Early in the 1990s two Japanese researchers Masaiki Kurosu and Kaori Kashimura (1995) carried out research which involved users experiencing differing layouts for the controls of cash machines or ATMs (automated teller machines). All versions of the ATMs in the study were identical in terms of function, the number of buttons and how they operated but, while some were designed to look attractive, others were deliberately designed to look ugly and unattractive. The findings were that the users considered the attractively designed ATMs to have better functionality. Kurosu and Kashimura concluded that attractive things really did work better.

Tractinsky (2005), an Israeli scientist, was very sceptical of the findings of Kurosu and Kashimura. He felt that aesthetic preferences were culturally dependent and that while the Japanese with their strong aesthetic traditions may prefer to use attractive ATMs it was unlikely that the practically minded Israelis would react the same way. Using the same ATM layouts as Kurosu and Kashimura had used, Tractinsky designed a new experiment with rigorous methodological controls. To his surprise the results from the original Japanese experiments were replicated.

The research by both Kurosu and Kashimura, and Tractinsky proved that if something looks wrong it will not be considered to work well and that conversely, if something looks good it will be perceived to work well.
3.5 Design education

3.5.1 Can good design be taught?
If design involves knowledge, research, planning, context, creativity, risk-taking, problem-solving, constraints, reflection, decision-making as identified in Figure 3.3 then these aspects are what must be encouraged and developed. As Badke-Schaub et al. (2005) say if it is accepted that designing is not a purely intuitive artistic activity but rather one that can be taught then a certain body of knowledge is required for the education of designers. This knowledge should give them the skills they need to support them in their daily work activities.

Badke-Schaub et al. argue that although “different disciplines propose different approaches to designing for optimum results” there are similarities related to two issues. They go on to give these two issues as “general strategies, heuristics and operations” and “a basic underlying structure”. The first could be said to be ‘general rules’ such as those given by Descartes in his famous work Rules for the direction of the mind which was written in 1628 and published in 1701. An example is Rule VIII “If we are to understand a problem perfectly, we must free it from any superfluous conceptions, reduce it to the simplest terms, and by a process of enumeration, split it up into the smallest possible parts.” (Joachim, 1997). The second issue referred to by Badke-Schaub et al. is about the process. They say that there are various models which refer to structures for the design process and that the underlying structure of many of these could be referred to as “the principles of the general problem-solving theory”. For this they cite Dörner (1972 and 1996). From the work of Badke-Schaub et al. two areas that require to be taught are rules and process.

3.5.2 The beginnings of modern-day design education
Design education is generally considered to be a relatively new phenomenon (Lawson, 2005) however the UK has had formal education in both art and design since 1937 (Bird, 2000) due to work by people such as Benjamin Haydon. Haydon was a Manchester teacher and member of a Government Select Committee of 1935 which looked at increasing the wealth of the nation through fine art and design.

The Bauhaus in Germany is considered to be the institution which first brought together the teaching of arts and crafts as we now know it. It operated from 1919 until 1933 and was the inspiration for many of the design programmes that started in the UK in the 1950s and 1960s. The Bauhaus strove for rationality and
functionality in design with form following, and flowing from, function. In the 60s and 70s higher education was something that was only accessible to a very small percentage of school leavers and the number of students studying on these new art and design programmes was much smaller than the number that go on to study art and design today – only a few thousand compared to more than 52,000 in 2009 (UCAS, 2010).

3.5.3 Deciding what to teach
It is now commonly accepted that designers require formal instruction and periods of academic study that take place in an academic institution (Lawson, 2005 p.6).

The Quality Assurance Agency for Higher Education (QAA, 2002) now sets subject benchmarking statements to “provide a means for the academic community to describe the nature and characteristics of programmes in a specific subject”. However while subject benchmark statements provide “general guidance for articulating the learning outcomes associated with the programme” these are “not a specification of a detailed curriculum in the subject”. (QAA, 2002)

What needs to be studied on a Textile Design programme has been an area of special interest for the author. Papers in 1997 by the author on teaching textile design to the ELIA Changing needs seminar in Manchester and a European Academy of Design international conference in Stockholm presented research into what was taught in programmes across the UK. Five areas were identified.

1. Drawing/practical design work (such as life drawing, observational drawing, design projects etc.).
2. Textile technology (such as textile materials, textile processes, fabric structures etc.).
3. General business management (such as accounting, costing, economics, marketing, retailing etc.).
4. Design-related studies (such as professional practice of design, commercial aspects, history of fashion, history of design etc.).
5. Other (includes complementary studies, popular culture, research methodology etc.).

While this research was undertaken several years ago, looking at current textile design programme content (via an internet search) it is evident that what is taught for the most part is still essentially knowledge and practical skills.
3.5.4 Teaching design elements and principles

In the author’s experience there is little formal teaching of design elements and principles and design rules and she considers this to be an oversight. A scholarly approach to design is frequently missing in design course curricula and this view is echoed by Kimberley Elam, Chair of the Graphic and Interactive Communication Department at Ringling College of Art and Design in her foreword to the revised edition of *Universal Principles of Design* (Lidwell et al, 2010). As has already been stated in publication 8 the author considers that to be able to use colour and the other design elements successfully there has to be an understanding of the basic rules which underpin most design work. And while Mark Getlein (2008) suggests the principles of design are almost instinctive this cannot be relied upon. Elam in *Universal Principles of Design* (Lidwell et al, 2010) considers the principles of design “brings the designer to an understanding of the intuitive”. Leaving design to instinct is to fail students by not empowering them to develop and hone skills in designing.

Hann and Thomas (2007) also consider the teaching of design rules to be crucial in any design education. In a paper entitled *Towards a design syllabus for the twenty-first century* (Hann and Thomas, 2007) they advocate teaching an understanding of more fundamental theoretical issues. They state “geometric concepts and principles are of importance to the success of all two- and three-dimensional design and should thus form an important element of the curriculum in all design courses”.

3.5.5 Teaching design activities and process

The process of design is not something that is always studied as a subject itself. McDonagh-Philp and Lebbon (2000) consider that for the most part design students are taught to follow a generic process which provides a framework, and, that this framework is enhanced through the activity of designing and their experiences. However Lawson (2005) feels that students pay too much attention to the end-product and that they “fail to reflect sufficiently on the process”. The author’s experience is that students frequently make ill-informed assumptions throughout the problem-solving process and that they need encouragement (and time) to think and reflect more. Reflection (or hindsight) is now considered to be a very important part of the learning process with students in many institutions being encouraged to keep reflective diaries or logs. Schön (1983) felt that what he termed as ‘reflection in action’ could be taught. Lawson considers that a full understanding of the process helps designers relate to all the stake-holders and this in turn will inevitably lead to more satisfactory designs.
Publications 3 and 4 look at how some areas of textile design can best be taught by a more student–centred learning approach. Enquiry and problem-based learning strategies are used to allow students to develop their knowledge and processes with an emphasis on reflection.

3.5.6 Teaching problem-solving

With design being considered to be essentially about problem-solving (Archer, 1965; Jones, 1970; Cross, 1975; Simon, 1996) there is a need to teach students problem-solving skills. The author’s experience in both industry and in higher education along with that of Collis and Hiley also indicates that there is a need to make undergraduates aware that all individuals have the potential to develop creative problem-solving (design) skills. The belief of the author and her colleagues is that the acquisition of such skills can enhance all their learning. However with much of education strategy often wholly focused on acquiring and assessing explicit knowledge the result can often be individuals wary of and unable to cope with open-ended problem scenarios. To achieve their full potential individuals need guidance in developing problem-solving and creative design skills. The author, along with Collis and Hiley, considers everyone to have these skills but that these so often are not developed. The module described in publications 11 and 12 has been developed to enhance students’ problem-solving skills. It comprises of interactive sessions covering: context; problem-definition; function and form; decision-making and evaluation; reflection (Figure 3.8).

![Figure 3.8 Aspects of real-world problem-solving](The Author)
There are strong similarities between this and Figure 3.6 which shows the main activities in design. These similarities are expanded upon later and illustrated in Figure 3.10.

3.5.7 Teaching emotional aspects
As has been already discussed products are not just about function but also about satisfying “aspirations, [and] cultural, social and emotional needs” (McDonagh-Philp and Lebbon, 2000). In their paper ‘Emotional domain in product design’ in the Design Journal, McDonagh-Philp and Lebbon (2000) discuss the importance of teaching the emotional aspects of design. Maclachlan et al. (2009) also discuss the importance of introducing students to the area of emotional design in a paper presented to the 17th International Conference on Engineering Design.

To create positive emotional relationships between users and designed product it is considered very important for designers to empathise with their users (McDonagh-Philp and Lebbon, 2000). However as Lawson (2000, pp 85-86) says “A great deal of design today is commissioned by clients who are not themselves the users”.

Too often the client in any design exercise is not the person who will experience the design. Architects design for the commissioning organisations rather than the people who will use the building and on the high street it is buyers who decide on the product designs to be offered for sale, not the ultimate users. Lawson says that communication between designers and users is frequently indirect and he talks about organisational politics creating barriers and filtering communications (Lawson, 2005, pp. 85-86). For a design to be successful however designers need to take the users into account. In an article (RIBA, 2010) about one of the buildings shortlisted for the 2010 Stirling prize, Clapham Manor Primary School, it was noted that the architects worked closely with building users.

Overall the project provides an extremely inventive and uplifting example of what the next generation of school buildings could be, it avoids generic solutions and looks to use the very best contemporary thinking about what makes a good education environment. It is also clearly a result of a positive collaboration between the architects, their teams and a strong headmaster with a very clear educational vision. (RIBA, 2010)
3.5.8 What is required from design education

Educating designers in academic institutions is very time-dependent. Most design programmes in England are either two years (BTEc and Foundation) or 3 years (BA and BSc). In such limited time frames just how to cover all that future designers need to know is impossible and however well knowledge and skills are covered a designer will learn more in their first year of working than in any year in education. What should however be possible is to equip students with core basic design skills that will form a framework for future practice.
3.6 Summary and areas for further work

3.6.1 Core design aspects
The research has been about exploring the design process, the activities and issues, and elements involved – from both an industry and education point of view. The main findings from the work presented in this PhD by published work and other work by the author (see appendix II) are summarised in the list below and the author presents these as core aspects of design.

- ‘Design’ is a process.
- Design is a problem-solving process and problem-solving is a design process.
- For the most effective outcomes a creative and structured approach is required.
- This design/problem-solving process is based on generic rules and principles which are applicable across all discipline areas.
- The collaborative/cross disciplinary elements reinforce the concept that there are processes involved that are not unique to individuals or discipline specific.
- A greater understanding of the process is of benefit to all individuals and organisations.
- Any design/problem solving activity will normally result in more than one solution option.

These core design aspects highlight key generic knowledge and skills that designers need to consider to be able to design effectively.

- Designers need to understand what design is, and the factors and issues that affect it.
- Designers need to have an understanding of design theory; they should know about design elements and principles, and design rules.
- Designers need to understand the activities involved in the design process.
- Designers need to be aware of and consider the emotional aspects of design.

The results of the research have informed the author’s teaching practice. These have been and will continue to be disseminated through publications to benefit the wider education arena.
3.6.2 What design is
There are many definitions of design but design can be considered to be in essence a problem-solving process (Archer, 1965; Jones, 1970; Cross, 1975; Simon, 1996). Jones (1970) gives what he regarded as the ‘ultimate definition’ of design as “to initiate change in man-made things”.

3.6.3 Design theory - elements and principles, and rules
The key design elements are line, shape, form, space, colour, value and texture (Wilson, 2001, pp. 32-36). The principles are balance, movement, repetition, emphasis/contrast and unity (Wilson 2001, p37). The design elements are used according to these principles. The key design rules are outlined in publication 8. Understanding of such design rules is key for improving design understanding.

3.6.4 Design activities and the design process
Designers need to have an understanding of the design process. The design process at its simplest is given in Figure 3.1. This and the main activities of design as identified in Figure 3.6 have been combined into a developed model of the design process. This is shown in Figure 3.9. The model now has evaluation shown as a stage (stages) and has combined need with requirement and design realisation with finished design. Reflection is also now shown an ongoing aspect of the process.

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Figure 3.9 A developed design-process model (The Author)
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The creative problem-solving process which has already been explained and shown on page 39 as Figure 3.7 is reproduced again on the next page. This essentially shows the same process as in Figure 3.9 but in more detail with the addition of context and time. The model of the creative problem-solving process in Figure 3.7 is considered to be a better representation of the design process as it is less linear and more clearly allows for different paths through the process.

Figure 3.7 The creative problem-solving process (Collis, Hiley and Wilson)

Figure 3.3 which illustrates what design involves and Figure 3.8 which shows aspects of real-world problem-solving can also be brought together and Figure 3.11 shows these combined. This again gives evidence to support the argument that design and problem-solving can be considered one and the same and highlights the aspects of design/creative problem-solving that designers need to consider.
3.6.5 Emotional aspects

Research has shown the importance of how products are perceived and that users react to products on an emotional level (Jordan, 2000 and Norman, 2004). In publication 8 the author turns the premise that attractive things are perceived to work better round and poses the research question: if something works really well, is it perceived to look good? Are products that are easier to use by virtue of their function and usability inherently more attractive? The engine inside a Ferrari is designed for performance and for many it is an object of beauty. Products that are considered to be truly excellent items in terms of how they work also, more often than not, are considered to look attractive. Examples of this include Google and the iPod.

3.6.6 The best design – beautiful products that perform well?

What are considered often to be the most successful products in terms of function are those without any unnecessary extra features; that is the best functional design is usually simple design. Examples of successful products in terms of design and function are the iPod and Google. In publications 9 and 10, papers presented by the author to conferences in Japan (Wilson, 2005) and Pakistan (Wilson, 2007), it is suggested that the best design falls in the crossover between behavioural/functional design and positive visceral design where functional design can be considered to be essentially design that fulfils performance requirements to
a high level (Figure 3.11). At this crossover are beautiful products that perform well.

![Figure 3.11](image)

**Figure 3.11**  A model for performance and aesthetics
(The Author)

### 3.6.7 Areas for further work

The *Handbook of textile design* is ten years old. With the author’s work subsequent to the publication the intention is to update this.

There is also need for a book which takes much of the research undertaken into design and the design process and presents this in an appropriate and succinct manner for students. It is the intention of the author to write such a book.

More work needs to be done with regard to how people respond to designs in order to better understand what is perceived to be good design. Some initial work by the author has explored reactions to drawing quality and this attempts to prove that while it may be difficult to say why a drawing is liked above another there will be a consensus of opinion.

The work on repetition is being written as a paper for publication. This whole area of why variation is important in repetition offers opportunities for further exciting research.

Statement word count 12, 837
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Publication 1

Book

Located in the pocket at the back.
Publication 2

Exhibition catalogue

Located in the pocket at the back.
Publication 3

Refereed journal paper
Refereed journal paper
Publication 5

Refereed journal paper
Refereed journal paper
Publication 7

Refereed journal paper
Conference paper - invited

Conference paper - invited

Conference paper and book chapter
Conference paper
Conference paper
Appendix I – Repetition and variation

Repetition and variation – an initial empirical study
With the aid of a small grant from the Arts and Humanities Research Council an initial empirical study by the author explores the emotional aspects of repeating pattern with regard to variation. The objectives were to bring about a better understanding of repetition in artwork and design and the emotional responses to repeated elements in terms of numbers and the level of formality/variation. Responses to a variety of repeated themes and elements were elicited from a wide range of observers by means of questionnaires. The results of this study were presented in a paper at the 2006 Seoul Costume Culture Association and Ars Textrina Joint International Conference. They are presented again in this appendix.

Research methodology
The research was undertaken via experiments that used simple pattern, repeated in different ways in terms of the number and degree of variation within the elements, to elicit response. The experiments used natural elements and abstract patterns in series, both selected for use for their apparent timelessness and lack of negative connotations. Elements were repeated in different ways to create a series of two thematically linked images and designs. So that responses were not influenced by colour the experiments used black images on a white ground.

Sets of these images were created and a sample group of observers were asked to give their preferences. The observers were staff and students at The University of Manchester who responded to an email invitation to take part in this study. The PowerPoint presentation was shown to the observers in the Digital Print Studio at the university. The observers' responses to the image sets were recorded via questionnaires.

Experiment 1
The first experiment used simple leaf shapes. The leaves were derived from work previously exhibited by the author that had been found to have a wide appeal and no negative connotations. There were basically two leaf shapes - three variations of one leaf and a second leaf. This gave four leaf shapes in all. The four leaves are shown in Figure A1.
In total there were 21 pairs of images. Observers were asked via a PowerPoint presentation to indicate whether they had a preference for one of the images or no preference. Thirty-six observers took part in this first experiment. Figure A2 shows observer preferences from the first experiment as a bar chart. Each pair of images is represented by a different colour; preference for the image on the left is shown by the left bar and preference for the image on the right is shown by the right bar, with the middle bar indicating the numbers of observers that had no preference.

The 21 pairs of images are presented in Figure A3. The bar chart to the right of each pair of images shows the preferences of the observers. In the left column the number of observers who preferred the image to the left is shown, the right column shows the number of people who preferred the image on the right. The middle column gives the number of people who said they had no preference. The red dot on each pair indicates which pair was preferred or if there was no preference.
Figure A3  The 21 pairs of leaves in Experiment 1 with observer preferences
(The Author)
The main findings:

- for most sets there was a significant preference for one image in each pair over another;
- the variations of leaf 1 were preferred to the more solid leaf 1 (sets 1 – 3);
- leaf 2 was preferred to all three variations of leaf 1 (sets 10 – 12);
- the images that used leaf 2 with any variation of leaf 1 were consistently preferred to images that just used variations of one leaf, whatever leaf that might be (sets 13 – 18);
- when leaf 2 was used with a variation of leaf 1 and compared with leaf 2 and a different variation of leaf 1 there was no real preference. (sets 19 – 21).

Conclusions:
From the findings leaves with more interest are preferred to those with less interest and patterns with variation are preferred over those with no variation.

Experiment 2

The findings from Experiment 1 were used to inform the design of a second experiment. Three different leaf silhouettes were used – leaf 1, leaf 1 variation 2 and leaf 2. In addition squares and spots were used – two differently sized spots and three differently sized squares. There were four sets of pairs using the leaves, four sets using the spots and four sets using the squares. Observers were asked to give preferences between the 12 pairs of images.

Experiment 2 was first undertaken via a PowerPoint presentation (part i), again with a simple questionnaire. As for Experiment 1, the observers came from staff and students at The University of Manchester who had been invited by email to take part. Again the experiment took place in the Digital Print Studio. There were 86 observers. The same experiment was undertaken via an exhibition at the Whitworth Art Gallery (part ii). This time the pairs of images were displayed at the Whitworth Art Gallery with members of the public being asked for their preferences. The results discussed here are from the 194 responses that were analysed. The exhibition proved so popular it stayed up for three months rather than the month it was initially scheduled for display.
The results are shown in the bar charts in Figures A5, A6 and A7. The bar chart to the left for each pair shows the results from the PowerPoint experiment while the results from the Whitworth Art Gallery experiment are shown in the bar chart to the right.
While preferences for set 1 and set 2 differ in the two parts of Experiment 2 there is not a huge amount of preference for either set in either part. Sets 3 and 4 however both show a significant preference for the image that uses one variation of leaf 1 along with leaf 2 in both parts of the experiment. This echoes the findings of Experiment 1.

![Figure A6](image)

**Figure A6**  Spot pairs in Experiment 2 (the Author)

Figure A6 shows the four pairs of spot images with graphs from the PowerPoint experiment shown on the left and the Whitworth experiment on the right. For set 5 both the PowerPoint and the Whitworth experiments saw observers preferring the pattern with the two differently sized spots. Set 6 saw a difference between the preferences of the two sets of observers but taken together the two patterns were pretty much equally liked. For set 7 there was a marked preference for the pattern with the two differently sized spots. For set 8 both groups of observers showed a slight preference for the pattern on the right.
Figure A7 shows the four pairs of square images with graphs from the PowerPoint experiment shown on the left and the Whitworth experiment on the right. In set 9 there is a clear preference for the pattern on the right which has two differently sized squares. In set 10 there is a slight preference for the more dense pattern. Set 11 shows a slight preference for the pattern on the right where there is a greater difference in the size of the squares used. Set 11 shows an overall difference in preference from the observers in the two experiments.

These initial experiments suggest that there is indeed a preference for designs with a degree of variation. When a design consists of images that are exactly alike repeated in a uniform and regular manner then that design tends to become very rigid and formal and on the whole is not preferred. By varying the shapes and the spaces between them more interest is created and that generally has greater appeal.
Appendix II – Other outputs

Published Books

Invited book chapters submitted

Refereed journal papers

Conference papers
• Wilson, J. (2005) ‘The Burberry Check – a case study in emergence’, *Emergence, design and communication*, The University of Manchester,
September 2005.


**Published articles**


**Consultancy work undertaken**

- Le Coq Sportif  
  *Men’s and women’s sportswear*

- Selectus Ltd  
  *Illustration boards for sales team*

- Lifeguard Knitwear Ltd  
  *Children’s knit range for Spring/Summer 1986*

- Colin Cook Knitwear Ltd  
  *Children’s cut and sewn knitwear range*
• Romp and Rest Ltd  
  Childrenswear leisure range
• Powell Knitwear Ltd  
  Cut and sewn women’s fashion knitwear ranges
• Markfield Fabrics Ltd  
  Knitted fabric ranges
• Scottish Development Agency  
  Advisory panel member
• Boftex Ltd  
  Men’s and women’s knitwear ranges
• William Patons Ltd  
  Re-design of their Bootsox product range
• Falkland Islands  
  Men’s and women’s classic knitwear

Exhibitions of design and artwork
• Painting selected for exhibition in Trafford Open Art Exhibition, 2008.
• Invited to exhibit work at opening of new art gallery in Chorlton, September 2006 – Arty’s, two canvases sold in first month, invited to exhibit for a second month.
• Invited to exhibit work in The Attic art gallery in Bury, August 2006, one canvas sold.
• Invited to participate in Artlink exhibition 21st January to 29th April 2006, Stockport Art Gallery.
• Exhibited at *Digital design and painted leaves* – an exhibition with Aileen Collis and Vicki Wheeler at Hulme Hall, Manchester, 24th – 27th May 2006, (5 framed artworks on paper 12 artworks on canvas sold).
• Two paintings selected for exhibition at the Stockport Open Art Exhibition, 2005.
• Two designs short listed for Refocus Calendar Competition 2004, these were exhibited at the Artist and Illustrators Exhibition, 22nd - 25th July 2005, at the Business Design Centre in Islington London.
• Five pieces of work selected for inclusion in the 2004 summer exhibition at Wendy Levy Gallery, Didsbury, Manchester.
• *Painted leaves on canvas* - an exhibition of work on canvas, The Bar, Chorlton, Manchester, scheduled for 9th March – 6th April 2004
• *Painted leaves on paper* - an exhibition of 20 original artworks, The Bar, Chorlton, Manchester, 10th February – 8th March 2004.
• *On canvas and paper – a journey in time* – an exhibition of original artwork, Hulme Hall, Manchester, 27th – 29th November 2003 (15 framed artworks on paper, 18 artworks on canvas, 10 pieces of mounted artwork sold).
• One framed artwork selected for Stockport Open Exhibition 2003.
• *Painted leaves 2*, an exhibition of original artwork, UMIST Manchester, 14th – 25th March 2003 (15 framed paintings exhibited, 6 framed paintings sold, 14 mounted pieces of artwork sold).
• *Painted leaves*, an exhibition of original artwork, Hulme Hall, Manchester, 26\textsuperscript{th} – 30\textsuperscript{th} November 2002 (18 framed paintings exhibited, 15 framed paintings sold, 32 mounted pieces of artwork sold).

• Profit by Design - A 1985 Design Council touring exhibition which show-cased work done for Powell Knitwear - an interview was featured on the TV programme Look North West.

**Commissions of artwork**

• A series of five painting commissioned for the foyer of the George Begg Building, The University of Manchester (July 2006).

• One canvas for private client, July 2005.

• Three canvas panels for private client, October 2003.

• Five canvas panels for private client, September 2003.

• One framed artwork for private client, September 2003.

• One framed artwork for private client, July 2003.


• Commissioned painting for Hulme Hall, University of Manchester, 2001.


• Five wall panels for Maths and Social Sciences Building, UMIST, 1997.

• Five wall panels for George Begg Building at UMIST, 1996.

• Artwork entitled ‘Science and Technology’, first prize winner UMIST art competition, 1989.

**Other design work**