Contents

Abstract I
Content II
List of Tables VIII
List of Figures IX

Chapter 1 Introduction

1.1 Overview of Smart Clothing Development 1
   1.1.1 Definition and Origin of Smart Clothing 1
   1.1.2 Participants in Smart Clothing Development 2
   1.1.3 Drivers behind Smart Clothing Development 3
   1.1.4 Evolution and Future Trends of Smart Clothing 4
   1.1.5 Current Situation of Smart Clothing Development 9
   1.1.6 Problems of Smart Clothing Development 10
   1.1.7 Summary of Smart Clothing Development 13

1.2 Theories and Models of New Product Development (NPD) Process 14
   1.2.1 Strategic Approach and NPD Conceptual Models 14
      • Definition of the Strategic Approach in NPD process 14
      • Key Elements of Strategic Approach in NPD Process 16
      • Definition of the New Product Development (NPD) Process 16
      • Generic Models of the New Product Development (NPD) Process 17
      • Relationship between the Strategic Approach and the Conceptual Model 19
      • Summary of Strategic Approach and Conceptual Models of NPD Process 23
1.2.2 Collaborative Approach for NPD Process

- Definition of Collaborative Approach in NPD Process
- Current Situation of Collaborative Approach in NPD Process
- Proposed Theories to Improve Collaboration in NPD Process
- Summary of the Collaborative Approach for NPD Process

1.3 Problem Statement and Hypotheses

1.4 Research Scope

1.5 Aim and Objectives

1.6 Research Contributions

1.7 Structure of the Thesis

Chapter 2 Literature Review

2.1 Apparel NPD Process in Practice

- 2.1.1 Apparel Product Development in Context
- 2.1.2 NPD Process in Apparel Industry
- 2.1.3 Strategic Approaches and NPD Models

2.2 Electronic NPD Process in Practice

- 2.2.1 Electronic Product Development in Context
- 2.2.2 NPD Process in Electronic Industry
- 2.2.3 Strategic Approaches and NPD Models

2.3 Smart Clothing NPD Process in Practice

- 2.3.1 NPD Process in Smart Clothing Projects
- 2.3.2 Comparison Between NPD Models
  - Comparison
Chapter 3 Research Methods

3.1 Semi-structure Interviews  80
• Aims  80
• Subjects  80
• Materials  83
• Procedures  84

3.2 Case Study  84
• Aims  84
• Subjects  84
• Materials  87
• Procedures  87

3.3 Questionnaire  88
• Aims  88
• Hypotheses  89
• Participants  89
• Materials  90

3.4 Focus group  91
• Aims  92
• Subjects  92
• Materials  94
3.5 Analytical Methods

3.5.1 Grounded Theory Analysis
- Open Coding
- Axial Coding

3.6 Conclusion

Chapter 4 Key Findings and Discussion

4.1 Methods to Balance All Contributions
- Main Problems of Smart Clothing Development
- Alternative Ways to Solve Identified Problems
- Conclusion – Methods to Balance All Contributions

4.2 Methods to Overcome Creative Constrains
- Alternative Ways to Overcome the Creative Constraints
- Conclusion – Methods to Overcome the Constraints

4.3 Methods to Achieve Full Integration
- Contributions from Fashion Designers
- Contributions from Product Designers
- Alternative Ways to Achieve Full Integration
- Conclusion – Methods to Achieve Full Integration

4.4 Smart Clothing’s Context
- User Profile and Requirements
- Vision of Future Lifestyle
- New Design Direction
Chapter 5 Model Formulation

5.1 Conceptual Model’s Requirements 154

5.2 Creative Techniques 156

5.2.1 Lateral Thinking 156

5.2.2 Six Thinking Hats and Boundary Shifting 157

• The Six Thinking Hats 157

• Boundary Shifting 158

5.3 Model Formulating Procedure 160

5.3.1 Identifying Dominating Concepts 160

5.3.2 Continuity Analysis 161

5.3.3 Challenging Invalid Concepts 164

• The Concept Fan 165

• Provocation 167

• The Random Input 172

5.3.4 Evaluate and Implement New Ideas 174

5.4 Conceptual model and implementation 188

Chapter 6 Validation and Modification

6.1 Validation Process 193

• Aims 193

• Hypotheses 193
• Subjects 194
• Materials 195

6.2 Results and Statistical Analyses 195
6.3 Model Modification 198

Chapter 7 Conclusion

7.1 Contributions of the Research 211
7.2 Limitations of the Research 213
7.3 Suggestions for Further Research 213

References 215

Appendix

Appendix A Questionnaire Survey i
Appendix B Questionnaire Results vi
Appendix C Statistical Analysis viii
Appendix D Validation Questionnaire xii
Appendix E Profiles of the Experts xvii
Appendix F Results of Model Validation xxii
Appendix G Validation Result Analysis xxvii

Publications
List of Tables

Table 2.1: Five examples of the NPD processes employed in the fashion industry 47
Table 2.2: Five examples of the NPD processes employed in the electronic industry 58
Table 2.3: Four examples of the NPD processes employed in the Smart Clothing area 67
Table 3.1: Profiles of each interviewee 82
Table 3.2: Age groups of the questionnaire respondents 90
Table 3.3: Profiles of all the participants in the second type of the focus groups 93
Table 3.4: Example of properties and dimensional range within the categories 100
Table 3.5: Advantages and disadvantages of each research methods 103
Table 4.1: Properties and dimension range of ‘Balanced Contribution’ Phenomenon 111
Table 4.2: Principles and work procedures of all disciplines involved 117
Table 4.3: Properties and dimension range of ‘Creative Constrain Breakthrough’ 119
Table 4.4: Properties and dimension range of ‘Full Integration’ Phenomenon 130
Table 4.5: Desirable factors affecting consumer’s purchasing 135
Table 4.6: Comparison of the frequencies of purchasing 135
Table 4.7: Undesirable factors affecting consumer’s purchasing 136
Table 4.8: Users’ preference – comparison between three different products 138
Table 4.9: Smart Clothing’s design directions deduced from the interviews 141
Table 4.10: Smart Clothing’s design directions deduced from the focus groups 143
Table 5.1: The new ideas developed through the use of lateral thinking method 174
List of Figures

Figure 1.1: Diagram explaining evolution of the Smart Clothing development 5
Figure 1.2: Examples of Smart Clothing applications from the first period 6
Figure 1.3: Examples of Smart Clothing applications from the second period 7
Figure 1.4: Examples of Smart Clothing applications from the third period 8
Figure 1.5: Examples of Smart Clothing applications available in the market 10
Figure 1.6: Diagram representing the key problems and relationships 11
Figure 1.7: Functional/technical approach VS fashion approach 12
Figure 1.8: A generic Stage-Gate New Product Process (Cooper, 1993) 18
Figure 1.9: Steps of the design process (Pahl and Beitz, 1984) 18
Figure 1.10: Fashion Design cycle (Rhodes, 1995) 21
Figure 1.11: Matsushita Industrial’s Fusion style of NPD process (Hughes, 1995) 21
Figure 1.12: Product development framework emphasising retailers’ influence 22
Figure 1.13: Conceptual models proposed to improve cross-functional cooperation 28
Figure 1.14: Cross-functional integration and Multifunctional team 29
Figure 1.15: Sonnenwald’s conceptual models 30
Figure 1.16: Factors influencing charged behaviour (Sethi and Nicholson, 2000) 31
Figure 1.17: Diagram showing focus of the research 35
Figure 2.1: Retail product development model 41
Figure 2.2: Fashion Calendar 42
Figure 2.3: The process of apparel design and product development 44
Figure 2.4: The generic fashion design process (Sinha, 2001) 45
Figure 2.5: Comparison between five different design processes (Sinha, 2001) 50
Figure 2.6: Comparison of the NPD models in apparel industry 51
Figure 2.7: Design Flow (DTI's Electronic Design Programme, 2002b) 56
Figure 2.8: Traditional NPD Process (DTI's Electronic Design Programme, 2002a) 57
Figure 2.9: Xerox’s interdisciplinary team and Philips’ model of design function 57
Figure 2.10: Project phase sequence (Monds, 1984) 58
Figure 2.11: Philips’ NPD process – the Design Track (Heskett, 1989) 61
Figure 2.12: Comparison of the NPD models in consumer electronic industry 62
Figure 2.13: Relationship between clothing, technology and user 67
Figure 2.14: Design Process employed in example no. 3 70
Figure 2.15: The outputs of the four examples selected 71
Figure 2.16: Computational garments and accessories developed by the engineers 71
Figure 2.17: Risk Management Funnel and Microsoft NPD process 74
Figure 3.1: Diagram presenting key issues addressed in objectives 3 – 6 77
Figure 3.2: Diagram demonstrating structure of primary research 79
Figure 3.3: Diagram demonstrating three focus groups conducted in this research 94
Figure 3.4: Diagram showing relationships between information and analysis methods 97
Figure 3.5: Example of labelling procedure 100
Figure 3.6: Example of discovering categories and naming categories 100
Figure 3.7: Paradigm Model presenting relationship of sub and main categories 101
Figure 3.8: Paradigm Model presenting result of this research 102
Figure 4.1: Integration of qualitative results and quantitative results 105
Figure 4.2: Paradigm Model – phenomenon of balancing all contributions 113
Figure 4.3: Paradigm Model – phenomenon of the creative constraint breakthrough 120
Figure 4.4: The overlapping of electronic product design and clothing design 129
Figure 4.5: Paradigm Model – phenomenon of a full integration achievement 131
Figure 4.6: Pie charts illustrating purchasing criteria of three different products 135
Figure 4.7: Undesirable factors influencing purchasing behaviour 137
Figure 4.8: Spectrum of purchasing criteria illustrating position of different products 139
Figure 4.9: Diagram demonstrating a consensus agreement from all the stakeholders 141
Figure 4.10: New design directions based on the consensus views of stakeholders 147
Figure 4.11: Diagram illustrating Simon and Krose’s theories 147
Figure 4.12: Diagram demonstrating product context of sportswear products 148
Figure 4.13: Diagram describing context of sportswear application of Smart Clothing 149
Figure 4.14: Sample of physical appearance regarded as ‘Smart’ design 150
Figure 4.15: Diagram showing how all results are combined 151
Figure 5.1: A sample of the ideas derived from the lateral thinking technique 157
Figure 5.2: How the change of one constraint can affect the others 159
Figure 5.3: The concept fan demonstrating alternative ideas for the new NPD model 165
Figure 5.4: Bubble diagram presenting a rough idea derived from the concept fan 166
Figure 5.5: Diagram demonstrating an idea derived from the provocation statement 171
Figure 5.6: Diagram demonstrating the relationships between all development tasks 177
Figure 5.7: The structure of Smart Clothing development process is identified 178
Figure 5.8: Positioning participants into the Smart Clothing development structure 179
Figure 5.9: Diagram demonstrating how the framework can be customised 181
Figure 5.10: Diagram demonstrating how the boundary is constructed and extended 182
Figure 5.11: Framework presenting all tasks in details, which can be altered 184
Figure 5.12: The framework being revised and combined with the generic models 184
Figure 5.13: Details within the framework is revised throughout the NPD process 185
Figure 5.14: Different directions on thinking required in the different areas 188
Figure 5.15: The electronic model positions all participants and tasks automatically 189
Figure 5.16: Electronic model provides information about tasks and participants 190
Figure 5.17: Electronic model explains how to extend a boundary into different areas 191
Figure 6.1: Histogram illustrating the scores measuring importance of five key issues 196
Figure 6.2: Histogram demonstrating the scores measuring practicality 197
Figure 6.3: The conceptual model at the highest level after the first modification 200
Figure 6.4: All the terms used in detailed model was revised and replaced 201
Figure 6.5: Certain terms which could lead to misinterpretation or confusion 202
Figure 6.6: Detail is presented in dialogue box when a particular task is selected 203
Figure 6.7: First step – the participants specify their expertise and main contributions 204
Figure 6.8: Second step – the participants specify their contributions in related areas 205
Figure 6.9: Human shape is used to present working boundaries and relationships 206
Figure 6.10: Boundaries can be updated in order to improve the working relationship 207
Figure 6.11: A summary of the final conceptual model and how it can be employed 210