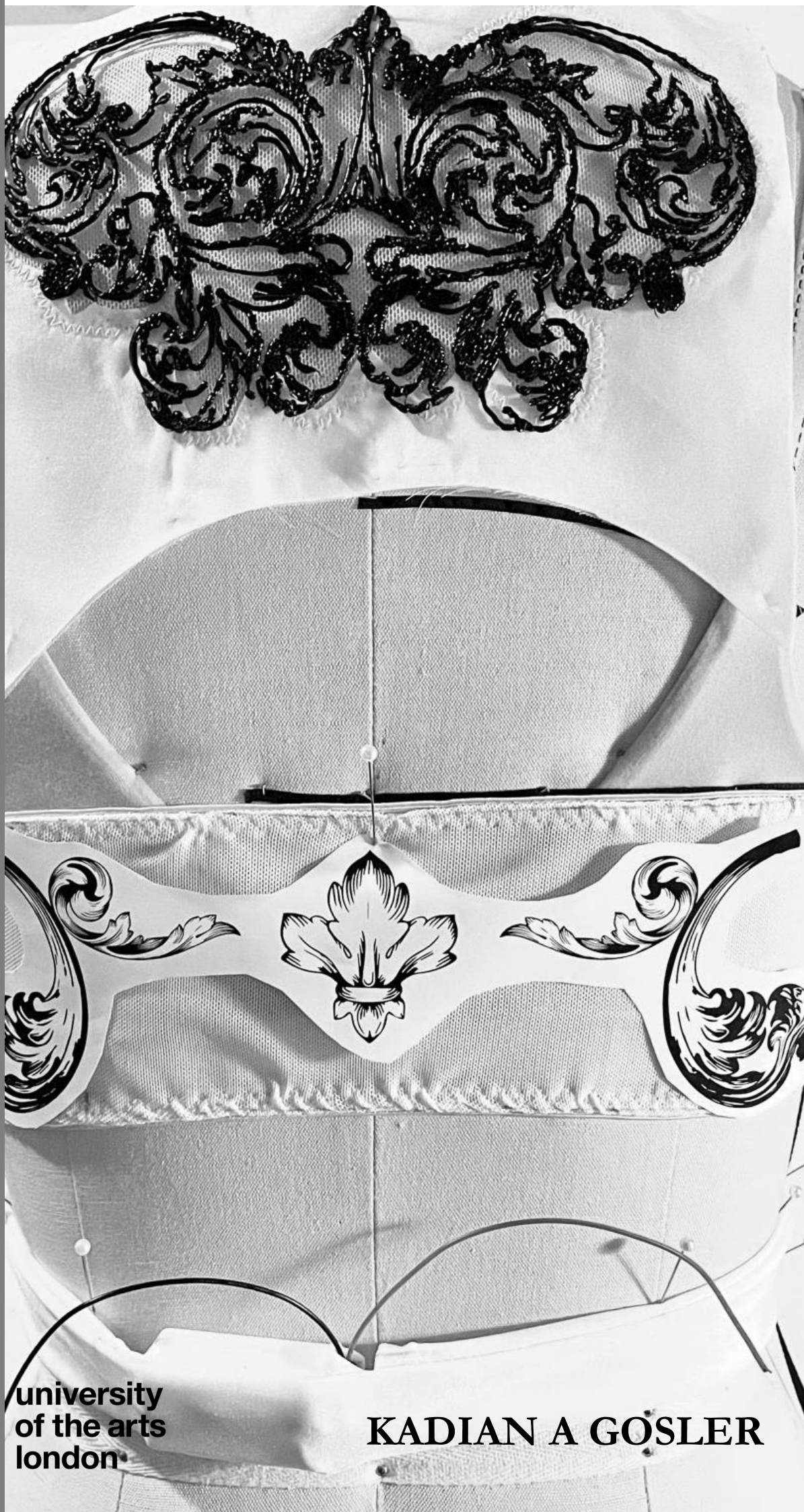
Smart Bras:

Developing an Experience-centred Bra Wearables Design Process *with* and *for* Mature Women



ual: university of the arts london

KADIAN A GOSLER

COVER IMAGE: First toile of Luisia massage BW prototype.

IMAGES: All images are by Kadian A Gosler unless otherwise noted.

Copyright 2023 Kadian A Gosler, Unless otherwise noted

‘Smart Bras’

Developing an Experience-Centred Bra Wearables Design Process *with* and *for* Mature Women

KADIAN A. GOSLER

Thesis submitted in partial fulfilment
of the requirements for the degree of
Doctor of Philosophy (PhD)

University of the Arts London
London College of Fashion
April 2023

To Black women: Big up unnou selves cause dem nah guh do it.

Abstract

This theory and practice study developed an experience-centred design and development process for bras with "smart" capabilities, termed Bra Wearables (BW) — a subsection of smart bras with electrical, mechanical, and chemical properties. With the 2005 commercialisation and subsequent decline of Sports Bra Wearables (SBW), questions arose as to why this innovative niche failed. This study posits that the bra must evolve into BW by becoming a "woman-centred technology" (Almeida, 2017), created with women's involvement, needs, and experience at the centre. Moreover, focus should be on marginalised women, such as mature women (MW) who are often omitted from the fashion and technology space. Underpinned by a Deweyan Pragmatist framework, a woman-centred and pragmatic research-*through*/*into*-design approach – this exploratory study follows a Four-Stage Research Process (Research, Define, Develop, and Reflect) to execute the newly created BW Design and Development Process (BWD&DP).

The "research" stage disseminates a questionnaire for Western-based mature (45 – 64 years) Black and white women. Results substantiate a Factors Affecting Bra Experience Conceptual Model, indicating the direct connection between ageing and the bra-wearing experience on MW's feminine-sexuality, identity, and body-image. Furthermore, the questionnaire uncovers differences in mature Black and white women's bra experience. Lastly, a Technology Acceptance Model (TAM) uncovers that the design process influences BW interest, which strongly and positively influences the acceptance of BW. This denotes the significance of developing a participatory BWD&DP for BW acceptance by wearers.

The "define" stage realises the "Research & Concept Development" phase of the initial BWD&DP, focusing solely on mature Black women through a mixture of qualitative methods. Thematic analysis is used to analyse data from a generative workshop and digital dialogue, while the interview data are examined through a theory-driven codebook. The codebook underpins the interdisciplinary Bra Experience Theoretical Framework, evidencing that bra experience is complex and psychologically, socially, and affectively connected for bra wearers. Data are triangulated from the quantitative and qualitative methods to extend the Functional, Expressive, and Aesthetic (FEA) Consumer Needs Model, tying theory and practice, and developing design criteria for BW.

The "develop" stage concludes the "Research & Concept Development" phase with a participative creative workshop and enacts the "Pattern & Prototype Development" phase with a digital fit models session, design practice producing two BW prototypes, and a critique-driven focus group. Participants complete the phase by evaluating the actualised prototypes and demonstrating the importance of physically interacting with the prototypes. The design-researcher's personal experience becomes essential as it enables insights to be accessed about intertwining hardware and traditional bra materials, processes, and new manners of designing *with* and *for* participants.

The "reflect" stage concludes the research process, allowing for reflections on the developed BWD&DP, validations from bra designers and wearable technology experts, and originality of the research methodology. This research-*through/into*-design approach establishes the need for empathy to centre experience throughout the BWD&DP utilising empathic conceptualisations (Surma-Aho and Hölttä-Otto, 2018) and empathy-based methods such as 'body-storming' (Buchenau and Fulton Suri, 2000) and 'drawing-as-seeing' (Mida and Casey, 2020).

This study confirms the need to utilise empathy to understand marginalised bra-wearers experiences and examine the wearer-garment experience through an interdisciplinary theoretical experiential framework to design *for* future garment experiences. Moreover, the developed BWD&DP suggests an artisanal approach is apt when designing experience-centred BW. The findings of this study have practical implications for smart bra and BW researchers and technologists seeking to develop new concepts, design-researchers exploring new methods of engaging wearers in the design process, and fashion researchers exploring new ways of understanding the wearer-garment relationship. Additionally, industry may find the approaches utilised to be helpful in developing an experience-centred design process.

Acknowledgements

A magnificent tree cannot be without roots and water. This thesis would not have been possible without the people who held me up and those that poured into me. I would like to offer my sincerest gratitude to:

- My husband, Jacob, and exquisite child, Kian, I am most proud of sharing this journey called life with you.
- My brothers, Dwight, Kaion, and Harik, and mother Marlene, thank you for your energy and light. Without you all, there is no me.
- My grandmother, Millicent, thank you for always centring education and pushing me to attain; and to grandpa, Ivan, you will never know how much I appreciate everything you have done. This is for you!
- My extended family for your prayers and encouragement.
- My faves, Donaldvin and Lena, thank you for always being a friend across space and time.
- My PhD colleagues, Rawan Maki, Claudette Davis-Bonnick and Dr Rose Sinclair, thank you for the chats, walks, laughter and so much more.
- The numerous academic communities (Zobo Research Collective, The Caribbean Fashion and Design Research Network, African Diaspora Postgraduate Student group, PhD Forum, and #AcademicTwitter) that provided me space to learn, vent and grow.
- Black academics on Twitter, thank you for sharing your ups and downs and paving a path.
- The Bath & Bristol R&D Fellowship, thank you for the community, funding, and opportunity to become a better academic.
- To my DoS, Professor Sandy Black, and many Co-Supervisors along the way: Professor Kapsali, Dr Bardey, and Dr Roncha, thank you for your support, feedback, and input.
- The participants, I thank you whole heartedly for your time, stories, intimacies, laughter, and honesty. This thesis would not be what it is without you.
- To past Kadian, thank you for sticking through this journey with all the obstacles presented. You are forever stronger than you know.

Contents

ABSTRACT 6

ACKNOWLEDGEMENTS 9

LIST OF FIGURES, IMAGES, AND TABLES 19

GLOSSARY, ACRONYMS AND DEFINITIONS 26

1. INTRODUCTION 29

1.1. PERSONAL MOTIVATION 29
1.1.1. BACKGROUND AS A DESIGNER 29
1.1.2. DESIGN VISION AND APPROACH 31
1.1.3. MY INTEREST IN FASHION TECHNOLOGY 31
1.1.4. MY CONCERN AS A DESIGNER 31
1.2. RESEARCH SCOPE 32
1.2.1. INVISIBILISED WOMEN IN THE BRA INDUSTRY 33
1.2.2. EXPERIENCE *OF* AND *WITH* CLOTHING 33
1.3. CONTEXTUALISING THE RESEARCH 35
1.3.1. BRA WEARABLES (BW) INTRODUCTION 35
1.3.2. SMART TECHNOLOGY IN THE BRA 36
1.4. DIFFICULTY DESIGNING AND DEVELOPING SMART CLOTHING 37
1.5. EXPLORING A NEW PATH 38
1.6. AIMS AND OBJECTIVES 39
1.7. PRACTICE AND RESEARCH APPROACH 41
1.8. AUDIENCE 42
1.9. THESIS STRUCTURE 43
1.10. CONTRIBUTIONS TO KNOWLEDGE 46
1.11. BOUNDARIES OF THE INQUIRY 46

PART A: CONTEXTUAL & LITERATURE REVIEW 49

2. DESIGN AND TECHNOLOGY IN THE BRA 51

2.1. BRA HISTORY 51

2.1.1. TECHNOLOGY, HEALTH, AND THE BRA 52
2.2. DEFINITION AND ORIGIN OF BRA WEARABLES (BW) 54
2.2.1. BRIEF OVERVIEW OF SMART CLOTHING/WEARABLE TECHNOLOGY 54
2.3. BRA WEARABLES (BW) FIELD 56
2.3.1. SECTORS OF BRA WEARABLES (BW) 59
2.3.2. CURRENT SITUATION AND PROBLEMS OF BW DEVELOPMENT 71
2.3.3. FUTURE AREAS/DESIGN OPPORTUNITIES FOR BW 72
2.4. SUMMARY 73

3. BRA DESIGN PROCESSES 75

3.1. DESIGN PROCESSES OVERVIEW 75
3.1.1. APPAREL DESIGN PROCESSES 76
3.1.2. NEW PRODUCT DESIGN (ENGINEERING AND PRODUCT DESIGN PROCESSES) 77
3.1.3. FUNCTIONAL APPAREL DESIGN PROCESSES 80
3.2. EXPLORING BRA DESIGN PROCESSES 84
3.2.1. MARKET TIERS: FAST FASHION, MID-TIER, ARTISANAL, HIGH-END, SPECIALITY 85
3.2.2. CUT-AND-SEWN /MOULDED/ KNIT BRA DESIGN PROCESSES 86
3.2.3. FIT AND PROTOTYPING IN THE BRA D&DP 89
3.2.4. THE WEARER IN THE DESIGN PROCESS 89
3.3. SPORTS BRA DESIGN PROCESSES 90
3.3.1. SPORTS BRA DESIGN PROCESSES 90
3.3.2. SPORTS BRA WEARABLES (SBW) D&DP 91
3.4. STAGES IN BRA DESIGN AND PROTOTYPING 92
3.4.1. 2D CAD/3D CAD 92
3.4.2. PATTERN DEVELOPMENT 93
3.4.3. FIT PROCESS 94
3.4.4. GRADING PROCESS AND WEAR TRIAL 94
3.4.5. THE FUTURE: 3D SCANNING AND 3D-PRINTING 95
3.5. HUMAN-CENTRED DESIGN (HCD) 96
3.5.1. USER-CENTRED, PARTICIPATORY, CO-DESIGN, AND EMPATHIC DESIGN 97
3.6. SUMMARY 99

4. MATURE WOMEN AND THE BRA 101

4.1. MATURE WOMEN AND FASHION 101
4.1.1. FASHION 101
4.1.2. BRA 102

4.1.3. INVISIBILITY AND INTERSECTIONALITY 103
4.2. MATURE WOMEN'S POTENTIAL RELATIONSHIP TO THE BRA 104
4.2.1. AGEING AND BODY CHANGES 105
4.2.2. WAYS MATURE WOMEN EXPERIENCE THE BRA 107
4.2.3. MATURE WOMEN'S WEARING & PURCHASING HABITS 112
4.2.4. FACTORS AFFECTING BRA EXPERIENCE CONCEPTUAL MODEL 114
4.3. SCAFFOLDING THE BRA EXPERIENCE THEORETICAL FRAMEWORK 115
4.3.1. SCAFFOLDING EXPERIENCE-BASED THEORIES 116
4.4. THE RISE OF TECH WELLNESS FOR MATURE WOMEN 117
4.5. SUMMARY 119

PART A SUMMARY 121

PART B: METHODOLOGY & RESEARCH DESIGN 123

5. RESEARCH METHODOLOGY 125

5.1. INTRODUCTION 125
5.2. DEWEYAN PRAGMATIST FRAMEWORK 126
5.3. WOMAN-CENTRED APPROACH 129
5.3.1. FEMINIST INFLUENCES 130
5.3.2. DESIGNING *FOR* AND *WITH* WOMEN 131
5.4. PRAGMATIC APPROACH 132
5.4.1. PRAGMATIST AESTHETIC APPROACH 133
5.4.2. DESIGN AND EMOTION 133
5.5. RESEARCH-*THROUGH* AND *FOR*-EXPERIENCE-CENTRED DESIGN 138
5.5.1. VALIDITY/APPLICABILITY 139
5.6. REFLEXIVITY 139
5.7. SUMMARY 141

6. RESEARCH DESIGN 145

6.1. FOUR-STAGE RESEARCH PROCESS – RESEARCH/DEFINE/DEVELOP/REFLECT 145
6.1.1. RESEARCH 150
6.1.2. DEFINE 157
6.1.3. DEVELOP 174
6.1.4. REFLECT 186
6.2. PARTICIPANTS OVERVIEW 188

6.3. ETHICS **189**
6.4. RESEARCHER POSITIONALITY **189**
6.5. SUMMARY **192**

PART B SUMMARY **195**

PART C: RESEARCH FINDINGS **197**

7. RESEARCH **199**

7.1. MATURE WOMEN'S BRA EXPERIENCE **200**
7.1.1. DEMOGRAPHICS OF SAMPLE 200
7.1.2. RESULTS AND DISCUSSION SUMMARISED 202
7.1.3. SUMMARY OF CONSTRUCTS AND ANALYSIS 205
7.1.4. BRA EXPERIENCE STRUCTURAL MODEL – DISCUSSION OF KEY FINDINGS 207
7.2. FACTORS AFFECTING BW ACCEPTANCE **209**
7.2.1. FACTOR ANALYSIS, INSTRUMENT RELIABILITY, AND VALIDITY 210
7.2.2. FINDINGS 212
7.2.3. CONTRIBUTIONS AND IMPLICATIONS 214
7.3. DEVELOPMENT OF THE BWD&DP **215**
7.3.1. PROCESSUAL REVIEW OF BRA, FUNCTIONAL AND SMART CLOTHING PROCESSES 216
7.3.2. INITIAL BWD&DP DEVELOPED 221
7.4. SUMMARY **226**

8. DEFINE **229**

8.1. MATURE BLACK WOMEN'S BRA EXPERIENCE **231**
8.1.1. BRA USAGE 231
8.1.2. BRA EXPERIENCE 233
8.1.3. DESIGN ATTRIBUTES 236
8.1.4. BRA WEARABLES INTEREST 237
8.2. INSIGHTS INTO THE MULTI-LEVEL BRA EXPERIENCE OF BLACK WOMEN **239**
8.2.1. EMBODIED PRACTICE EXEMPLARS 244
8.2.2. AFFECTIVE EXPERIENCE EXEMPLARS 247
8.2.3. ENCLOTHED COGNITION EXEMPLARS 250
8.3. REFLECTION – COLLATING BRA EXPERIENCE **252**
8.4. IDENTIFICATION OF WEARER NEEDS AND DESIGN REQUIREMENTS **254**
8.4.1. UPDATING THE FSEA MODEL WITH THE BRA EXPERIENCE THEORETICAL FRAMEWORK 254

8.4.2. ANALYSIS AND TRIANGULATION OF RESULTS 256
8.4.3. DEFINING THE DESIGN CRITERIA AND INTERACTION MATRIX 258
8.5. DESIGN-RESEARCHER REFLECTION 261
8.6. SUMMARY 264

9. DEVELOP 267

9.1. BWD&DP 268
9.1.1. INITIAL BWD&DP REVIEW 269
9.2. BW CONCEPTS DEVELOPMENT 270
9.2.1. INTRODUCTION TO WORKSHOP ACTIVITIES 270
9.2.2. DESIGN CONCEPTUALISATIONS 271
9.3. FIT MODEL DEVELOPMENTS 274
9.3.1. MAKING THE PARTICIPANTS DIGITAL 274
9.3.2. DIGITAL PROTOTYPING (AI, PSD, CLO3D) 275
9.3.3. FIT MODEL DESIGN & EMOTION EXPERIENCE 277
9.4. PROTOTYPING BW 280
9.4.1. PATTERN & PROTOTYPE DEVELOPMENT 280
9.4.2. DEVELOPMENT REFLECTIONS 288
9.5. PARTICIPANTS REVIEW 292
9.5.1. COLLABORATIVE REVIEW RESULTS 294
9.5.2. PARTICIPANTS' EVALUATIONS EXAMINED THROUGH THE FOUR PLEASURES FRAMEWORK & BWFSEA MODEL 299
9.6. DESIGN-RESEARCHER REFLECTION – EXPERIENCES 302
9.7. SUMMARY 306

10. REFLECT 309

10.1. REFLECTION ON THE SITUATION 310
10.1.1. BW STATE-OF-THE-ART 311
10.1.2. SIGNIFICANCE OF THE DESIGN PROCESS 311
10.2. REFLECTION ON THE DESIGN-AS-PRACTICE 323
10.2.1. DESIGNERS' EXPERIENCE DESIGNING BW 323
10.2.2. IMPLEMENTING NEW METHODS FOR DESIGNING *FOR* EXPERIENCE 324
10.2.3. DESIGNING *WITH* WOMEN — BLACK WOMEN'S DESIGN PROCESS EXPERIENCES 329
10.2.4. WEAVING EXPERIENCE AND EMPATHY INTO DESIGN-AS-PRACTICE 330
10.3. REFLECTION ON THE DESIGN RESEARCH 331
10.3.1. FOUR-STAGE RESEARCH PROCESS METHODOLOGY 334

10.3.2. WOMAN-CENTRED METHODOLOGY 335
10.4. SUMMARY 336

PART C SUMMARY 339

11. CONCLUSION 341

11.1. SUMMARY OF THE RESEARCH 341
11.1.1. ACCOMPLISHING THE AIMS AND OBJECTIVES 341
11.2. LIMITATIONS AND SUGGESTIONS 343
11.2.1. ACCESS TO INFORMATION 343
11.2.2. ACCESS TO TECHNOLOGY 343
11.2.3. ACCESS TO ADVANCED TECHNIQUES & MACHINERY 344
11.2.4. ENVIRONMENT 345
11.3. CONTRIBUTION TO KNOWLEDGE 345
11.3.1. CONTEXTUAL CONTRIBUTION 345
11.3.2. THEORETICAL CONTRIBUTION 346
11.3.3. METHODOLOGICAL CONTRIBUTION 347
11.4. RECOMMENDATIONS FOR FUTURE RESEARCH 347
11.4.1. FUTURE RESEARCH SITUATION 347
11.4.2. FUTURE WORK PRACTICE AS DESIGN 348
11.4.3. FUTURE WORK METHODOLOGY 348

REFERENCE 351

APPENDIX 407

A. BRA TYPOLOGY 407

B. BRA IMAGE DATABASE 408

C. VARIOUS DESIGN PROCESSES 411

D. ASSESSING DESIGN RESEARCH 413

E. CALL FOR PARTICIPANTS 415

F. SAMPLE WORKBOOK (GENERATIVE WORKSHOP) 416

G. GENERATIVE WORKSHOP PHASE 2 & 3 EXPLAINED 424

H. GENERATIVE WORKSHOP OUTLINE 427

I. CONSUMER QUESTIONNAIRE 431

J. QUESTIONNAIRE ANALYSIS 444

J.1. FACTORS AFFECTING BRA EXPERIENCE 444

J.1.1. DEMOGRAPHICS OF SAMPLE 444

J.1.2. EXPLORATORY FACTOR ANALYSIS 449

J.1.3. ASSUMPTIONS OF NORMALITY 450

J.1.4. DIFFERENCE BETWEEN FACTORS AFFECTING BLACK & WHITE WOMEN 451

J.1.5. BRA EXPERIENCE STRUCTURAL MODEL 456

J.1.6. ASSESSING THE MEASUREMENT MODEL 458

J.1.7. ASSESSING THE STRUCTURAL MODEL 460

J.1.8. MODEL FIT 461

J.2. FACTORS AFFECTING BW ACCEPTANCE 462

J.2.1. FACTOR ANALYSIS, INSTRUMENT RELIABILITY, AND VALIDITY 462

J.2.2. INSTRUMENT DESCRIPTIVE STATISTICS RESULTS 465

J.2.3. DATA ANALYSIS 466

K. INTERVIEW QUESTIONS 473

L. DESIGN PRACTICE 476

L.1. INITIATING DESIGN PRACTICE 476

L.1.1. MOOD BOARDS, VISUAL, TACTILE AND OLFACTORY EXPLORATIONS 478

L.1.2. EMPATHY ACTIVITIES 484

L.1.3. DESIGN SKETCHES 487

L.1.4. MATERIAL EXPLORATION 489

M. FIT MODEL QUESTIONNAIRE 499

N. EMOTION ASSESSMENTS 504

O. ANNOTATED PORTFOLIO 507

P. UPDATED BWD&DP 508

Q. VALIDITY QUESTIONNAIRE 514

R. VALIDITY RESULTS 515

S. VALIDITY CODING 520

T. CURRENT WEB RESULTS FOR 'SMART BRA' 526

U. ADDENDUM ON MW BRA SHOPPING 528

V. CODEBOOK ANALYSIS FOR INTERVIEWS 529

W. BWD&DP OBSTACLES AND OPPORTUNITIES 530

List of Figures, Images, and Tables

Fig.1.1. Master's research project. 30
Fig.1.2. Representation of marginalised bra wearers. 32
Fig.1.3. Examples of Wearables Fashion Designers. 35
Fig.1.4. Product Development Forces 36
Fig.1.5. Research gaps addressed by this study 38
Fig.1.6. Research aims. 39
Fig.1.7. Research Design Plan 40
Fig.1.8. Practice research quality indicators applicable to this study. 42
Fig.1.9. Thesis structure 44
Fig.2.1. One of the first proto-bras patented as a 'Bosom Pad' in 1873 by Helen M. Millar. 51
Table 2.2. Brief Health-based Bra Patents 1940s-2000's. 53
Fig.2.3. Top: 'Massage Bra' (Williams, 1940). Bottom: 'Hearing-Aid Bra' (Shanahan, 1950) 54
Fig.2.4. Supa Smart Sports Bra with AI features. 55
Fig.2.5. Bras Advanced Through Technology with 3D printed underwires. 56
Fig.2.6. Bras Advanced Through Knitting Technology 56
Fig.2.7. Bra Wearables (BW) Modern History Timeline 58
Fig.2.8. Bra Wearables (BW) Mapping 59
Fig.2.9. Preventative Health Bras. 59
Fig.2.10. Mental and Emotional Wellness Bras. 61
Fig.2.11. Medical-Centred Bra Patents 62
Fig.2.12. Early vibrating bras marketed as breast enlargers in the '70s. 63
Fig.2.13. Body Enhancement Bras. 64
Fig.2.14. Maternity and Nursing Bras. 64
Fig.2.15. Mastectomy Bras. 65
Fig.2.16. Sports and Fitness Bras. 66
Fig.2.17. Physical Safety Bras. 67
Fig.2.18. Glamour and Fashion Bras. 68
Fig.2.19. Sex and Pleasure Bras. 69
Fig.2.20. Retail Made Easy Bras. 70
Fig.2.21. Examples of BW constructions 71
Fig.3.1. Various design processes. 75
Fig.3.2. Fuzzy Front-End in Design Processes 78
Fig.3.3. Original FEA Consumer Needs Model. 81
Fig.3.4. Areas of concern for Smart Clothing Designers. 82
Fig.3.5. 5-Step Design Framework for CMT factory 84
Fig.3.6. Structured cut-and-sewn Bra Anatomy. (*Source:* Sweetnothingsnyc by Kim Hamilton) 85
Fig.3.7. Various bra construction types. 86
Table 3.8. Cut-and-Sew, Knit and Moulded Design Processes 88
Fig.3.9. Sports Bra Silhouettes (*left to right*) Compression, Encapsulation, and Hybrid 90
Fig.3.10. Sports Bras Advanced through Technology. 91
Fig.3.11. Automated Manufacturing Process for SBW 92
Fig.3.12. Samples of 2D CADS sent to buyers and factories. 92
Fig.3.13. 3D CAD Design from photorealistic design, developing patterns and fitting in specialist software, to mocking up and fitting on the form. 93

FIG.3.14. EXAMPLES OF 3D-PRINTED BRAS. 95
FIG.3.15. MAP OF HUMAN-CENTRED APPROACHES 97
TABLE 3.16. HUMAN-CENTRED APPROACHES EXPLAINED 97
FIG.4.1. GENERIC FACTORS AFFECTING BRA EXPERIENCE CONCEPTUAL MODEL 103
FIG.4.2. MARKETING IMAGES OF MATURE WOMEN IN BRAS. 104
FIG.4.3. ONE OF THE FEW AVAILABLE IMAGES OF A MATURE BLACK WOMAN IN LINGERIE. (SOMA INTIMATES, 2018) 110
FIG.4.4. AMENDED FACTORS AFFECTING BRA EXPERIENCE CONCEPTUAL MODEL 115
FIG.4.5. BRA EXPERIENCE THEORETICAL FRAMEWORK 115
FIG.5.1. DEWEYAN PRAGMATIST FRAMEWORK AND APPROACH 126
FIG.5.2. HUMAN-CENTRED DESIGN (HCD) MAP 131
FIG.5.3. FUNDAMENTAL ASPECTS OF PARTICIPATORY DESIGN. 132
FIG.5.4. LANDSCAPE OF HUMAN-CENTRED DESIGN RESEARCH ILLUSTRATING AREA THIS STUDY OCCUPIES. 133
FIG.5.5. MODELS OF PRODUCT/GARMENT EXPERIENCE 135
FIG.5.6. BRA EXPERIENCE THEORETICAL FRAMEWORK 136
FIG.5.7. RESEARCH APPROACHES AND ACTIONS THEY FACILITATE. 141
FIG.6.1. FOUR-STAGE RESEARCH PROCESS FOR THE STUDY. 145
FIG.6.2. DIAGRAM REPRESENTING THE OBJECTIVES, METHODS, AND ACTIONS ALL SITUATED WITHIN THE FOUR-STAGE RESEARCH PROCESS AND CORRESPONDING RESULTS CHAPTERS. 146
FIG.6.3. MIXED METHOD SEQUENTIAL PROCESS 148
FIG.6.4. RESEARCH TIMELINE 149
FIG.6.5. RESEARCH SECTION OF FOUR-STAGE PROCESS. 150
FIG.6.6. AMENDED FACTORS AFFECTING BRA EXPERIENCE CONCEPTUAL MODEL. 152
TABLE 6.7. QUESTIONNAIRE DEVELOPMENT. 152
FIG.6.8. MEMOS AND MIND-MAP ANALYSING QUESTIONNAIRE. 154
TABLE 6.9. STATISTICAL PROGRAMS AND ANALYSES 155
FIG.6.10. PARTIAL ILLUSTRATION OF THE DEVISED INITIAL BWD&DP. 156
FIG.6.11. DEFINE SECTION OF FOUR-STAGE PROCESS. 157
FIG.6.12. CONTEXTMAPPING PHASES 158
FIG.6.13. IMAGE OF BRA PROBES 160
FIG.6.14. *LEFT:* ACTIVITY 1 'BRA ASSORTMENT'. *MIDDLE:* ACTIVITY 2 'MIND-MAP'. *RIGHT:* ACTIVITY 3 'BRA DESIGN' 160
FIG.6.15. MIND MAP DEMONSTRATING PART OF THE ANALYSIS TO FIND PATTERNS 161
FIG.6.16. BANNER FEATURED IN THE EVENTBRITE LISTING 162
FIG.6.17. DIGITAL DIALOGUE MIND MAPPING ANALYSIS SAMPLE. 163
FIG.6.18. BRA EXPERIENCE THEORETICAL FRAMEWORK. 164
FIG.6.19. ITERATIVE MODEL OF INQUIRY AND REFLECTIONS. 170
FIG.6.20. INITIAL BW DESIGN SKETCHES 172
FIG.6.21. DEVELOP SECTION OF FOUR-STAGE PROCESS. 174
FIG.6.22. SCREENSHOTS OF THE IDEATION ACTIVITIES. 175
FIG.6.23. SAMPLE OF ONE CONCEPT SHOWN IN THE DESIGN STAGE. 176
FIG.6.24. SLIDE SHOWCASING MULTIPLE BRA STYLES. 176
FIG.6.25. *LEFT*: PARTICIPANT RECRUITMENT POSTER. *RIGHT*: VISUAL ANALYSIS. 177
FIG.6.26. AVATAR OF FIT MODEL CLARY CREATED IN CLO3D. 178
FIG.6.27. EMOTIONAL RESPONSE QUESTIONS AND EMOCARDS 179
FIG.6.28. BRA WEARABLES ADJECTIVES 180
FIG.6.29. ANALYSIS OF FIT INTERVIEWS. 180
FIG.6.30. ANALYSIS OF EMOTIONS AND ADJECTIVES. 181

FIG.6.31. DIGITAL NOTES DURING PRODUCT DEVELOPMENT. 182
FIG.6.32. THREE STAGES IN DEVELOPING AN EXPERIENCE-CENTRED ANNOTATED PORTFOLIO 183
FIG.6.33. EXPERIENCE-BASED BRA DESIGN ANNOTATED PORTFOLIO ANALYSIS. 183
FIG.6.34. COLLABORATIVE REVIEW ANALYSIS USING MIND MAPPING. 185
FIG.6.35. REFLECT SECTION OF THE FOUR-STAGE PROCESS. 186
TABLE 6.36. PARTICIPANTS THROUGHOUT THE STUDY. 188
FIG.6.37. RESEARCHER POSITIONING INSIDER/OUTSIDER 190
FIG.6.38. PHOTOS FROM REFLECTIVE JOURNALS. 190
TABLE 7.1. CHART ILLUSTRATES THE *RESEARCH* STAGE AND THE CORRESPONDING RESULT SECTIONS DISCUSSED IN CHAPTER 7. 199
TABLE 7.2. DEMOGRAPHIC STATISTICS 201
FIG.7.3. BRA SAMPLES AND COLOURS SHOWN IN QUESTIONNAIRE. 204
TABLE 7.4. CONSTRUCTS FOR BRA EXPERIENCE. 205
FIG.7.5. DESCRIPTIVE STATISTICS 206
FIG.7.6. GENERIC FACTORS AFFECTING BRA EXPERIENCE CONCEPTUAL MODEL 207
FIG.7.7. VALIDATED FACTORS AFFECTING BRA EXPERIENCE CONCEPTUAL MODEL 208
FIG.7.8. TECHNOLOGY ACCEPTANCE MODEL 209
TABLE 7.9. CONSTRUCTS FOR BWTAM 210
FIG.7.10. SUMMARY OF MEASUREMENT SCALE 211
FIG.7.11. THE BWTAM STRUCTURAL MODEL 214
FIG.7.12. CONFIRMED BWTAM CONCEPTUAL MODEL 214
FIG.7.13. STRUCTURED BRA D&DP FROM RESEARCH. 216
FIG.7.14. REAL-WORLD STRUCTURED BRA D&DP. 217
FIG.7.15. FUNCTIONAL SPORTS BRA D&DP 218
FIG.7.16. SPORTS BRA WEARABLES (SBW) D&DP 219
FIG.7.17. SMART CLOTHING D&DP 220
FIG.7.18. IMAGE ILLUSTRATING A COMPARATIVE PROCESS ANALYSIS. 221
FIG.7.19. PART 1: THE INITIAL BRA WEARABLES DESIGN AND DEVELOPMENT PROCESS (BWD&DP) 224
FIG.7.20. PART 2: THE INITIAL BRA WEARABLES DESIGN AND DEVELOPMENT PROCESS (BWD&DP) 225
FIG.8.1. CHART ILLUSTRATES THE *DEFINE* SECTION METHODS, ANALYSIS, AND OUTCOMES IN THE RESEARCH PROCESS. 229
FIG.8.2. BWD&DP COVERED. 230
FIG.8.3. IMAGES FROM ACTIVITY BOOKLET WITH PARTICIPANTS MARKS 232
FIG.8.4. BRA EXPERIENCE THEORETICAL FRAMEWORK. 240
FIG.8.5. BRA-WEARING EXPERIENCE MIND-MAP. 243
FIG.8.6. WEARER METHODS RESULTS LINKED 253
FIG.8.7. FSEA MODEL UPDATED WITH THE BRA EXPERIENCE THEORETICAL FRAMEWORK. 254
TABLE 8.8. FUNCTIONAL, STRUCTURAL, EXPRESSIVE, AND AESTHETIC (FSEA) MAPPING OF CODES 256
TABLE 8.9. DESIGN CRITERIA 259
TABLE 8.10. INTERACTION MATRIX OF DESIGN CRITERIA – O= NO CONFLICT, ✓ = ACCOMMODATIONS, ✕ = CONFLICT 260
FIG.8.11. DESIGNERS' WORK DESK 262
FIG.9.1. CHART ILLUSTRATES THE *DEVELOP* SECTION METHODS, ANALYSIS, AND OUTCOMES IN THE RESEARCH PROCESS. 267
FIG.9.2. BWD&DP COVERED. 269
FIG.9.3. CONCEPTS PRESENTED IN DESIGN WORKSHOP 271
FIG.9.4. TESTING BATTERY PLACEMENT ON THE BODY. 272
FIG.9.5. STYLE BOARD 273
FIG.9.6. DESIGN CONCEPTS ARE SHOWN AS FLAT CADS. 273

FIG.9.7. DIGITAL FIT MODEL MEASUREMENTS IN CLO3D WITH MODEL MEASUREMENTS WITHOUT A BRA. 274
FIG.9.8. BRA DESIGN ATTEMPTED IN CLO3D. 275
FIG.9.9. PARTICIPANTS AS AVATAR FIT MODELS. 276
FIG.9.10. ANALYSIS OF EMOTIONS AND ADJECTIVES. 277
FIG.9.11. IMAGES DEMONSTRATING DRAPING ON FORM, PATTERN LAYOUT, AND SCANNING TO DIGITAL FORMAT. 281
FIG.9.12. PATTERNS ARE ACTUALISED AND ADJUSTED IN ADOBE ILLUSTRATOR. 281
FIG.9.13. PATTERNS DIGITALLY PRINTED, CUT ON PAPER AND CALICO, AND THEN REFITTED. 282
FIG.9.14. IMAGES SHOWCASING THE PROCESS FOR LUISIA MOVING FROM DIGITAL TO DRESS FORM, MANNEQUIN, AND PAPER. 282
FIG.9.15. STEPS TO DEVELOPING LUISIA HARDWARE AND SOFTWARE TECHNOLOGY. 283
FIG.9.16. DEVELOPING THE LUISIA PROTOTYPES. 283
FIG.9.17. DEVELOPING LAVINIA PROTOTYPES. 284
FIG.9.18. DEVELOPING 3D HAND-PRINTED EMBELLISHMENTS. 285
FIG.9.19. INVESTIGATION OF TPE FILAMENT COLOURING. 285
FIG.9.20. IMAGES SHOWING THE PATTERN PIECES, FASTENINGS, AND CLOSURE FOR THE LUISIA AND LAVINIA BRA PROTOTYPES. 286
FIG.9.21. TRADITIONAL TECHNIQUES MIXED WITH TECHNOLOGY 286
FIG.9.22. TESTING 3D PRINTING PENS. 287
FIG.9.23. INTEGRATING TECHNOLOGY. 287
FIG.9.24. BWD&DP ANNOTATED PORTFOLIO THEMES 288
FIG.9.25. EXAMPLES OF PROTOTYPES ON THE DRESS FORM. 293
FIG.9.26. OVERARCHING THEMES FROM THE COLLABORATIVE REVIEW FOCUS GROUP. 294
FIG.9.27. SLIDES FROM THE FOCUS GROUP ILLUSTRATING THE LAVINIA DESIGN ON THE DIGITAL FIT MODEL, DRESS FORM, AND FIT MODEL. 295
FIG.9.28. THE SOLAR PANEL BIKINI. (ANDREW SCHNEIDER, 2011) 297
FIG.9.29. SLIDES FROM THE FOCUS GROUP ILLUSTRATING THE LUISIA DESIGN ON THE DIGITAL FIT MODEL, DRESS FORM, AND FIT MODEL. 299
FIG.9.30. PERCEIVED PROTOTYPE EXPERIENCE THROUGH THE FOUR PLEASURE FRAMEWORK 300
FIG.9.31. BWFSEA CONSUMER NEEDS MODEL 301
FIG.10.1. CHART ILLUSTRATES THE *REFLECT* SECTION METHODS, ANALYSIS, AND OUTCOMES IN THE RESEARCH PROCESS. 309
TABLE 10.2. RESEARCH OUTCOMES MAPPED 310
FIG.10.3. UPDATED BWD&DP 314
TABLE 10.4. VALIDATION QUESTIONS (*TOP*) AND RESULTS (*BOTTOM*). 320
FIG.10.5. ARTISANAL FASHION APPROACH (*BLACK*) AND BW (*GOLD*) SIMILARITIES. 322
FIG.10.6. CONSTRUCTION OF EMPATHIC UNDERSTANDING IN DESIGN. 325
FIG.10.7. EMPATHIC CONCEPTUALISATION THROUGH THE FOUR-STAGE RESEARCH PROCESS. 326
FIG.10.8. BWD&DP SHOWCASES AREAS WHERE EMPATHY OCCURS (*GOLD CIRCLE*). 330
FIG.10.9. WEARER AND DESIGN-RESEARCHERS EXPERIENCE THROUGHOUT. 333
FIG.10.10. FOUR-STAGE RESEARCH MODEL DEMONSTRATES PATHS TO ORIGINAL CONTRIBUTIONS TO KNOWLEDGE. 334
TABLE 11.1. ACCOMPLISHING THE AIMS AND OBJECTIVES. 342
FIG.C.1. ASSORTED DESIGN PROCESSES. 411
FIG.C.2. PROCESS FOR A SMART WATERPROOF JACKET. 412
FIG.D.1. EXEMPLARS OF ASSESSMENT INDICATORS 414
FIG.G.1. *LEFT:* PAGE FROM A PARTICIPANTS' WORKBOOK. *RIGHT*: LATENT NEEDS MODEL*. 424
FIG.J.1. WORDS TO DESCRIBE MENOPAUSE (*N* = 206) 444
TABLE J.2. AGE AND MENOPAUSE EXPERIENCE ON FEMININITY, SEXUALITY, AND FEELING WOMANLY 444
TABLE J.3. MATURE WOMEN'S BREAST AND BRA EXPERIENCE 446

TABLE J.4. BRAS APPROPRIATENESS 447
TABLE J.5. COLOUR APPROPRIATENESS 448
TABLE J.6. CONSTRUCTS FOR BRA EXPERIENCE. 449
TABLE J.7. SHAPIRO-WILK TEST RESULTS 450
TABLE J.8. SPEARMAN'S RHO CORRELATION MATRIX 450
TABLE J.9. MANN-WHITNEY U TEST BETWEEN BLACK AND WHITE WOMEN'S DEMOGRAPHICS 452
TABLE J.10. MEAN RANK RESULTS 452
TABLE J.11. AGE AND MENOPAUSAL EFFECT ON BLACK AND WHITE WOMEN 453
TABLE J.12. MANN-WHITNEY U SIGNIFICANCE ON AGE AND MENOPAUSAL EFFECT ON BLACK AND WHITE WOMEN 453
TABLE J.13. MANN-WHITNEY U MEAN RANK RESULTS 454
TABLE J.14. MANN-WHITNEY U RESULTS 455
FIG.J.15. GENERIC FACTORS AFFECTING BRA EXPERIENCE CONCEPTUAL MODEL 456
FIG.J.16. DESCRIPTIVE STATISTICS 458
TABLE J.17. AVERAGE VARIANCE EXTRACTED (AVE) AND FORNELL-LARCKER CRITERION 459
TABLE J.18. HETEROTRAIT-MONOTRAIT RATIO (HTMT) 459
FIG.J.19. BRA-WEARING EXPERIENCE STRUCTURAL (CONCEPTUAL) MODEL 460
TABLE J.20. PATH COEFFICIENTS 460
TABLE J.21. SPECIFIC INDIRECT EFFECTS 461
TABLE J.22. CONSTRUCTS FOR BWTAM. 462
TABLE J.23. KMO AND BARTLETT'S TEST OF SPHERICITY 462
FIG.J.24. SUMMARY OF MEASUREMENT SCALE 464
TABLE J.25. CRONBACH ALPHA (A), COMPOSITE RELIABILITY (CR), AVERAGE VARIANCE EXTRACTED (AVE) AND FORNELL-LARCKER CRITERION 468
TABLE J.26. HETEROTRAIT-MONOTRAIT RATIO (HTMT) 468
TABLE J.27. COLLINEARITY VALUES INNER STATISTICS (VIF) 469
FIG.J.28. BRA WEARABLES STRUCTURAL MODEL 469
TABLE J.29. BRA WEARABLES STRUCTURAL MODEL IN CHART FORM 470
TABLE J.30. BW STRUCTURAL MODEL F-SQUARE RESULTS 470
TABLE J.31. R^2 AND R^2 ADJUSTED VALUES 471
TABLE J.32. SPECIFIC INDIRECT EFFECTS 471
FIG.L.1. PROGRESSION CHART ILLUSTRATING THE CYCLICAL SEQUENCE 477
FIG.L.2. TRADITIONAL MOOD BOARD 'MASTERING BAROQUE' (TOP) AND MASSAGE BRA EXPERIENCE MAP (BOTTOM). 480
FIG.L.3. EMBROIDERY EXPLORATION. 482
FIG.L.4. 3D PRINTING PEN MOTIFS AND DESIGN EXPLORATION. 483
FIG.L.5. THE DESIGN-RESEARCHERS' FIRST-PERSON EXPERIMENTAL EXPERIENCE OF HOT FLUSHES. 484
FIG.L.6. A SELECTION OF EMPATHY EXPLORATIONS THROUGH SKETCHING THE MW'S BODY. 486
FIG.L.7. EARLIEST CROQUIS STUDY 487
FIG.L.8. INTEGRATION OF MULTIPLE STAGES IN EARLY PROTOTYPING 488
FIG.L.9. ARDUINO BOARDS, AN AFFORDABLE DUPLICATE BOARD CALLED UNO, AND LED STRIP SAMPLE. 490
FIG.L.10. CODING AND WIRING IMAGES FOR LEDS WITH PUSH BUTTON AND A TEMPERATURE SENSOR WITH READINGS 491
FIG.L.11. IMAGES SHOWING MASSAGE POINTS ON THE BODY (*LEFT*) AND SKETCHING NOTES FOR A MASSAGE BRA (*RIGHT*) 492
FIG.L.12. MOTOR EXPLORATION AND INTEGRATION WITH EMBROIDERY 492
FIG.L.13. VIBRATION COIN MOTOR EXPLORATION, SCHEMATICS, AND CALICO LAYOUT 493
FIG.L.14. SAMPLES OF RESISTIVE SUBSTRATES USED IN DETECTING SLIGHT BREATHING. 494
TABLE L.15. SUBSTRATES STRETCHED AND RELAXED 495
FIG.L.16. COOLING POINTS ON THE BODY (*LEFT*) AND SKETCHING NOTES FOR A COOLING BRA (*RIGHT*) 497

FIG.L.17. PELTIER SCHEMATICS AND WIRING CONNECTION 497
FIG.N.1. ANALYSIS OF EMOTIONAL CHARTS 504
FIG.N.2. ANALYSIS OF FIT MODELS RESPONSES 505
FIG.N.3. FIT MODELS DESIGN EMOTION WORD CLOUD 506
FIG.P.1. AMENDED BWD&DP 508
FIG.P.2. AMENDED BWD&DP CHART WITH POTENTIAL STAKEHOLDERS AND INPUT 510
TABLE R.1. EXPERT VALIDATION QUESTIONS 515
TABLE R.2. EXPERT VALIDATION PARTICIPANTS 515
TABLE R.3. SUMMARY OF EXPERT VALIDATION RESULTS 516
FIG.U.1. GOOGLE SEARCH SHOWING SMART BRA RESULTS 526
FIG.U.2. TOP SMART BRA RESULT FROM A GOOGLE SEARCH 526
FIG.U.3. ANOTHER EXAMPLE OF A TRADITIONAL BRA MARKETED AS A SMART BRA 527

Glossary, Acronyms and Definitions

TERMS	ACRONYMS	DEFINITIONS
Everyday/Traditional/ Foundational Bra		An engineered structured breast-supporting product with over 42 pieces in a variety of cup silhouettes, styles and fabrics designed for non-rigorous daily activities.
Sports Bra		A knit fabricated bra explicitly designed for the engagement of physical activities. The sports bra comes in three bodies: an encapsulation bra, where the breasts are separated like an everyday bra but constricted; a compression bra, where the breasts are housed together in a high neckline design with a high level of restriction in movement; and a hybrid/combination bra, which is a mixture of both a compression and encapsulation style.
Advanced Bras		Bras advanced through technology having 3D printed materials or made from technologically enhanced materials or machinery.
Smart Bra		A bra enhanced with passive 'smart' capabilities able to sense stimuli and react providing minimal feedback through phase-change, shape-memory, or colour-change.
Wearable Technology		'… any electronic device that is small enough and light enough to be worn or carried on the body' (Timmins and McCann, 2015, p. 187).
E-Textiles		'Wearable technology that is woven/sewn into clothing and operated/controlled by an integrated control panel or operation button' (Timmins and McCann, 2015, p. 187).
Sports Bra Wearables	**SBW**	A sports bra enhanced with mechanical and electrical components.
Bra Wearables	**BW**	A technologically advanced bra with 'smart' capabilities able to sense and react to stimuli from the body through mechanical and electrical components.
Mature Women	**MW**	Women between the ages of 45 and 65, according to prior research (Birtwistle and Tsim, 2005; Risius et al., 2012).
Wearer		Wearer is used to describe the women in the design process. The terminology 'wearer' is more apt as the focus is on the women's multifaceted experience and interaction with BW, unlike the term 'user', which tends to focus on the usability and functionality of the product.
Design and Development Process	**D&DP**	The industrial process of generating ideas for a product using systematic stages towards creation. Process usually follows problem statement/identification, conceptual design, prototype development, evaluation, and production.
Technology Acceptance Model	**TAM**	TAM 'is one of the most popular theoretical models for investigating consumer's acceptance of technology. [Utilising] perceived ease of use and perceived usefulness, [as] primary predictors for consumers' adoption of technology' (Perry, 2016, pp. 171-2).
Functional, (Structural), Expressive, Aesthetic Consumer Needs Model	**FSEA/FEA**	'… a teaching tool to facilitate the design research and evaluation stages of the apparel design process' (Orzada and Kallal, 2021, p. 26)
Human-Centred Design	**HCD**	'In […] (HCD), researchers and designers attempt to cooperate with or learn from potential users of products or services which they are developing. Their goal is to develop products that match users' practices, needs and preferences' (Steen, 2011, p. 45).
Human-Computer Interaction	**HCI**	'HCI addresses the interaction between a human and a computer' (McCarthy and Wright, 2004, p. 10).
Experience-Centred Design		'Experience-centred design is concerned with designing for the richness of human experience with the wide variety of new technologies and media that are available' (Wright and McCarthy, 2010, p. 2). 'It can and should attempt to impact people's lived experience in ways that are socially, politically, and personally meaningful' (Wright and McCarthy, 2010, p. 9).
Experience		'For Dewey, experience is constituted by the relationship between self and object, where the self is always already engaged and comes to every situation with personal interests and ideologies' (McCarthy and Wright, 2004, p. 17). '… felt experience points to the emotional and sensual quality of experience' (McCarthy and Wright, 2004, p. 13).

Practice Research		'Practice research in design is a form of networked, constructive knowledge production and practice development. […] It results in the production of new concepts/designs and new knowledge, relevant to and for assessment by the community in the situation, as well as in new concepts/designs and new knowledge for design practice and for design research' (Kaszynska, Kimbell, and Bailey, 2022, p. 3).
Research-*through*-Design	**RtD**	'… design activities that play a formative role in the generation of knowledge […] gaining actionable understanding of a complex situation, framing and reframing it, and iteratively developing prototypes' (Stappers and Giaccardi, 2017, Section 4.3.1.4.)
Research-*through*-Experience-Centred-Design	**RtXD**	'… often involves intervening in a system and documenting and analyzing what happens and what can be learned from it. […] It involves the researcher as an agent in the situation being studied, taking some action in the situation to evaluate the action or throw light on how the situation is understood' (Wright and McCarthy, 2010, pp. 91-2).
Research-*for*-Design	**RfD**	'… conducting studies to learn specific information about the situation for which design is made' (Stappers and Giaccardi, 2017, Section 4.3.1.3.).
Research-*for*-Experience-Centred-Design	**RfXD**	'As well as producing artifacts or systems […] experience-centred design projects are also geared toward understanding user experience and the design process' (Wright and McCarthy, 2010, p. 87).
Bra Experience Theoretical Framework		A theoretical framework created in this study through the scaffolding of existing experience-centred theories to aid in understanding the multifaceted bra experience.
Factors Affecting Bra Experience Conceptual Model		A conceptual model developed from Hart and Dewsnaps (2010) argument that the bra is connected to the wearer through functional, physiological, psychographic, psychological, economic, and psychosocial factors. The developed model illustrates the relationship between sense-of-self factors and bra-wearing for mature women.

1

1. INTRODUCTION

Chapter 1 introduces my personal motivation as a designer (1.1.), the research context (1.2.), scope (1.3.), difficulty designing and developing smart clothing (1.4.), need for exploring a new path (1.5.), and the aims and objectives (1.6.). The chapter further acquaints the reader with the practice and research approach (1.7.), audience (1.8.), thesis structure (1.9.), contributions to knowledge (1.10.), and the boundaries within the study (1.11.).

1.1. Personal Motivation

'Innovation, after all, breeds inequity, not inevitably, but predictably'.
(Benjamin, 2022, p. 17)

1.1.1. Background as a Designer

My educational and professional background is fashion-based, beginning the journey at 15 years old while attending the High School of Fashion Industries in New York City (NYC). Besides the basic disciplines, I was acquainted with designing general fashion; however, the lingerie field drew my attention. The intricacy and skills needed fascinated and challenged me. Moreover, specialising in lingerie design at the Fashion Institute of Technology (FIT) between 2006 and 2009, introduced me to developing bespoke couture pieces. These one-offs formed my penchant for well-made designs that told a story, captured an emotion, and aroused the wearer. Nevertheless, once I graduated, I set my sights on working within the NYC lingerie manufacturing industry rather than starting a brand. This experience of working in a fast-paced environment where designs were created digitally and then sent off to East Asia to be manufactured was disassociating. Collections were constantly developing, with hundreds of units manufactured per style, including numerous colourways. There were many instances where I never saw the final production of a design, already attending to newer seasons. Companies varied, and as I progressed to head designer, I was removed from the day-to-day development and was only made aware when issues arose[1].

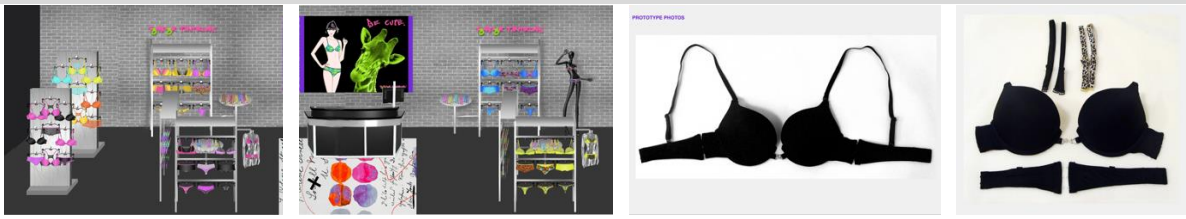
[1] Researchers have documented the designer's decreasing involvement past the concept and prototype development phase in large-scale manufacturing processes (Sinha, 2002; Gwilt, 2011).

Reflecting on the experience, I can discern how the environment can be damaging[2] to designers; however, I enjoyed the pace and continuously pushed to develop newer ideas. Not all the designs fared well, and I wanted to understand *why*. This piqued my interest as some styles and colours sold well in different parts of the U.S. and not so well in others. While seasonally and culturally, the areas are different, I was interested in what other factors contributed, such as breast size, relationship status, and particularly age and 'race'[3].

My growing interest in the consumer led me back to school for a Master's in merchandising and management at the Academy of Art University (2010-2013). During the three-year programme, I focused on the tween/teen[4] intimates' market, researching their bra needs and investigating the current market offerings. During the study, I realised that age, which was not definitively demarcated in the industry, affects the consumers' buying options and sense-of-self, specifically identity. Tween/teen girls' intimates were marketed according to identity proxies – *sporty* via Victoria's Secret Pink Label, *all-American* via Gilly Hicks, *girl next* door via Aerie, and *edgy* via Hot Topic. My study uncovered that this demographic felt compelled to wear and associate their underwear with their identity.

1. and 2. Images of potential store layout.
3. Image of modular push-up bra assembled.
4. Image of modular prototype disassembled.

Fig.1.1. Master's research project.
Source: Gosler, 2013



As a designer and wearer, I approach lingerie with curiosity and through experimentation. Wanting to provide the tween/teen participants with a similar experience, during the Master's study, I developed a DIY (Design-It-Yourself) bra (**Fig.1.1.**). The premise was that various components that made up a bra (i.e., straps, cups, wings, and trimmings) could easily be mixed-and-matched, enabling the wearer to experiment with assorted styles. By prototyping this concept, I became interested in adding advanced technology to the bra, which would facilitate modularity. My supervisor advised me to patent my idea, introducing me to the United States Patent Database. Sifting through bra patents online, I became acquainted with inventive ideas open to innovative advancements. I developed a unique design and marketing concept with this new information and the degree programme's goal.

[2] The production environment induces burnout (Cochrane, 2015; Singer, 2015; Mondalek, 2019) and disillusionment in designers. Not only is there a distance between the designer and their creations, but the speed of new designs can prompt detachment. In my career, I have witnessed several designers leave the field, with this being one reason.
[3] This study places the word 'race' in quotations per the American Anthropological Associations' policy that the word is a social construct with no substantial or legitimate definition (Cruz and Duplass, 2009).
[4] Tween/teen refers to the market for young girls between 11 and 18.

Unfortunately, applying it in the real world was challenging. Although my degree enabled me to progress as a lingerie designer and merchandiser, the company I worked for lacked interest in the research and development needed to experiment with my new concept. Through speaking with colleagues at companies on similar and mid-market tiers, I learned that many companies were not interested in experimenting with new ideas due to cost, time, or lack of access to necessary facilities. My professional limitations were recognised; however, the Master's degree sparked a yearning for more knowledge and experimentation.

1.1.2. Design Vision and Approach

My approach to designing and lingerie is constantly evolving. It is both personal and extrinsic, with a need to be creative and a desire to share that with wearers. The products' aesthetic has always been a focal point, as wearers are engaged through the first look. It is also the aesthetic that is central to industry buyers. Nevertheless, as I endeavour to understand the consumer, my focus has shifted to apprehending their sensorial and emotional experience *with* lingerie. During my Master's, the research demonstrated that tweens/teens wore bras earlier and required larger sizing options. However, a limited number of bra brands aimed at that demographic forced them to purchase brands catered to older demographics. I wondered how they experienced these brands and the effect on how they saw themselves. Furthermore, I began to query whether this phenomenon was the same for women of varying ages. As I continued designing, I created scenarios about the wearers and wanted my designs to enrich their lives apart from wearing a beautiful bra set.

1.1.3. My Interest in Fashion Technology

My introduction to fashion technology was serendipitous. One afternoon, while receiving acupuncture, I wondered whether a bra could access these pressure points, allowing me to continue my day. That evening marked the beginning of my research journey into smart bras. The concepts I found, such as breast cancer-detecting bras, were inspirational but not aesthetically appealing. They looked more sci-fi and like a piece of machinery than an actual bra or, at the very least, something wearable. I queried how wearers were supposed to be interested in such a garment. Even if the functionality was effective, would most wearers be interested aesthetically? How would they feel wearing such a garment in social or professional spaces? How would the garment make them feel about themselves? On the other hand, I queried *why* the garment was designed this way. What were the missed opportunities? While I had minimal understanding of the hardware and technology aspect, I queried how my bra expertise and desire to understand the criticality of the wearers' experience could benefit this developing field.

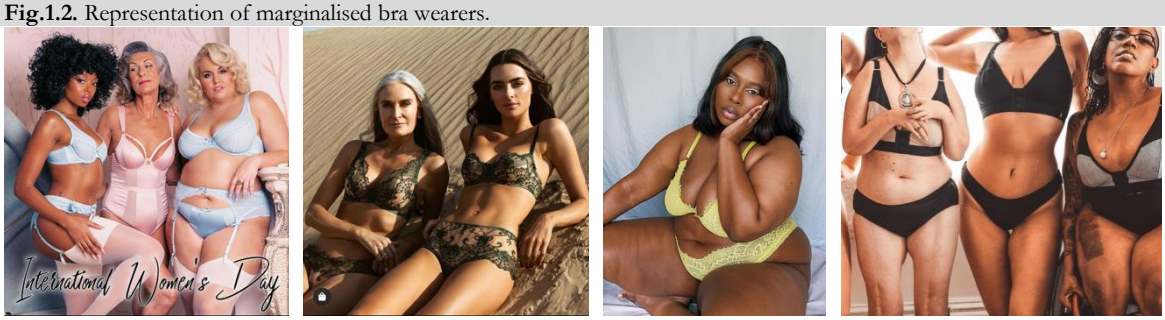
1.1.4. My Concern as a Designer

My 12 years as a designer and merchandiser provided lived experiences and comprehension of how the industry operates. This has led to several concerns as a designer for the evolution of smart bras and Bra

Wearables. The first concern is the development of under-researched products that repel wearers and deter them from the burgeoning field. The second concern is the lack of comprehension and guidance in designing and developing products. Due to the complexity of designing and manufacturing products, the lingerie industry is slow to change (Section 3.4.). Therefore, introducing new products requires valuable research, guidelines, and insights. The third concern, and not the least important, is the fear of further exclusion of marginalised bra wearers. Since 2015, the industry has slowly begun developing products for marginalised women such as disabled, larger, and older women (**Fig.1.2.**). However, the traditional design process (DP) focuses on the product, leading to this study's hypothesis that a new DP is necessary to centre the wearers and enable more insights into their wants, needs, and experiences.

1. Playful Promises, @PlayfulPromises,
2. ID Sarrieri, @Idsarrieri,
3. Uye Surana, @Uyesurana
4. Intimately, 2020

Fig.1.2. Representation of marginalised bra wearers.



1.2. Research Scope

As prior research has yet to document the design and development process (D&DP) of a cut-and-sewn smart bra, specifically Bra Wearables (BW), this thesis endeavours to provide insight into the process. The bra field and consumer base are exceptionally vast[5]; therefore, this research concentrates on designing and developing BW for the mid-tier range foundational bra. The types of fabrications, designs, and design processes will develop from that of the mid-tier range. The bra D&DP deviates based on the bra shape, style, and type of bra: knit, moulded, and cut-and-sewn (Hardaker and Fozzard, 1997), as illustrated in Section 3.2. and Appendix A. This research focuses on the cut-and-sewn bra, the number two bra construction sold in the U.K. (Dover, 2018). Furthermore, developing a cut-and-sewn bra is more accessible due to the availability of the necessary machinery. Lastly, the concentration is on mature Black[6] and white women, aged 45-64 years, in Western societies (i.e., the U.S. and U.K.).

[5] The bra market in the U.S. alone is $7.2bn (Barrie, 2019) with approximately six categories and 30+ styles and shapes (Appendix A), catering roughly to 135m (D. I. S. US Census Bureau, 2017) women between the ages of 15-85+.
[6] *IMPORTANT* I capitalise 'Black' when referring to one group of women as it is meant to represent the vast array of African diasporic cultures – Nigerians, Ghanaians, Jamaicans, Brazilians, etc., – within both the U.S. and U.K. 'When speaking of a culture, ethnicity or group of people, the name should be capitalized. Black with a capital B refers to people of the African diaspora. Lowercase black is simply a color' (Tharps, 2014). I do not capitalise the "w" in white women as I am referring to the grouping of women by their skin colour.

This study is not focused on whether there is a need for BW – but proceeds from the understanding that brands, designers, and researchers are already developing and attempting to advance BW products. Therefore, I advance from the postulation that direction and guidelines are necessary if this field progresses.

1.2.1. Invisibilised Women in the Bra Industry

Like the fashion industry, the bra industry centres on the young, able-bodied, idyllically beautiful, and thin white population (Tiggemann and Lynch, 2001; Holmlund, Hagman and Polsa, 2011). Western lingerie research similarly concentrates on younger, middle-class white women. This insularity produces a gap in designing for diverse women and researching their experiences, rendering them invisible. This research focuses on two areas of marginalisation: 'race' and age. The lingerie industry[7] and bra research field rarely centre Black women. To date, only one Western study, 'Women, Clothing Size and Inequality' (Bishop, Gruys and Evans, 2018), has dominantly included Black women in their bra research. However, the study does not discuss 'race' as a factor in their experience[8].

Similarly, there are limited images of mature women (MW) in lingerie and fewer brands designing products for them[9]. The limited bra research on MW notes dissatisfaction with the fit and design due to changes in their breasts and body (Risius, 2012; Kim, Kim and Ashdown, 2014; Risius *et al.*, 2014). Dissatisfaction can also be attributed to a size issue, as larger-breasted women face difficulty finding bras that are fashionable, comfortable, and fit (Filipe *et al.*, 2015). Menopause may increase breast size (Voda, Christy and Morgan, 1991; Chrisler and Ghiz, 1993), causing MW[10] to be neglected based on age and breast size.

Therefore, insights are needed into the specific experiences of mature Black women.

1.2.2. Experience *of* and *with* Clothing

There have been several studies on the experience of clothing for ageing men (Sadkowska, 2018), Black men (Spencer, 2022), men's underwear (Clancy and Barry, 2022), men's clothing (Barry and Martin, 2016), plus-size men (Thompson, 2020), plus-size women (Peters, 2014), and mature women (Holmlund, Hagman and Polsa, 2011; Mohylsky, 2011; Peters, Shelton and Thomas, 2011; Romans, 2018). However, a gap exists in understanding women's undergarments and Black women's clothing experiences (Davis, 2015;

---

[7] In 2014, Nubian Skin successfully launched a range of bras in skin tones for darker women, which led many brands to do so as well. It began a lingerie movement to change the way brands market beige bras referring to them as "nude" when the colour only represents white skin. One of the largest bra sellers, Marks & Spencers, recently introduced a wider range of nude bras in 2021(Morris, 2021). The significance of this can only be understood when placed in the context of the beige bra being almost 100 years old.

[8] Does 'race' matter in bras? After examining 180 women (90 Asian/ 90 white) Bra researcher, Shin (2009, 2014), asserts that there are ethnic differences in body shape that affects bra fit, thus affecting the bra experience. This may also extend to Black women, although it has not been researched.

[9] Does 'age' matter in bras? Bra researchers Ashdown and Na (2008) discovered differences in upper torso measurements that affect bra fit after examining 80 women (40 women between 19-35 years/ 40 women over 55 years). Hence, this indicates that mature women need bras designed specifically for their ageing bodies (Risius, 2012; Sharland, 2018).

[10] This research does not intend to interrogate breast size and the difficulties in designing or fitting plus-size bras; however, breast sizing does impact bra experience. Therefore, it is noted where mentioned by the participants.

Matthews, 2020). Clothing is influenced by socio-cultural norms, meaning different cultures have different ways of understanding and experiencing clothes (Roach-Higgins and Eicher, 1992). Clothes allow people to express individuality or conform, as it communicates a message about who the wearer is and their beliefs (Entwistle, 2015). Therefore, it is imperative to understand how various wearers experience diverse types of clothing.

Wearers navigate and understand clothing through embodied experiences (Valle-Noronha, 2019). The multisensory perception of clothing (i.e., sight, smell, sound, touch) is vital to comprehending experience (Chong Kwan, 2016; Burcikova, 2019). Burcikova (2019) maintains that the clothing experience is complex, intertwining facets of design, wearer expectations and relationship to clothing.

Quinn (2012, p. 32) posits that 'Future fashions will […] be inextricably intertwined with our experiences of wearing them'. However, smart clothing is complex, with many obstacles ranging from technical design to designing for the social facet, such as social acceptability and the physical, physiological, and psychological nature of the wearing experience (Dunne, 2010). Dunne and Smyth (2007) argue the significance of understanding the smart clothings' impact on wearers' sense-of-self when developing concepts. Many smart garments do not make it to market because they are not well-tested, the design is not attractive, or the device was not considered for how it will affect the person wearing it (Ariyatum, 2005; Toussaint, 2018). Thus, smart clothing may have commercial potential if wearers can provide critical assessments and experiential insights during the DP prior to production (Cranny-Francis, 2013). Toussaint (2018, p. 19) asserts that smart clothing will 'strongly affect how people communicate, behave and relate to themselves and to others'. Thus, bringing wearers into the DP may provide a better understanding of the social concerns (Tomico *et al.*, 2017).

To design *for* a clothing experience, an understanding is needed of how people experience clothing and the various factors that influence the clothing experience. Several factors can influence the clothing experience, including the clothing itself, the environment, the person's past clothing experiences, socio-cultural norms, and the interaction between all these elements (Roach-Higgins and Eicher, 1992; Woodward, 2005; Niinimäki, 2011; Entwistle, 2015). However, Valle-Noronha (2019, p. 7) assert that there are 'few considerations on the experience between wearer and [clothes] articulated at a theoretical level with little applications to practice'. To investigate clothing experience, a philosophical perspective that allows for positioning and understanding of experience applicable to practice is advantageous (Chapter 5). Deweyan Pragmatism postulates that experience is continuous and connected (Dewey, 1997). It contends that our experiences shape our understanding of the world. Therefore, the wearers' past clothing experiences inform how they experience future products. Similarly, Niinimäki and Koskinen (2011) argue that designers should understand wearers' past experiences to develop future products that provide a pleasurable experience. Therefore, designers and researchers must shift the focus, centring the wearer's experiences in order to design and develop pleasurable smart clothing.

1.3. Contextualising the Research

The research field uses a variety of terms to discuss clothing with added technology, such as 'Techno-Fashion' (Toussaint, 2018), 'Fashionable Technology' (Seymour, 2008), 'Fashionable Wearables' (Kaner and Coşkun, 2017), 'Wearable Fashion' (Hosomi, Tsukamoto and Nishio, 2007; Li *et al.*, 2017), and 'Smart Clothing' (Cho, Lee and Cho, 2009; Suh, Carroll and Cassill, 2010). The terms do not differentiate by garment or types of technology incorporated, rendering them a catch-all. As the research resides within this space, it is significant to specify terminology. Throughout this research, I use *wearable technology*[11] and *smart clothing,* referring to the broader technology field in fashion. Similarly, the study uses the term *smart bra* to reference bras with technological functions as an umbrella terminology. However, it is essential to note that the term smart bra is muddied as the media uses it to reference any advanced bra. Therefore, I introduce the new term *Bra Wearables* (BW) to focus on bras specifically enhanced with electrical, mechanical, and chemical materiality (Section 2.2.).

1.3.1. Bra Wearables (BW) Introduction

1. Hussein Chalayan, *One Hundred and Eleven*, 2007
2. Hussein Chalayan, *Airborne Dress,* 2007
3. Iris Van Herpen, *Hypnosis*, 2019
4. Iris Van Herpen, *Syntopia,* 2018
5. Chromat, *Momentum,* 2015

Fig.1.3. Examples of Wearables Fashion Designers.

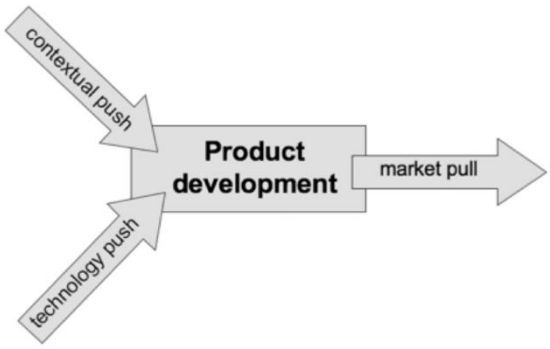
Fashion has continuously experimented with technology, using it to inspire designers both within the design of garments and in runway presentations, as seen in designs by Hussein Chalayan, Iris Van Herpen, and lingerie brand Chromat (Stead, 2005; Seymour, 2008; Clarke and Harris, 2012), see **Fig.1.3**. Technology symbolises the future and ideas of a futuristic utopia propelled by science fiction and fantasy films and high fashion ads. Bras have always had an intertwined relationship with technology since its early inception (Farrell-Beck *et al.*, 1998), evolving due to technological advancements in machinery, fabrics and design elements, such as bra closures, underwires, and padding (Shin, 2009). Forward-thinking lingerie and swimwear brand Chromat[12] 'believe[s] garments will be able to adapt and respond to your body and the

[11] I designate the term 'wearables fashion' to refer to runway and editorial designs, while 'smart clothing' relates to clothing designed to be worn in social/professional occasions.
[12] In 2015, Chromat was the first lingerie brand to introduce 3D body scanning, VR, 3D printed, responsive and technology infused wearables into their runway designs (Shapiro, 2015; Chromat #TechTalks: 3D Body Scans, Virtual Reality, 3D Printed Clothing & Responsive Garments, 2015).

surrounding environment' (*Chromat #TECHTALKS: 3D Printing*, 2015). With underwear being the closest worn garment to our body and often described as *a second skin*, it is understandable why the smart fashion field looks towards smart underwear. There are numerous academic papers with researchers placing technology into the bra (Varadan *et al.*, 2011; Hegde *et al.*, 2012; Kumar *et al.*, 2012; Kwon *et al.*, 2014; Titz and Luxey, 2014; Moreno and Herrera, 2019; Raji *et al.*, 2019; Shathi *et al.*, 2020; S. Lee *et al.*, 2021). BW, bras with advanced technology, as the next stage of bra evolution is not implausible. However, it may be challenging to sustain commercially if the focus is on technological advancements, not the wearers' needs (Perry *et al.*, 2017).

1.3.2. Smart Technology in the Bra

Fig.1.4. Product Development Forces
Source: Stappers et al., (2009)



There has been over 30 years of academic and commercial research into smart technology in the bra (**Fig.2.7.**, p. 58), and nearly half of that has occurred since the first commercial Sports Bra Wearables[13] (SBW). Due to the bra's location and necessary precision to fit the body, it is in a prime position to detect vital signs. This has made it an optimal garment for researchers looking to place and evaluate their technology, as noted in the previous paragraph. In most of these research endeavours, technology and creation are the focal points – technology push (Kwon *et al.*, 2014; Raji *et al.*, 2019) – and not the experience of the wearer – consumer (market) pull. Stappers et al. (2009) argues that researchers should utilise a contextual push to address consumers' tacit and latent needs and dreams to develop innovative products (**Fig.1.4.**). To do so Sanders and Stappers (2008) recommend a human-centred approach to design using participatory or co-design methods, which brings the wearers into the DP. The contextual push, coupled with the technology push, may aid in product development leading to innovative products informing a consumer (market) pull (Sanders and Stappers, 2012).

SBW has seen commercial success, albeit fleeting, as very few products have sustained commerciality (Chapter 2). It is significant to note commercial success can be defined as a business's ability to generate

[13] Sports Bra Wearables (SBW) is a term used to discuss sports bras developed to incorporate mechanical, electrical, and chemical functions. This term is further discussed in Chapter 2, Section 2.3.

profit, gain market share, deliver customer satisfaction, and achieve business objectives – regardless of manufacturing size thus including SME's. Martin Ashby, Chief Innovation Officer at Prevayl limited, argues for 'designing for consumers' using consumer-led design and 'more female-centric research' due to the challenges of mass-marketing smart clothing (Ashby, 2022). We can hypothesise that if the needs of the wearers are understood through a woman-centred approach in the DP, then bras with smart technology may have consumer acceptance and, thus, commercial potential. Nevertheless, the sports bra D&DP differs from the traditional cut-and-sewn bra; thus, insights from SBW can inform a BW process, but it cannot be copied as-is (Chapter 3). Therefore, there is a gap in knowledge of the BW design and development process (BWD&DP).

1.4. Difficulty Designing and Developing Smart Clothing

Designing and developing smart clothing is complex containing numerous obstacles, thus requiring guidance (Dunne, Ashdown and Smyth, 2005; McCann, Hurford and Martin, 2005). The smart clothing field comprises multiple disciples (i.e., apparel design, textile design, material engineering and computer science) that must collaborate. Additionally, apparel manufacturers must collaborate with electronic manufacturers with different practices and timelines (Dunne, 2010; Molla, Compton and Dunne, 2018; Islam Molla, 2020). The disciplines involved have different approaches, processes, and ways of viewing the products (Dunne, 2010). As a nascent field, more insight is needed to develop standard practices. Design direction is necessary to inform product development (Ariyatum, Holland and Harrison, 2004). Moreover, innovative design approaches are required for an in-depth understanding of the consumers (Ariyatum, Holland and Harrison, 2004), their needs (McCann, Hurford and Martin, 2005), and their potential relationship with the technology (Park and DeLong, 2009).

Salahuddin and Romeo (2020, p. 58) found that manufacturers and wearers 'differ in their opinion as to which features are more important'. Product developers and designers focused more on the technical facets, such as the function and problem-solving (Perry *et al.*, 2017; Salahuddin and Romeo, 2020). In contrast, wearers were more interested in a product that was easy to use, aesthetically pleasing and pleasurable (Perry *et al.*, 2017; Ju and Lee, 2020; Mahmood and Lee, 2021). Perry et al. (2017, p. 8) argue that smart clothing should be viewed as both 'technology and garment', requiring fashion designers to partake throughout the development to aid product designers and engineers centre the consumer needs, garment aesthetic and function (McCann, Hurford and Martin, 2005).

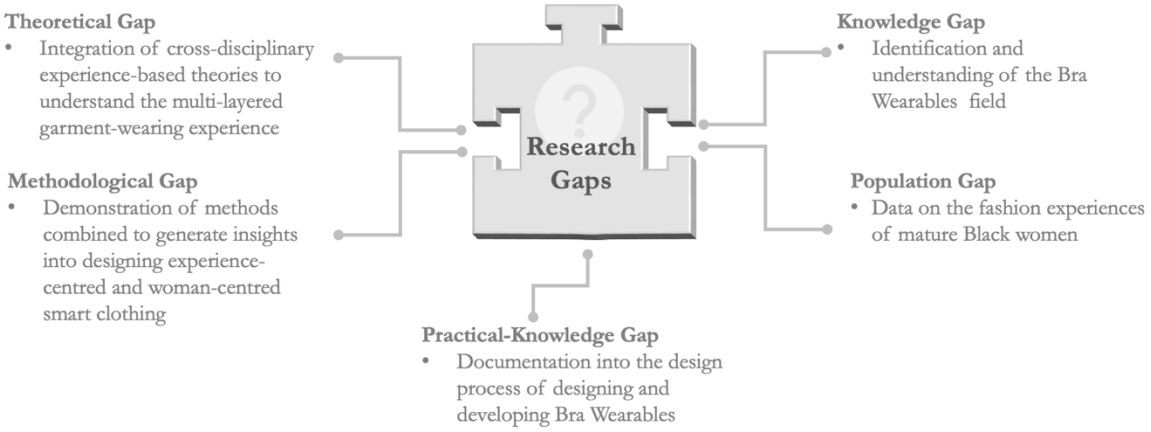
To move forward, a wearer-centred multidisciplinary approach employing functional apparel tactics and redevelopment of the D&DP that includes both apparel and electronic integration is necessary (Ariyatum *et al.*, 2005; McCann, Hurford and Martin, 2005; Dunne, 2010).

1.5. Exploring a New Path

The smart clothing field is complex; however, so is the bra industry (Hardaker and Fozzard, 1997). Combining both requires a significantly different approach and process than outerwear. As discussed in the prior sections, a multidisciplinary approach that centres the wearers' needs and experience with the garment is necessary to develop BW. Dialogue is imperative between the designers and wearers when investigating experience, which requires new methods and approaches (Wright and McCarthy, 2010). Niinimäki and Koskinen (2011) suggest an empathic approach to access more profound insights about the wearers' past, present, and future experiences leading to the development of a pleasurable product experience. A product that is enjoyable, aesthetically pleasing, useful and timeless is considered a pleasurable product experience (Forlizzi, Disalvo and Hanington, 2003). Essentially, the DP should be participatory, allowing a dialogue with the wearers, inquiry into their experiences, and continuous interaction and feedback (Sanders and Stappers, 2008, 2012).

Moreover, guidance and a design approach are necessary to assist the multidisciplinary team in balancing the technical and creative issues (McCann, Hurford and Martin, 2005). Therefore, this study addresses the following research gaps in **Fig.1.5.** and queries, 'What can we learn from an experience-centred bra wearables design and development process (BWD&DP)?'

Fig.1.5. Research gaps addressed by this study



1.6. Aims and Objectives

This study aims to develop an experience-centred BWD&DP by understanding the diverse MW consumer's bra experience and investigating the opportunities for technology in a range of bra products, to help inform BW design and the potential product experience. Below, the research aims (**Fig.1.6.**) and design plan (**Fig.1.7.**) are presented.

Fig.1.6. Research aims.

AIM 1. To comprehend whether the wearers' bra experience is significant in developing a BWD&DP.
Objectives
1A. Identify the factors that affect how mature women experience the bra. **1B.** Investigate whether Black and white women experience the bra differently. **1C.** Explore the current bra experiences of mature women. **1D.** Utilise the TAM to determine if being a part of the BWD&DP affects mature women's acceptance and purchase intention.
AIM 2. To investigate approaches that can be utilised to inform the design of BW that improves the bra wearers' experience.
Objectives
2A. Scope the BW field to map the state of the art. **2B.** Examine various design processes to develop an initial BWD&DP. **2C.** Explore ways of integrating the bra wearer and their experience into the BWD&DP. **2D.** Investigate ways of integrating technology into the bra (i.e., new design elements, bra form, composition). **2E.** Develop BW products that allow for the exploration of designing for meaningful and pleasurable experiences.
AIM 3. To interrogate the different types of "experiences" (i.e., the design-researcher and wearer) that aid in informing the BWD&DP.
Objectives
3A. Demonstrate utilisation of a woman-centred methodology in the design process for understanding & developing BW products *for* and *with* the mature female wearer.

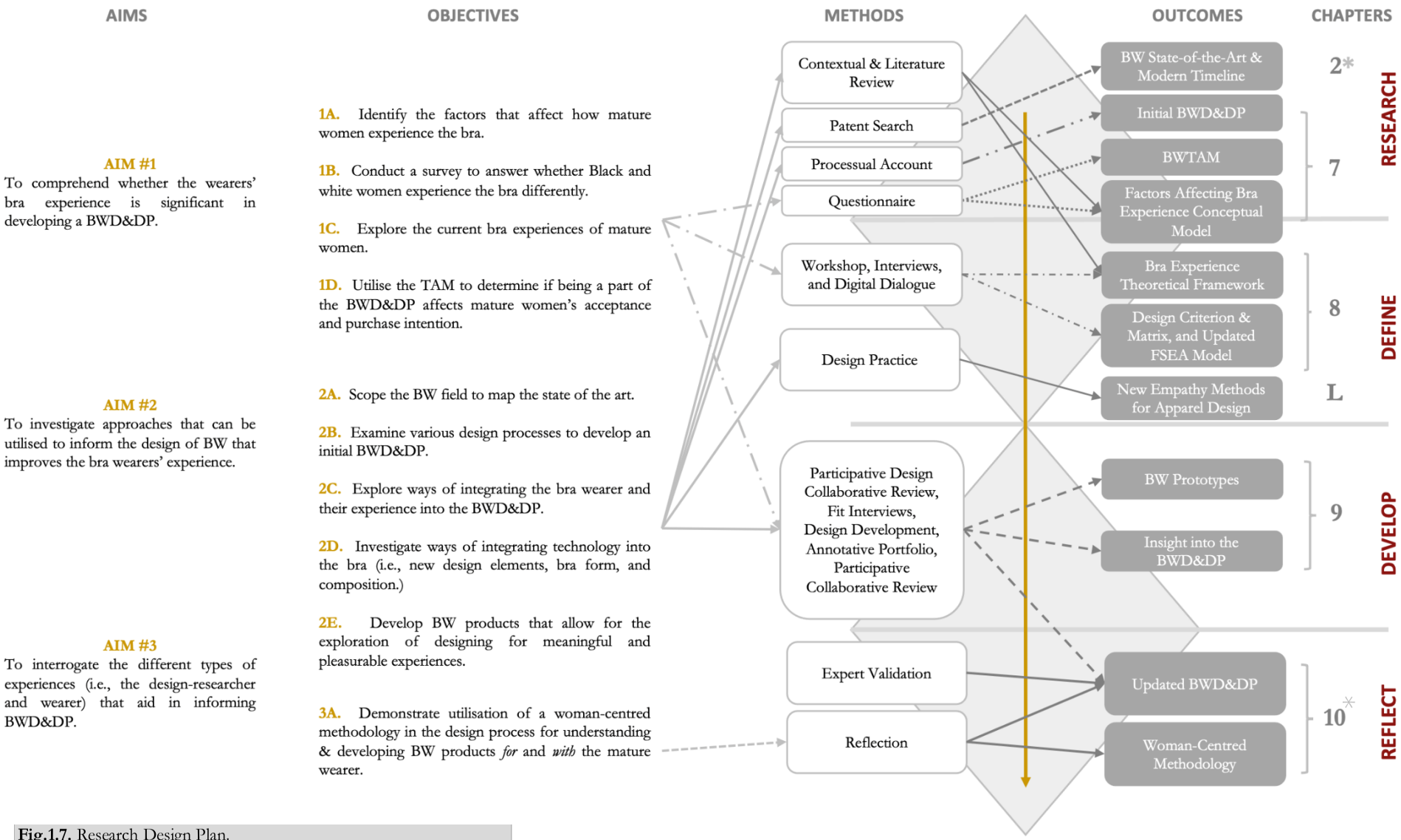


Fig.1.7. Research Design Plan.
*Asterisk signals chapters not a part of the BWD&DP

1.7. Practice and Research Approach

This interdisciplinary research is both theory and practice-based. Practice explores the situation, addresses the research aims, and contributes professional practical knowledge. Candy (2019) posits that practice-based research utilises practitioner knowledge in understanding product and process creation. Moreover, Kimbell (2011, p. 286) advises design-researchers to bridge the knowledge between academia and industry through practice, especially in 'challenging new contexts'. By utilising practice, the design-researcher can extend their design knowledge outside industry constraints, as discussed in Section 1.1.1. As such, this allows the design-researcher to apply their own professional-informed approach to practice and tacit knowledge. Baker (2011, p. 33) establishes that 'practice research and subjectivity [are] intertwined, and mutually inform […] each other'. In practice research such as this, 'the researcher takes a dual role, being "researcher as subject" and investigating from the first-person perspective' (Xue and Desmet, 2019, p. 45). Van Oorschot et al. (2022, p. 3) add that 'the design researcher's own perspective must become part of the studies design process, to clarify how "design" is understood in a specific complex situation' providing a necessary richness. The difference between this practice research and the traditional professional approach is the role of reflection. Friedman (2003, p. 521) asserts, 'to reach from doing to knowing requires the articulation and critical inquiry that leads a practitioner to reflective insight'. Schöns' (1983) theory of reflective practice underpins the practice and research approach, facilitating a cyclical manner of exploration and reflection.

Moreover, this theory and practice-based research approach is defined by Wright and McCarthy (2010) as research-*for*-experience-centred design (RfXD) and research-*through*-experience-centred design (RtXD). Golsteijn et al. (2014, p. 429) argue for the usage of both research-*through*-design and research-*for*-design, as 'they can be extremely powerful […] used together effectively'. They suggest employing both in 'topics that are currently non-existing or unexplored' such as this study (Golsteijn *et al.*, 2014, p. 429). Both approaches are further discussed below and in Section 5.5.

RfXD is inspired by research-*for*-design, where the end product is an artefact (Frayling, 1993). In this approach, findings are used to inspire designs and designing. Wright and McCarthy (2010, p. 87) posit that 'experience-centred design projects are […] geared toward understanding [wearer] experience and the design process'. Methods are selected to gain insight *into* and understanding *of* participant's lived experiences. Generative workshops utilising evocative stimuli and semi-structured storytelling interviews were conducted to comprehend the wearer's experience within the D&DP.

RtXD, similarly, is inspired by research-*through*-design (Frayling, 1993). It is classified as research conducted through 'practitioner activity' (Archer, 1995, p. 11) to examine and reflect on insights, producing 'designerly contribution to new knowledge' (Stappers and Giaccardi, 2017, sec. 43.4.1). Wright and McCarthy (2010, p. 92) establish that RtXD requires the usage of 'methodologies that are developmental and reflect on the

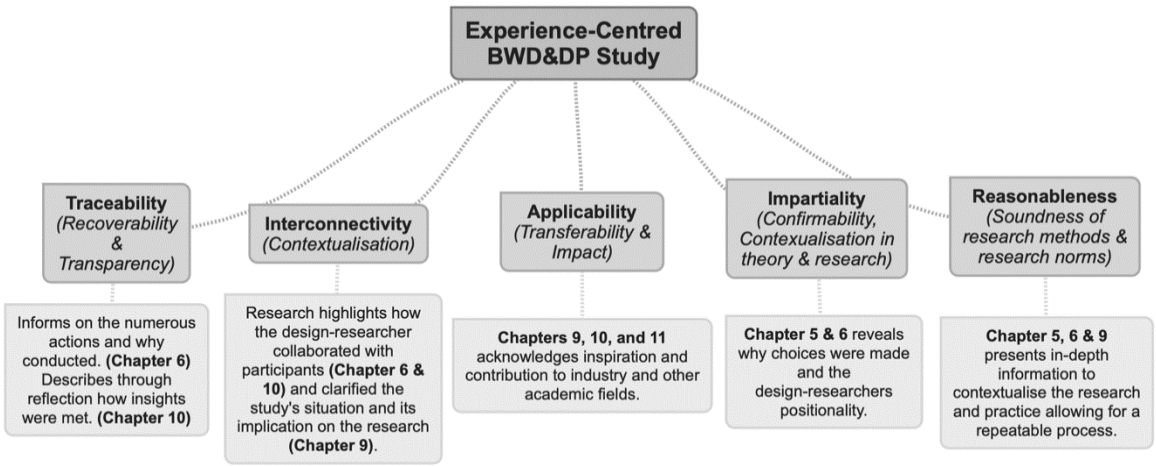
designers' actions and outcomes'. As such, this study employs a Four-Stage Research Process (Section 6.1.) that enables the investigation into the D&DP, focusing on the experience of the design-researcher, relying on their first-person account. Furthermore, an annotative portfolio method enabled the design-researcher to document and reflect on the actions (Sections 6.1.3.3. and 9.4.2.). This approach intertwines with Schön's (1983, 1995) reflection-in-action through practice and research. Both are operations the design-researcher employed during the inquiry process.

Lastly, a Deweyan Pragmatist framework supports the practice and research approaches (Section 5.2.). Dalsgaard (2014) asserts that a Deweyan pragmatist approach is theoretically and practically advantageous. The 'pragmatic maxim' (Dalsgaard, 2014, p. 146) explains that the 'meaning of our conceptualizations of the world – ideas, theories, assumptions, etc. – should be evaluated based on their consequences and implications in practice'. Essentially, theory and practice combine, with 'theories stem[ming] from practice' and employed as 'instruments for practice' (Dalsgaard, 2014, p. 146). In this study, the Bra Wearables Technology Acceptance Model (BWTAM) and the Bra Experience Theoretical Framework are both instruments for practice. They evolved from the situation and aided the design-researcher in actions and comprehension.

1.8. Audience

The primary audience for this study is designers and design-researchers seeking to develop BW or wearable products with participants. The secondary audience is design-researchers exploring innovative approaches to practice research with outcomes guided towards academia and industry. Lastly, researchers from other disciplines, such as consumer psychology, sociology, marketing, and Black women's studies, may find this study relevant.

Fig.1.8. Practice research quality indicators applicable to this study.
Source: Author, adapted from Prochner and Godin, 2022



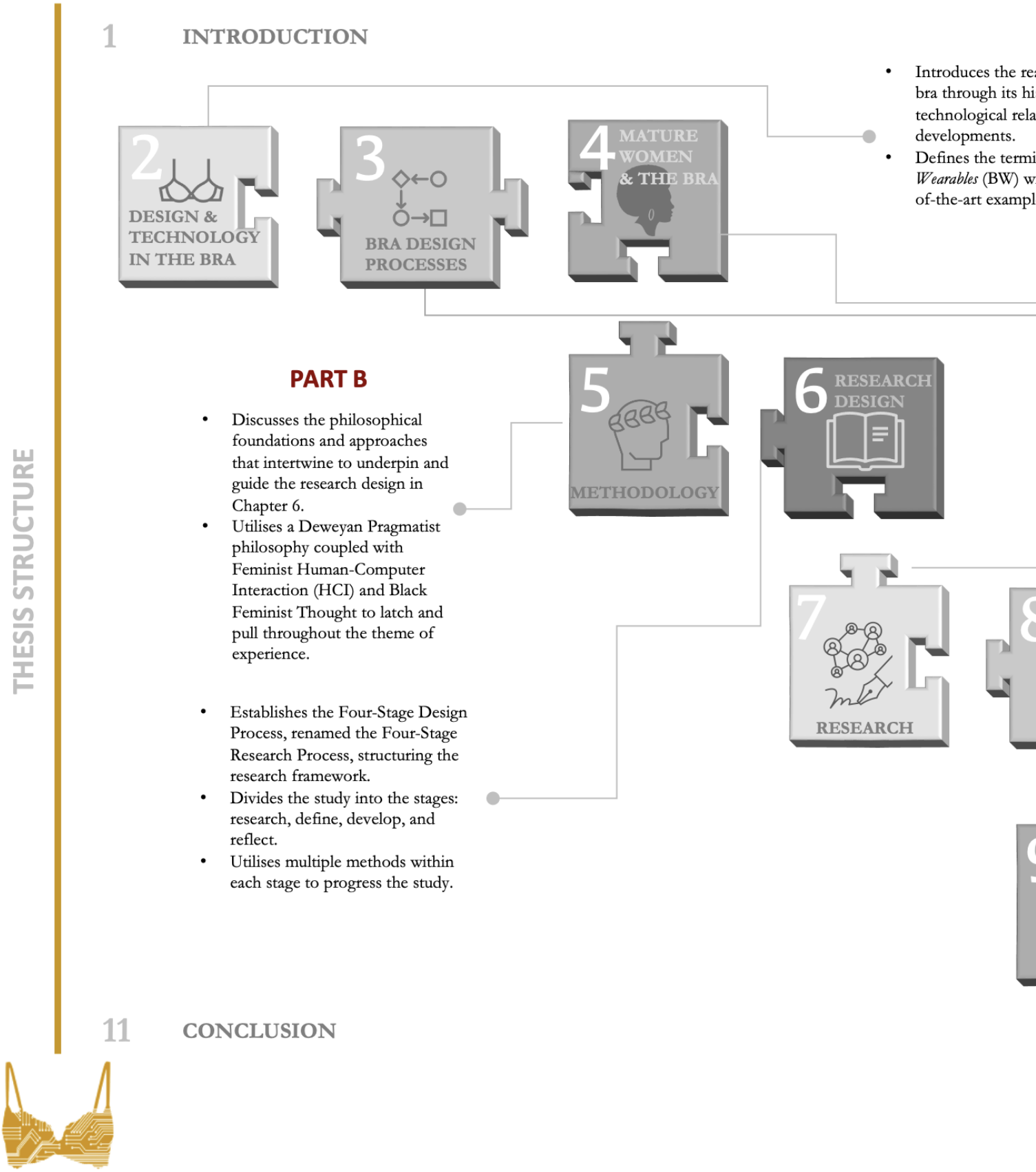
Moreover, practice research, and those utilising Pragmatism in design research, require assessment indicators as they are 'difficult to plan and evaluate' (Prochner and Godin, 2022, p. 1). Practice research 'is

still in its formative stage' (Stappers and Giaccardi, 2017). Thus, recent papers and panel discussions provide insights into how it should be approached and judged (Bye *et al.*, 2022; Kaszynska, Kimbell and Bailey, 2022; Prochner and Godin, 2022), which this study uses as a guide (**Fig.1.8.**). Prochner and Godin (2022) are used to assess the quality of the study as a marker. Bye et al., (2022) research informs the need to strongly tie this practice research to a methodological philosophy. Kaszynska, Kimbell, and Bailey (2022) research provide a reflective framework to discuss the multiple new knowledge claims produced in practice research. See Appendix D for more information on understanding how this author approached writing about practice research.

1.9. Thesis Structure

This thesis is divided into parts A (Literature and Contextual review), B (Methodology and Research design), and C (Findings); bookended by Chapters 1 and 11, the introduction and conclusion. Chapter 11 concludes the thesis by reviewing the aims and findings, limitations and suggestions, new knowledge contributions, and future research directions. See **Fig.1.9.** for the thesis structure.

Fig.1.9. Thesis structure



PART A

ader to the
storical and
tionship and

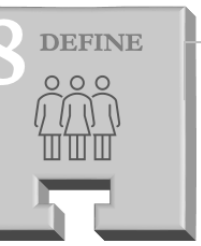
inology *Bra*
ith BW state-
es.

- Acquaints the reader with the complex nature of the D&DP. Reviews multiple D&DP before narrowing to the various bra DP.
- Assesses the sports bra D&DP, detailing the contrast between traditional bra D&DP.
- Details the distinct stages of a traditional bra D&DP.

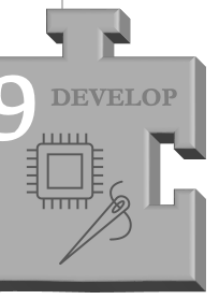
- Juxtaposes the available research on mature white women with information on Black women from disparate fields such as health, gerontology, body studies, and Black Feminists studies.
- Illustrates the difference in bra experience between young and older women and the potential differences between Black and white women.
- Uncovers a Factors Affecting Bra Experience Conceptual Model, analysing how the consumers' sense-of-self is affected by bra-wearing.
- Concludes with an emerging Bra Experience Theoretical Framework combining the social, physio-affective, and psychological experiences of bra-wearing.

PART C

- *Research* stage, reveals the results of an online questionnaire and the creation of the initial BWD&DP.
- The questionnaire substantiates the Factors Affecting Bra Experience Conceptual Model, provides knowledge of MW's current bra experience, and a BW Technology Acceptance Model (BWTAM).
- The chapter concludes with the development of the initial BWD&DP which becomes the guideline for the practice portion of the research.



- *Define* stage, introduces the reader to the beginning stages of the BWD&DP with the "Research & Concept Development" phase.
- Gathers participants' experiences and needs through qualitative methods such as generative workshops, digital dialogue, and semi-structured interviews.
- Applies the Bra Experience Theoretical Framework, generating an in-depth Bra-Wearing Experience Map that demonstrates the intricacy.
- Triangulates data from qualitative and quantitative methods to develop the design criteria, an interaction matrix, and a BW Functional, Structural, Expressive, and Aesthetic (BWFSEA) consumer needs model.
- Reflects on the design-researchers' induction with practice activities to investigate designing and developing BW.



- *Develop* stage, encompasses the finishing steps in the "Research & Concept Development" phase and completes the "Pattern & Prototype Development" phase of the BWD&DP.
- Enacts design steps by collaborating with participants to develop concepts, provide insights and feedback on the digital fit model, and assess the prototypes.
- Documents, critiques, and reflects on the D&DP for two BW prototypes.
- The chapter concludes by discussing opportunities and obstacles for manufacturing BW and validating the BWFSEA model.

- *Reflect* stage, completes the research with reflections using a design research outcomes analytic framework (Kaszynska, Kimbell and Bailey, 2022).
- Provides reflections on the concepts, designs and knowledge produced for the situation, design-as-practice, and design research.

1.10. Contributions to Knowledge

This thesis aims to make several research contributions:

- Insight into the emerging BW field through a state-of-the-art and modern historical timeline.
- A Factors Affecting Bra Experience Conceptual Model that informs on mature women's bra experience and how that affects their sense-of-self.
- A Bra Experience Theoretical Framework developed from interdisciplinary theories to enhance knowledge about the multifaceted bra-wearing experience.
- A BW Technology Acceptance Model (BWTAM) that confirms factors that influence the acceptance of BW.
- A practical framework – BW Functional, Structural, Expressive, and Aesthetic consumer needs model (BWFSEA) and Four Pleasures Framework – that assesses BW needs in the D&DP.
- Original experience-driven Bra Wearables Design & Development Process (BWD&DP).
- A woman-centred methodology placing multiple experiences and expertise on equal grounds while centring the participants.

1.11. Boundaries of the Inquiry

The study faced several boundaries: time, costs, access to necessary training and study participants, and expert sample size. Discussed below is a brief overview of the boundaries.

Time inevitably becomes a constraint when conducting research. In this case, finding the *right* time to complete the sequential activities was essential. Due to the global pandemic, tumultuous lockdowns, and other extenuating circumstances, navigating the right time to perform workshops, seek in-person product development assistance, or access in-person feedback was problematic. Activities were spaced out in the hopes of finding the *right* time to enact them. As a result, some activities occurred months apart while others occurred at similar times.

As a traditional lingerie designer without any smart clothing experience, I required access to additional resources and training to learn the basics. Courses were not available year-round and focused specifically on the electrical hardware rather than the textile wearable facets. Unfortunately, without university assistance and access to their wearable labs, the study approached acquiring technologist skills through bricolage methods utilising a mix of online open-access resources. This limited the essential dialogue and feedback necessary when entering a new field.

Wearable technology research requires significant funding. Costs become a boundary to acquiring various technological materials, especially when approaching research using trial-and-error. In fact, cost intersects

with time. As a self-funded researcher, acquiring the materials and machinery needed to learn, test, and develop concepts became costly. Unfortunately, due to Brexit and the pandemic, importing particular hardware or machinery became costly. In one instance, a smaller cooling motor was needed; however, the price had increased from £7.99 to over £30 and required three weeks before delivery. The cost boundary affected the materials utilised.

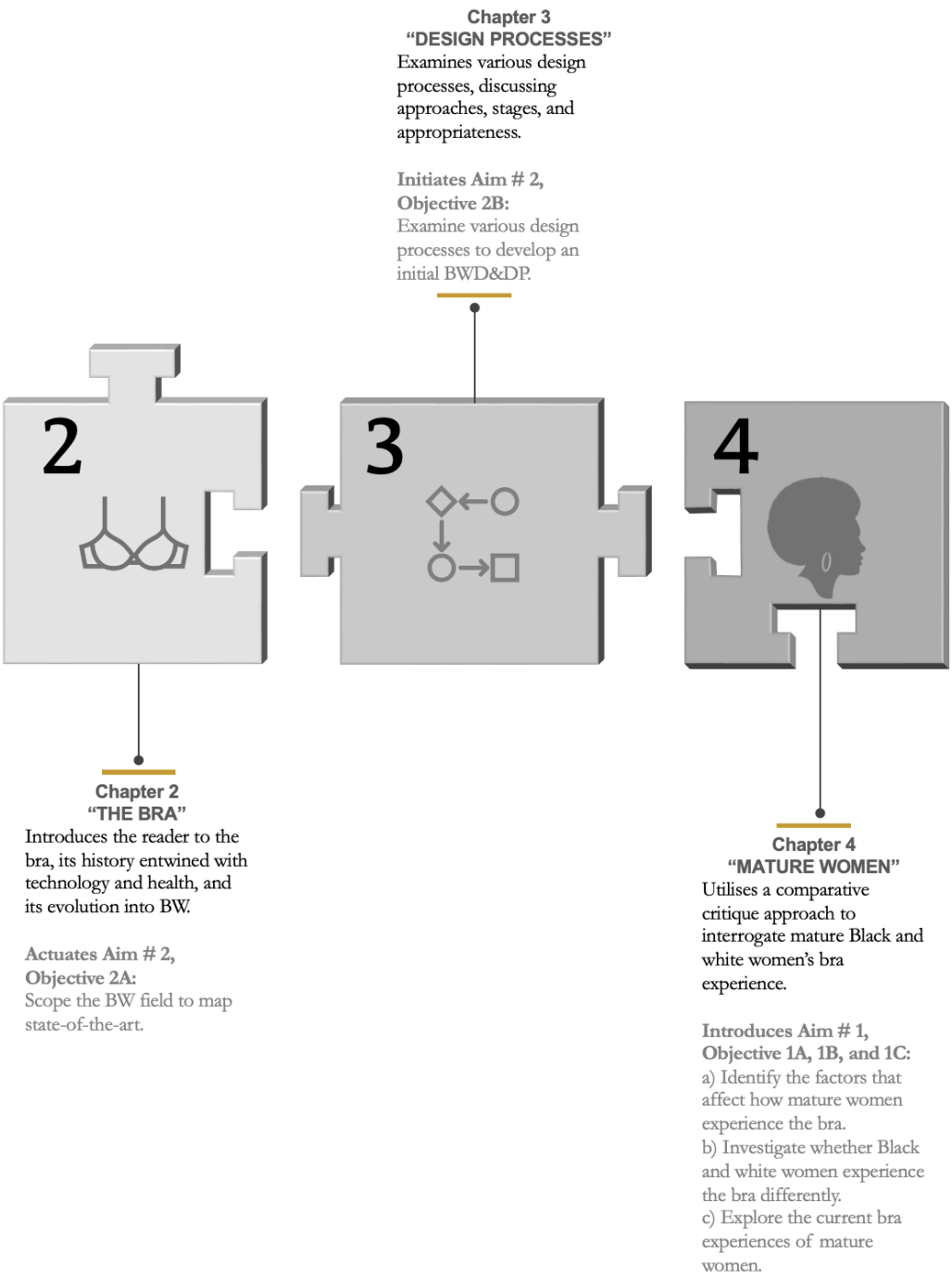
Access to the study's participants is another boundary. Black women tend not to participate in research for many reasons, such as the research not being beneficial for them, no compensation, a non-diverse research team with researchers that do not represent them, and distrust of the obscure research process (Lillington, Johnson and Chlebowski, 2000; Williams and Anderson, 2021). Conducting this study evidenced that time is crucial for them. All the women who partook held jobs and had familial care duties. Therefore, activities had to be meticulously scheduled according to participants' needs. Many women worked in healthcare, meaning they underwent intense work-related stress during the study period. A few participants mentioned the sadness of their situation. Others lost loved ones due to Covid-19 and ceased participation. Nevertheless, partaking in the study became a space to relax and find a community.

The study's interview and focus group sample sizes may be a boundary. Throughout the study, fifteen participants partook across various methods; however, only five participated in more than four methods. Only six women were interviewed in-depth about their past and present bra experiences. While the participant sample size is relatively small, readers should view the findings as explorative and denotative of mature Black women's multifarious experiences.

A further boundary is the sample size and possible selection for expert validation. This nascent BW field has very few *experts*, with many of those with the knowledge not partaking in this study. Therefore, the validation is based on a small selection of either e-textile/smart fashion or bra experts. Most do not grasp the BW field; however, they can provide insights from their perspective.

PART A: Contextual & Literature Review

Part A comprises Chapters 2, 3, and 4 which initiates the inquiry and frames the design and research situation. Each chapter introduces one of the three (the bra, design process, and mature women) areas establishing the background and current practices.



2

2. DESIGN AND TECHNOLOGY IN THE BRA

Chapter 2 introduces the bra history (2.1.), insight into the definitions and origins of Bra Wearables (BW) (2.2.), and provides a state-of-the-art of the BW field (2.3.).

2.1. Bra History

The history of the bra has been reviewed exhaustively unearthing numerous facets assisting in its development (Saint-Laurent, 1968; Carter, 1992; Hawthorne and Want, 1992; Farrell-Beck *et al.*, 1998; Cunnington and Cunnington, 2000; Farrell-Beck and Gau, 2001; Fields, 2007; Ewing, 2010). Professor Shin's thesis 'The Origins and Evolution of the Bra' (2009) comprehensively reviews the history of modern-day bras and documents the bras' evolution through technological advancements in materials, hardware, and machinery. Similarly, independent bra researcher, Lorraine Hamilton Smith, examined the history of British bras through object-analysis. Hamilton Smith concluded that although patternmaking and material innovations aided the bra's advancement, 'there have been relatively few new features introduced since the late 1970s' (Hamilton Smith, 2018, p. 96). The word 'features' refers to the overall form, build, and materials based on a material culture approach. This design-researchers' examination of historical utility patents demonstrated that one of the earliest bra patents by Helen M. Millar in 1873 (Millar, 1873) looks like the modern-day bra, indicating the form had not changed much in almost 150 years (**Fig.2.1.**). Although Hamilton Smiths' assessment is founded based on her approach to reviewing manufactured styles, much can be learned from examining inventive designs in bra patents.

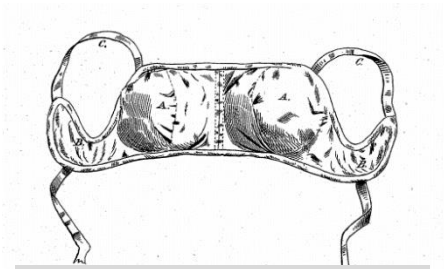


Fig.2.1. One of the first proto-bras patented as a 'Bosom Pad' in 1873 by Helen M. Millar.

Utility patents provide in-depth detail about the thinking of the social times. Information is provided through concept details, idea reasoning, materials selected, images, and additional timeline data through patent citations (Farrell-Beck *et al.*, 1998; Farrell-Beck and Gau, 2001). Patents can be viewed as archival documents of dress history maintained in a database filled with inventive concepts that inform and inspire future generations. Fashion historians utilise patents as a creative medium to recreate historical garments (Jungnickel, 2022), inspire digital textile and apparel design through replications (Parsons, 2015), and inform on the garments' effect on historical wearers (Jungnickel, 2020). Other researchers utilise patents to build

concise insights into product histories like menopausal pads (Kidd and Farrell-Beck, 1997), women's riding skirts (Peteu and Helvenston Gray, 2009), waterproof dresses (Shephard, 2012), and bras for larger-breasted women (Keist and Marcketti, 2019). Researchers in engineering have utilised patents to investigate the development of fashion trends (Park and Kim, 2010; Lee and Han, 2020) and textile (Park and Kim, 2009) to inform and inspire designers. Comparably, this study uses patents to inform about historical innovative bra ideas, ground the emerging BW field, and inspire the design-researcher.

Rather than review the exhaustive bra history, the following section briefly discusses the connection between health, technology, and the bra by examining utility patents[14]. Then shifts to discussing its next potential phase of evolution – Smart Bras and Bra Wearables (BW).

2.1.1. Technology, Health, and the Bra

There is a significant link between health and the bras' development. The modern-day bra is associated with health as underwear reformers in the 1800s pushed for more hygienic corsets utilising new health-based fabrics, such as Aertex and Viyella (Ewing, 2010). Additionally, women became educated as nurses, physicians, health practitioners and non-specialists (Farrell-Beck and Gau, 2001), providing more insights into their health and underwear requirements. Farrell-Beck et al. (1998) document, through patents from the 1860s to 1940s, the rise of the bra and inventor's health-centred and wellness intentions. Within the same period, an analysis of bra patents indicates that due to health concerns, inventors often applied novelty materials like hair, mesh wire, Tampico/grass, paper, and rubber (Gosler, 2020).

[14] When discussing inventions and innovations in the bra, it is necessary to review the products that made it to market and those that remained as patents, which may have inspired later designs. Patent searches can be used to examine the history of a product providing a visual timeline of the physical changes in aesthetics, materials, pattern construction and machinery inventions, as well as stimulate the development of new ideas. This notion is tied to the Theory of Inventive Problem Solving (TRIZ), discussed in Section 3.1.2., which argues for the examination of patents to find patterns to help foster solutions for design problems (Altshuller, 1984).

Name of Patentee	Patent Number	Date Filed	Date Granted	Abbreviated Health Claim
Gladys M Hart	US2436430A	1945	1948	Brassiere with 'a comfortable and convenient support for the parts of a hearing aid equipment, … rendered inconspicuous, …'
Ettleson Ruth	US2457989A	1946	1949	Cathedral Brassiere updated so as not to 'bear uncomfortably and injuriously against the breasts'
Perle W Shanahan	US2503847A	1947	1950	Brassiere particularly designed for carrying, in a comfortable and concealed manner, the transmitting unit of a hearing-aid apparatus
Henry M Plehn	US2506172A	1947	1950	Brassiere that will follow the changing contour of the breasts during the monthly cycle and supply the same positive control
Helen B Radler	US2717602A	1953	1955	Surgical Brassiere 'worn during convalescence after an-operation in which either one or both breasts have been removed'
Michael Ginsburg	US2782416A	1954	1957	Brassiere for posture 'enable a more healthful posture of the wearer without any discomfort'
William R Jones	US3035571A	1959	1962	Therapeutic Brassiere 'which provides a gentle massaging effect thereby relieving tension and fatigue...'
Samuel M Librande	US3478739A	1967	1969	Protective Brassiere 'a semi-rigid shock absorbing bra worn for protection of the female breast area during athletic competition'
Albert Defru	US3439682A	1967	1969	Therapeutic Brassiere 'elimination of bones and wires helps prevent lymphatic congestion…free blood circulation…development of pectoral muscles'
NASA	US3995621A	1976	1976	Brassiere 'enhancing the detection of malignant tissue in the breasts… fitted with a pair of liquid-perfused cooling panels'
Shiow Mey Chan	GB2041223A	1979	Abandoned	Massage Brassiere 'which can be worn for constant application of massage and physical therapy to the bust'
H. E. Clark, P. T. Clarl	US4220157A	1978	1980	Brassiere for 'athletic activity so that stress on breast tissue caused by activity-induced bouncing does not occur'
Charles Blanckmeister	US4300568A	1979	1981	Therapeutic Bra 'to provide a therapeutic bra which is designed for easily being put on or removed, by physically partly incapacitated persons'
Janice K. Sherwood	US4699144A	1985	1987	Mastectomy Brassiere 'supporting cup for the normal breast and a substantially flat band portion to fit to the chest of the removed breast, '
Christina L. Ekins	US4781651A	1987	1988	Athletic Brassiere 'prevents breast sag and thereby reduces the bouncing of the breasts.'
N. M. Raml, C. J. Janiszewski	US4804351A	1987	1989	Surgical Brassiere 'reducing stress along a mid-sternal incisional line of a female patient following cardio-thoracic surgery'
Francina J. Rainville	US4917651A	1988	1990	Front opening brassiere 'for handicapped people provides detachable and adjustable fabric fastening pads…, and finger loops for those who cannot grip'
H. L. Moretz, D.L. Brier	US5441436A	1992	1995	Moisture Managing Brassiere for 'more healthful environment for the breasts'
Yi-Mou Suen, Kuo-Liang Liou, Liang-Hung Ho	US5782671A	1997	1998	Magnetic Brassiere 'magnetic force which may promote blood circulation and metabolism in the breasts'
Chin-Tang Chen	US6089953A	1998	2000	Fragrant Brassiere 'helpful to a wearer's spiritual and physical health'
Lynn Elizabeth Kilbride, Janette Kaye Cothrel	US6319091B1	1999	2001	Brassiere 'for disabled women not having the full use of both upper extremities, wherein the brassiere is adapted to be put on, removed, and adjusted by the wearer alone'
Michelle L. Judson	US6174217B1	2000	2001	Inserts are provided in a variety of colors, appearances, or scents for placement into the undergarments…
Kasper H. Bejoian	WO2003052033A2	2000		An odor altering material is incorporated within the voids of the carrier member to form an odor altering member…
Kathleen Gendel	US20040185748A1	2003	2004	Antimicrobial Bra 'to assist in infection control after breast surgery and to generally control microbes on the skin of a woman's breast area'
김순옥오혜지오민지	KR200364285Y1	2004	2004	'the bra and both wings and shoulder straps, and fragrance in the armpits of both wings'
Tania A. Talamo	US7959488B2	2007	2011	Brassiere for 'promoting and providing well-being, health and cosmetic benefits and therapeutic effects to a wearer'
James Morales	US7309275B1	2005	2007	Therapeutic Brassiere' to provide thermal therapy to a breast'
Laura Spagna	US20070298684A1	2006	Abandoned	Brassiere 'for holding an automated medication dispensing device… such as an insulin pump.'
Brandon Solotoff	US8821210B2	2011	2014	Brassiere 'with an adjustable lift feature that provides vertical support, … for healthier support of the woman's breast tissue.'
S. Rose, J. Dixon, J. Cohen	US9622704B2	2016	2017	Stress Test Bra to monitor for heart disease with 'health parameter sensor configured to transmit health parameter signals to a monitoring device'
A.C. Cahan, K.R. Skeuse, P. Dowd, B. O. Poepping	US20180352874A1	2016	Pending	Cantilevered Bra that 'provides increased comfort and reduced fungal infections and rashes' for larger breasted women

Table 2.2. Brief Health-based Bra Patents 1940s-2000's.

Similarly, and succinctly, picking-up from the 1940s to date, this design-researcher identified the continuous link in bras that concentrate on therapeutic and health wellness. **Table 2.2.** shows that bra concepts ranged across the field from mastectomy, sports bras, and daily wear to bras for hospital-based operative procedures. As early as 1939, Walter Emmett Williams filed a patent for a massage bra that would 'mildly massage' the breasts while also 'kill[ing] the odors of perspiration' (Williams, 1940). Another patent featured technological improvements with electrical components to assist hard-of-hearing women by incorporating a hearing aid in the bra (Shanahan, 1950). The patents in **Fig.2.3.** are exemplars of early wearable technology in the bra.

A further example is the bras from the late 1980s-early 1990s. The rise of breast augmentations during this period heralded several bra patents using various fillings, like air, gel, and water, to achieve similar looks. These bras inspired new *passively* smart bra inventions utilising micro-encapsulation techniques focusing on sensory stimulations for health. These bras would release scents or medicine as the wearers' body temperature rose. **Table 2.2.** exemplifies bras with technology for health purposes.

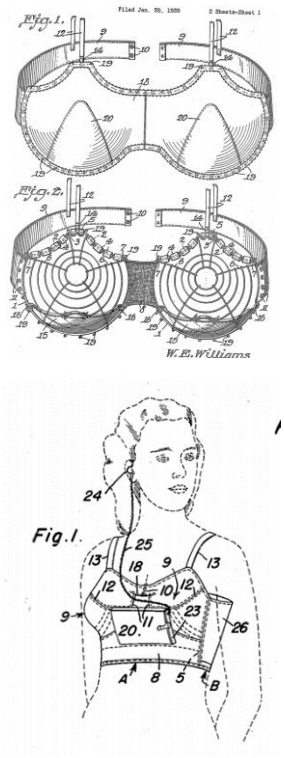


Fig.2.3. Top: 'Massage Bra' (Williams, 1940). Bottom: 'Hearing-Aid Bra' (Shanahan, 1950).

2.2. Definition and Origin of Bra Wearables (BW)

2.2.1. Brief overview of Smart Clothing/Wearable Technology

The definition of *smart clothing* is garments created with textiles that can sense and react to external or internal stimuli, which may be mechanical, magnetic, electrical, thermal, or chemical (Tao, 2001; Kettley, 2016). However, some researchers disagree, defining smart clothing as clothing with textiles that can react to more than just environmental changes while also being beneficial to the wearer (Kirstein, 2013). They exclude nonelectronic smart textiles, like phase-change, antimicrobial, shape-memory materials, and thermochromic dyes, which provide minimal feedback. There are varying degrees of smartness ranging between *passive*, which can only sense the environment and user based on sensors; *active*, which can sense and react as a result of sensed environment utilising an actuator function; or *very smart*, which can detect, respond, and adapt based on self-adapting learning systems (Tao, 2001; Ariyatum, 2005; Stoppa and Chiolerio, 2014; Kettley, 2016). Some researchers and industry experts place smart clothing under the umbrella of wearable technology, meaning a technologically enhanced garment or product worn on the body (Dunne, Ashdown and Smyth, 2005), and refer to it in the shorter term as *wearables* (Tomico *et al.*, 2013; Guler, Gannon and Sicchio, 2016; Genç *et al.*, 2018). Wearable technology by some is synonymous

with smart clothing, while others have separated its meaning by defining it as only electronic devices such as jewellery, watches, and glasses (Timmins and McCann, 2015; Kettley, 2016), allowing for the term smart clothing to be used instead when discussing garments (Watkins and Dunne, 2015). Lastly, some may use wearables, referring only to smart clothing with computational, mechanical, and electrical technology.

According to Van Langenhove and Hertleer (2004), the textile or garment must have sensors, actuators, and processors to be considered smart. A processor is necessary to learn and adapt to different programming for the highest degree of smartness (Watkins and Dunne, 2015, p. 128). The sensors sense stimuli in the environment and signal the processor to execute a function permitting the actuator to conduct the physical change (Watkins and Dunne, 2015). Examples of stimuli that can be sensed are light, heat, electricity, pressure, and liquid or gas. Wearables technology researcher Prahl (2015, p. 55) details the potential of electronic wearables sensors as:

> 'biochemical (i.e. sweat/pH, lactate, oxygen, glucose), physiological (i.e. ECG, EEG, temperature, respiration, skin properties), biomechanical (i.e. motion, gesture, movement, muscle contraction, acceleration, vibration), chemical & environmental (i.e. VOCs/pollution, EMR, radiation, bacteria, vapour, smell, temperature, position, movement) and deformation (i.e. pressure, impact, touch, stretch, wear, abrasion)'.

The stimuli are sensed by e-textiles, defined as smart fabric 'using a combination of textile fibres, yarns or fabrics combined/integrated/ assembled with (micro)electronic components such as conductive wires, microsystems, sensors, actuators, energy capture or storage devices, heat, light or sound-emitting devices etc.', (SmartX, 2022)[15]. The e-textiles may be created through channels such as 'embroidering, sewing, knitting, weaving, spinning, braiding, coating/lamination, printing, and chemical treatments' (Stoppa and Chiolerio, 2014, pp. 11958–11959). Often hard sensors are integrated into the garment towards end of production, such as sewable microcontroller boards, resistors, and wiring (Islam Molla, 2020). The brand Supa's 'Supa Powered Smart Sports bra'[16] is an example of e-textiles and hardware connection in one garment (**Fig.2.4.**). The heart rate, motion, and temperature sensors are woven into the fabric; however, a removable reactor is connected to the bra and is needed to relay the data via Bluetooth to a smartphone (Charara, 2017).

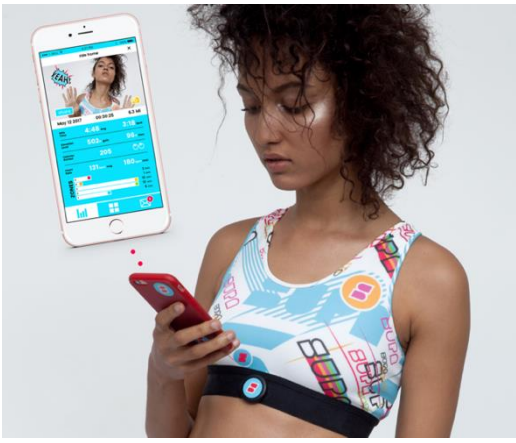


Fig.2.4. Supa Smart Sports Bra with AI features.
Source: Charara, 2017

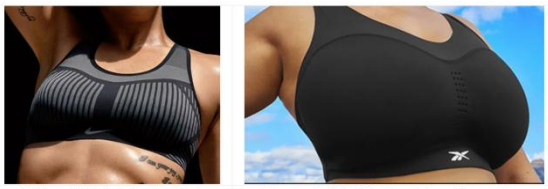
[15] https://www.smartx-europe.eu/faq/
[16] https://www.movesense.com/showcase/supa/

Reviewing the bras' history and how technology aided its development created a foundation for how the bra has evolved, helping to understand how the area of wearable technology may be the next step in its evolution. Garlinksa and Ropert (2013, p. 377) posit that 'invention is a new idea and innovation is the commercialisation of the invention[17]'. The smart bra field is ill-defined, nevertheless, it has had minimal innovation in terms of commercial success, with *smart* sports bras being the only area thus far. On the other hand, there has been a wealth of inventions in patents and academic research presenting possibilities and ideas that can be used to influence new developments. Therefore, while lacking in innovation, the field is booming with inventions that should be explored to define and scope the area successfully.

2.3. Bra Wearables (BW) Field

Fig.2.5. Bras Advanced Through Technology with 3D printed underwires.
1. Bioform Bra (2000)
2. Trusst Bra (2015)
3. Evelyn & Bobbie (2017)
4. Endeer (2018)

In patents and research papers, the terms 'E-bra' (Varadan *et al.*, 2011; Kumar *et al.*, 2012), 'Bionic bra' (Steele *et al.*, 2018), 'Intelligent bra' (Wu *et al.*, 2019; Mou *et al.*, 2020), and 'Smart Bra' (Masry *et al.*, 2021; Linti *et al.*, 2022) are utilised to describe a bra with technological enhancements. Bra researchers placed bras enhanced through advanced technology and with *smart* capabilities under the same term 'Smart Bra' (Shin, 2009; Yu and Ng, 2014). The former includes bras such as the Bioform Bra (2000), Curvessence (2012), Trusst Lingerie (2015), and Endeer (2018) (**Fig.2.5.**) that utilise 3D printing to update or replace underwires. While the latter refers to *smart* bras with *passive* features, meaning self-tightening, colour-changing capabilities and *active* with electrical/mechanical components. The market and media also apply the term 'smart bra' to describe smart sports bras, with smart technology functions and those that are enhanced through advanced technology, like Nike's Flywire Knit Bra (2017) and Reebok's PureMove Sports bra (2018) (**Fig.2.6.**). In this way, smart bra is a blanket terminology



Nike (2018) *Flywire Knit Sports Bra* | Reebok (2021) *PureMove Sports Bra*

Fig.2.6. Bras Advanced Through Knitting Technology

[17] Garlinksa and Ropert (2013) are summarising the definition from Professor of Strategy Enterprise and Innovation, Paul Trott.

that references any bra category with various degrees of smartness and bras enhanced through advanced technology. Thus, smart bra[18] is an umbrella term that is broadly utilised and is in need of refinement.

This study introduces a new term, Bra Wearables (BW), to specifically adhere to bras enhanced with mechanical and electrical components, which may also contain *passive* smartness. A state-of-the-art scoping highlights BW is dissectible into several sectors: preventative health, medical-centred, physical safety, body enhancement, maternity and nursing, mastectomy, mental and emotional well-being, glamour and fashion, retail made easy, sex and pleasure, and sports and fitness, which is separately named Sports Bra Wearables (SBW)[19]. Developments are occurring continuously through industry and academic research; therefore, examining innovations, inventions[20], and works-in-progress is vital to scope this emerging and fragmented field. With the modern BW field extending over 30 years, there have been significant developments in this area – with a boom in the early 2000s – through industry and academic research (**Fig.2.7.** illustrates timeline).

[18] As of March 2023, a Google search of the term 'smart bra' returns top results of products with no smartness. See examples in Appendix T.
[19] Due to sports bras having a different D&DP, materials, form, and functionality, the design-researcher chose to provide it with a different acronym. In Chapter 3, Section 3.3., the reason for this differentiation is explained. Additionally, in 2022, the design-researcher presented 'Controlling the Bounce: Sports Bra Patents 1860s – 1960s' at the New Dress in Dress History Conference 2022.
[20] The design-researcher developed a patent database to scope inventions within the BW field. Results from this endeavour were presented at the New Dress in Dress History Conference in 2021 with a paper titled 'Defining the Smart Bra Field: Insights from 21st Bra Patents'.

Bra Wearables Modern History

1989

'Chronobra'
Dr. Simpson & Dr. Griffiths
University Dept. of Surgery, Royal Infirmary Glasgow
- Early breasts cancer detection by measuring temperature/thermometric.

1999

'The Techno Bra'
Kursty Groves
The Royal College of Arts
- Built in heart rate monitor, wireless telephone, and a global positioning system locater.

2000

'Smart Bra'
Intelligent Polymer Research Institute, University of Wollongong
- Self tightens straps through sensing the wearers movement.

'The Bioform Bra'
Seymour Powell
- Created bra using 3D technology for larger bust sizes D & E.

2001

'The Brava Bra'
Dr. Roger Khan
- Breast enlargement bra with wearers gaining up to 1 cup size. Bra fitted with 2 suction cups & control box.

2002

'The Electronic Bra'
Research Team at DeMontfort University
- Bra detects cancer using electrical pulses.

2005

'Sensors in Sports Bra'
NuMetrex, Textronics ™
- Sports bra with built in heart monitor.

2007

'Cancer Screening Bra'
Bolton University Centre for Research and Innovation
- Bra contains built in microwave antennae system to detect first signs of breast cancer.

2008

'ITBra'
Cyrcadia Health
- Early breast cancer detection in a bra worn once a week.

2013

'Emotional Eating Bra'
Microsoft, University of Rochester and University of Southampton
- Bra fitted with device that monitors wearers' emotional state through EKG and skin conductivity.

2014

'The True Love Bra'
Ravijour Brand
- Bra will unlock after senses heart rate and body temperature.

2016

'Heart Disease Bra'
Bloomer Tech.
- Smart Bra that monitors cardiac health.

'Breast Cancer Bra'
Colombia National University
- Smart Bra that detects early breast cancer by measuring body temperature.

2017

'The Everyday Smart Bra'
Vitali
- Smart Bra guides wearer to breathe, monitors heartrate and posture.

'The Auto-Exploration Bra'
EVA, Julian Rios Cantu
- Wearable device which can be placed in the bra to detect breast cancer through thermal patterns and tissue elasticity.

2019

'Somainnofit'
Soma Intimates
- Bra measures breasts size for bra sizing with brands range.

© 2020 KADIAN A. GOSLER

Fig.2.7. Bra Wearables (BW) Modern History Timeline

2.3.1. Sectors of Bra Wearables (BW)

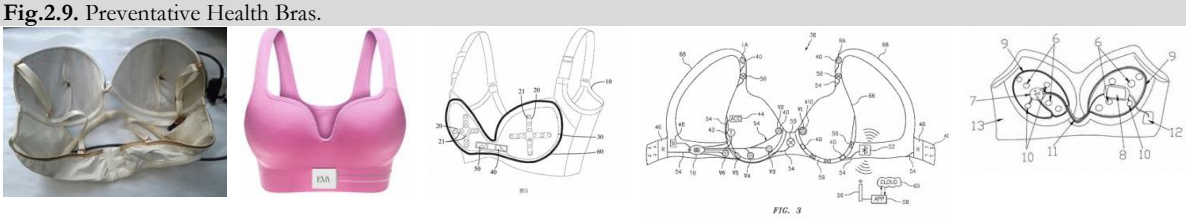
Eleven scoped areas of the BW field were explored (**Fig.2.8.**). The examples are not exhaustive; instead, they introduce each sector with a selection of exemplars discussed below.

Fig.2.8. Bra Wearables (BW) Mapping

2.3.1.1. Preventative Health

1. 'Chronobra'. (Simpson *et al.*, 2013)
2. 'The Auto-Exploration Bra (EVA)'. Julian Rios Cantu. (Gaurano, 2017)
3. 'Intelligent Bra'.(王军 and 彭甲海, 2018)
4. Heart Health Bra. (Chong Rodriguez and Abarca Abarca, 2019)
5. 'Massage Physiotherapy Bra' (易拥军, 2014)

Fig.2.9. Preventative Health Bras.



Preventative health includes taking the pre-emptive precautions necessary to prevent illnesses or diseases by being health-conscious. In this area, bras sense the body's biochemical and physiological outputs to monitor the wearers' health for early detection or prevention (**Fig.2.9.**). Early cancer-detecting bras and

other BW promoting healthy living dominate this space. In 2002, a research team at DeMontfort University created a breast cancer-detecting bra that used small electric currents to decipher between healthy breast tissue and those with tumorous cells (*Electric bra could spot cancer*, 2002; Wang and McCormick, 2005). The bra called 'The Electronic Bra' was successful in the lab; however, it required more testing on women. Later in 2007, the 'Cancer Screening Bra' by Dr Elias Siores, from Bolton University Centre for Research and Innovation, employed a microwave antennae system, a thermographic approach, to detect slightly raised temperature caused by tumours to alert the wearer to seek medical attention (Simpson, 2007). The thermographic approach was introduced in 1989 by Dr Hugh Simpson in his 'Chronobra' utilising heat-sensing technology to predict breast cancer patients' medical outcomes (Simpson *et al.*, 2013). In 2008, industry-led research conducted by Cyrcadia Health introduced their early breast cancer-detecting bra named 'iTBra' (Zhou, 2015). Their approach was similar, as they tracked circadian temperature changes within the breast.

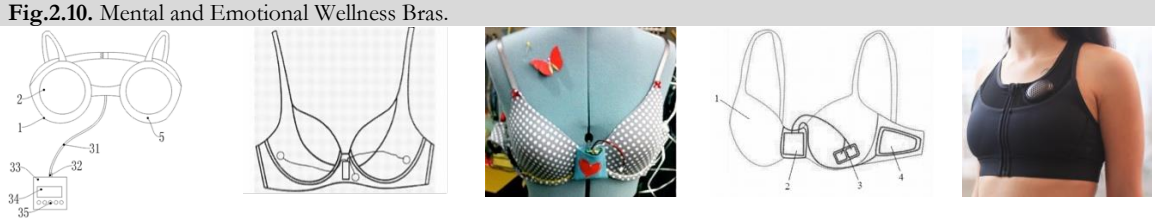
Another cancer-detecting bra marketed is 'EVA' (2017), the auto exploration bra that detects cancer through thermal patterns and tissue elasticity (Gaurano, 2017). The product was first marketed as a pink sports bra but was later changed to an insertable wearables cup. Cyrcadia, similarly, abandoned their iTBra, instead developing a wearable bra insert. The shift from a bra to a separate wearables device is happening frequently as companies cannot discern a complete integration for the bra product; however, inventors and academic researchers are still developing BW concepts. Lastly, in 2016, Bloomer Tech. announced their 'Bloomer Bra', a BW that monitors cardiac health to help prevent cardiovascular disease through electrophysiological and biometric measurements (Chong Rodriguez and Abarca Abarca, 2019). Still in development, they aim to seamlessly embed circuits into e-textiles that would sense heart, pulse, and respiratory rates, and detect the hearts' electrical activity (ECG).

Other preventative and health-based BW include concepts for massaging the breasts as a form of therapeutic and physiotherapy treatment. Chien-Feng Lin filed a patent for a massaging bra with cooling features that would 'enhance the blood circulation and stimulate the metabolism of the lymphatic tissues of the breasts' (Lin, 2012). Similarly, Hangzhou Kangci Biotechnology Co Ltd. filed a patent for a massage physio and thermotherapy bra with heating and vibration features to stimulate circulation and prevent breast disease(易拥军, 2014). Many health-based patents claim to prevent or cure certain illnesses; however, little evidence is provided for their effectiveness.

2.3.1.2. Mental and Emotional Wellness

1. 'Safe and Portable PhotoTherapy Bra'. (吴育林 and 梁明, 2017)
2. 'Smart bra capable of playing sound'. (张植强, 2015)
3. 'Emotional Eating bra'. Microsoft, University of Rochester, and University of South Hampton. (Anthony, 2013)
4. 'Intelligent bra capable of recording sleep states'. (王卫东 *et al.*, 2017a)
5. 'The Everyday Smart Bra'. Vitali. (Kapfunde, 2017)

Fig.2.10. Mental and Emotional Wellness Bras.



According to the World Health Organization (WHO), mental and emotional well-being is essential to overall health. Maintaining positive mental health requires developing coping skills to deal with life stressors. Emotional well-being entails establishing habits to manage or combat stress, anxiety, depression, impulse control, and other mood-related risk behaviours. Numerous health-based BW has been patented within this category (**Fig.2.10.**). This sector began with chemical-infused passive BW with therapeutic perfumery and moisturising sensors towards the end of the 1990s. A Google patent search demonstrates that between 1997 and 2010, sixty-nine patents were filed for sensory-releasing bras within the bra patent classification 'A41C3/0042 Brassieres diffusing perfume or the like'. Bra patents indicate these bras released scents or oils, such as aloe vera, once the wearers' body temperature rose to assist in sensory relaxation (Berg, 1999; Wu, Lin and Wu, 2000; Wang, 2001; 이광용 *et al.*, 2003; 정학년, 2003). Many of these inventions impregnated the materials (microencapsulation) or housed the chemicals in pockets in the bra pads, at the centre front gore or side cradle.

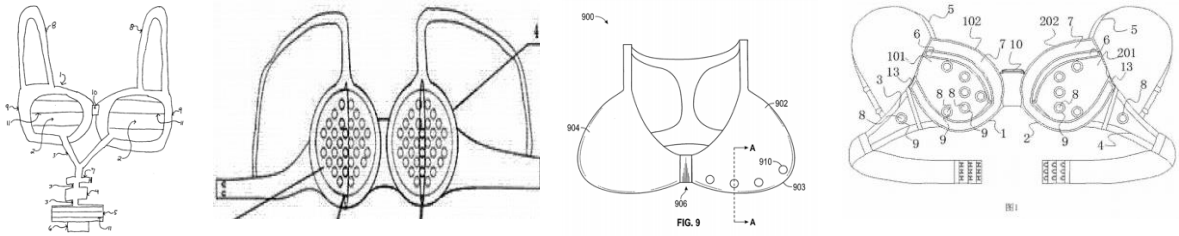
The early therapeutic bras precipitated the health-based BW of the late 2010s. In 2017, a patent application was filed for a 'Phototherapy Bra' (吴育林 and 梁明, 2017) equipped with an electrically connected 'light-emitting optical fibre guide' to treat mood and sleep-related disorders like seasonal affective disorder, non-seasonal depression, and circadian rhythm sleep disorder, as well as to naturally treat skin disorders (i.e. vitiligo, psoriasis, and eczema). A 'Music Massage Brassiere' (卢洁虹, 2015) received a patent that allows the user to adjust the massage features to correspond with the vibrations from the music selected through Bluetooth from another device, namely a cell phone. The bra has Bluetooth pairing, LED display modules, wireless connection, and wireless charging. The inventors note their focus on the consumers' experience to create a bra that delivers improved healthcare. In 2013, an industry and academic partnership between Microsoft, the University of Rochester, and the University of Southampton led to the creation of an 'Emotional eating Bra'. The bra was designed to combat stress and emotional eating by monitoring the wearers' emotional state through sensors measuring electrocardiogram (EKG) for heart rate, electrodermal (EDA) for detecting moisture in the skin, and respiratory rate (Anthony, 2013). Based on press releases,

women commenters were unhappy with what they perceived as sexist undertones. Due to the backlash, the collaborators quietly stopped promoting their prototyped concept. A few patents were filed for smart sleep bras that could record the wearers' heartbeat, blood pressure, and sleep sounds to provide data for doctors to aid in treating insomnia (王卫东 *et al.*, 2016, 2017a, 2017b). Another wellness bra was introduced in 2017 by Vitali as a 'smart sports bra' that monitored heart rate, but was rebranded as an everyday bra that assisted wearers in monitoring stress levels (Kapfunde, 2017). Vitali's 'Everyday Smart Bra' claims to guide the wearer in relieving stress through monitoring breathing, posture, and heart rate. Although some products sold when earlier launched as a smart sports bra, they have yet to release the foundational everyday bra style, with the brand now shuttered.

2.3.1.3. Medical-Centred Bras

1. 'Method and apparatus for preoperative estimation of breast implant volume' (Falsetti, 2005)
2. 'Bra device for treating breast lobular hyperplasia'. (陆兆丹, 宓现强 and 钟福清, 2012)
3. 'Stress test bra' (Ross, Dixon and Cohen, 2017)
4. 'Medical brassiere' (余召师 and 刘松春, 2017)

Fig.2.11. Medical-Centred Bra Patents



BW are being designed for usage in the medical field or to be worn at home while transmitting the data to the doctors on an application system. These concepts fall within the arena of medical-centred BW (**Fig.2.11.**). Many of these bras are designed with specific ailments or procedures to treat or make the process easier. For example, Andrew E Falsetti (2005) filed a patent for a procedural bra to be worn prior to breast augmentation to help estimate the desired 'breast implant volume' and lower regret. The bra – worn during a preoperative meeting – is filled with 'air, water, or other substance' with a gauge attached to measure the implant size. Another concept worn at the doctor's office is the 'Stress Test Bra' (Ross, Dixon and Cohen, 2017). Ross, Dixon, and Cohen highlight cardiovascular disease as one of the top killers of women in America. They developed a bra enhanced with ultrasound technology to create images of the heart while the wearer is resting and record the wearers' heart electrical activity while active. Further equipped with EKG pads, the bra purportedly replaces the need for the doctor to place the pads directly on the wearers' breasts, potentially making the experience physically, mentally, and emotionally more comfortable.

Other bras are designed to be worn at home, with the data made available for the doctor through application systems. Researchers at the University of Shanghai for Science and Technology developed a bra to treat Cyclomastopathy (陆兆丹, 宓现强 and 钟福清, 2012), also known commonly as 'fibrocystic disease of the breasts' according to Mayo Clinic (*Fibrocystic breasts - Symptoms and causes*, 2021). The design uses an LED light source with varying wavelengths to 'promote cell differentiation', 'blood circulation', and 'suppress the mammary gland tissue', which the inventors believe is

a safer alternative (陆兆丹, 宓现强 and 钟福清, 2012). Similarly, doctors at the Ezhou Central Hospital patented a therapeutic acupuncture-based bra to rid the body of certain toxins titled 'Medical Brassiere' (余召师 and 刘松春, 2017). The bra is claimed to act as an additional treatment by compressing the breasts with a hot and cold feature while massaging specific traditional acupuncture points via vibration motors. Many medical BW patents follow similar prescriptions where the concept and functions are claimed to treat or prevent an illness; however, very few explain the in-depth technicality or science behind the *how*. The patent's merit is based on the newness, not the practicability.

2.3.1.4. Body Enhancement

Throughout history, one of the bras' main functions was to enhance the breast by lifting and increasing the size. Added components like lemons or breast pads were commonly placed within the bra cups as early as 1869. After the introduction of breast augmentation in the '60s, women could enhance their breasts surgically, but many wanted a safer and more natural option. By the '70s, brands such as Fredricks and American Image Corp. were advertising bras with small vibration modules inserted at the centre to increase breasts size (**Fig.2.12.**). Although not much was found on how well these products sold, the trend towards larger breasts continued. During the '90s, women achieved the desired look due to readily available breast augmentation, and the revamp of the Wonderbra in microfibre with different pad fillings enabling a fuller natural appearance.

Receiving a patent in 2002, Dr Roger K Khouri created 'The Brava Bra' (Khouri, 2002), enabling wearers to gain up to one cup size naturally without surgical enhancement by expanding the breast tissue (**Fig.2.13.**). The bra is fitted with two suction cups and a control box to be worn for 12 to 14 hours daily up to 20 weeks. A 2007 study shows a 75% approval rate of satisfied or very satisfied out of 40 women who used the Brava Bra (Schlenz and Kaider, 2007). In 2015 Milan Milicin introduced his 'Enhance Bra', shortened to 'E-Bra', which claims to enhance breasts one cup size in just a week of wearing for five minutes three times a day (Foster, 2015). The bra has a vibrating electrical function set to timed intervals. Dr Salzhauer, a Miami plastic surgeon, tested the device separately and claimed results; however, he believes the next stage is proper clinical trials (Lynch, 2015). This field has seen an overflow of inexpensive

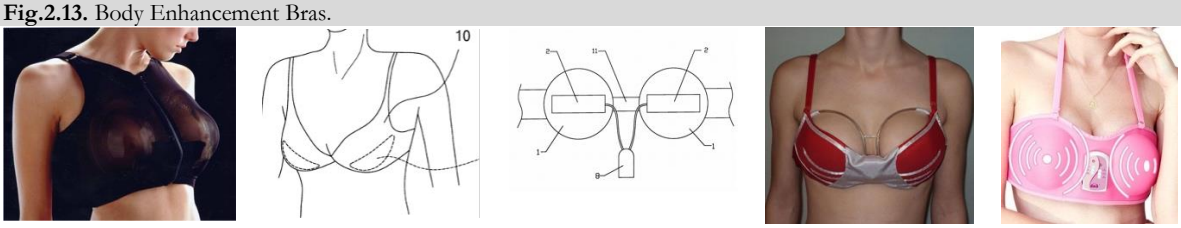
1. Vibrator Bra. **1972**. Fredricks of Hollywood.
2. Vibra-Bra by American Image Ad, Madamoiselle, June 1972, p 177.
3. Vibrating Bra. **1971.** Designer Malrait shown at the "20th International Show of Inventions".

Fig.2.12. Early vibrating bras marketed as breast enlargers in the '70s.

massage bras promising breast size increase sold on eBay, and AliExpress made in China. China has the most patents for bras with massage functions, claiming therapeutic and holistic health benefits or breast enlargement.

1. 'The Brava Bra'. (Khouri, 2002)
2. 'The bust massage vibrator'. (김신동, 2001)
3. 'Silicone pulse electronic breast-augmentation Bra'. (郭晓松, 2013)
4. 'Enhance Bra'. Milan Milicin. (Foster, 2015)
5. 'Electric Breast Enlarger Massager'. Generic style found on eBay and AliExpress, 2018.

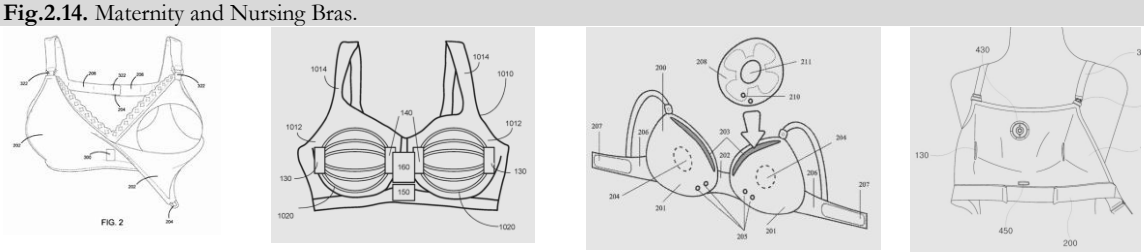
Fig.2.13. Body Enhancement Bras.



2.3.1.5. Maternity and Nursing

1. 'Technologies for monitoring breastfeeding'. (Rider, Taite and Ron, 2018)
2. 'Systems, Devices and Methods for Monitoring Breastfeeding'. (Goodall *et al.*, 2020)
3. 'Automated Compression Nursing and Pumping…' (Looney, Kumar and Vazquez Ortiz, 2018)
4. 'Breast-feeding brassiere with massage function'. (김선미, 2019)

Fig.2.14. Maternity and Nursing Bras.



The area of maternity and nursing is composed of bras designed to assist the wearer in breastfeeding and caring for milk-filled breasts (**Fig.2.14.**). Historically, nursing bras have been technologically advanced, exploiting innovative materials and design concepts to aid in the act. In the early 19th century, bra patents illustrated tubes attached to the bra cup and nipple to move the milk from breast to baby (Cunningham, 1910), hinged caps to open the circular mini closure on a cup to access just the nipple (Murray, 1899), and made from rubber (Chambers, 1894; Cunningham, 1910) to safeguard the wearers' outer garment. Inventors in this space aimed to ease the difficulty of nursing and aid healthy breasts. Modern BW in this field are no different.

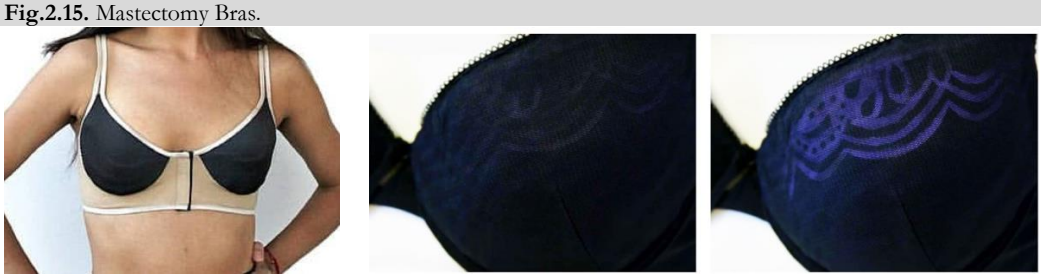
By the mid-2000s, pioneering nursing BW were available with bras designed to be attached to a breast pump permitting hands-free pumping. Currently, the field is seeing commercial success with a separate insertable wearable smart breast pump called Elvie, which easily inserts into a traditional bra (Hahn, 2021). However, behind the scenes, numerous patents are being filed for bras to do more than assist with pumping. Bras are being designed to collect breastfeeding data like logging the time of feedings, the breast nursed from, length

of nursing, and an estimation of the amount nursed. In one BW example, a 'use' and 'latch' sensor is placed on each bra strap, and when unhooked, the data begins recording, storing the information on a mobile device (Rider, Taite and Ron, 2018). Goodall *et al.* (2020) filed a patent for a nursing BW that would monitor the curvature of the breasts to record the 'volume of milk expressed' for each feeding session in a phone app. Some bras have additional capabilities, like massage features, to assist with mastitis and pumping. Two concepts claiming this are patents US20180126052A1 (Looney, Kumar and Vazquez Ortiz, 2018) and KR102004979B1 (김선미, 2019) (**Fig.2.14.**). 김선미's patent utilises air pockets as a pumping mechanism to massage the breasts while nursing to promote lactation. The pumping action is governed via a controller that can change the pressure or apply the massage in directed areas. Similarly, Looney, Kumar, and Vasquez Ortiz's (2018) concept uses an air-pumping action to massage the breasts in different patterns while feeding or pumping. A singular component of many of these new concepts is that they are meant to be worn during active living.

2.3.1.6. Mastectomy

1. 'Autoadjustable Bra'. (Lazaro Vasquez, 2019)
2. Aymée. *Image two and three* (Menheere *et al.*, 2018)

Fig.2.15. Mastectomy Bras.



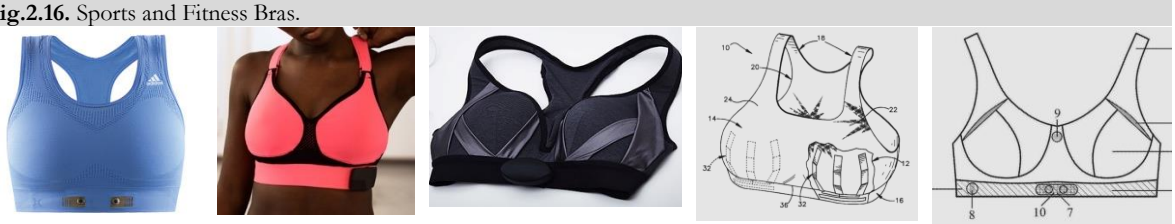
Designers and researchers are exploring advanced technology to build better mastectomy BW (**Fig.2.15.**); however, concepts are limited within this area. Mastectomy BW can be designed to aid in scar and tissue healing, enable the aesthetic of having balanced breasts, and encourage healthy living.

In 2019, Architect Eldy Lazaro Vasquez developed a BW to assist wearers with breast asymmetry to balance the bra cups utilising parametric designs enabled through soft robotics and air channels (Lazaro Vasquez, 2019). The soft robotics functionality permits the air channels, designed into three sections, within the bra cup to fill. Each cup side is programmed to fill until they are evenly matched. Therefore, if the right cup is acceptable, the left will fill until it reaches the same distance and measurement. The design eliminates the use of metal underwires that irritate the scar tissues. Researchers developed a BW to assist women with breast cancer to become more physically active. The bra called Aymée was developed to change colours through thermochromic ink (Menheere *et al.*, 2018). After achieving their daily physical activity goal, the wearer must push a button, which initiates the heating feature, enabling the hidden design to appear. The study's participants felt the concept would promote personal pride in achieving their goals.

2.3.1.7. Sports and Fitness

1. NuMetrex Sports Bra. **2006.** Adidas
2. OmBra Sports Bra. **2016** OmSignal
3. Hera Smart Coach Sports Bra. **2016**
4. 'Piezoelectrically controlled active wear'. (Pottenger, 2001)
5. 'Multifunctional smart sports bra'. (徐朔 and 王建萍, 2017)

Fig.2.16. Sports and Fitness Bras.

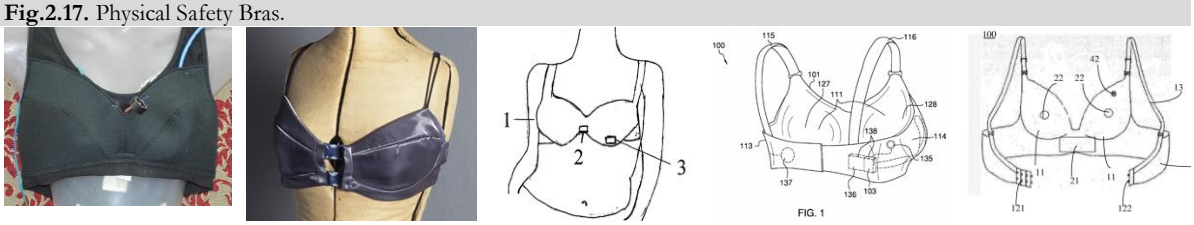


The sports and fitness area (**Fig.2.16.**) has seen the most advancement in wearable technology due to collaborative research by industry and academia. Products within this area have seen innovative outcomes, experiencing commercial success. One of the first Sports Bra Wearables (SBW) was patented in 2001 by Michael D Pottenger (2001), designed with piezoelectric transducers and other electrical components to reduce breast bounce during workouts. If resistance is detected after determining the breast force during activity, the transducers stiffen. This concept is a precursor to bras with shape memory polymers acting similarly to Randall *et al.* (2016) and Reeboks PureMove sports bra (Aouf, 2018). Textronics Inc. introduced the first commercial SBW with their NuMetrex bra (2006), enhanced with e-textiles that sense electrocardiogram (ECG), allowing for heart rate monitoring that uses a removable WearLink transmitter to transmit data to a smartwatch. Adidas purchased the NuMetrex bra, rebranding it as Adidas miCoach sports bra (2012), adding a miCoach app for a better user experience. The success of this bra influenced other brands with similar style heart rate monitoring SBW, such as Victoria's Secret 'Incredible Bra' (Lamkin, 2014), Sensoria (2015), Mi Pulse Smart Sports Bra (2016), and Supa Powered Smart Sports Bra (2017). A few brands deviated, introducing more options through biometric sensing. OmSignal Activewear Bra (2016) shifted by introducing physiological respiration sensors to monitor breathing rates and biomechanical sensors to assist in relaying calories burnt to the wearers. Hera Smart Sports Bra (2016) claims to help with 'real-time' coaching during workouts by sensing speed, distance, heart rate, intensity, calories burned, GPS, and body position. This product has numerous press release write-ups, yet no sample has been presented. Unfortunately, by 2017, many of these brands' products are now defunct, with only Sensoria and Mi Pulse Smart Sports Bra selling products, while OmSignal and Supa plan to revamp their products. A recent study on the reliability and validity of SBW, specifically Adidas miCoach, Sensoria, and Berlei, indicated that some bras were only valid during certain activities such as rest, walking, or running (Navalta *et al.*, 2020). Thus, the decline of SBW may have been due to their lack of reliability. Nevertheless, the SBW field is still developing as new patents are being filed (孙金美 and 宋晓霞, 2018; Stasey, Gummin and Wyatt, 2020; 門若 *et al.*, 2021).

2.3.1.8. Physical Safety

1. Society Harnessing Equipment (SHE) by Manisha Mohan (Manuel, 2014)
2. 'The Techno Bra' by Kursty Groves. (Kahney, 1998)
3. 'The anti-infringement underwear…'. (何珊, 2015)
4. 'Heated bra with a GPS module'. (Aiello, 2016)
5. 'Smart Bra and Protective System…' (刘凯霞 *et al.*, 2018)

Fig.2.17. Physical Safety Bras.

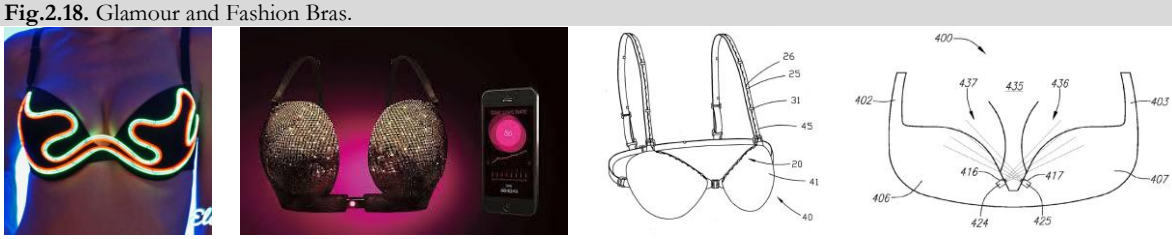


Physical safety bras include bras designed to keep wearers safe from the natural elements and assault (**Fig.2.17.**). Janet Aiello patented a 'Heated Bra with a GPS Module' to allow hikers, skiers, and other cold outdoor sports participants to partake safely (Aiello, 2016). Aiello claims that the heated elements allow wearers to stay warm and comfortable. The GPS feature keeps track of the wearer and may be shared with a mapping software in the event of trouble. On the other end of the safety spectrum are bras invented specifically to stop rape or assault. In 1998, 'The Techno Bra' was developed by Kursty Groves while attending The Royal College of Arts (Kahney, 1998). The bra featured a built-in heart rate monitor, wireless telephone, and GPS locator that would alert the wearers' predefined contacts if they were in trouble. A similar concept was debuted in 2017, by researcher Manisha Mohan from the Massachusetts Institute of Technology (MIT), in the form of an attachable wearable device (Mohan, Sra and Schmandt, 2017). The device is placed through adhesive into the bra neckline area. If the bra is forcibly ripped from the body, the device sends a message and GPS location to prearranged contacts before beginning auto-recording. Previously, in 2013, Manisha Mohan and a group of engineers in India developed an anti-rape bra called 'Society Harnessing Equipment (SHE)'. The bra senses pressure (such as hugs, grabs, squeezes, and pinches) and emits a shock strong enough to severely burn a would-be assaulter before alerting the police through a GPS locator (Krishnan, 2014; Manuel, 2014). A waterproof, insulating layer protects the wearer and calibrates pressure sensors to keep hugs from activating the bra. A few other bra patents also feature the shock function if pulled upon (Liu *et al.*, 2018; 刘凯霞 *et al.*, 2018; Bonde *et al.*, 2020), with some claiming to send direct reports and GPS locations to the police through a pre-registered system (何珊, 2015).

2.3.1.9. Glamour and Fashion

1. Light up Bra. **2018.** Electric Stylesvia Amazon[21]
2. 'The True Love Bra'. **2014** Ravijour Brand
3. 'Lighting emitting devices used … brassiere'. **2007** Shu-Ching Hsu, *US20070236916A1*
4. 'Fashion illumination system'. **2007** Bruce L. Finn, *US7878675B2*

Fig.2.18. Glamour and Fashion Bras.



Glamour BW is seeing some success in LED light-enhanced bras for raves, festivals, and dance events (**Fig.2.18.**). Some of these bras were available on Amazon and Etsy shops for affordable prices. Online retailer Electric Styles has carved out a niche for light-changing styles. The light-up styles feature glowing electroluminescent wires with four modes (permanently on, fast or slow blinking) sewn onto bras. The bra also features sound-responsive sensors that enable the lights to blink with the music. Other styles, such as the 'Light Up Fur Bra', feature colour-changing options with a hidden pocket in the bra wing for batteries. Additionally, Triumph Lingerie created a 'Close Sisters Bra' in 2014 that would change colours and patterns when the electronic paper encountered another bra of the same design. The concept was another one of their social commentary bras, highlighting the bonds between female friendships in Japan.

Japanese brand Ravijour created the 'True Love Bra' in 2014, which would only unlock from the front clasp if the wearer was in the presence of their true love (Daria, 2014; *Apparently This Bra Only Unhooks Itself For True Love*, 2014). The bra is equipped with a heart rate sensor set to a defined threshold to differentiate the heart rate from other heart palpations (i.e., feelings of fear, slight arousal, a rapid heartbeat from exercise). A Bluetooth device connects the bra to a phone app that analyses the sensors' data, signalling when to unlock. The 'True Love Bra' was developed for the brand's 10th anniversary, more for promotion than to sell. Chromat, a lingerie and swimwear brand, has been at the forefront, merging the area of architecture, fashion, and technology through 'innovative design and cutting-edge technical fabrics' with the products receiving rave reviews from fashion critics (*Chromat #TECHTALKS: 3D Printing*, 2015). In 2015, they introduced 3D-printed caged bra designs with laser lights beaming from the nipples and an LED caged bra with a matching mask, all for fashion. These designs were not meant to be worn, but to inspire designers to think and work creatively with technology.

Patents within this field similarly tend to focus on bras that light up. Shu-Ching Hsu filed a patent for a bra with LEDs along the straps and neckline that the wearer can control (Hsu, 2007). Bruce L. Finn patented

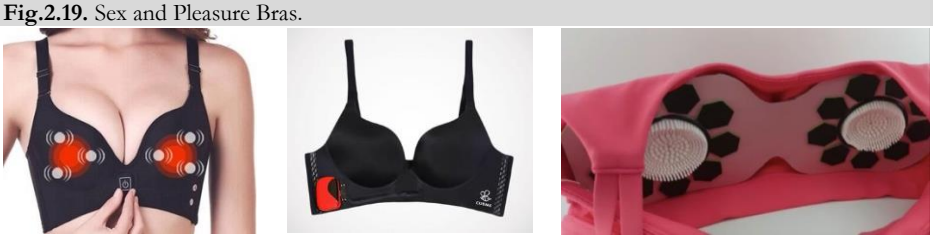
[21] https://www.amazon.com/Electric-Styles-Black-Electroluminescent-Light/dp/B00B66MMXA?ref_=ast_sto_dp

a similar concept with their 'Fashion Illumination System' bra (Finn, 2011). Finn differentiates by designing the light to focus directly upon the wearer's skin 'in an alluring way' like a spotlight. The lighting could also be programmed to spell words on the wearers' décolletage.

2.3.1.10. Sex and Pleasure

1. 'Breast Massaging'. Unknown Brand via AliExpress.
2. Massage Bra. **2016**. CUEME. Tracy Li.
3. Vibrating Massage Bra. **2016**. BigoDicky via Indiegogo.

Fig.2.19. Sex and Pleasure Bras.



The porn industry generally accepts technology as the future and is primed to experiment with augmented reality (AR), virtual reality (VR), and sex robots. There is a dramatic rise in Sextech, 'technology and technology-driven ventures, designed to enhance, innovate and disrupt in every area of human sexuality and human sexual experience' (Gallop, 2015) and Sensualtech, technology-enhanced products for 'exploration, experimentation and expression with renewed sexual sensibility' (Tucker, 2016). Sextech and Sensualtech introduced wearables products into the market, but not many fashion-based items. Nevertheless, the last decade witnessed numerous patents for massage bras that double as nipple stimulation for sexual arousal[22] (**Fig.2.19.**).

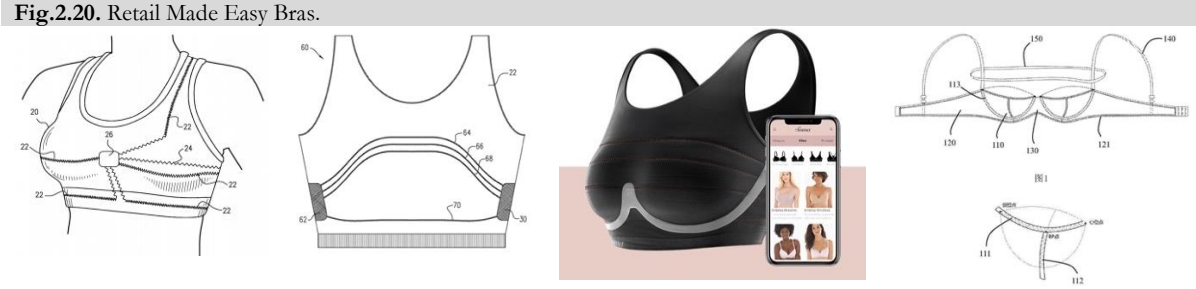
In 2016, Tracy Li launched CueMe, a bra and underwear set connecting the wearer with a partner who could control the vibrations and massage features for intimate pleasure through a phone app (Li, 2018). While the CueMe bra was available to purchase through Amazon and other sites, some sex-based bras had trouble launching. In 2018, BigoDicky attempted to crowdfund their nipple-stimulating bra, equipped with eighteen 'electrode impulse and a rotational massager' on removable hardware (Tse *et al.*, 2016). The bras' stimulation function could be controlled by a phone app or voice-controlled – additionally, the four developers designed a VR function to heighten the experience. The brand's funding campaign did not receive enough funds; instead, receiving backlash on social media. Women complained about the terrible design, hinting that the concept was designed from a male view. Although massage bras are being sold, very few are outright positioning for this sector, instead marketing as breast stimulators. In fact, some are marketed as massage bras but do not stipulate whether it is for health or sexual benefits.

[22] A study by Levin and Meston (2006) reveals that 81.5% of 153 women studied agree that nipple and breast stimulation cause sexual arousal.

2.3.1.11. Retail Made Easy

1. 'Self-measuring Bra'. (Cooper and Slobodkin, 2019)
2. 'Automatic Measuring Bra'. (Cooper and Slobodkin, 2020)
3. Soma Innofit Bra. ('SomaInnofit Review: Trying a Smart Bra On for Size', 2019)
4. 'Three-Dimensional Body Measuring Bra'. (杨雪梅, 2017)

Fig.2.20. Retail Made Easy Bras.



Inventors also seek to make bra buying easier for wearers (**Fig.2.20.**). The mid-2010s introduced a small number of bra brands that began using fit algorithms and apps to assist buyers in shopping online. Bra brand ThirdLove pioneered the concept with their AI-powered app, which attempted to recommend the correct bra size (Grothaus, 2013). The potential buyer would take photos of themselves in tight-fitting garments, then the app would register their measurements to recommend the brands' closest fitting bra size. Although ThirdLove discontinued the app a few years later due to inaccuracies, Wacoal released their myBraFit AI-powered app in 2021(Lee, 2021). Wacoals' myBraFit app requires buyers to wear a pre-owned bra with an underwire and scan their bodies at 360 degrees. Then, after answering a few questions, Wacoal's app would suggest a bra from the brand.

Other concepts are also being developed where the potential buyer would try on a bra designed for reading the body's measurements (Cooper and Slobodkin, 2019, 2020; 'SOMAINNOFIT™, New Bra Fit Technology', 2019). These bras are designed with conductive fibres to measure the zigzagged elastic stretch change once the garment is on the wearer. The data is subsequently sent to an app that relays the output in terms of sizing. In the case of Soma Innofit Bra, the reading relays the wearers' bra measurements with recommended bras from the brand. The design is a one-off purchase meant to fit any breast size, as the material is knitted in the round, allowing wearers to accurately purchase bras.

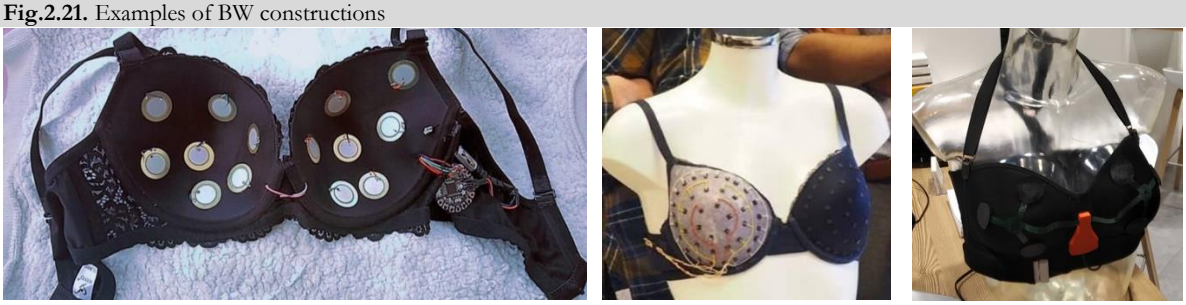
Researchers are developing future-facing concepts for customised bras designed through 3D printing and scanning (see Section 3.4.5.). In 2019, Ari van Twillert launched her innovative bra with a 3D-printed cage design to replace underwires (Roberts-Islam, 2019). Before purchasing, the consumer is scanned with a hand-held 3D scanner; the data is then sent to a 3D printing manufacturer along with the bra style, enabling a three-day manufacturing period. This process has increased the bra prices significantly to €595-895. Conversely, mid-tier bra brand Wacoal introduced 3D body scanners in Japanese stores to help women select correctly fitted bras (Lamba, 2019). To assist brands in entering this arena, researchers at Huizhou University filed a patent for a bra to aid in 3D body measurements (杨雪梅, 2017). The bra has technical elements that allow several body points to be accurately scanned.

2.3.2. Current Situation and Problems of BW Development

Even after 30 years of research, BW is still in its infancy. This review of the state-of-the-art did not factor in swimwear bras, as they are outside this research's scope. While this study queries from a lingerie designers' perspective, I chose not to critique the concepts based on aesthetics or design. Most of the BW patents did not discuss the fabrication or trimmings of the bra designs, instead focusing on the functionality and materiality of the technological elements. The lack of information about materiality produces a gap in understanding how the concepts fully integrate. This leads to the main query of how the hardware is married to the fabric and design and what can be learned to assist in its development.

1. 'Breast Cancer Detection Bra'. Credit: Kemisola Bolarinwa, 2023
2. 'Breast Cancer Detection Bra'. Credit: École Polytechnique Fédérale de Lausanne, 2020
3. 'Wellness Bra'. (@Icosamed_, 2019)

Fig.2.21. Examples of BW constructions



BW prototypes must be developed through interdisciplinary, academic and industry cooperation, requiring cross-team collaboration. Academia and industry need to partner as academia has the talent and time while the industry has the resources and experience (Ashby, 2022). A multidisciplinary team is necessary to identify potential applications, cohesive product development, and understand the target consumers' need for commercial success (Garlinska and Röpert, 2013). The academic research teams have been from hard disciplines, focusing more on the technology and its development, rather than the wearer's experience of the created product. Therefore, the approach is to place the technology onto existing bras (**Fig.2.21.**), not focusing on function, aesthetics or ergonomically comfortable wear and usage. A bra designer has a critical perspective that is missing from the academic teams, which the industry collaboration would provide. The bra is complex in design, as it has many styles with different design qualities and make-up (Appendix A and B). Introducing new fabrics to the product requires insight that only a bra designer/patternmaker/grader can provide. In Chapter 3, the complexity of designing within this area is clarified.

Another critical missing component is the consumer and their valuable insight. Often patents and projects are focused first on the product being created (technology-push) and then on finding a target consumer. That design approach proves a concept is achievable but not that it will possess value to consumers as their user requirements, lifestyle, and purchasing criteria have not been understood (Ariyatum *et al.*, 2005). The target consumer should be determined and discussed before designing or developing the invention (McCann, Hurford and Martin, 2005; Garlinska and Röpert, 2013). Prahl (2015, p. 338) agrees, noting that

only after clearly defining the user and applications can the design team understand and define an approach based on 'user needs and desires in terms of aesthetics, functionality, usability, price-points and other related […] criteria's'. During traditional bra design, the target consumer may have the opportunity to have input towards the end of the D&DP through focus groups or fit trials (Hardaker and Fozzard, 1997). Depending on the market tier, consumers may not have any input. This manner of approach must change when designing for BW. In traditional bras, consumers' highest complaints across all age and size ranges are fit, quality and comfort according to the June 2018 Mintel report (Dover, 2018). Therefore, adding technology to a product that already has issues for the wearers, means taking extra care to understand how to overcome those issues to provide value.

2.3.3. Future Areas/Design Opportunities for BW

As the BW field is nascent, there are opportunities for designers and researchers to:

1. Research the BW needs of various age groups, as BW is currently designed utilising a specific needs-based approach.
2. Further research on the mental and emotional implications of wearing health-based BW on wearers.
3. Consider the ethical implications of BW to ensure they are designed to respect the wearers' autonomy and privacy.
4. Document the development of BW prototypes, producing insights into various approaches, techniques, and materiality.
5. Evolve the bra form and style to include technology.
6. Redevelop the D&DP by implementing participatory practices to move from technology-push to contextual-push and consumer-pull concepts.

This study focuses on numbers 4 through 6, providing further insights into BW.

2.4. Summary

Chapter 2

- ***Introduced*** the reader to the bra field, utilising patents and contextual research to establish the connection between technology and the bras' advancement.

- ***Evidenced*** an evolving BW field highlighting its modern historical timeline and state-of-the-art with eleven subfields and exemplars.

- ***Differentiated*** between the umbrella terminology, 'smart bra', and the more specific field of bras with mechanical, electrical, and chemical properties, Bra Wearables (BW).

- ***Suggest*** that a new approach and more insight is necessary for advancing the BW field.

3

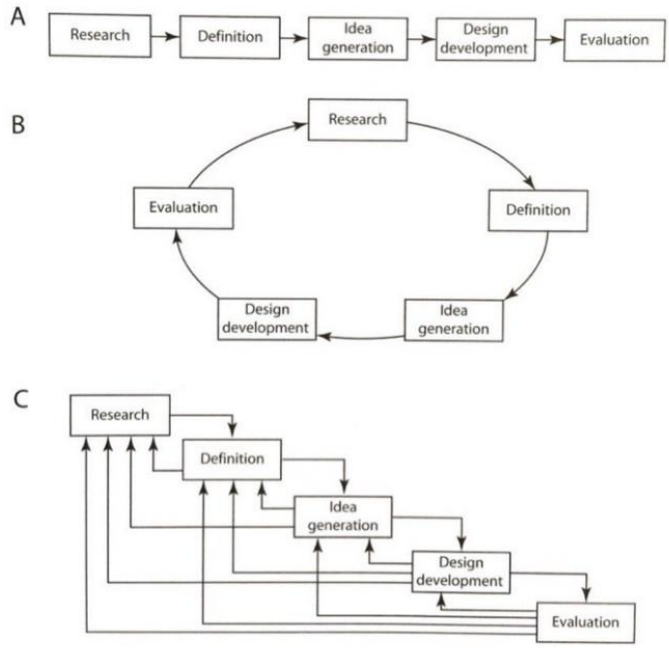
3. BRA DESIGN PROCESSES

As this study aims to develop a BWD&DP, it is necessary to comprehend the bra and wearable technology design and development process (D&DP). Bra design centres on the product's aesthetic and functionality, while wearable technology design focuses on electronics, functionality, and efficiency (Dunne, 2004; Watkins and Dunne, 2015). Dunne (2004) surmises that the two, fashion and technology, must combine into a single process. Ariyatum (2005, p. 73) argues that 'product designers must incorporate fashion thinking in their design procedures, and fashion designers must integrate product think into their[s]'. To identify elements imperative to a D&DP, this chapter reviews various design processes (DP) to understand their foundations and frameworks.

The chapter begins by overviewing multiple DP (3.1.), then focuses on traditional bra (3.2.) and sports bra DP (3.3.). Specific insights into designing and prototyping a structured bra are discussed (3.4.), ending with a review of several Human-Computer Design (HCD) approaches (3.5.) that introduce wearers into the DP.

3.1. Design Processes Overview

Fig.3.1. Various design processes.
Source: A- linear, B-circular, C-reiterative (Watkins and Dunne, 2015, p. 3)



A design process (DP) is essential to the creation of most products. Regan et al. (1998, p. 37) conclude that a DP is 'based on skill, knowledge, inspiration, experience, and problem-solving techniques'. With numerous products available, DP vary widely and can be applied differently. **Fig.3.1.** illustrates that the process can be linear and sequential, repetitive, circular, or reiterative, returning to the various stages (Koberg and Bagnall, 1981; Watkins and Dunne, 2015). As apparel is developed to fit a wide range of people, utilising different forms of material and construction, rarely is the process linear. The apparel D&DP, informed by the creative D&DP, is often reiterative, problem-solving along the way. The reiterative creative D&DP is a system of thinking, 'divergently', exploring information, concepts and ideas, and then 'convergently', focusing on specific elements (Koberg and Bagnall, 1981; Watkins and Dunne, 2015). This system of thinking allows DP to progress.

To begin exploring the multitude of DP, a table was developed to aid in structuring the information (Appendix C). The sections are divided into new product, apparel, functional apparel, and intimate apparel design. Although the processes vary in stages and length, they often fall within five phases: problem statement/identification, conceptual design, prototype development, evaluation and refinement, and solution/production. For the sake of simplicity, this section provides an overview of the pertinent apparel DP (3.1.1.), new product DP (3.1.2.) and functional apparel DP (3.1.3.) to understand the practicality for a BWD&DP.

3.1.1. Apparel Design Processes

Four foundational apparel DP are introduced within this section.

Koberg and Bagnall (1981) established their seven-stages design and creative process. They maintain that the D&DP is a problem-solving journey 'involv[ing] the conscious application of incentives, intentions, decisions, action, and evaluations' (Koberg and Bagnall, 1981, p. 16). Their seven-stage process contains: accepting the situation, analysing information, defining, ideating, selecting, implementing, and evaluating. The first three stages (i.e., accept the situation, analyse, and define) can be simplified under problem statement/identification (Appendix C). Additionally, the fourth and fifth stages (i.e., ideate and select) fall within the conceptual design stage. The DP is advantageous as it can be explored in multiple ways: linear, circular, and reiterative (**Fig.3.1.**). Although not apparel-based, their creative problem-solving D&DP has applicability to apparel design and inspired the development of functional apparel DP.

Labat and Sokolowski (1999) developed their industry-facing three-stage D&DP for textile production. The process was created after examining architecture, engineering, industrial product design, and apparel DP. Through examination, they surmised that the D&DP has three stages: problem definition and research, creative exploration, and implementation. Within each stage, there are multiple steps centring continuous exploration. First, the process begins with an initial problem; then, designers seek a solution through research before establishing design criteria. Next, designers enter the creative exploration stage, considered

'the least well-defined' (LaBat and Sokolowski, 1999, p. 18). In this stage, preliminary ideas are developed, refined, prototyped, and evaluated. The last stage is implementation, entailing product refinement, which focuses on producing the designs. Labat and Sokolowski's process centres the wearer in both the problem definition and creative exploration stages, attempting to understand their needs (i.e., function, aesthetic, and economics).

Orlando's (1979) New Design Process Model was inspired by Jones' 1973 (see 3.1.2.) three-stage product DP: divergence, transformation, and convergence. However, Orlando expanded his process to six stages: request, design exploration, problem identification, design criteria and specification, prototype, and evaluation. Orlando's design can be communicated through Jones' three stages. Within the divergence stage, a wealth of information is gathered, aligning with Orlando's first three stages (i.e., request, design exploration, and problem identification). The next stage, transformation, facilitates insight into the creative process, aligning with Orlando's fourth stage, design criteria and specification. The last stage is convergence, where the objective is effectuated and accords with the final two stages in Orlando's process (i.e., prototype and evaluation).

Researchers have uncovered similarities between apparel design and engineering DP (Regan, Kincade and Sheldon, 1998). Regan et al. (1998) created their linear apparel D&DP for mass production, founded on design engineering theory. They submitted that 'the apparel design process is a scientific and problematic building block process', resulting in a seven-stage linear D&DP (Regan, Kincade and Sheldon, 1998, p. 40). The seven stages include problem recognition, problem definition, exploration of the problem, search for alternatives, evaluation and decision-making, solution specification, and solution communication. To minimise mistakes in mass production, their D&DP places emphasis on the problem statement/identification phase.

3.1.2. New Product Design (Engineering and Product Design Processes)

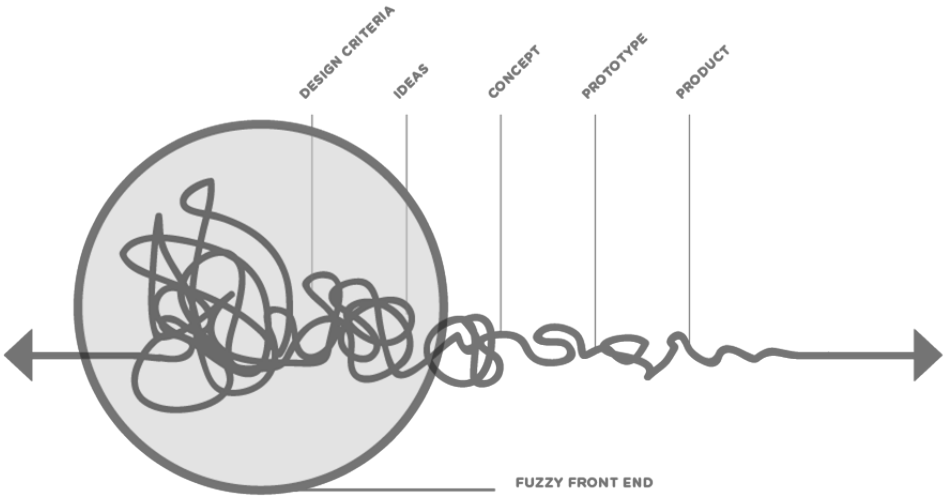
The BWD&DP needs to integrate not just the bra's functionality but also the electronics' functionality; thus, it is also essential to examine engineering DP. This section introduces engineering and product DP, as they often overlap.

Engineering design is a problem-solving decision-making process (Gorea, 2017). The process is function-oriented, requiring ideation, definition, and comprehension of the technical product or artefact (Ulrich and Eppinger, 2000; Pahl *et al.*, 2007; Ullman, 2009). One approach often used in engineering design is the TRIZ method. After studying hundreds of thousands of patents, Genrich Altshuller and Rafik Shapiro developed the Theory of Innovative Problem-Solving (TRIZ, a Russian phrase). TRIZ is a methodology and theory for assisting engineers in solving design problems

(Altshuller, 1984, 2002). As a methodology, TRIZ provides tools, a contradiction matrix[23] for supporting problem-solving to technical issues when mixing different design elements, and forty principles[24] for technical innovation (Altshuller, 1999, 2002). TRIZ aids the stimulation of creativity and solving technical problems when mixing different fields (Altshuller, 1996; Vincent, 2006), such as fashion and technology. Although TRIZ is often used in product development, it has been applied in fashion to design an automated zipper (Baharom *et al.*, 2017; 2018), combine biomimetic with functional design in a responsive knitted sports bra (Gorea, 2017), and develop innovative bra strap ideas on a theoretical level (Lovel *et al.*, 2006). TRIZ can assist with developing ideas for innovating the bra silhouette and hardware integration for BW.

Jones (1973) product DP was used to inform numerous apparel DP. The process is abstract, consisting of three stages: analysis, synthesis, and evaluation. Jones developed the process, aiming to balance logical analysis and creative thinking. The analysis stage has several sub-processes to acquire the design requirements, which Jones refers to as performance specifications. In the synthesis stage, creative thinking occurs to find solutions for the performance specifications. Finally, in the evaluation stage, the designs' performance is evaluated by the operation, manufacturer, and sales team before finalising the design. Jones' product DP indefiniteness allows it to easily be adapted.

Fig.3.2. Fuzzy Front-End in Design Processes
Source: Sanders and Stappers (2008) 'Co-creation and the new landscapes of design'
Image adapted by Jean Chisholm



Acklin (2010) created a design-driven innovation process to aid small and medium-sized enterprises (SMEs) in developing innovative products. This process aims to aid stakeholders, i.e., the design and design management teams, in the fuzzy front end of the D&DP (Acklin, 2010, p. 54). The fuzzy front-

[23] Contradiction Matrix https://triz40.com/aff_Matrix_TRIZ.php
[24] 40 Principles for invention https://triz-journal.com/40-inventive-principles-examples/

end relates to the ambiguity and messiness that occurs in the initial stages of the product DP when trying to establish consumer needs and design elements (**Fig.3.2.**). Acklin's process is circular, with the possibility of stages conducted concurrently. There are five stages: impulse, research, development, strategy, implementation, and evolution. Impulse, strategy, and evolution will be explained. Impulse pertains to 'market observation, and analysis and assessment' of the field, focusing on the overall market and consumer trends (Acklin, 2010, p. 56). After development, strategy is applied in the middle of the process, allowing the products to inform business strategy development rather than the other way around. Lastly, evolution occurs after implementation, enabling consumer feedback to aid in evolving the product.

3.1.2.1. Incremental vs Innovative Product Design Process

According to Hoonhout (2007), new products can emerge through either an incremental or innovative DP. Incremental DP involves building upon an existing product (next generation) for improvement, while innovative DP is employed when introducing an entirely new-to-market product (novel product generation). Hoonhout (2007, p. 22) provides a rich assessment of the differences between the processes, with a significant factor being the 'direct involvement and participation of consumers [which takes place] at different times and in different ways in the [DP]'. According to Morris and Ashdown (2015, p. 2), the decision to involve consumers in a project depends on factors like 'newness, complexity, innovativeness, timing, and price-point'. While consumers may provide valuable information, it is crucial to acknowledge that designers are responsible for a distinct transformative process that transforms consumer input into meaningful knowledge (*ibid*). HCD processes (see Section 3.5.) involve consumer participation through the generation of collages, sketches, and notes capturing intricate design aspects (McCann, 2015). Designers, leveraging their vast expertise and understanding, analyse these contributions to fulfil user expectations and requirements. Thus, a combination of expertise and intuition is utilised by designers during the HCD innovative DP to refine and filter user information (Morris and Ashdown, 2015), thereby directing the product's strategic direction. The synergy is enhanced by the expert stakeholders' tacit knowledge and experience (McCann, 2015), which requires the barriers between the experts' fields to fade, enabling ideation and progression (Hoonhout, 2007; Weber, 2011). Considering consumer desires and experiences in innovation is a new concept with few defined techniques and tools (Agouridas *et al.*, 2006; Tito *et al.*, 2006), researchers assert that the innovative DP must be an iterative process requiring evaluate-and-feedback loops to understand and inform the next stages (Hoonhout, 2007; Weber, 2011). Nevertheless, consumer input at the beginning stages of the innovative DP is ill-advised, with the focus suggested on understanding their needs and experiences holistically (Weber, 2011). This methodology not only recognises the importance of user feedback but also emphasises the pivotal function that designers fulfil in amalgamating and guiding innovation.

3.1.3. Functional Apparel Design Processes

McCann (2003) asserts that the functional DP is similar to the product DP. The functional D&DP is iterative, based on wearer requirements, and multiple assessments to define the design criteria and inform development. Functional apparel consists of clothing designed for utility purposes. Below, a few functional processes are reviewed before discussing Lamb and Kallal's (1992) FEA consumer needs framework (3.1.3.1.) and smart clothing (3.1.3.2.).

Similar to Orlando (1979), DeJonge (1984) developed a functional apparel D&DP influenced by Jones' (1973) three-stage product DP. The proposed functional apparel D&DP has seven stages: initial request, exploring the design situation, recognising the problem structure, developing design research specifications, establishing design criteria, prototyping, and evaluation. DeJonge highlights the significance of the initial step in the DP, emphasising exploration and reappraisal of the design problem, dedicating the first four stages to understanding user needs. Although the process is linear with no mention of reiteration, DeJonge specifies evaluating the prototype against the established design criteria. This functional D&DP is meant to be flexible, allowing designers to apply it to different garments.

Inspired by Koberg and Bagnall (1981), Watkins (1988) developed a reiterative functional apparel D&DP utilising the same seven stages: acceptance, analysis, define, ideate, select, implement, and evaluate. As Watkins' DP is aimed at apparel design students, the process is more individual-focused. During these stages, the students are advised to problem-solve by researching and proceeding cautiously, utilising the stages as guidance. Like Koberg and Bagnall (1981), the first three stages are dedicated to problem identification. Watkins urges the design students to thoroughly define the problem as it leads to specific design goals that do not hamper creativity. Watkins recommends that the students oscillate between 'divergence or spreading out to look for a wide variety of ideas and convergence or centering on one idea' (Watkins, 1988, p. 10). The process is unrestricted and meant to be utilised in developing a wide range of products.

Carroll and Kincade (2007) created an inclusive design framework for apparel development. Their framework is user-centred and based on problem-solving, inspired by DeJonge (1984), LaBat and Sokolowski (1999), Lamb and Kallal (1992), and Regan, Kincade, and Sheldon (1998). Carroll and Kincades' (2007) inclusive apparel design framework is circular, containing five stages: needs identification, co-design and prototype development, wear testing, evaluation and feedback, and implementation and production. This process includes 'wear-testing and inclusive design evaluation', steps not specified in other apparel DP (Carroll and Kincade, 2007, p. 298). Their process urges blending consumers' and industry's needs and centring consumer feedback before production and after purchase and consumption.

3.1.3.1. FEA Consumer Needs Model

Fig.3.3. Original FEA Consumer Needs Model.
Source: Orzada and Kallal (2021).

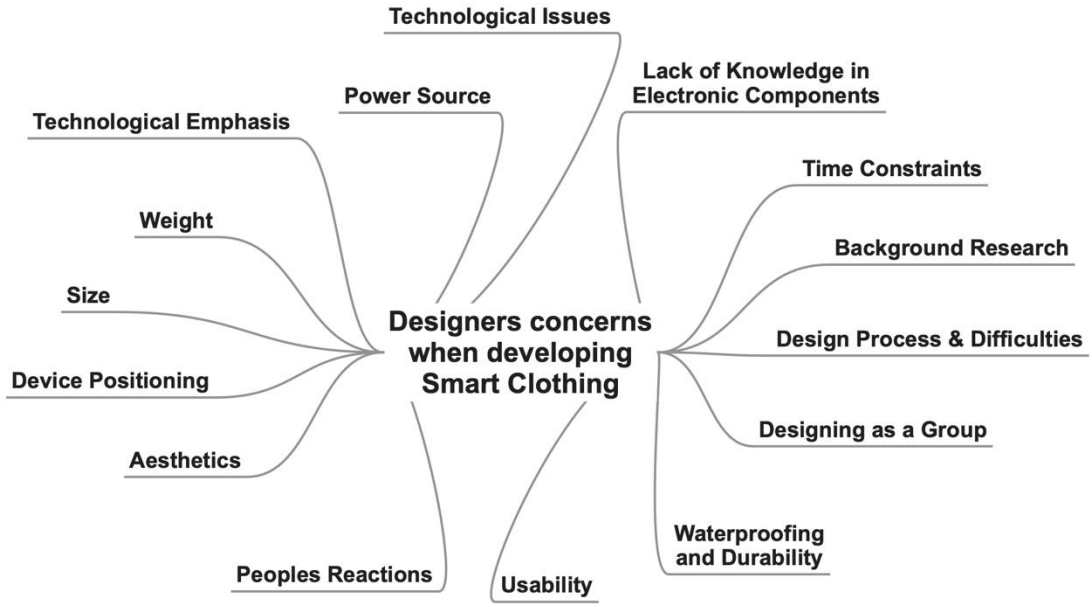
Functional apparel design is underpinned by understanding the wearers and the situation. To help assess the wearer's needs, apparel design educators Lamb and Kallal (1992) developed their apparel D&DP and a Functional, Expressive, Aesthetic (FEA) design framework (**Fig.3.3.**). Lamb and Kallal's design process derived from Koberg and Bagnall's (1981) and Watkin's (1988) processes. Their apparel D&DP contains six steps: problem identification, preliminary ideas, design refinement, prototype development, evaluation, and implementation (Lamb and Kallal, 1992, p. 44). They suggest implementing the framework within their D&DP where it is most effective, at the problem identification and evaluation stages. The FEA framework has three needs categories: functional, expressive, and aesthetic. Functional entails the fit, mobility, comfort, protection, and donning and doffing of the garment. Expressive encapsulates the wearer's values, roles, status, and self-esteem. Aesthetics encompasses art elements, design principles, and body-garment relationships (Orzada and Kallal, 2021). In the centre is the target consumer, surrounded by culture, which influences the functional, expressive, and aesthetic elements. The FEA framework allows designers and researchers to create a 'user-centred product' by 'connect[ing] the design research and evaluation stages'(Orzada and Kallal, 2021, p. 24). Utilising the framework throughout the D&DP as an assessment tool allows designers to actively focus on the wearers' needs.

This framework has been applied to design for chemotherapy-based headwear (Ghalachyan and MacGillivray, 2016), clothing for disabled adolescent girls (Stokes and Black, 2012), mature women's golf wear (Chae and Evenson, 2014), mature women's activewear (Hwang, 2017), and plus-size apparel (Hudson and Hwang, 2020). It has also been utilised to investigate smart fashion, namely solar-powered clothing (Hwang, Chung and Sanders, 2016; McKinney *et al.*, 2017) and smart apparel (Bakhshian and Lee, 2022). Davis (1996) modified the FEA framework to include 'Structure' (FSEA), pertaining to the garments' construction, materiality, form, and effect on the body. An and Lee (2015) amended

the framework to include features for designing *for* emotional fashion needs, utilising an approach stemming from the Emotion and Design field (Section 5.4.2.). The FEA framework is potentially beneficial to employ in the BWD&DP, as it aids researchers in focusing on their target consumers' needs. This study utilises the updated FSEA model (Section 8.4.1.).

3.1.3.2. Smart Clothing Design Processes

Fig.3.4. Areas of concern for Smart Clothing Designers.
Image adapted from: Nugroho (2013, p. 131) 'Clusters of relevant Meanings'.



Smart Clothing DP are imperative to investigate for design and manufacturing as it is a new field, requiring integration of 'apparel design, fibre science, electronic engineering, and computer science knowledge' (Perry, 2017, p. 2). The DP necessitates a diverse team from different disciplines in the D&DP, including the wearer (Morris, 2011). However, designing and manufacturing smart clothing face numerous limitations (**Fig.3.4.**), namely, a lack of training and knowledge in this area (Ariyatum, 2005; Nugroho, 2013; Perry, 2017). The smart clothing D&DP attempts to integrate functionality and usability, requiring designers to place the wearers' body and experience of the garment at the forefront (Nugroho, 2013). To do so requires designers to understand the ergonomics of the body, and in this case, the breast and upper torso. Dunne, Ashdown, and Smyth (2005) argue that smart clothing coincides with functional apparel design. McCann et al. (2005) suggest the utilisation of the functional apparel D&DP as a basis for developing smart clothing as it is user-centred. The functional D&DP was exploited in several smart clothing research as it integrates well with engineering components (McCann, Hurford and Martin, 2005; Kincade, Regan and Gibson, 2007; Gupta, 2011; McCann and Bryson, 2014; Chunyan and Yue, 2015; Watkins and Dunne, 2015; Gorea, 2017).

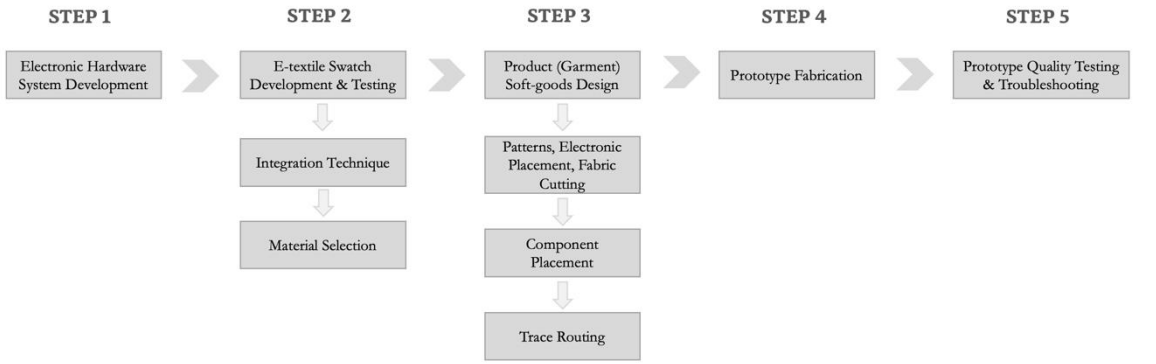
Gupta (2011) proposed a functional apparel D&DP for wearable technology inclusive of six stages: user survey, user requirements, garment design, garment assembly, garment testing and analysis, and production. In each stage, multiple steps are proposed; only some will be highlighted below. To initiate the process, Gupta suggests a user survey to understand and define the user requirements regarding functionality in physiological, biomechanical, ergonomic, and psychological terms. First, materials are selected to develop the technical textiles within the design stage before design and pattern engineering. Gupta (2011, p. 331) suggests that designers 'move away from […] designing in 2D (material centric) to designing in 3D (garment shells)'. This proposes moving away from the vital human aspect of design necessary for bra development — as Hardaker and Fozzard (1997) assert, the bra D&DP is based on heuristic knowledge acquired through a material-centric approach. Next, Gupta proposes that the product be evaluated for appropriateness during garment testing and analysis. If the design is not appropriate, the process begins again at the garment design stage. The assumption is that if the garment fails, it is due to bench-scale testing or field trials. However, Gupta overlooks that the process may need to restart at the user requirement stage if wearers find it unappealing during the trial stage.

McCann et al. (2005, p. 2) proposed their innovative smart clothing D&DP, which mixes theoretical (The 'Critical Path') and practical elements. The process has several stages: identification of user needs, textile/fabric development, body measurement/size and fitting, garment design, pattern development and grading, prototyping modelling and simulation, integration of smart technology, fitting, garment manufacture, and distribution. The process is user-centred, beginning by comprehending the user needs, namely demands of the body, activity/end-use, culture and aesthetic considerations. McCann et al. (2005) argue that a process closer to industrial and product design is necessary due to the requirements of developing smart clothing. Their process relies heavily on advanced machinery, which requires capital resources and skilled workers. Like Gupta (2011), once user needs are established, textiles and fabrics are developed prior to garment design; thus, the fabrics inform the design. For the design stage, they establish that more guidance is necessary for the designers and patternmakers, who should move away from working on traditional mannequins to understand the body's needs. McCann et al. (2005) suggest that better-fitting garments can be effectuated through 3D body scanning and 3D cutting techniques. However, 3D scanning technologies are not commonly used in the bra industry due to the high costs (Yick, Wu, Ma, *et al.*, 2011).

Dunne, Ashdown, and McDonald (2002) utilised a functional approach, based on the principle of system engineering (Ariyatum, 2005, p. 70), to developing a nine-staged DP for smart clothing. The stages are: user identification, identify user needs, identify architectural requirements, preliminary aesthetic design, design decision, selection of alternatives, evaluation criteria, alternative evaluation, and solution selection. Ariyatum (2005, p. 70) critiques this DP as lacking information on the fashion aspect, which highlights the processes' positive focus on wearability and social acceptance. Nevertheless, the DP showcases a general

overview of the apparel and electronic integration process, providing information into potential stages and stakeholder integration.

Fig.3.5. 5-Step Design Framework for CMT factory
Image created from Islam Molla, Compton, and Dunne (2020)



Islam Molla (2020) developed a scalable mass-manufacture-centred smart clothing DP. The process is propelled by the 'lack of emphasis on consideration of manufacturing variables and design issues that emerge during the product development process' (Islam Molla, Compton and Dunne, 2020, p. 1). Islam Molla's process is geared towards the technical aspects of manufacturing since it is 'the largest barrier to successful garment integration of electronics' (Dunne, Gioberto and Simon, 2015, p. 620). Within the process is a five-step design framework for cut-make-trim (CMT) factories (**Fig.3.5.**). The five steps are electronic hardware development, e-textile swatch development and testing, garment design, prototype fabrication and prototype quality testing and troubleshooting. Notably, the process affords attention to the e-textile development and garment design stage, providing insights into the sub-steps. However, the process suggested is linear and overly simplified, disregarding the chaotic nature of the D&DP. The steps suggested may occur in tandem and are missing essential stages within concept development before step one. Furthermore, it removes the wearer and skips the initial problem identification and concept design stage, also called the fuzzy front-end (**Fig.3.2.**). Importantly, that stage is considered the most significant and ill-understood in apparel, smart clothing, and intimate design. Nevertheless, Islam Molla's process allows innovative insight into the surface attachment and integration stage.

The practice of surface attachment and integration is easier for sports bras and knit bras due to the ability to weave or knit in conductors (Dunne, Gioberto and Simon, 2015). However, this process may be more complicated for the structured bra. Therefore, further insight into integrating technology into the structured bra is needed.

3.2. Exploring Bra Design Processes

Bra researchers erroneously blur the structured bra and sports bra design fields, often failing to distinguish the difference. Each bra D&DP exemplifies the disparity in design, materials, functionality, purpose, and consumer focus. The various traditional bra D&DPs are distinguished and presented in this section.

3.2.1. Market Tiers: Fast Fashion, Mid-tier, Artisanal, High-End, Speciality

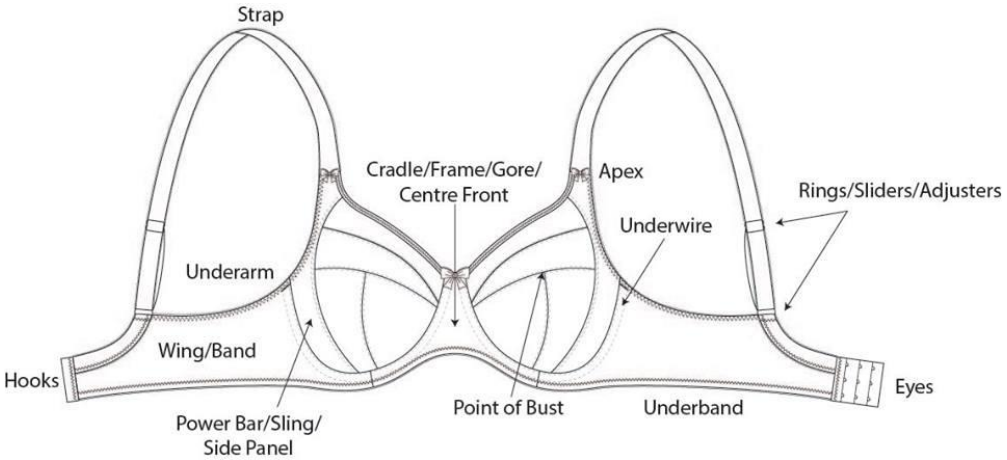


Fig.3.6. Structured cut-and-sewn Bra Anatomy. (*Source:* Sweetnothingsnyc by Kim Hamilton)

Traditionally, structured bras are designed to support breasts by holding them upward and away from the body, with the underband doing most of the work and the straps and cups assisting (Zheng, Yu and Fan, 2009). In bra design, the constant interrelating issues are function, comfort[25] (Yu, 2011) and aesthetics. Technological innovations in materials further complicate the multidimensional relationship. The trade-offs are visible and felt depending on the bra brands' tier (i.e., fashion, mid-tier, artisanal, or high-end).

Fast-fashion brands such as Zara, Primark, H&M, and Forever 21 places less emphasis on comfort, function, and technological innovations with shorter D&DP. On the other hand, mid-tier brands such as Wacoal, Triumph, and Simone Perele have longer D&DP due to their emphasis on fit, comfort, function, and innovation. Artisanal and high-end brands will vary in their process, depending on what they try to emphasise about their brand, whether aesthetic, luxury, or functionality. As illustrated in Appendix C, depending on the tier and brand, there may be more or fewer stages within each phase. Introducing smart technology into any of these tiers will alter their D&DP.

The bra D&DP alters depending on the function and type of bra silhouette, design style, and fabrication (Hardaker and Fozzard, 1997). The bra D&DP is comparable to the three classifications noted by Evbuowwan et al. (1996 as cited in Gorea, 2017, p. 52), '(a) routine designs…derived from common prototypes with the same set of features and […] structure; (b) redesigns; these involve modifying an existing design to satisfy new requirements or improve its performance under new requirements, and (c) non-routine designs, original or new designs'. Therefore, although systematic,

[25] The number one complaint from bra wearers surrounds comfort; although women are usually not specific on comfort necessities and the comfort acceptability varies. Yu (2011, p. 427) defines aspects of bra comfort as 'sensorial, thermal, motion, aesthetically and hygienic'. Introducing smart technology will further complicate comfort requiring technical fit knowledge.

the bra D&DP is inorganic, requiring the design team to continuously learn from doing, thus developing heuristic knowledge (Hardaker and Fozzard, 1997; Chan, Yu and Newton, 2001).

3.2.2. Cut-and-Sewn /Moulded/ Knit Bra Design Processes

1. Cut-and-Sew Bra. *Source:* Elomi 2021.
2. Moulded Bra. *Source:* Elomi 2021.
3. Knit Bra. *Source:* Varley.

Fig.3.7. Various bra construction types.

Bras are produced through various technologies that change the DP, such as cut-and-sew, seamless knitting, moulding, bonding, welding, and laminating (Fong, 2017). Industrial bra D&DP are propriety intelligence; hence, limited information is available. **Table 3.8.** demonstrates the differentiation in the process for the top three bra classifications (**Fig.3.7.**); Cut-and-Sewn, Knit and Moulded bras (see Appendix A for more information). Each classification DP has modifications according to tier, styles, fabrications, designs and factory abilities, solidifying the statement 'there is no typical intimate apparel design process' (Chan, 2002, p. 74). The constant amongst the bra D&DP is the difficulties shared in; 'fitting and sizing, technical and production limitations, the balance of aesthetic and functional performance, and material selection and usage' (Chan, 2002, p. 77). Furthermore, each bra classification requires different machinery that affects the production time and operation procedure.

The cut-and-sewn method is the most traditional method of bra development, and the area this study focuses on. This method utilises complex engineering to take 2D shapes in a mixture of fabric properties to shape and lift the breast anatomy (Shin, 2009). Materials in this bra classification are often composed of stretch and non-woven fabrics (*Manufacturing a Bra In Lean Setup*, 2012). Cut-and-sewn bras require skilled team members from designers, patternmakers, and sewists to fit technologists. Structured bras can range from 25 to 64 components and fastenings combined on 4 to 6 different types of machinery compiled of '18 to 42 sewing operations' (Battarra *et al.*, 2021). Essentially, this process is complex. Although cut-and-sewn bras are difficult to sew and fit, they provide better shaping, lifting, gathering and supporting of the breasts (Yue, 2019).

Seamless knit bras are designed to be wire-free, reduce seams, and fit a broader range of wearers through fabrics with stretch properties. Sizing for seamless knit bras is based on letters ranging from extra small to extra-large. However, fitting a knit bra is difficult due to the varying pressure needed to hold the breasts firmly and comfortably, yet be relaxed enough to pull over the wearer's head (Lau and Yu, 2016). The D&DP of knit bras rely on skilled designers, with a wide array of knowledge on different stitches and yarns,

who work with specialised design programs. The technologists must also be skilled and knowledgeable about the machinery, yarns, and other materials (Lau and Yu, 2016). They collaborate within a DP built around 'trial and error, experience, [and] rough calculations'(Wai Fong, 2014). The seamless knit DP reduces material wastage (Lam, 2005) and is purportedly shorter than the traditional cut-and-sewn process. This process offers advantages by enabling the designs to 'remain in digital form from designer to manufacturer', allowing for easier design modifications, and affording a variety in 'knitting construction[s]' (Wai Fong, 2014, p. 22). While seamless knit bras offer advantages such as being more comfortable than cut-and-sewn, there are disadvantages such as lacking uplift support, compression of the breasts or production of a 'mono' breast effect, and limited style options (Zheng, 2007; Zheng, Yu and Fan, 2008).

Moulded bras, such as T-shirt bras, have significantly impacted the bra market, being the highest sellers in the U.S. and U.K. (Risius, 2012). These bras are considered physiologically and socially comfortable due to the removal of seams on the cups, and padding which conceals the nipples (W. Yu *et al.*, 2006). The entire DP can be computerised, from patternmaking to cup development with specially designed male and female plastic mould heads (Lee, 2020). A bullet head or contour moulding machine is often utilised in industry, each with varying techniques and time requirements, differentiating the DP. An advantage of moulding is the reduction of labour and assembly costs (C. Lee *et al.*, 2021), although Shin (2009) highlights that some processes can have 21 steps. The cup shapes are simple to design and cut, with the filled bra pads and underwires sealed into the bra enclosure prior to final moulding. There are limitations when the cups are designed for larger breasts leading to deformations and wrinkling (Yick, Wu, Ma, *et al.*, 2011). Optimal moulding conditions vary between sizes, such as 34B and 34D (Yick, Wu, Yip, *et al.*, 2011), requiring a costly trial-and-error process. However, the correct estimations of moulding temperature, dwell time, and mould head size can shorten the process (Wu *et al.*, 2011). This DP may be extended when introducing new yarns, material compositions and chemical finishes (Shin, 2009). Although moulded bras have a shorter DP than cut-and-sewn bras, the process is still 'highly complex, time-consuming and error-prone[d]' (Yick, Wu, Ma, *et al.*, 2011).

Table 3.8. Cut-and-Sew, Knit and Moulded Design Processes

	Research	Design	Technical Design & First Pattern	Prototype	Fit	Product Testing	Finishing Process	Grading & Digitizing Patterns	Evaluations	Quality Assurance	Production
Cut-and-Sewn Bra	Materials, Fabrics	CAD or Hand	Patternmaking Digital & Hand Process, First Pattern Sample	Cut & Sewn first sample, Trial & Error	Fit to model & form *(Complex)*			Computerized sometimes Hand, Fit to range of Sizes	Wearer Trials, Laundering	For correct cup shape and appearance	Production
Seamless Knitted Bra: Circular Knitting/Flat (V-Bed)	Type of knitting, Yarns/ fibres	Hand to CAD (Computer-to-Knit Programs) Visualising Stitches & Yarns	Knitting Parameters, Trial & Error, Calculations-Programmable knit	Machine Knit Full or w/cut-and-sewn components (*Faster Prototype*)	Fit to model & form *(Medium)*	Electric Stretch Tester of garment	Circular Knitting (10 steps: Boarding, Dyeing, Washing, etc)	Computerized	Wearer Trials	Search for Knitting defects	Production, Quick w/minimum wastage & workers
Moulded Bra/ Seamless Moulded Bra	Fabric, Cup Design, Moulding Process desired	CAD or Hand	Factory: Design Bra Cup for moulding, Fabric Testing, Testing Optimal Moulding conditions	Moulding Process (*Complex & Time Consuming*) Trial & Error	Fit to model & form *(Easy)*	Colour fastness & Hardness, Post Moulding Shrinkage		Grade Moulded Cup sizes and Patterns, Computerized	Testing & Evaluations of Moulded Cups and Bra Design	For correct cup shape and appearance	Production

3.2.3. Fit and Prototyping in the Bra D&DP

Bra prototyping involves skilled teams of patternmakers, first sewist for pattern development, and a team of fit technicians for fitting. Bra pattern development is referred to as a 'dark art' (Shin, Ng and Liang, 2010) as few books are written on it (Shin, 2007). Prototyping is not often conducted in the same place as the designing (Sayem, Kennon and Clarke, 2010), unless the brand is artisanal. Depending on the brand tier and whether they have space for an in-house factory set-up, most brands will send their designs to a local small factory or overseas. This means designers and patternmakers must communicate via email, production data management (PDM) or product life management (PLM) software (Burke and Sinclair, 2015). PDM and PLM software are web-based, enabling stakeholders involved in the production process and supply chain to update members in real time on their actions[26]. Brands with smaller sewing spaces in-house will create samples and technical packages to ship to manufacturers to develop overseas. Artisanal brands may make all products in-house (Aakko, 2016). A technique used by lower-tiered and fast-fashion brands is the 'Pick and Stitch' or 'knock-off' method, where well-designed mid-tier brands' bras are purchased and sent to factories to develop overseas (Shin, 2009; Haffenden and Smith, 2015). This technique shortens the D&DP and can produce satisfactory bras.

Fit interrelates with comfort and requires specialist knowledge provided by fit technicians and designers in the bra D&DP (Yu, 2011). The fit process changes by tiers and brands. Higher-end, artisanal, and mid-tier brands with financial resources opt for professional fit models within their size range[27]. If working through the PDM or PLM, factories will fit during development and post images within the software, enabling the designers to make comments (Burke and Sinclair, 2015). Fast-fashion brands can fit several times on a form during factory development. Once preproduction samples are accepted, fast-fashion brands may fit on staff (Hardaker and Fozzard, 1997) or send to the buyers who fit on their own models. Speciality brands like Ann Nahari, designing bras for larger breasts, develop concepts in-house and fit throughout the process (Rashed, 2016). The fit process is based on trial-and-error and is complicated by changes in fabric and bra cup silhouettes (Luk and Yu, 2016). Depending on the brand tier, more or less time is dedicated to the fit process.

To develop BW, both fit and prototyping will be imperative in the D&DP. Not all tiers or brands will have access to extend or amend their process. Therefore, a new D&DP is required.

3.2.4. The Wearer in the Design Process

Following a user-centred approach, the traditional bra D&DP includes wearers as a source of information through questionnaires or focus groups before or during the D&DP. User-centred is research-led and

[26] http://wfx.benetton.co.in/Web-Pdm-fashion-apparel.aspx
[27] To read more from a lingerie fit model see https://www.thelingerieaddict.com/2019/12/sample-sizes-lingerie-fit-model.html

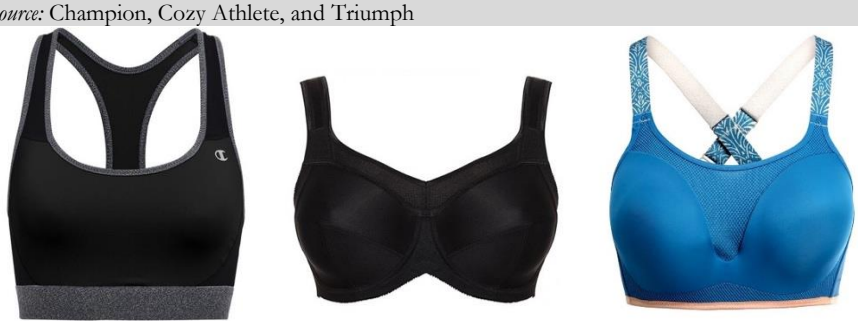
expert-driven, with designers creating products for the 'user'[28], who is seen as the 'subject', engaging them periodically in the D&DP to study their behaviour for product design or usability testing (Sanders, 2002, 2006), this is discussed further in Section 3.5. Bra designers overwhelmingly engage consumers during the evaluation stage, at the end of the D&DP, for fit trials requiring information on product wear and laundering (Hardaker and Fozzard, 1997; Luk and Yu, 2016). Thus, while the wearer is a part of the bra D&DP, their expertise and insights may be provided too late. As discussed in Section 3.1.3.2., the smart clothing DP requires the wearer to be engaged throughout – this aspect should be a part of a BWD&DP.

3.3. Sports Bra Design Processes

Sports bras, a part of the athletic and bra market, are considered separate for many reasons. Merging fields such as biomechanics, anatomy, anthropometry, health, textile science and engineering, and sports science, sports bra design has evolved into its own area. A sports bra is designed for various physical activities that support the breasts by constricting vigorous movements, providing comfort and support to the wearer (Yip and Yu, 2006; Yu and Zhou, 2016). In addition to sports bras' function, materials, and design, the intent and purpose deviate from the everyday foundational bra. Sports bras have a higher neckline to reduce bounce, thicker straps, often racer-style back to allow for arm movement, a heavier elastic underband to protect the bra from riding up over the breasts, and are meant to be worn for brief periods (Calasibetta, Tortora and Abling, 2002; Bowles, Steele and Chaunchaiyakul, 2005; Coltman, McGhee and Steele, 2015; Yu and Zhou, 2016). As the body is intended to be in motion while wearing a sports bra, strap positioning, certain material characteristics like breathability and wicking, and the absence of specific hardware like underwires are essential (Bowles, 2012).

3.3.1. Sports Bra Design Processes

Fig.3.9. Sports Bra Silhouettes (*left to right*) Compression, Encapsulation, and Hybrid
Source: Champion, Cozy Athlete, and Triumph



Sports bras are designed in three silhouettes (**Fig.3.9.**); 1) compression, using a high neckline to firmly secure and flatten the breasts, which are housed in one compartment against the body; 2) an encapsulation,

[28] This thesis refers to the consumer as wearer.

which separately supports each breast; and 3) hybrid/combination, which combines both compression and encapsulation (Page and Steele, 1999; Yu and Zhou, 2016). Each silhouette accommodates different activities and breast sizes according to style and material. Researchers argue that compression styles are best for smaller breasts, with larger breasts benefiting from encapsulation; however, this has not been validated (Yu and Zhou, 2016). Fit and comfort are the highest complaints about sports bras after bra strap slippage or digging. Furthermore, sports bra designers must consider the breasts' motion and the materials' function (Krenzer, Starr and Branson, 2005).

The sports bra D&DP evolved from the functional apparel D&DP, grounded in problem-solving with a combination of design and engineering focused on wearer needs and conditions of use (Watkins, 1988; Gupta, 2011; Watkins and Dunne, 2015). The D&DP differs depending on whether the sports bra is cut-and-sewn, using traditional methods, or seamless knit, using speciality machinery (Gorea, 2017). The D&DP relies heavily on researching the wearers' breasts movements, body needs, material response and wearability, and testing during activity.

1. Reebok PureMove Sports Bra, 2018
2. Nike Flyknit Sports Bra, 2018

Fig.3.10. Sports Bras Advanced through Technology.

The Nike Flyknit racer bra (2018) and Reebok PureMove bra (2018) press releases mention the functional D&DP of these technologically advanced sports bras (**Fig.3.10.**). Both press releases referenced extensive wearer studies with athletes, hundreds of hours of biometrics research, continuous testing on breast displacement/motion, and countless hours of testing materials, wear, and washability (Yotka, 2017; Aouf, 2018; Nike News, 2019). It took two to three years to develop both bras, although each component was developed previously[29]. Considering that different sports bras are needed for certain activities, it is evident why the wearer and the intended use are consequential to its design.

3.3.2. Sports Bra Wearables (SBW) D&DP

Sports Bra Wearables (SBW), defined as sports bras with smart technology, were introduced commercially in 2005. Unfortunately, due to restrictive business practices, the D&DP for the products are often kept secret. Information found in press releases produced some insights into the SBWD&DP for the brand OmBra. OmBra measures steps, cadence, pacing, and running rhythm, and provides feedback and coaching through the companion app OmRun (Brandon, 2016). The D&DP, often incorporating the consumer, took three years with over 1,683 prototypes. The D&DP centred on four key areas: aesthetic, support, comfort, and technology, with each stage eliciting

[29] The Flyknit technology for Nike's bra was developed first for their sneaker division in 2012 which took four years and 'teams of programmers, engineers and designers' (Etherington, 2012). Reebok's PureMove technology was previously developed by the University of Delaware for NASA's spacesuits (Aouf, 2018).

iterative designs and prototypes. Iterations and testing within each area and continuous consumer integration are similarly identified in academic SBW research (Haffenden and Smith, 2015).

A significant portion of research into smart technology and the bra is conducted on sports bras. Sports bras' foundation relies heavily on textile development, making it less complicated to integrate smart textiles technology into knitwear (Kongahage and Foroughi, 2019). Academic researchers tend to purchase sports bras and place the technology onto them (Steele *et al.*, 2018). Others develop the SBW from the start, generating useful information for the D&DP (Dunne, 2004; Haffenden and Smith, 2015). Lee et al. (2021) devised an automated manufacturing D&DP for SBW (**Fig.3.11.**). The D&DP significantly reduces personnel and removes the wearer. However, the process produced a lightweight sports bra, which questions its usefulness for physical activities.

Fig.3.11. Automated Manufacturing Process for SBW
Source: Lee et al., (2021)

3.4. Stages in Bra Design and Prototyping

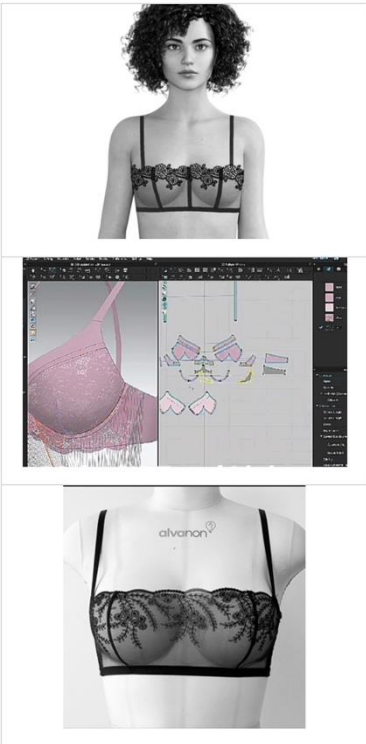
The bra D&DP is complex and developed through engineering principles (Shin, 2009), requiring intricate construction techniques. Due to the intricacy of bra development, trial-and-error is a staple in the D&DP (Hardaker and Fozzard, 1997). As the bra D&DP changes based on the type, fabrication, and design – there is no single process. Therefore, the following sections highlight the general phases each process has.

3.4.1. 2D CAD/3D CAD

Fig.3.12. Samples of 2D CADS sent to buyers and factories.

Computer-Aided Design (CAD) has been normalised within the lingerie design field. Designers use CADs (**Fig.3.12.**) to present coloured 2D concepts, called flats, to buyers and develop technical packs sent to manufacturers overseas (Aldrich, 2011). Programs such as Adobe Illustrator and Photoshop are utilised to

create styles, colourways, and patterns, 'speeding up the design process' (Burke and Sinclair, 2015). McCann (2014b) suggests that 3D CAD, also known as digital prototyping, is useful for designing and developing patterns which can be completed in tandem, expediting the D&DP (Park, Kim and Sohn, 2011). Programs such as Vstitcher (Browzer), CLO3D (CLO Virtual Fashion Inc.), and 3D Suite (OptiTex) allow the designer to create styles on a digital model, actualise the patterns, produce sewing instructions, and fit (**Fig.3.13.**). Researchers have highlighted the advantages for designers using 3D CAD programs, such as developing better patternmaking skills (Baytar, 2017) and understanding various body shapes and garment relationship (Hudson and Hwang, 2020). Furthermore, the program lessens material wastage (McQuillan, 2020), facilitates time-saving (Sayem, Kennon and Clarke, 2010), and reduces prototyping costs (Park and DeLong, 2009). 3D CAD fitting is promising for apparel but has disadvantages for some garments that vary in tension needs and layered fabrications (Lee and Park, 2017), like the bra. Sun *et al.* (2019) states that the rigidity of the digital fit models does not allow for accurate pressure and soft breast tissue displacement, instead suggesting the Finite Element Model (FEM) application. While FEM is applied in numerous bra research (Cai, Yu and Chen, 2016; Cai, 2017; Ruixin, 2020; Zhang, Yick, Chen, *et al.*, 2020), the application is highly complex and still in the initial stages. Nevertheless, incorporating 3D CAD enables DP to evolve, and integrate into the functional D&DP (Watkins and Dunne, 2015), allowing team members to improve their problem-solving skills (Baytar, 2017).



1. @ContourAtelier, 2020.
2. CLO3D Program @Dream_withme, 2020.
3. @ContourAtelier, 2020.

Fig.3.13. 3D CAD Design from photorealistic design, developing patterns and fitting in specialist software, to mocking up and fitting on the form.

3.4.2. Pattern Development

The pattern development process is the most critical stage in bra development. Through pattern development, a bra is created from various breast-lifting fabrics and materials. Secrecy of brands patternmaking process limits knowledge in this area. Bra patternmakers train through hands-on apprenticeships, taking up to 10 years to become experts (Hardaker and Fozzard, 1997). They become experts with knowledge of how various materials perform, gain abilities in interpreting the designers' sketches, comprehend trade-offs in the design's development, and understand how the various bra styles must fit. Through their hands-on experience, they gain the knowledge necessary to solve unfamiliar problems (Lawson, 2006; Lawson and Dorst, 2009). Bra designs, especially cut-and-sewn styles, utilise combinations of woven and knit materials, requiring specialised patternmaking knowledge, such as 'negative

ease', allowing the bra to fit snugly but comfortably against breasts (Shin, 2009). Effective patternmaking produces a decent fit, balancing the body's needs and the garment (Ashdown and O'Connell, 2006). Bra pattern development generally takes two to six months to develop (Hardaker and Fozzard, 1997), which depends on the brands' tier and DP. Fast-fashion brands knock-off patterns from more established bra brands (Joseph-Armstrong, 2009), shortening this stage. Pattern development can be produced through four methods: draping on the form, pattern drafting from anthropometric body or form measurements, flat pattern from bodice blocks, and knock-off from prior designs (Shin, 2014; Dove, 2016). While separate approaches, each method can be combined during the bra development to meet the design needs. Sample patterns are developed sizes 34B and 34D for larger sizes (Hardaker and Fozzard, 1997; Shin, 2009). Structured bra patterns range from 24 to 64 pieces, including cups, gore or cradle, side panel, wings, and numerous fastenings (**Fig.3.6.**, p. 85). Lee et al. (2013) assert that technical designers must have seven years of experience before becoming sufficient to aid in measuring, grading, fitting and being present to provide insights at various stages throughout the D&DP. Once patterns are developed, they are sewn and ready for fitting.

3.4.3. Fit Process

Fit is essential to the bra D&DP, and is often implemented throughout the pattern development, grading, and preproduction stages. The bra fit process is iterative, having numerous rounds before proceeding. Some brands fit solely on the form; others use professional fit models or staff (Hardaker and Fozzard, 1997). Nevertheless, often, the form is the first mode of fitting. Professional bra fit models acquire knowledge over time that aids in simplifying the fitting process. They provide feedback on fit comfort, verbalising areas of discomfort, pressure, and other valuable affective information. Separately, bra fitters examine if any areas are bulging, gapping, riding up, digging, or pressing into the breasts too tightly. Bra fitters work in a team of two, having a fitting assistant (Luk and Yu, 2016). When fitting, they utilise a fit assessment criteria conducting anywhere from 10 to 20 sessions for new styles (Luk and Yu, 2016), lasting from two to eight months or more (Hardaker and Fozzard, 1997). Bra fitters – like patternmakers – must understand the breast and body movement, comfort parameters, materials characteristics, bra cup design and how to communicate the necessary changes to the patternmaker and sewists. Numerous prototypes are developed to get the best-fitting product. When incorporating smart technology, fit and sizing becomes an area of concern (Dunne, Ashdown and Smyth, 2005). Haffenden and Smith (2015) commented that fitting was essential during the development of their SBW. Only during this stage did they realise that 'the necessary adjustments for the older body shape could […] be made' (Haffenden and Smith, 2015, p. 377).

3.4.4. Grading Process and Wear Trial

The grading and the fit process are the most extended phases of the bra D&DP. Grading is the act of using a tried-and-true pattern to move specific measurement points up or down to change the size (Schofield and LaBat, 2005; Ashdown and O'Connell, 2006). Bra brands will either fit a few core sizes – using cross-

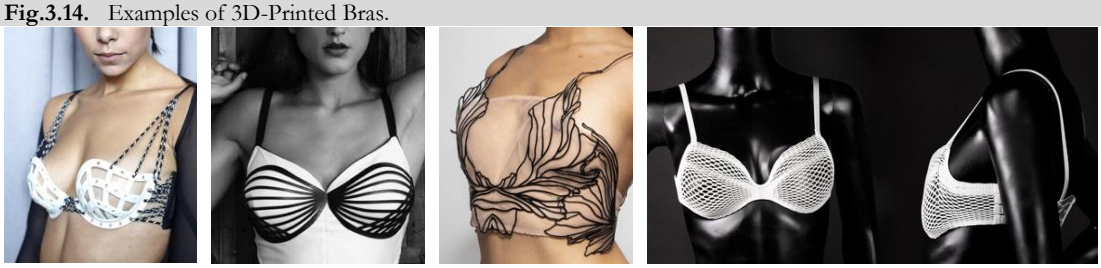
grading for the rest – or fit all the sizes (Hardaker and Fozzard, 1997). Although fitting all the sizes could lead to better-fitting products, it extends the D&DP further and is costly. Brands range in size, offering from 59 to over 100s of different sizes[30]. The cross-grading method relies on utilising grade rules to develop additional sizes. Bra sizes 34B and 34D are often used to grade bras sizes up or down. Each brand has its own grading measurements and rules. An example of grading is when the bra cup size, based on the underwire, stays the same while measurements on the wing and the cradle change. Graded sample fittings occur after the final sample fitting and before the pre-production sample fitting (Luk and Yu, 2016).

Once the pre-production fittings are accepted, then, wear trials begin. During wear trials, the wearer may wear the bra from one week to a month (Hardaker and Fozzard, 1997). They must also launder the bra to see how well it holds up. The brand will then review the information provided by the wearers. Depending on the brands' tier, the wearers can be potential consumers or staff. Information provided during this time will define whether the style moves on to production, is amended, or cancelled.

3.4.5. The Future: 3D Scanning and 3D-Printing

1. Chromat, 2015.
2. Mesh Lingerie by Lidewij van Twillert, 2015.
3. Stephanie Santos, 2020.
4. 'Algorithmic post-mastectomy bra'. Lisa Marks, 2019.

Fig.3.14. Examples of 3D-Printed Bras.



The future of the bra field may be technology-based. Both academics and industry are investigating and developing bras using different technologies such as 3D scanning and 3D printing.

3D scanning is generally used at the end of the production process to help consumers find a bra that fits; however, some brands, like van Twillert, use it pre-design to develop custom bras. Established brands, like Wacoal, are testing body scanning technologies mixed with advanced physical garments to allow wearers to scan themselves in the privacy of their homes (Satenstein, 2021). However, 3D scanning has disadvantages and requires more testing for the bra field (Stevenson, 2022). Reid et al. (2020) contend that 3D body scanning does not consider the wearers' fit preferences. Moreover, body scanning relies on accuracy, which is imperative for the bra to fit. If the scanning is imprecise, the bra cup size is miscalculated between 3-11% (Coltman, Steele and McGhee, 2017). Nevertheless, Stevenson (2022, p. 549) suggests that bra manufacturers 'harness […] the infinite measurement data produced through body-scanning and develop

[30] Websites have been created to help bra buyers shop various brands. Bratabase, a bra database, includes the brands, bra style range, and the brands bra size range. https://www.bratabase.com/

[…] a common verbal and visual communication of fit analysis'. Stevenson believes this will make it easier for bra wearers to purchase well-fitting bras. While innovative, more research is needed to understand body scanning in lingerie from the wearers' perspective.

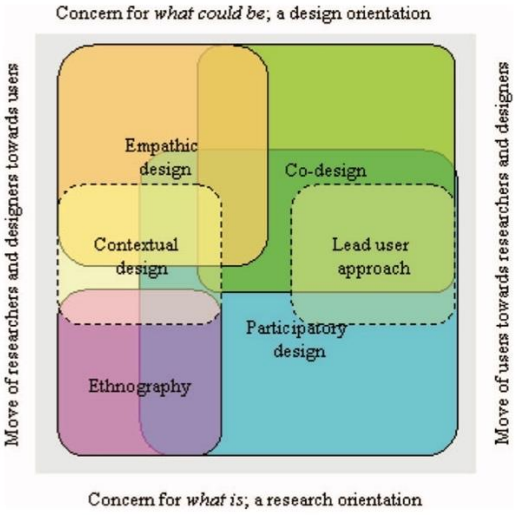
3D printing enables concepts digitally developed using CAD, 3D scanning or photogrammetry (Ambrosi and Pumera, 2016) to be printed into 3D objects, referred to as additive manufacturing (Gibson, Rosen and Stucker, 2015) or rapid prototyping (Vanderploeg, Lee and Mamp, 2017). 3D printing became mainstream in 2008 (Lin, 2020), enabling universities and businesses to acquire printers. The commercial printers are mostly fused deposition modelling (FDM), such as those offered by MakerBot, Prusa, Creality, and Ender (Ambrosi and Pumera, 2016). Later a range of FDM-based 3D printing pens aimed at makers and children (João *et al.*, 2020) were introduced, such as 3Doodler and Mynt 3D, enabling design students to partake. Various filaments are available to explore in a fashion context to develop 3D-printed fashion or textiles. Most utilised filaments are polylactic acid (PLA), acrylonitrile-butadiene-styrene (ABS), and flexible filaments like thermoplastic elastomer (TPE) and thermoplastic polyurethane (TPU). Due to TPU's flexibility, stretchability, and ability to be sewn onto traditional fabric, it has strong potential within fashion (Chun, 2017).

Many concepts are developed by design students and small brands experimenting with new processes and machinery. **Fig.3.14.** highlights four designers evolving the bra through 3D printing. Brands Chromat and Mesh used PLA filaments to create shell-like structures for the cup, essentially encasing the breasts. Although Chromat was for runway purposes, Mesh sells these under and outerwear bras, marketing them as customised for each individual. Stephanie Santos creates her bra pieces using a 3D printing pen, hand-printing the designs onto fabric. Like Mesh, her pieces blur the line between underwear and bras worn as outerwear. Lisa Marks mixed 3D printing with traditional lace making to create a mastectomy bra with illusionary properties. From the front, the cups appear balanced, but it is not so. Several researchers (Vanderploeg, Lee and Mamp, 2017; Arribas and Alfaro, 2018; Lin, 2020; Chan *et al.*, 2021) argued that the future is in 3D-printed apparel; however, more research is necessary with wearers on its wearability, physical and social comfort.

3.5. Human-Centred Design (HCD)

Human-centred design (HCD) is often regulated to services and non-fashion products, namely technology-based products. However, Ferraro and Ugur (2011, p. 1) advise that 'due to the intimate interaction between technologies and [the] human body […] designers should approach embedding technologies on human body in different levels, which are physical, psychological and social'. To do so, with technology being married to apparel, requires a human-centred approach to design. User-centred, participatory, empathic, and Co-design are all under the heading of HCD; however, they offer different understandings, 'starting points' and 'emphases' (Steen, 2011). While different, these approaches do overlap (**Fig.3.15.**).

Fig.3.15. Map of Human-Centred Approaches
Source: Steen (2011) 'Tensions in human-centred design'



3.5.1. User-Centred, Participatory, Co-Design, and Empathic Design

Table 3.16. Human-Centred Approaches Explained
Source: Steen (2011) 'Tensions in human-centred design'

Approach	Significations	Concerns/Direction
User-Centred Design (Lead user approach)	• 'approach is typically oriented towards commercial and business concerns' • 'is concerned with people that encounter problems in their current practices (*what is*) and develop innovations to solve these problems (*what could be*)'	• Users move towards researchers' and designers' activities • Concern for *what could be* (design orientation) and *what is* (research orientation)
Participatory Design	• 'attempts to give future users of a system a role in its design, evaluation and implementation' • 'users are treated as experts, and […] bring their (tacit) knowledge and skills into the research and design process'	• Researchers and designers move towards users • Concern with *what is* (research orientation) and *what could be* (design orientation)
Co-Design	• 'to cooperate creatively, […] jointly explore and envision ideas, make and discuss sketches' • 'everyday people' are participants/co-creators, rather than customers and users' • 'they contribute as 'experts of their experiences'	• Users move towards researchers' and designers' activities • Concern with *what could be* (design orientation) and *what is* (research orientation)
Empathic Design	• 'designers can empathise with other people's experiences in different physical, social and cultural contexts' • 'designers and users can jointly participate in role-playing to create or evaluate ideas for new products'	• Researchers and designers move towards users • Concern for *what could be* (design orientation)

In HCD, design-researchers collaborate with participants to develop products for them. Steen (2011, p. 45) informs HCD is not without its faults, as design-researchers 'need to combine and balance users' knowledge and ideas with their own knowledge and ideas'. Steen adds, 'the second tension […] occurs because HCD aims to both understand the present and to design for the future' (2011, p. 48). The need for balance creates degrees of interaction with the participants, questioning how much to involve or centre them. The choice selected by the design-researcher will enable them to decide on an approach, i.e., either user-centred (lead

user), participatory, empathic or co-design. To summarise the points in Steen's in-depth seminal paper, **Table 3.16.** illustrates the differences between each approach.

McCann et al. (2005) advise that for the smart clothing field to grow, the D&DP must be user-centred, bringing the wearers into the beginning stages and continuously after that for positive design outcomes (Sanders and Stappers, 2008). User-centred design has several connotations, mostly pertaining to extracting information from the participants and not designing *with* them (Marti and Bannon, 2009). Smart clothing design is often approached either through user-centred or participatory design; however, Stewart and Williams (2005) warn against reliance on insights from a small user sample, cautioning against creating highly customised products for a narrow audience. Despite involvement in novelty product development, Burr and Matthews (2008) caution that this does not guarantee commercial success. Nevertheless, participatory design views the wearers as partners and experts who should be designed *with* in the D&DP (Sanders and Dandavate, 1999).

In designing SBW for the ageing population, Haffenden and Smith (2015) used co-design, a participatory approach, with a handful of women participating in the DP. This exemplifies that a co-design approach to SBW is possible on a small scale, with valuable input from the wearers at certain stages. However, co-design proved challenging, due to attempting to manage the difficulties of designing SBW with the wearers' preferences and expectations (Haffenden and Smith, 2015).

One bra study attempted co-design (Liao and Lee, 2010) using focus group interviews, consumer group interviews and questionnaires. These methods were employed to extract information *from*, rather than design *with,* participants. Liao and Lee (2010, pp. 217–218) explain that they utilised 'selectable design technology provided by the manufacturer, [then allowed] consumers [to] select levels of these attributes'. As the participants did not jointly explore, envision, or create concepts, the process utilised cannot be seen as co-design (Steen, 2011). Instead, the researchers used participatory design to create concepts and ask participants' opinions. Co-designing within the bra D&DP with participants is a difficult endeavour. It would require participants to understand the relationship and balance between the bra anatomy and materials.

An approach is necessary that brings together the designers' and wearers' expertise. **Fig.3.15.** demonstrates an overlap of empathic, participatory and co-design. In that nexus lies an opportunity for developing BW by utilising an innovative approach to the D&DP. Approaches from all three areas may combine, facilitating a distinct perspective for BW (see Section 5.3.2.). Designers could move towards wearers understanding their experiences to design for future-facing products – an empathic approach (Section 5.4.2.2.). Additionally, they could bring the wearers into the D&DP to jointly envision concepts during the pre-design or design phases – a co-design approach. Lastly, by employing the wearers as experts, designers could engender to apprehend their experiences to understand 'what is', to design for 'what could be' – a participatory approach. This requires bringing the wearers into the D&DP at multiple points, such as during

'design, evaluation, and implementation' (Steen, 2011). Employing the different approaches in one D&DP may facilitate opportunities to design smart clothing *with* and *for* wearers.

3.6. Summary

Chapter 3

- ***Introduced*** numerous DP, providing information on the differences between a sports bra and structured bras' D&DP.
- ***Argued*** that much can be learnt from the sports bras' functional design approach that permitted SBW development.
- ***Established*** that the bra D&DP, with its skilful approach to design and development, is comparable to the engineering DP.
- ***Reviewed*** smart clothing D&DP which offers insights into becoming wearer-centred based on the functional apparel D&DP. These processes are further examined to inform the development of the initial BWD&DP (Section 7.3.).
- ***Proposed*** that to evolve for BW, the bra D&DP must merge its expert product-focused capabilities with a human-centred approach (detailed in Chapters 5 and 6).

4

4. MATURE WOMEN AND THE BRA

The world's ageing population is rising, with women set to outlive men, becoming one of the largest demographics by 2050 (United Nations, Department of Economic and Social Affairs, Population Division, 2017). From 2015 – 2050 the U.K. population between the ages of 45 to 64, defined as middle-aged by the Cambridge dictionary and as mature women (MW) in this study, will continuously be the dominant age group, according to BMI Research, a U.K. Consumer & Retail Report Firm. MW own up to 80% of the financial wealth in the U.K. (Birtwistle and Tsim, 2005), earn more than younger women 25 to 44 years (US Census Bureau, 2017), and is considered to be the 'most economically secure' and the 'highest spenders' in the U.S. (Birtwistle and Tsim, 2005). Mintel, a global marketing and research firm, has referred to this consumer base as 'invisible' women. The size of this demographic and spending potential is not one to ignore, yet it is by the fashion and intimate apparel industries in the U.K. and U.S.

Chapter 4 endeavours to provide insight into the lingerie experiences of mature Black women. However, as there is a lack of research on their experiences, this section critically analyses white women's experience paralleling how it may differ[31] from Black women's. Black women hold a particular intersectional space due to the intersection of race, gender, class, and sexuality, which affects how they experience fashion.

4.1. Mature Women and Fashion

'Fashion and age sit uncomfortably together'. (Twigg, 2013, p. 1)

This section introduces MW and fashion (4.1.1.), the bra (4.1.2.), and their invisibility and intersectionality (4.1.3.)

4.1.1. Fashion

Fashion centres youth, generally ignoring ageing, thus leaving MW dissatisfied with the styles provided to them (Goldsberry, Shim and Reich, 1996; Thomas and Peters, 2009; Holmlund, Hagman and Polsa, 2011;

[31] Although Black and white women are being discussed, this research is not a comparative study. Thomas (2004) argues for Black women to be researched outside the shadow of whiteness, without being contrasted to white women. While in agreement, this literature review could not proceed with the lack of information available on Black women, fashion, and the bra.

Lövgren, 2016). MW have low involvement and perceived importance of fashion, although they consider clothing an essential aspect of their lives and identity (O'Cass, 2000; McFatter, 2005; Holmlund, Hagman and Polsa, 2011). Clothing is a way for women to display their sense of fashion, identity, and personality while also signalling to others their place in society (Miller, Davis and Rowold, 1982; Entwistle, 2000b; Twigg, 2007; Peters, Shelton and Thomas, 2011). Research substantiates MW desire for clothing with better colour selections that are fashionably trendy, made from natural materials, easy to launder, regulate temperature, comfortable in both function and aesthetic, and consistent in sizing and fit (Thomas and Peters, 2009; Holmlund, Hagman and Polsa, 2011; McCann, 2014a; Lövgren, 2016).

Fit is a significant issue for most MW as garments are designed with youthful bodies as the base (Goldsberry, Shim and Reich, 1996; McCann, 2014a; Lee, Hwang and Baytar, 2018). There is limited research on creating clothing for mature female consumers (Schofield *et al.*, 2006; McCann, 2014a; Townsend, Sadkowska and Sissons, 2016). Goldsberry and colleagues (1996) advise design schools to teach new designers how to cater to different body types, specifically ageing women, to combat MW alienation in fashion. Designers, especially young designers, must learn how to design for the ageing and become equipped with the skills to alter or develop the necessary new design approaches and processes (McCann, 2014a). Researchers recommend that manufacturers understand MW biological, social, economic and psychological needs to provide suitable products (Holmlund, Hagman and Polsa, 2011; McCann, 2014a). They must also comprehend the physiological and cultural factors of age (Twigg, 2007; Hurd Clarke, 2011). In doing so, designers as cultural mediators can alter how MW experience ageing through fashion (Twigg, 2012), and in this case, the bra.

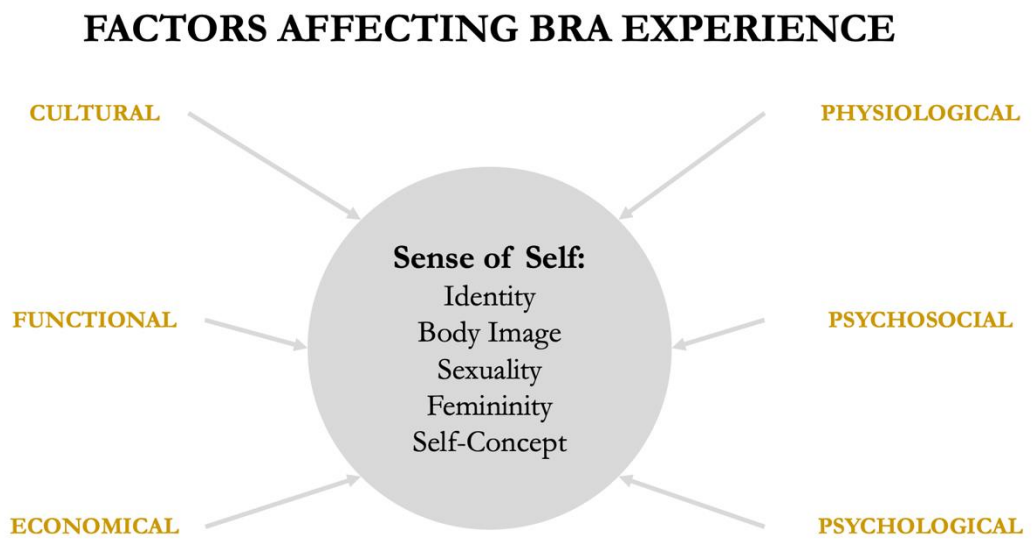
4.1.2. Bra

The bra is an inconspicuous fashion item as it is not easily visible to others, being hidden under clothing (Hume and Mills, 2013; Vigolo and Ugolini, 2016). However, this design-researcher considers the bra an inconspicuous-conspicuous item as it is also subjected to 'social scrutiny' (Granot and Brashear, 2008, p. 992) in how it appears under clothing, which may affect others' perception of the wearer. Like outer apparel, the bra is a social tool that sends messages to other women (Miller, Davis and Rowold, 1982; Sukumar, 2007; Twigg, 2007). Therefore, women desire discreetness from their bra – aware of the message their underwear sends – and is conscious of choosing the *right* lingerie for various situations (Tsaousi, 2011; Tsaousi and Brewis, 2013). This knowledge is referred to as embodied cultural capital, acquired through the trial-and-error experience of bra-wearing and knowing what is socially best for particular situations (Tsaousi, 2011).

Like the body, the bra is imbued with cultural, social, and historical meanings, due to its proximity to the breast (Millsted and Frith, 2003, p. 455). It has similar connotations to the breast, symbolising womanhood, femininity, feminine identity, and sexuality (Young, 1992; Latteier, 1998). As an essential foundation garment in MW wardrobe from early pubescent and worn until death, the bra signals *becoming* a woman and

is a part of how she experiences herself as such (Ayalah and Weinstock, 1979). A mature woman has acquired over 35 years of bra experience and knowledge throughout her day-to-day life activities and multiple life-stages. Thus, the wearing and purchasing factors for the bra are complicated as it intersects with various elements of the wearers' life, for example, functional, physiological, psychographic, psychological, psychosocial and economic (Hart and Dewsnap, 2001). A general Factors Affecting Bra Experience conceptual model was created (**Fig.4.1.**), applying these factors as a compass. The factors enable the design-researcher to distinguish variables important to the wearers' bra experience.

Fig.4.1. Generic Factors Affecting Bra Experience Conceptual Model
Source: Model developed from Hart & Dewsnap, 2001; Twigg, 2007; Holmlund et al., 2011; Hurd Clarke, 2011; McCann, 2014.

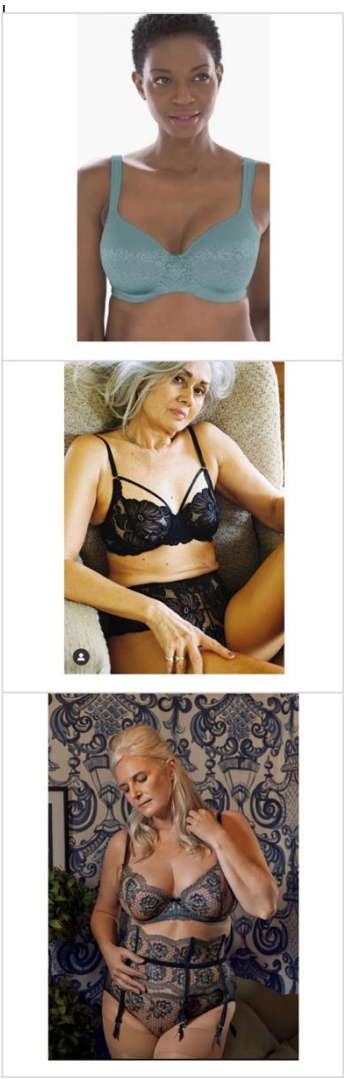


To design bras for MW, understanding the product's meaning is critical. Hume and Mills (2013, p. 466) explain product meaning as 'what the product means to the consumer and how they perceive the product'. The conceptual model (**Fig.4.1.**), which investigates the relationship women have with the bra based on their experiences with it, will serve as a guide for comprehending the product's significance to them. The following sections examine research on MW to develop a general concept of how they potentially experience the bra.

4.1.3. Invisibility and Intersectionality

To date, there are few Western bra brands dedicated to MW. The exception is an American bra brand, Soma Intimates, who declares they are specifically for 'women 30[32] years and older[33]', employing images of diverse MW. Although bra brands may have lines that MW purchase from, the brands do not specifically advertise as being dedicated to them. Wacoal Europe features a mature woman on their U.K. site, and American mass-retailer Walmart shows images of diverse MW to sell lingerie; however, the faces are cut at

[32] They use 'women 35 and older' in their 2017 Annual Report. http://eproxymaterials.com/interactive/chs2017/
[33] http://chicosfas.com/about-us/default.aspx



1. Soma Intimates (2021)
2. Lonely Lingerie (2020)
3. Playful Promises (2021)

Fig.4.2. Marketing images of mature women in bras.

the nose, making it harder to discern. Some brands, like Calvin Klein Intimates, 2017, exploited one-off advertisements featuring a mature model but did not show MW for their collections. Recently, smaller indie brands like Lonely Lingerie and Playful Promises have begun to feature MW on their sites and social media (**Fig.4.2.**). Despite these smaller brands pushing the boundary, there is still a lack of diversity in age throughout the industry. It is also noteworthy that of those mentioned, only Soma Intimates features clear images of MW who are Black or of an ethnic minority.

In the billion-pound U.K. & U.S. bra markets, images of MW are rare. Depictions of mature Black women are almost non-existent due to the intersectional points of ageism and racism. The lack of diversity echoes in Western research, where fashion, bra and ageing scholars centre primarily on white women. Professor Kimberlé Crenshaw, terms this 'intersectionality', where several points of exclusion and oppression exist in one body (Crenshaw, 1989). The mature white woman may be facing sexism and, newly experiencing ageism; however, the mature Black woman faces sexism, racism, classism — and now— ageism, providing her with a unique experience and perspective (Hill Collins, 2004). Due to the two intertwining components of their identity, 'race' and gender, Black women's experiences may differ from white women.

4.2. Mature Women's Potential Relationship to the Bra

Eastern bra researchers have produced numerous papers on mature and older women (Park and Sohn, 2001; Na, 2009; Park and Jang, 2014, 2015; Lau *et al.*, 2020), arguing the need for age-specific bra styles and design approaches (Lau *et al.*, 2020; Zhang, Yick, Yip, *et al.*, 2020; Choi *et al.*, 2021). Nevertheless, Western research on the relationship and experience of MW – whether Black or white – and the bra[34] is lacking. Therefore, the following sections attempt to build an understanding by venturing into other disciplines such as Body Studies, Gerontology, Medicine, Black Feminism, Cultural Studies, and Fashion Studies. This section discusses ageing and body changes (4.2.1.), ways MW experience the bra (4.2.2.), MW wearing and purchasing habits (4.2.3.), and Factors Affecting Bra Experience Conceptual model (4.2.4.).

[34] This literature review centres on the everyday bra. There are lots of research on sports bras ranging in varying breast size and age, but they are outside the remit of this study. Including a number of the results from those studies would blur the review. However, some sports bra research findings are applied where possible and apt.

4.2.1. Ageing and Body Changes

This section introduces physical ageing and menopause (4.2.1.1.), breast discourse (4.2.1.2.), and body-image (4.2.1.3.).

4.2.1.1. Physical Ageing and Menopause

Age is the optimum segmentation criterion for understanding lingerie consumption ahead of all other factors, such as social or economic class (Amy-Chinn, Jantzen and Ostergaard, 2006). Nevertheless, there is limited research to apprehend how MW experience their ageing breasts and how that affects their bra consumption (Paulson and Willig, 2008; Risius *et al.*, 2014). As women age, their bodies change with menopausal-based weight gain (Rodin, Silberstein and Striegel-Moore, 1984; Voda, Christy and Morgan, 1991; Beşer, Aydemir and Bozkaya, 1994; Kilpela *et al.*, 2015; Hurd Clarke, 2018), breasts size increase (Chrisler and Ghiz, 1993), skin ptosis (sagging skin), and breasts ptosis (sagging of breasts) (Park and Sohn, 2001; Na, 2009; Kim, Kim and Ashdown, 2014). Across socio-economical classes, breasts were among the most problematic body area, and weight gain was the most difficult to accept, leading to the dislike of viewing their nude bodies (Deeks and McCabe, 2001; Hurd Clarke and Griffin, 2008; Vares, 2009; Hurd Clarke, 2011).

4.2.1.2. Breast Discourse

'Breasts: Our Most Public Private Parts' (Spadola, 1998)

Women's breasted experience is rarely examined outside of a health-based lens, although women consider their breasts an essential aspect of their identity. Women's dissatisfaction with their breasts is linked to lowered self-esteem, self-consciousness, and denigrating feelings about their femininity (Koff and Benavage, 1998). Cultural, ethnic (DeBraganza and Hausenblas, 2010) and social factors all influence a woman's body and breast image. In Western society, breasts symbolise femaleness, femininity, and womanhood (Young, 1992; Thomas, 2006; Naugler, 2009), evolving and entwining with women's sense-of-self (Young, 1992). The public display of breasts through lingerie advertisements created the perception of the perfect breasts on the perfect body, popularised in modern times by Victoria's Secret Angel models. Naugler (2009, p. 104) argues that the 'ideal breasts are white', youthful, decently sized – not too big or too small – and perky. The specificity of the ideal breasts excludes breasts that are on Black, ageing, or larger bodies.

Paulson and Willig (2008) examined how older white women (58+) discuss their ageing bodies, focusing on the languages they used to understand their experience. The findings indicate a disconnect between the mind and the ageing body, with the participants focusing on maintaining an active mind and keeping the

body busy so as not to dwell on it. This correlates with earlier results that as women aged, the importance of their physical appearance and dissatisfaction with their bodies decreased due to increased cognitive control (Webster and Tiggemann, 2003). Fernandes (2016, p. 22) confirms this notion in their study as the larger-breasted MW were conscious and dissatisfied with the weight gained in both body and breasts; however, they accepted the changes referring to it as 'attitudes of self-kindness'. Nevertheless, implementing cognitive control to lower expectations of their body does not equate to satisfaction with it. MW still engaged in 'beauty work' (Hurd Clarke and Griffin, 2008), such as dying their hair or other extremes like Botox or surgery.

How MW experience their body and breasts varies. As women age, they gain significant weight, increasing their breast size (Chrisler and Ghiz, 1993). Larger-breasted women are at a higher risk of mis-purchasing (Filipe *et al.*, 2015) and tend to wear smaller, incorrectly fitting bras (Wood, Cameron and Fitzgerald, 2008). Fernandes's (2016) study on the breast experiences of older larger-breasted women reveals their constant battle. They were conscious of how their larger breasts negatively affected posture and clothes options, citing fears of unwanted attention, or seeming to be showing them off. Sagging is also an issue which begins in some women around their 40's and increases with age (Park and Sohn, 2001; Na, 2009; Kim, Kim and Ashdown, 2014). The American Society of Plastic Surgeons, in their 2017 Cosmetic Surgery, reported that the highest procedure for women 40+ was breast lift, followed by breast implant removal (American Society of Plastic Surgeons, 2017). This demonstrates how aware MW are of their breasts and how it is perceived as they age.

4.2.1.3. Body-Image

Ageing and its effects on breasts, as well as body-image, 'the way people think and feel about their bodies' (Cornwell and Schmitt, 1990), affects how women consume the bra (Tsarenko and Strizhakova, 2015). What MW feared most about ageing was loneliness, 'losing [their] sense-of-self, becoming invisible [and] being seen as an asexual being', body changes (Bernard and Harding Davies, 2000, p. 69), and losing their good looks (Winterich, 2007a). This fear fuels the act of 'beauty work' (Hurd Clarke and Griffin, 2008), such as hair dying, make-up, and invasive and non-invasive cosmetic surgery. Breast augmentation is one of the top three cosmetic surgical procedures for women between the ages of 40-54 in the U.S. (American Society of Plastic Surgeons, 2017) and the U.K. (BAAPS Audit, 2017). It is noteworthy that white women participate by far more, 70-85%, in most procedures, with Black women at the lowest end.

It is well documented that white and Black women experience their body-images differently (Allan, Mayo and Michel, 1993; Molloy and Herzberger, 1998, 2002; Lovejoy, 2001; Mama *et al.*, 2011). Socio-cultural factors, ethnic norms, and socio-economic standing influence how women of different 'races' experience and feel about their ageing bodies and body-image (Allan, Mayo and Michel, 1993; Stormer and Thompson, 1996; Heinberg, 2001; DeBraganza and Hausenblas, 2010). White women generally adhere to the dominant beauty ideal constructed around thinness pushed by the broader media. In contrast, Black women have

diverse beauty and weight standards with extensive variables for beauty ideals and higher self-esteem influenced by friends, family and peers (Celio, Zabinsky and Wilfley, 2004).

On the other hand, as Black women move up in economic standing/class, removing themselves from Black ethnic culture, their beauty ideals begin to align with white women leading them to have similar dissatisfaction with their bodies (Allan, Mayo and Michel, 1993; Celio, Zabinsky and Wilfley, 2004). Socio-economic status impinges on body-image as women who are of higher socio-economic status and education tend to be more focused on, and dissatisfied with, their body-image with this trend continuing into old age (McLaren and Kuh, 2004a, 2004b; Dumas *et al.* 2005 as cited in Hurd Clarke, 2011). Body-image differs by 'race' and is affected by age, more so for white women, who have higher body-image dissatisfaction due to moving further away from the dominant beauty ideal than Black women, who have a broader beauty ideal spectrum and higher positive body-image (Sussman, Truong and Lim, 2007). This is not to portray Black women as monolithic or unaffected by ageing. West (2012) asserts that the difference may be whether the Black woman identifies with the Black beauty standards or the dominant.

4.2.2. Ways Mature Women Experience the Bra

This section discusses how MW experienced the bra related to their sense-of-self. The factors derived from the Generic Factors Affecting Bra Experience conceptual model (**Fig.4.1.**, p.103). Below reviews identity (4.2.2.1.), self-concept and image (4.2.2.2.), age (4.2.2.3.), femininity (4.2.2.4.), and sexuality (4.2.2.5.).

4.2.2.1. Identity

Fashion scholar, Joanne Entwistle (2000b), advocates that the body holds multiple identities and conveys symbols, such as age and 'race' (Oberg, 2003; Garstka *et al.*, 2004), that are read by others to determine a person's social identity. To understand the bra experience of MW, it is essential to examine self-identity, a woman's identification with what she thinks/feels about herself, and social-identity, others' beliefs and impression of the woman as an individual and collective (Goffman, 1972 as cited in Oberg, 2003; Barker, 2012). As well as individual-identity, created from the 'relationship between the self-image and public image' (Jenkins, 1996 as cited in Bernard *et al.*, 2000, p. 14). Oberg (2003) argues that ageing is the wedge that begins to disrupt the individual-identity driving a distance between social-identity and self-identity.

The bra can modify a woman's body and signal her cultural and economic capital and multiple identities (Tsaousi and Brewis, 2013; Tsaousi, 2016). MW are cognisant of their numerous identities, which they oscillate between depending on the social setting, using dress, and wearing the *right* bra, to signal to others their age *appropriateness* and embodied cultural capital (Apter, 1995 as cited in Bernard *et al.*, 2000; Sukumar, 2007; Peters, Shelton and Thomas, 2011; Tsaousi, 2016). Although semi-visible women use the wearing of specific bras as a 'Technology of the self' (Foucault, 1988) to channel, construct or avoid various feminine-identities across gender, sexuality, age, and class (Storr, 2002; Amy-Chinn, Jantzen and Ostergaard, 2006;

Tsaousi, 2011; R. Wood, 2016). As women age, society forces them into a precarious situation due to their fear of change and loss of their identity and self-image. This is compounded by the internalised ageism acquired from socio-cultural norms (Bernard and Harding Davies, 2000, p. 70; Granville, 2000). They can dress in a manner that is comfortable to their continuous identity − which may be younger than their chronological age − and be viewed as inappropriate, 'mutton dressed as lamb' (Fairhurst, 1998), 'grotesque' (Holland, 2012) and stigmatised/penalised in social settings. Alternatively, they can perform ageing by dressing 'age appropriately'(Woodward, 2001 as cited in Twigg, 2012) and assuming the older social-identity deemed fit, thus, erasing facets of their self and individual-identity (MacMaster, 2012). Doing so may harm MW's health and psychological well-being, lowering body-esteem — which depends on 'race'[35] (Sabik, 2015).

4.2.2.2. Self-Concept and Image

Social identity is a part of self-concept (Rudd and Lennon, 2001). Burcikova (2019, p. 61) explains that 'self-concept […] includes: the ideal self (the person you would like to be), the public self (the image one thinks other people have of you), and the real self (what you really think about yourself)'. Clothing allows people to portray their desired self-image, thus linking it to their self-concept (Kaiser, 1990; Parkins, 2020). The bra is no different, significantly impacting the social identity of women who utilise it as a 'social tool' (Sukumar, 2007). Hart (2016) establishes that bra wearers' attention to the visible display of their breast shape and contour when selecting a bra links their social image, self-concept, and the bra. The perception of others is important to how the breast is displayed, and the bra is worn. Ageing does not fracture these links, instead complicating them further.

Self-concept is vital to understanding how mature bra wearers consume the product (Hart and Dewsnap, 2001) as it intertwines with body-image (Chrisler and Ghiz, 1993). MW reported dissatisfaction with weight gain due to ageing, consequently lowering their body-esteem and negatively impacting their body-image (McLaren and Kuh, 2004a; Ginsberg *et al.*, 2016). Body-image is further related to menopausal symptoms (Nazarpour *et al.*, 2021). As women age, they feel the societal pressures to remain youthful, causing dissatisfaction, such as shame, in their outer appearance (Hofmeier *et al.*, 2017). Hofmeier *et al.* (2017) uncovered that the ageing experience is both physical and psychological, with some women feeling like they have lost their identity (Cameron *et al.*, 2019), causing anxiety and depression (Carrard *et al.*, 2021). Ageing had white women feeling a loss of self, due to weight gain; however, Black women were able to separate their weight from their self-concept (Thomas-Grumbach, 2018). Grey hair was a negative sign of ageing for white women, with Black women in the study accepting it with pride (Winterich, 2007b).

[35] Sabik (2015) found that ageism affects the health and well-being of Black and white women; however, only white women are further affected with lower body-esteem. They hypothesised the 'buffering effect', a theory that Black women 'are protected from negative body esteem and associated negative outcomes', or Black women's lifelong experience with racism and sexism has predisposed them to ageism (Sabik, 2015, p. 196).

MW exploit clothing as a 'mask' to cover the socio-cultural signs of ageing, fight the ageist stigma of 'letting oneself go', and dress to appease their family (Hurd Clarke, Griffin and Maliha, 2009). While the women are not dressing to necessarily stay with trends, they know that there are unwritten expectations for their appearance and attempt 'to get it right' (Goode, 2018, p. 15). By attending to their appearance, the women can portray an image of youth and good health, impacting how they feel about themselves.

Although self-reliant, Black women's self-concept is also tied to their community, indicating the significance of their social image and identity (Defrancisco and Chatham-Carpenter, 2000). Hill Collins (1986, p. s18) reports that 'Black women judge their behavior [and aesthetic] by comparing themselves to Black women'. Feelings of belonging to particular groups positively affect self-concept. Cash (2012, p. 42) establishes that 'a positive self-concept and strong social support may facilitate the development of a favourable evaluation of one's body and serve as a buffer against events threatening one's body-image'. On the other hand, Franklin (2003, p. 139) claims that what Black women 'wear in predominately white settings, reflect "choices" that in many ways have already been made for [them]'[36]. Thus, critique and feedback from others influence the wearers' self-esteem impacting their self-concept (Mair, 2018).

4.2.2.3. Age (Cognitive/Feel Age vs Chronological age vs Look Age)

Age[37] is said to be the optimal variable in segmenting the bra demographic (Amy-Chinn, Jantzen and Ostergaard, 2006) as ageing affects the bra consumer's behaviour (Tsarenko and Strizhakova, 2015); nevertheless, the authors made no variation between chronological age, the numerical age assigned, or cognitive age (also known as Feel-Age), the age one mentally feels (Oberg, 2003; Birtwistle and Tsim, 2005). Researchers observe that MW might have up to a 10-year cognitive/feel-age difference from their chronological age (Szmigin and Carrigan, 2000 as cited in Birtwistle and Tsim, 2005; Kilpela *et al.*, 2015). Mature Black women in Thomas-Grumbach's (2018) study noted feeling younger than their biological age. Age is further complicated by the 'Look-Age, how old one looks, [based on physical functioning and physical appearance]' (Oberg, 2003, p. 106). A study detailing the interaction of age components, conducted with Swedish MW, reveals on average, they felt their look-age was five years younger than their chronological age, and their feel-age was approximately fifteen years younger (Oberg and Tornstam, 1999 as cited in Oberg, 2003). The stats for Black women may differ as Elle, a Black British woman, opined, '[Black women] don't age as much as the Caucasian' (Granville, 2000, p. 91). Referring to the socio-cultural notion, Black women tend to receive cultural symbols of ageing, such as wrinkles, at a later age[38]. Foos,

---

[36] Franklin is referring to the notion of respectability politics (Kirkland, 2023). It purports for Black people to be treated fairly by the dominant society; they must dress in fine clothing.
[37] Age has many complex intricacies that are not well understood in its relation to fashion. Social age, 'the age of an individual as defined in terms of social roles and habits'(Barak and Schiffman, 1981), I believe, affects mature women. They are becoming mothers older, 40+, and beginning new careers, later placing them in new social roles. How this affects their fashion choices and experiences is still unknown. It is important to be aware that social age could affect the bra experience; however, it is outside the scope of this research.
[38] The prolonged youthfulness of Black women's skin is due to IGF1 gene, also known as the methuselah gene, which Black women may possess more of than white women found in a decade-long study conducted by D.Kimball and colleagues, Olay and 23andMe (Spivak, 2015).

Clark, and Terell (2006) found that Black and white women viewed ageing differently, which may be linked to historical and cultural differences. Significantly, Birtwistle and Tsim (2005) found that MW sought clothing closer to their cognitive age to reject negative elderly stereotypes.

4.2.2.4. Femininity

Entwistle (2000b, p. 185) contends, 'The female body […] is a body that is not only marked out as "feminine" but saturated with "sexual" meanings too'. Female bodies are read as less or more feminine than others depending on 'race', culture, and historical period. One constant in Western culture due to the lasting effects of slavery is Black women's bodies reading as less feminine (Carby, 2000), a concept they are conscious of from a young age (Ringrose, Tolman and Ragonese, 2018). Historically, this led Black women to emulate white women – cognate with Judith Butler's notion of 'Gender Performativity' (1988) – to be seen as more feminine (Hill Collins, 2008; hooks, 2014). Davis (2015) confirmed that clothes are essential to mature Black women's embodiment of femininity tied to their sense-of-self and self-esteem. The participants in Davis' study believed '…how they dress is a part of their race' (Davis, 2015, p. 139).

However, hegemonic femininity is seen as white, dainty, slim and youthful, which as women age, they move far from, also due to weight gain (Winterich, 2007b; Cameron *et al.*, 2019). Studies on mature white women revealed that ageing appeared more difficult as their bodies changed, no longer closer to the ideal (Liechty, 2012; Montemurro and Gillen, 2013). Thus, as white women age, they feel the stigma of ageism by moving further from the ideal, which impacts their understanding of their aged feminine identities (Hurd Clarke, 2011). However, Black women have different definitions of femininity (Cole and Zucker, 2007) that weight gain does not deter from (Bay-Cheng *et al.*, 2002), allowing them to rate themselves as more feminine than their white counterparts. Ageing may also affect Black women's feminine-identity, but to what degree is unclear as there is limited research available.

Fig.4.3. One of the few available images of a mature Black woman in lingerie. (Soma Intimates, 2018)

Historically, until recently, the media portrayed ageing women as 'asexual', 'unfeminine', and 'old hags', often depicting them as old-fashion or 'witch'-like (Markson, 2003). Within the last decade, fashion has advised women − Baby Boomers − how to age gracefully and successfully. Fashion media illustrate celebrities who aged appropriately, such as Helen Mirren (Wearing, 2012), by remaining thin, having full perfect hair, and showing minimal signs of ageing by looking younger than their chronological age. These subtleties demonstrate this new acceptable form of ageing femininity. Alternatively, they also construe to women how not to age in their harsh criticism of ageing celebrities like Madonna (Railton and Watson, 2012; Appleton, 2018). Society creates an overly simplified dualistic approach to ageing as a *right* and *wrong* way that is othered. As white women age, they are aware of how their bodies become *othered*, and their feminine-identity diminishes relative to their

younger selves and younger women. Black women are already aware of being *othered* in their femininity due to 'race' (Hill Collins, 2008). Nevertheless, as they age, Black women can co-opt and reverse the othering to their benefit, comparing their ageing to white women who are culturally stated to age more quickly.

Wearing a bra is one-way women can experience their feminine-identity (Amy-Chinn, Jantzen and Ostergaard, 2006) as they *do* or *perform* an act considered solely for the female gender. It allows women 'to experience, explore, experiment and play' (Jantzen, Østergaard and Vieira, 2006, p. 194) with different aspects of their feminine-identity, for example, girly, vamp or harlot, triggering the social meaning of the garment and its appearance. As women age, they are no longer afforded the same freedom to interact with various parts of their feminine-identity.

Through *othering*, women place their lingerie tastes, differentiating from those they deem inappropriate (R. Wood, 2016). In the process of *othering*, women are aware of the *right way* to consume lingerie and the *wrong way*, for example, in the bra colour options available to them. The colour selections impose feminine invisibility on MW, similar to Twigg's (2012) cultural invisibility, which is forced on this market with the 'don't-look-at-me' muted outerwear colours. Since social identity is a part of how women experience the bra, as it is conspicuously-inconspicuous, they must select the right bra to be presentable (social capital) within their social group.

4.2.2.5. Sexuality

There is a lack of scholarship on Black women's sexuality due to an 'imposed self-silence', as their sexuality is both hyper-visible and invisible within society (Hammonds, 2004). Black women's sexuality has been discussed as lascivious, deviant, animalistic (Fields, 2006), wild, promiscuous, and immoral (hooks, 1992) and was created in opposition to white women, which is considered the standard of sexual purity and innocence (hooks, 2014, 1992; Brown and McNair, 1995 as cited in Stephens and Phillips, 2003; Hill Collins, 2008). Sexuality is a significant component of identity; however, it is often ignored in conversations and the media when relating to ageing women. Many MW fear loneliness and being viewed as asexual (Bernard and Harding Davies, 2000, p. 69), often considering their age the most substantial barrier to 'sexual attractiveness, desirability or sexual behaviour' (Jen, 2017). Research indicates that sexual decline for women is not solely related to the biological and hormonal changes of menopause but to the negative socio-cultural connotation placed on sexuality, 'one's understanding of one's self as a sexual person' (Jen, 2018), and ageing (Ringa *et al.*, 2013). Dickerson and Rousseau (2010, p. 425) argue that 'ageism is the ultimate form of desexualisation', with Black women more so than white women, believing more favourable social attitudes towards ageing and sexuality would improve their sex life (AARP Research, 2005). The male gaze is still a significant factor in how MW judge and view their feminine and sexual selves (Hurd Clarke, 2011).

In a study by Oberg (2003), white women felt their sexual appeal decreased by 9.5% and their sexual activity by 15.8% between the ages of 45-64. The lack of sexual activity can be attributed to not having a partner,

health-related issues or stress (Fisher *et al.*, 2010). Although they felt their physical attractiveness slightly increased as they aged (Oberg, 2003) and believed their partners found them physically attractive, those in newer relationships were often ashamed and willing to forgo sexual intimacy because they were dissatisfied with their ageing bodies in a sexual context (AARP Research, 2005; Fisher *et al.*, 2010; Montemurro and Gillen, 2013; Thorpe *et al.*, 2015).

Wearing the bra induces physical and psychological sensations that affect women's self-confidence, self-esteem and self-image (Amy-Chinn, Jantzen and Ostergaard, 2006; Tsaousi, 2011; Risius, 2012). The bra is a technology that allows women to experience and perform aspects of their feminine sexuality and sexual identity. However, certain bodies have social limitations placed on what is appropriate. Delicate lingerie is not for larger-sized women, declared participants in one study (Jantzen, Østergaard and Vieira, 2006). In another, participants noted that women over 45 are not meant to wear sexy lingerie (Amy-Chinn, Jantzen and Ostergaard, 2006) as they are 'outside the sphere of […] acceptable sexuality' (Twigg, 2012). Through advertisements, the lingerie industry uses normalisation to place restrictions on undesirable bodies, which women then internalise. The internalisation aligns with Butler's (2011) discourse on the Foucauldian notion of the 'docile body' where lingerie disciplines women's bodies that stray from the ideal beauty. MW's sexuality should be non-existent, which is demonstrated by what types of bras are deemed *suitable* for them. One woman sums this up by stating, 'I don't want to go into this sort of middle-aged old lady with the plain, very plain stuff. I still feel very feminine, very sexy, so a bra should be too…' (Risius, 2012, p. 28).

4.2.3. Mature Women's Wearing & Purchasing Habits

> *'…only recently… have women begun to talk openly about their breasts. They have spoken of the adolescent's embarrassed pride, the adult woman's erotic pleasure, the nursing mother's joy, the breast-cancer patient's anguish and the health activist's determination, the brassiere designer's hype and the consumer's frustrations, the woman with big breasts who wishes they were smaller and the woman with small breasts who wishes they were bigger'. (Yalom, 1997, p. 275)*

4.2.3.1. Bra Wearing Habits: Bra-Breasts Experience

As quoted above by Marilyn Yalom in 'A History of the Breast'(1998), women have extensive and varied breast experiences. Around menopause, MW may experience changes in their breasts with increased size and breast ptosis. Due to the lack of information on menopause symptoms, the change to their breasts often surprises them, bringing uneasiness and stress. Fernandes' (2016) study on larger-breasted older

women's breasted experiences reveals the battle faced, as their voluminous breasts negatively affect posture and clothing fit. There are difficulties for larger-breasted women to find appropriately fitting bras as many retailers do not offer attractive designs or fuller sizes, and often increase the price of larger sizes (Bishop, Gruys and Evans, 2018). Larger-breasted women are at a higher risk of mis-purchasing (Filipe *et al.*, 2015). They tend to wear incorrectly fitting bras (Wood, Cameron and Fitzgerald, 2008), which affects their body-image (Bishop, Gruys and Evans, 2018) and social capital (Tsaousi, 2011). Since women do not know their correct bra size due to increasing breasts, they seek to be correctly fitted (Tsarenko and Strizhakova, 2015). Unfortunately, as the industries' bra-fitting practices are outdated (Pechter, 2008), and bras are not being successfully manufactured for their ageing breasts or body type, MW will continue to be disappointed (Kim, Kim and Ashdown, 2014). Many MW have taken to trial-and-error to find correctly fitting bras; however, most are unsuccessful (Hart and Dewsnap, 2001). Recent research proposes a new bra sizing system that considers age and BMI to assist the endeavour (Shi *et al.*, 2020).

4.2.3.2. Bra Purchasing

Women purchase new bras once they need to replace older ones due to loss of functionality, aesthetics, or breast sizing change due to pregnancy, nursing, menopause, or weight fluctuations (Hart and Dewsnap, 2001; Yip, Law and Wong, 2007; Hodgekiss, 2015). As women age, their breasts change, such as a decrease in skin thickness and elasticity, requiring a 'more supportive bra' (Coltman C. E., Steele J. R., and McGhee D. E., 2016). Liu et al. (2019) affirms that larger-breasted women shopped for bras differently than smaller-breasted women. Many women find bra shopping to be an unpleasant experience, citing 'the lack of attractive bras in larger sizes, lack of choice in general, the difficulties […] in finding bras that offer fit, comfort and the right body shape through clothes' (Hart and Dewsnap, 2001).

When shopping for a bra, the attributes most important to MW are aesthetic, practicalities, fabric, support, comfort, physiological aspects and brand (Tsarenko and Strizhakova, 2015), which Yip *et al.* (2007) further categorised into purchasing criteria based on functional and aesthetic concerns. A bra's functional aspects are often highlighted as a selling feature. Functional concerns included fit, product quality and price, while aesthetic concerns included bra style (and fabric design), store atmosphere and brand (Dewsnap and Hart, 2004; Yip, Law and Wong, 2007). Product quality means the bra fits comfortably, is functionally supportive, and is composed of quality fabric that is comfortable to wear and held up through multiple launderings (Risius, 2012; Hume and Mills, 2013). The importance of the relationship between quality, price, and comfortability varied among women, demonstrating that younger women consume bras differently than older women (Amy-Chinn, Jantzen and Ostergaard, 2006; Sukumar, 2007; Tsarenko and Strizhakova, 2015; Tsarenko and Lo, 2017).

As women age, their enjoyment and pleasure in bra purchasing decline (for more information see Appendix U). Younger women – 18-39 – tend to purchase bras more frequently due to new trends, special occasions or as a treat to please themselves or someone else, leading to higher hedonic consumption (Laurent and

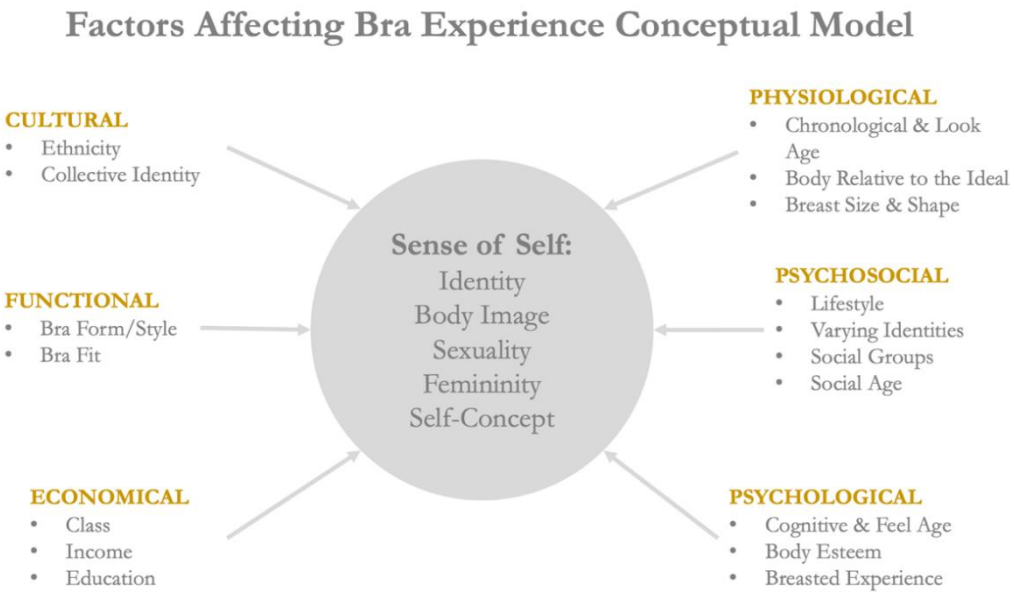
Kapferer, 1985; Yip, Law and Wong, 2007; Tsarenko and Lo, 2017). Market research shows women under 45 purchase more 'colourful and fashionable underwear' (Mintel 2004 in Amy-Chinn, Jantzen and Ostergaard, 2006) in colours such as 'pink, purple, blue, and yellow', which is associated with youth (Sukumar, 2007). The concept of vivid colours in lingerie allied to youth began as early as the 1930s, with manufacturers emphasising 'strong colours (red, blue, gold)' to entice the newly defined teen market (Farrell-Beck and Gau, 2001). MW are relegated to 'less extraordinary' and 'unadventurous colours' such as beige, black, and white (Sukumar, 2007; Risius, 2012). Sukumar (2007) explains the usage of colour as an 'unspoken code' to moderate behaviour, signifying what types of bras are age-appropriate.

Lingerie advertisements subconsciously further this message by using mostly youthful models, leading to a similar question posed by Amy-Chinn *et al.* (2006); how much do these messages affect or alter MW's purchases? Risius *et al.* (2014) confirm that MW were unhappy with the limited bra options available, citing colour selections as one of the reasons. A tumultuous cycle appears where bra brands sell muted colours to MW, making them feel this is the only appropriate option based on the unspoken code. They internalise this message as they feel uncomfortable purchasing livelier colours, although that is potentially what they desire. This further perpetuates the cycle as lingerie market researchers observe this purchase behaviour and recommend the same muted colours back to lingerie manufacturers as evidence of demand. Twigg (2012) acknowledged that the onus was on design directors, the cultural mediators, to help change how MW experienced ageing, specifically in fashion.

4.2.4. Factors Affecting Bra Experience Conceptual Model

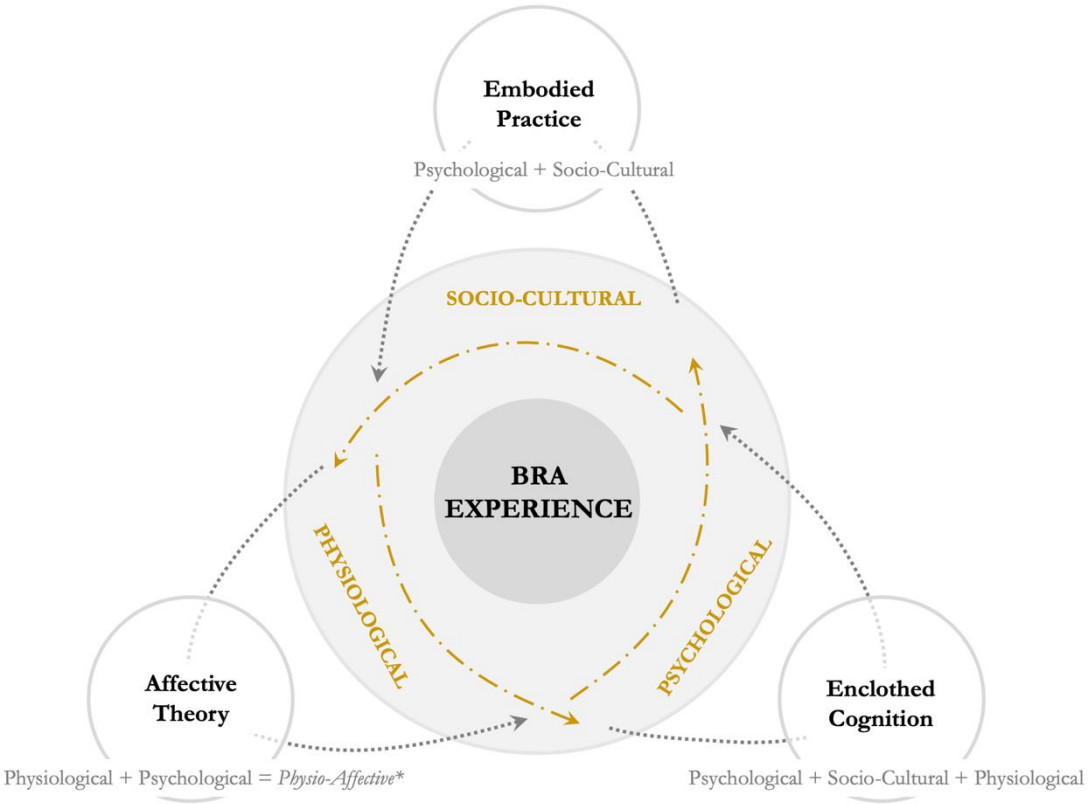
The contextual and literature review has established the connections of the cultural, functional, economic, physiological, psychosocial, and psychological factors to the sense-of-self variables (**Fig.4.4.**). The sense-of-self variables (identity, body-image, sexuality, femininity, and self-concept) relate to concepts that combine to affect how a person thinks of themselves and their behaviours. The significance of the sense-of-self variables to the bra and breast dynamic was explored in the previous section. Links were drawn between the bra-wearing experience and the intrapersonal sense-of-self variables. However, the ascertained connections must be examined further for MW's direct intrapersonal relationship between the bra and sense-of-self factors. The conceptual model is later substantiated in Section 7.2.

Fig.4.4. Amended Factors Affecting Bra Experience Conceptual Model



4.3. Scaffolding the Bra Experience Theoretical Framework

Fig.4.5. Bra Experience Theoretical Framework



This section discusses the development of The Bra Experience Theoretical Framework that was developed (**Fig.4.5.**) to discern the corporeal bra-wearing experiences of MW. The theoretical framework informs part of the research design and is evinced in Section 8.2.

4.3.1. Scaffolding Experience-based Theories

Lingerie researchers debate over the importance of lingerie being in 'what it does, rather than what it means' (Storr, 2002; Amy-Chinn, Jantzen and Ostergaard, 2006; Jantzen, Østergaard and Vieira, 2006); however, this design-researcher believes the significance is in how it is experienced combining both. Ruggerone and Stauss (2022, p. 2) assert that 'dress as a multi-sensory embodied practice' should be further examined. McCarthy and Wright (2004) suggest intertwining the various threads in experience (i.e., the sensual, emotional, compositional and spatio-temporal) to understand consumers' experiences with products. Bra-wearing experiences develop from interlacing relationships between the multi-sensory physical, psychological, and social aspects. However, as theories within each domain are viewed as separate, a new theoretical framework is necessary to understand the bra-wearing phenomenon. Scaffolding theories are a useful tool in design research when a phenomenon such as *experience* can be better understood through the interlacing of theories from various disciplines (Markussen, 2017). Thus, to understand MW's bra experiences, three experience-based theories are scaffolded: Affective theory from sociology (Ruggerone, 2017), Enclothed Cognition from social psychology (Adam and Galinsky, 2012), and Embodied Practice from fashion studies (Entwistle, 2000a). The scaffolded theories form the Bra Experience Theoretical Framework to aid in understanding how the wearers experience bras. While this framework does not encompass every experience related to bra-wearing, it offers a foundation from which to begin. Below examples from prior bra research are utilised to exemplify each theory.

4.3.1.1. Embodied Practice

The urban dictum of being hit by a motor vehicle and having emergency workers see their underwear as not being socially acceptable was repeated by a few women in separate studies (Jantzen, Østergaard and Vieira, 2006; Tsaousi, 2011). It is more than this hypothetical experience, with the gist being that women are aware of their bodies and how they must present it, even at a private level. In one study, the participant shared, 'If I do not wear a smart dress for a party then I would not wear delicate underwear. It would be completely wrong to wear delicate lingerie without some fancy clothes' (Jantzen, Østergaard and Vieira, 2006, p. 186). Although the lingerie is inconspicuous, the participant is adamant that she would be uncomfortable based on the possibility that someone notices. Similarly, Tsaousi (2011, p. 163) wrote of one of her participants, 'when she goes to the gym, she finds something that matches so she doesn't look "weird" to others'. Women are aware of the normalisation of socio-cultural beauty ideals; therefore, they rate and dress to present themselves accordingly. Embodied Practice (Entwistle, 2000a) is useful to comprehend the 'social factors and individual actions' that comprise how women experience the bra socially. Utilising embodied practice, the study seeks to comprehend if and how MW experience the bra socially.

4.3.1.2. Enclothed Cognition

Women actively and critically purchase and wear bras due to the nature of the garment. They consciously buy bras to perform certain sexual-, feminine-, and social identities (Tsaousi, 2016; R. Wood, 2016). For example, Lena wore mismatched underwear set to lectures and could not concentrate, which affected her ability to perform confidently (Jantzen, Østergaard and Vieira, 2006). The ability for women to psychologically access the symbolic meaning of bras, i.e., sultry, sporty, and confident, by physically wearing it can be grasped through Enclothed Cognition (Adam and Galinsky, 2012). Adam and Galinsky (2019, p. 159) amended enclothed cognition, highlighting the 'key tenet [is that] clothing can have an effect on how the wearer thinks, feels, and acts'. Enclothed cognition is the idea that our clothes can affect our thoughts, feelings, and behaviours. This is because our clothes symbolise our social identities and can influence how we think about ourselves. In one example, a participant, Jade, shared 'the feeling that she looked good in lingerie made her feel "more confident in the things I'm doing" when performing sexual activities with her partner' (Wood, 2015, p. 133). Adam and Galinsky (2019) introduce how dress can affect our mood and self-esteem. Exploiting enclothed cognition, the study seeks to understand whether the bra-wearing experience affects how MW think, feel, and act.

4.3.1.3. Affective Theory

In Woods' (2016, p. 7) study of how women feel while wearing lingerie, the consensus was it made them 'feel better about themselves and their bodies […creating] a feeling of confidence […] a pleasurable feeling of being wanted'. Ruggerone and Strauss (2022, p. 211) exemplify the affective experience, describing 'the body as something that affectively transforms in the encounter with clothes'. In one example, the participant, Christie, shared, 'it changes the way I feel, I would feel nicer, it would make me feel different. … I'm very conscious of it: I like wearing it, it feels different, I feel more special' (Tsaousi, 2011, p. 191). The feelings expressed from the experience can be comprehended through Affective theory, which connects the physical wearing and the physio-affective feeling about the bra – the 'feeling of being dressed' (Ruggerone, 2017). Together they create a tacit bra-body knowledge that the wearers do not always easily express or understand. Exploiting affective theory, the study seeks to apprehend the physio-affective experience of bra-wearing for MW.

4.4. The Rise of Tech Wellness for Mature Women

By 2025, 1.1 billion women globally (54 million in the U.S.) will be experiencing menopause (Das, 2019). Bloomberg estimates the menopause market to be $600 Billion (Mangum, 2021), as women spend approximately $2K a year to address their menopausal symptoms (Das, 2019). FemTech is a rising field dedicated to technologically advanced products catering to women's sexual (sextech), physical, mental, and emotional wellness (Goczyńska-Han *et al.*, 2020). The field is broad, ranging from incontinence underwear

(Modibodi), pelvic strengthener (Intimina), woman-centred health tracker bracelets (Bellabeat), and more. There are also numerous products for MW, namely a hypnotherapy app for menopausal women to help with emotional well-being (Clementine), a wearable bracelet to assist with hot flushes (Grace), a smart personal thermostat (Thermaband) and data-driven apps to help MW with their health (Femality). These products are a part of a larger Western movement to focus on the ageing population. The American Association of Retired Persons (AARP), an organisation dedicated to assisting the ageing population, created the 'Hacking Menopause Challenge' in 2020 – a first of its kind. After their annual study found that 93% of menopausal women were interested in technology to manage their symptoms (*AARP Announces "Hacking Menopause Challenge" Winners*, 2020). The call was to fund creatives to develop tech-enabled solutions for menopausal women. In 2021, the London Mayor launched a policy for menopausal working women, with the rise of Menopause Friendly, an 'initiative to train and certify menopause-supportive U.K. companies' (Costa, 2021). With the growing demographic, MW are being targeted as a rich market for FemTech products focused on educating, 'treating illnesses but also on giving women pleasure' (Goczyńska-Han *et al.*, 2020, p. 90).

4.5. Summary

Chapter 4

- ***Professed*** that mature women (MW) are marginalised in the bra industry and research field.

- ***Reasoned*** that the importance of the bra is not simply its functionality, but how it is experienced by wearers.

- ***Proposed*** differentiation in bra-wearing experience between mature Black and white women.

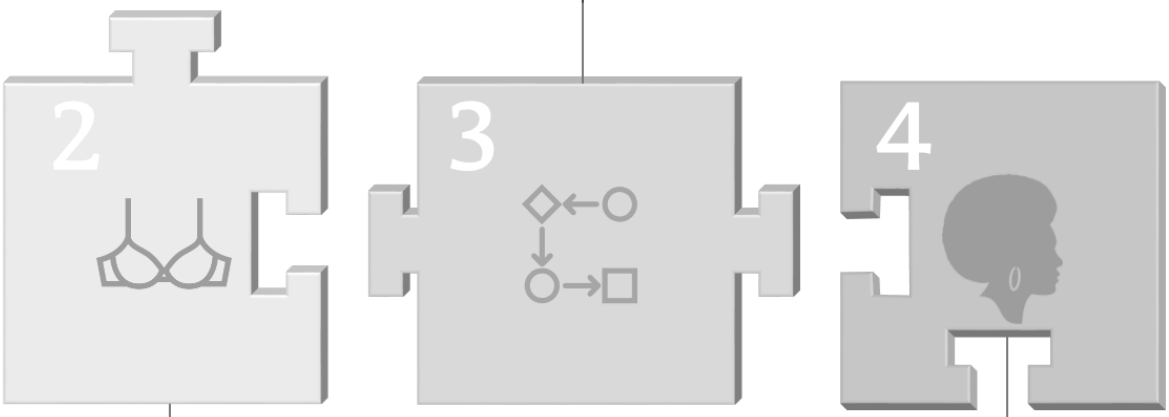
- ***Developed*** a general Factors Affecting Bra Experience Model (**Figure 4.4.**) indicating the bra's connection to women's 'sense-of-self'; however, further research is necessary applying it to MW.

- ***Created*** the Bra Experience Theoretical Framework (**Figure 4.5.**) proffering that bra-wearing is experienced psychologically, socially, and physio-affectively.

PART A SUMMARY

Together the contextual and literature review chapters substantiated the BW field and evidenced a gap in comprehension of the BWD&DP and how wearers may experience the process and product. Therefore, the three areas combine to underpin this study to provide empirical insights into the multi-layered situation.

Chapter 3
"DESIGN PROCESSES"
Chapter Three discussed the traditional bra design process, highlighting its shortcomings and the need for alteration to aid BW design. Options are available from functional apparel design to aid in inspiring a wearer-centred approach.

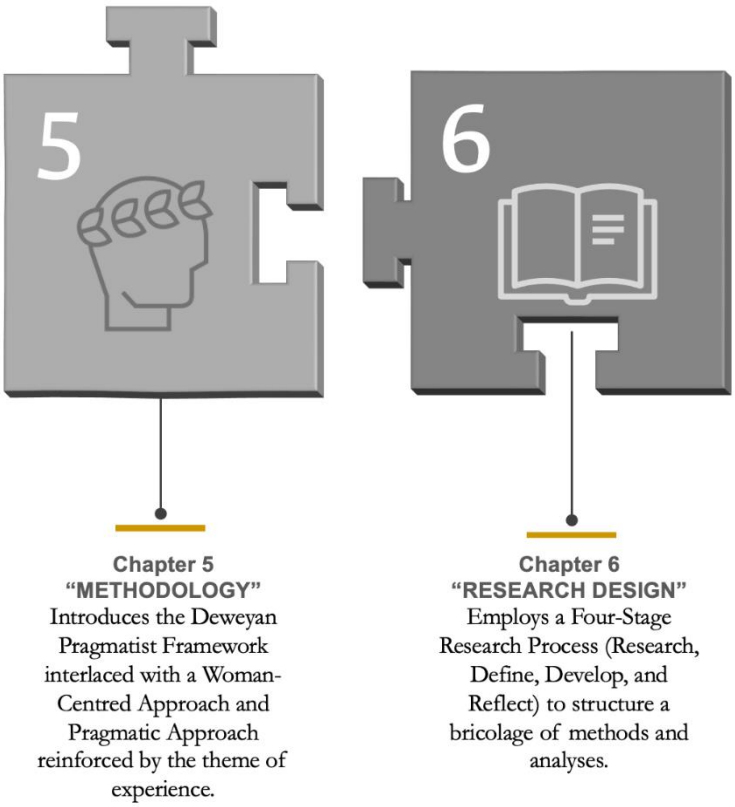


Chapter 2
"THE BRA"
Chapter Two introduced the BW state-of-the-art, providing insights into eleven sub-fields and a modern BW historical timeline. The chapter verifies the growing field and the need for more research.

Chapter 4
"MATURE WOMEN"
Chapter Four demonstrates a potential difference in how Black and white women experience the bra, highlights the bra's connection to mature women's sense-of-self through the Factors Affecting Bra Experience conceptual model, and produces a Bra Experience Theoretical Framework to comprehend how mature women experience the bra.

PART B: Methodology & Research Design

Part B comprises Chapter 5, 'Research Methodology', and Chapter 6, 'Research Design'. Together, the chapters introduce the reader to the technologies[39] (i.e., frameworks, theories, and approaches) utilised within the study.



[39] The term technologies is a Deweyan Pragmatist concept that refers to useful instruments such as frameworks, theories, approaches and materials used to facilitate research inquiry, discussed further in Section 5.2.

5

5. RESEARCH METHODOLOGY

'The imperative, as I see it, is to not only approach design from the perspectives of those who are routinely written out of Humanity – those who are typecast or get no speaking parts – but to draw on their insights, imagination, and expertise from the very beginning'. (Benjamin, 2022, p. 17)

To approach this study, I examined my philosophical worldview, which is 'a basic set of beliefs that guide action' (Guba, 1990, p. 17). I hold a Pragmatic worldview rooted in a transformational ontology (Prochner and Godin, 2022), problem-focused and based on 'actions, situations, and consequences' (Creswell and Creswell, 2018, p. 48). As a designer, academically trained in fashion design since the age of fifteen, problem-solving has become part of my ethos and attitude toward inquiry solidifying my pragmatic worldview. According to Creswell and Creswell (2018, p. 48), a pragmatic worldview 'opens the door to multiple methods, different worldviews, and different assumptions, as well as different forms of data collection and analysis', with the aim of changing a situation for the better. Additionally, this study embraces Benjamin's (2022) quote above, creating a space where participants are centred from the 'very beginning', which employs a constructivist worldview that knowledge is gained from participants 'subjective meanings of their [bra] experiences' (Creswell and Creswell, 2018, p. 46). Thus, by collaborating with marginalised participants and providing them with a voice, I incorporate a constructivist worldview within a transformative pragmatic worldview.

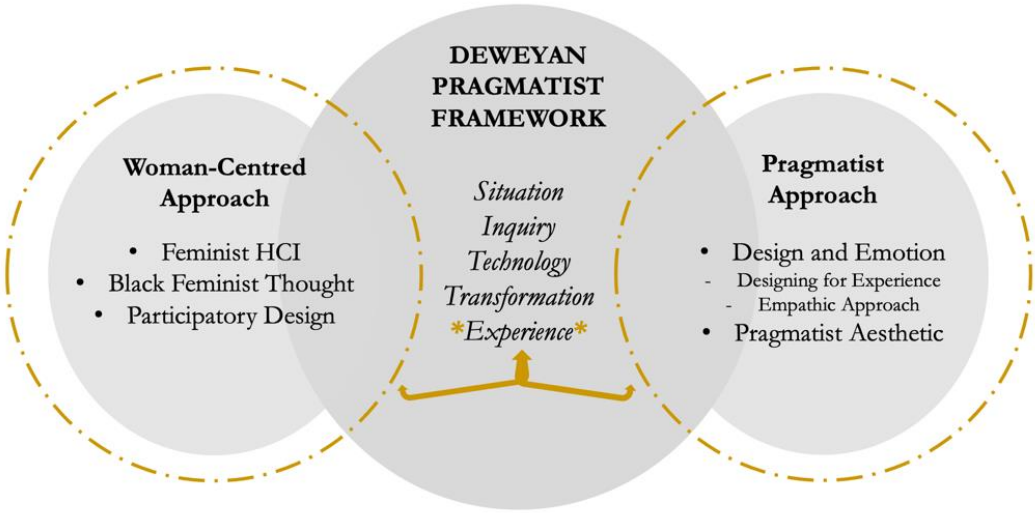
5.1. Introduction

Chapter 5 and **Fig.5.1.** outlines the multiple approaches underpinning the Pragmatist framework, exploited as a conceptual scaffold, to research *through* and *for* design in developing an experience-centred BWD&DP. The methodology was developed specifically as a design inquiry to navigate creating a D&DP based on the designer-wearer-product experience, wearer-product[40] experience, and designing a product for a pleasurable experience. Pragmatism's tenet of experiential inquiry facilitates the study's advancement, permitting the intersecting of theory and practice supported by a Deweyan Pragmatist Framework. In each section, *experience* is threaded throughout, connecting the approaches highlighted by the gold circular and arrow

[40] Wearer-product in this study refers to the participants and the design concepts, not their physical interaction with the materials/prototypes.

design in the research and framework approach (**Fig.5.1.**). **Fig.5.7.**, p141 further details and reiterates the approach connections within the pragmatist framework. The Deweyan Framework, outlined in Section 5.2., guides the research and design process, as a 'Deweyan inquiry can represent both practice as practice and practice in research' (Dixon, 2020, p. 87). Concluding this section, I explain how the Pragmatist tenet of pluralism facilitates multiple perspectives and approaches to a situation. This notion informs the approaches used: a Woman-Centred and a Pragmatist Approach.

Fig.5.1. Deweyan Pragmatist Framework and Approach



In Section 5.3., I discuss the concept of evolving the bra into a feminist technology, i.e., BW, by understanding women's relationship to the bra and designing for a better bra experience. I co-opt Almeida's (2017) women-centred perspective, placing the women's experience with the bra as the nucleus for future BW products. Feminist Human-Computer Interaction (HCI) (Bardzell, 2010; S. Bardzell and Bardzell, 2011) and Black Feminist Thought (Hill Collins, 2008), both built on Standpoint theory, are entwined to inform participant selection and engagement within the study. Significantly, this section communicates the approach of designing *for* and *with* the participants.

Next, Section 5.4. explains the Pragmatist approach to understanding experience within the D&DP and the complex wearer-product experience. I then move on to address the practice approach in Section 5.5., utilising research-*through*-experience-centred-design (RtXD) to enact the D&DP and research-*for*-experience-centred-design (RfXD) to develop a pleasurable bra. Lastly, in Section 5.6. I articulate the importance of reflexivity to this subjective and objective research as it guided me throughout the study.

5.2. Deweyan Pragmatist Framework

Pragmatist philosophy 'claim[s] that an ideology or proposition is true if it works satisfactorily, that the meaning of a proposition is found in the practical consequences of accepting it' (McDermid, no date).

Therefore, significance is placed on the practical application of the theories. Deweyan Pragmatism, established by American Philosopher John Dewey in 1859-1952 (Dixon, 2020), provides a framework for guiding and developing this theory and practice research to execute an experience-centred BWD&DP. Dewey's theory of inquiry and his approach to experience underpins this research philosophy. Interaction Design researcher Peter Dalsgaard (Dalsgaard, 2014, 2017; Dalsgaard and Dindler, 2014) has documented the ease with which Deweyan Pragmatism facilitates design thinking. Utilising Deweys' concepts of situation, inquiry, transformation, technology, and experience, Dalsgaard's well-cited article 'Pragmatism and Design Thinking' (2014) critically examines and connects the ways design practitioners and researchers can employ a pragmatist philosophy to interrogate the D&DP. According to Dixon (2020, p. 177), a Deweyan philosophical perspective is advantageous for 'design and design research involving practice' because it allows for 'a designerly approach to knowledge and reality'. Thus, I utilised Deweyan Pragmatism in developing the BWD&DP and the research design. The Deweyan concepts employed are discussed below, informing how they assist in framing the overall approach and guide the advancement of this study.

Situation. Deweyan Pragmatism acknowledges that the situation contains 'a subject and the surrounding environment, including other people, artifacts, physio-spatial surroundings' (Dalsgaard, 2014, p. 147). The situation must be considered within the study's framing; therefore, I often examined myself, the study's environment (often in my home studio), the participants, and the socio-cultural times as they situate the research experience. Moreover, the situation also includes the study's problematic context – where the BW field is advancing from a technology-push aspect without centring the wearers and their potential experience with the product. This dual-informed approach is vital to me in experiencing the study and the readers who must form judgements by understanding the situation's 'contextual whole'[41] (Dewey, 1998, pp. 66–67). Using Deweys' notion of situation, I demarcate the boundaries and position of the research.

Inquiry. Inquiry is 'the mode of thinking and doing' that begins an exploration for the researcher (Dalsgaard, 2014, p. 147). Dixon (2020, p. 66) explicates that design inquiry is a strategy centring on 'the experiences of designers and those who use the product'. Therefore, design-researchers who use this strategy must interlace 'research, practice, and knowing' (Dixon, 2020, p. 67). According to Dewey, designerly inquiry begins when the design-researcher becomes aware of an indeterminate situation – a problematic situation – as mentioned above, and changes it through practice research into a determinate situation (Dalsgaard, 2017). In this case, the lack of information and guidelines in designing BW is the indeterminate situation sought to be transformed. Dalsgaard (2014) reasons that past experiences often inform our awareness that a situation is indeterminate. This notion proves true as my interest in smart bras, as a designer brought me to the inquiry; however, noting there were no guides or collated information on the field, I initiated the study. Essential to the inquiry is to transform an indeterminate situation into a determinate one, utilising inquiring strategies constructed of inductive and deductive thinking. According

[41] It is important to note that inquiry into a situation provides or enables emergent information (Gaver et al., 2022). Therefore, the insights are unstable and vary across participants, places, activities, etc.

to Hansen (2016, p. 40), this is consistent with Dewey's view on the 'double movement of reflection'. Researchers have noted that this back-and-forth between 'knowing and doing', 'knowing and making' (Dixon, 2020, p. 183), 'knowing-through-action' (Dalsgaard, 2017), and 'action and reflection[42]' (Schön, 1995) are fundamentally intertwined in design inquiry.

Transformation. When entering an indeterminate situation, transformation to a determinate one is the aim, which enabled me to document the study, and indicate when a resolution is met. The transformation includes the design-researcher, the field, or both (Boydston, 1981-1990 in Dalsgaard, 2014), establishing that transformation occurs as my position moves from a traditional designer to a hybrid designer. Hansen (2016) includes the methods used by the design-researcher in their investigation as a part of their transformation as they either gain new insights or a more profound understanding of the situation. Additionally, further transformation manifests as the BW field is delineated and insights into BWD&DP are illuminated. Nevertheless, transformation in design research can be complex due to 'wicked problems' (Rittel and Webber, 1974); the concept that design is iterative and cannot be 'solved through traditional analytical problem solving' (Dalsgaard, 2014, p. 145). Instead, transformation must be judged on its outcome, specifically concerning the D&DP, whether the solution is 'good or bad' (Hansen, 2016).

Technology. The situation is tethered to Deweys' concept of technology, which encapsulates any instrument used to further the inquiry. Technology can be materials, concepts, or frameworks (Hansen, 2016) and is integral 'to the transformation of a situation' (Dalsgaard, 2014, p. 148). Dalsgaard (2017, p. 21) calls the usage of tools by designers 'instruments of inquiry', remarking on their necessity in design as 'they support design creativity and exploration. […] instruments not only augment designers' capabilities […], they also guide their perception and understanding of design problems and solutions'. As I progressed through the study, I often reflected on the technology available and how it facilitated or hindered my thinking, learning, and doing. Frequently, I relied on my background to sensemake, guide judgements and technology selections throughout the exploration and experimentation of the situation, resulting in abductive thinking (Kolko, 2010). During the practice portion, Dewey calls this phase experimentation[43]; technology is critical, as Covid-19 affected the study's situation and access to technology, requiring innovative approaches (discussed in Section 6.1.).

Experience. Dewey's notion of experience requires it to be scopious, tying experience '*to* the world, to the social, the temporal, the cultural, the historical, and more generally, to the human situation' (Dixon, 2020, p. 192). Thus, to investigate bra experience, this research ties it to the double-barrelled Deweyan notion of

[42] Reflection is essential to comprehension of experience, which Dewey refers to as secondary experience (Dixon, 2020, p. 87). As such, this research prioritises continuous reflection, culminating with Chapter 10, Reflect.

[43] As part of a pragmatist perspective, the experimental stage, also referred to as the practice, allows me to understand the situation through the intertwining of action and reflection (Dalsgaard, 2014). Deweyan Pragmatism champions the experiential nature of research, as it is through action – practice – can theories form. Dalsgaard (2014) notes experimentation affects the design-researcher, participants, and the 'subject' in this case, the BW field with the knowledge produced. This notion is discussed further in Section 10.3.

experiencing[44] (**Fig.4.4.**, p.115, Factors Affecting Bra Experience Conceptual Model), to the social, temporal, cultural (**Fig.4.5.**, p.115, Bra Experience Theoretical Framework), and the human situation with the wearers being a part of the BWD&DP (**Fig. 7.19.** and **7.20.,** p.224). Additionally, Dixon (2020) emphasises that applying Dewey's experience in design includes centring on 'certain individuals', 'moments in time', or 'personal occurrences'. This research focuses on Black women within a particular life stage, age group and their bra-wearing occurrences. Dewey's notion of experience is extended to the BWD&DP and the designed artefact. Dalsgaard (2014, p. 150) reasons that experience occurs through engaging in the D&DP investigating and developing products, and when the participants are brought into the BWD&DP and encounter the designs.

As part of the larger field of Pragmatism, Deweyan Pragmatism is also grounded in the tenet of pluralism. Pluralism maintains that there are multiple truths and 'that knowledge is shaped by multiple experiential viewpoints' (Whipps and Lake, 2017). This notion underpins the pluralistic nature of this research, engaging with different perspectives (the design-researcher and participants) in developing the BWD&DP. Melles (2008, p. 10) asserts that 'methodological pluralism is a hallmark of pragmatism', warranting utilising mixed methods and multiple approaches to explore the problem. The research framework (**Fig.5.1.** and **5.7.**, p.141) highlights this pluralistic effectuation, interweaving the notion of experience throughout the selected approaches.

5.3. Woman-Centred Approach

Interaction Design researcher Teresa Almeida (2017, p. 42) upholds 'a woman-centred approach embraces notions of women's bodies, […] and technology design that traverse knowledge and experience to accommodate positive experiences'. Applying a woman-centred approach, this study engendered navigating and developing a D&DP where women's future experience with the product is centred. A woman-centred approach entreats me to humanise the participants as individuals with disparate experiences in the research design and development of the BWD&DP. Consequently, the study uses direct quotes allowing the women's diverse experiences to be expressed in their voices. A woman-centred approach stipulates that the technology designed with women should 'enable or empower' them (Almeida, 2017, p. 38). This guiding notion influenced me to understand women's current experiences as mature women (MW) and design concepts that allow them to experience their bodies more pleasurably. The woman-centred approach is supported by feminist influences (5.3.1.) that enable designing *for* and *with* women (5.3.2.).

[44] Dewey separates experience, which he refers to as being 'double-barraled' (Dixon, 2020, p. 37), into active and passive. Dixon explains 'experiencing – what happens to a person, emotionally or otherwise' as one side of the experience. It is this internal happening that the Factors Affecting Bra Experience conceptual model explicates.

5.3.1. Feminist Influences

The bra is technological, developed from sophisticated engineering through advanced making and modern materials. A Historian of Technology, Judith McGaw (2003), defines the bra as a 'feminine technology', meaning it provides knowledge and acts as a tool enabling women to construct and practice various aspects of identity (Storr, 2002; Amy-Chinn, Jantzen and Ostergaard, 2006; Tsaousi, 2011; R. Wood, 2016). Moreover, this feminine technology enables women to acquire and continuously develop embodied knowledge (Tsaousi and Brewis, 2013; Tsaousi, 2016), aiding in self-development and advancement. In essence, women become bra experts due to their bra-wearing experiences and the knowledge acquired from the process. Since the bra enables women to understand and act out various aspects of themselves, placing technology into the garment requires understanding the various sense-of-self factors (Sections 4.2.4. and 7.1.4.) to design cautiously, taking care not to impede on their understanding of self. Fortuitously, this research advances the bra into a feminist technology 'that is designed, developed, or evolved (through users) with women's involvement … and interests in mind' (Almeida, 2017, p. 31). As BW fuses women's ways of being and interacting with technology, a human-centred perspective from feminist HCI is applied to aid in developing the human-technology relationship.

Feminist HCI is built upon standpoint theory, which argues for research to employ the participants' multifaceted perspectives (S. Bardzell and Bardzell, 2011) and focus on the lived experiences of marginalised groups as their situated knowledge from being at the edge of society can inform changes that benefit the majority (Harding, 2004; Hill Collins, 2004). Simply a feminist HCI approach informed the selection of marginalised mature Black women participants due to their intersectional experience of ageism, sexism, racism, and classism. Additionally, Black Feminist Thought, also built upon standpoint theory, facilitates my comprehension and approach in centring Black women's bra experiences. Black Feminist Thought denotes the importance of examining everyday experiences, validating subjectivity, and not engaging or reporting Black women as a monolith with one universal experience (Hill Collins, 2000). Within any selection of women, there is a spectrum of diversity based on economic, education, and sexual orientations, as well as varying breast sizes that also affect the bra experience. Thus, it is essential for me – and the readers – to note that the participants will have different experiences that inform their bra knowledge, providing a valuable range of insights lacking in the bra research field. Acknowledging the diversity of Black women, the research narrows the focus to those between the ages of 45-64 years who live within Western society: participants came from North America, U.K., Western Europe, and Australia[45].

Finally, the key methodological positions from feminist HCI employed are 'an empathetic relationship with research participants focused on understanding their experiences, Researcher/Practitioner self-disclosure, diverse and mixed methods to support dialectic information gathering and knowledge production, and

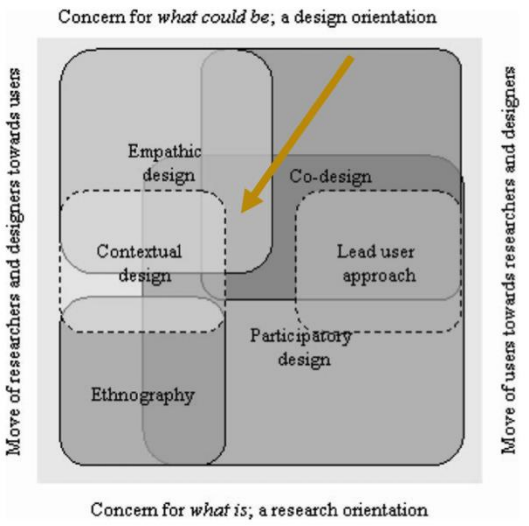
[45] Although the selection of women is narrowed to these specific locations, I am not ignorant that bra experiences or factors that affect the bra experiences may further be distinct due to cultural, social, regional, and national facets. Unfortunately, it is outside the scope of this study.

reflexivity' (S. Bardzell and Bardzell, 2011, p. 682). Striving to develop an empathic relationship with the women, the research applied an empathic approach discussed further within Section 5.4.2.2. Feminist HCI compels me to participate in the study through self-disclosure and reflexivity (detailed within Section 5.6). Additionally, the research utilises a mixed- and multi-method approach (**Fig.6.3.**, p.148) to accumulate information on MW and their experiences (Section 6.1.). A quantitative method, namely a questionnaire, is employed to collect a large amount of data to aid in developing statistically grounded models. In contrast, various qualitative methods such as workshops, dialogue sessions, and interviews are applied to amass in-depth information from the women on their bra experiences.

5.3.2. Designing *for* and *with* Women

A woman-centred approach promotes the emergence of designing *for* and *with* women; therefore, I placed the women's subjective experience coupled with my objective and subjective[46] experience within the research. The complexity of the bra requires the design-researchers' heuristic expertise to inform the designing of the technologically enhanced artefacts. In this manner, I am consciously designing *for* the women, empathising, and centring them while utilising the knowledge gained from interaction with the materials through practice. Working in my studio, fostered by the lack of physical interaction with participants, often meant placing myself into the wearers' role – through first-person methods – to judge whether the materials were soft or comfortable enough on the physical body. Throughout this process, I alternated between being an objective and subjective designer, navigating design research as an insider-outsider (Section 6.4. discusses my positionality as an outsider of the participants' age group). Furthermore, I examined my subjectivity as a designer and bra wearer to understand the choices made during the research in selecting design methods, designing products, and interpreting data.

Fig.5.2. Human-Centred Design (HCD) Map
Source: Steen (2011) 'Tensions in human-centred design' (Gold arrow indicates research position)

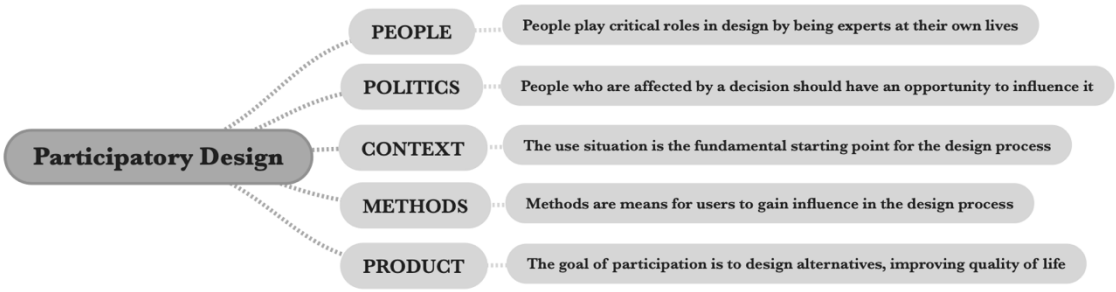


Designing *with* women mediates a dialogic approach, enabling the collaboration of expertise – the participants and design-researchers'– to inform the design direction and processes. Steen (2013) attests that Deweyan Pragmatism empowers co-design, as cultivated by Sanders and Stappers (2008), where participants collaboratively engage throughout the D&DP through 'making' and 'doing'. This allows the participants to become part of the D&DP. However, the bra D&DP made more complex with smart technology is not yet suitable for the nuanced co-design, as participants would not be equipped for the 'making' and 'doing' in the development phase.

[46] Pragmatism allows researchers to take both a subjective and objective viewpoint (Tashakkori and Teddlie, 1998, p. 23).

Furthermore, researchers (Van Kleef et al., 2005; Hoonhout, 2007) warn against co-designing innovative products with participants as they may struggle to express future needs, grasp the potential and limitations of emerging technologies, or envision possible applications. Thus, the larger field of participatory design is best to frame this research approach (**Fig.5.2.**). Halskov and Hansen (2015) indicate that there are five fundamental aspects of participatory design: people, politics, context, methods, and product (**Fig.5.3.**). Not all the aspects must be realised in one study; however, this research does include all aspects.

Fig.5.3. Fundamental aspects of participatory design.
Source: Halskov & Hansen (2015)



Participatory design is vast, underpinning various approaches such as co-design and empathic design (Steen, 2011), both incorporating the need to understand the participants' experiences enabling designing *for* and *with* them. This encompassing feature of participatory design permits the mixing of methods associated with the different approaches, so long as they support the inclusion of the wearers treated as experts throughout the D&DP (discussed in Section 3.5.1.). To illustrate, this research utilised co-design generative methods in the predesign phase of the design process; there, the participants 'make' and 'do' to gain insights into their wants, needs, and experiences (Section 6.1.2.1.). Nevertheless, as Steen (2011) posits, the difficulty will be for the design-researcher as they attempt to balance the participants' design wants and needs with their own. This study must also balance the developing knowledge of the technology and its parameters for BW (van Dongen, 2019). As the designer, I had to continuously reflect and deliberate on the variety of needs while centring the women's pleasurable experience as the end goal. Balancing various requirements and needs further substantiated designing *for* and *with* the women within the D&DP by bringing them in and out at certain stages.

5.4. Pragmatic Approach

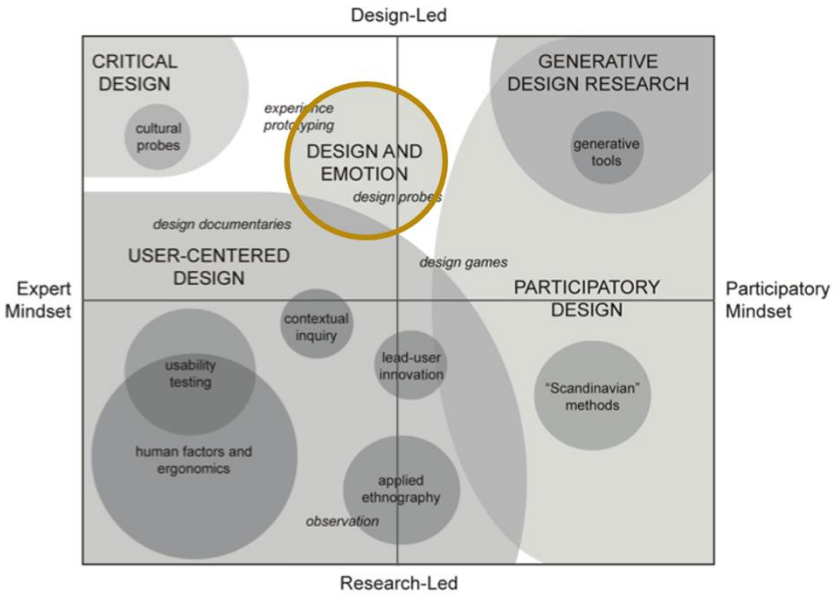
Additionally, this study takes a pragmatic approach, postulating that the focus is on selecting the best methods for the study, which assist the researcher in addressing the aims. It advocates establishing the most suitable approaches, 'what works' (Patton, 1990), to assist in the inquiry. Consequently, I selected methods from different fields within HCD to build the study's approach. This section discusses the pragmatist aesthetic approach to experience (5.4.1.) and the HCD field of Design & Emotion (5.4.2.), which interweaves experience and emotion.

5.4.1. Pragmatist Aesthetic Approach

The pragmatist aesthetic approach, developed through pragmatism's notion of lived experience, posits that aesthetics is another tool to investigate the development of an experience-centred D&DP. It supports an understanding of experience and interaction between the wearer and the product, the wearer and the design-researcher, and the design-researcher and the product (Wright, Wallace and McCarthy, 2008). The experience, Wright et al. (2008, p. 18:2) posit, 'emerges in the interplay between the [wearer], context, culture and history', the design-researcher, and materials. One of pragmatist aesthetics' themes apt to this study is the *dialogical* view of experience, which is exploited to comprehend women's experiences within the BWD&DP and my own. The dialogical approach maintains 'that making sense of an encounter is as much about what the person brings to the experience as it is about what [they] encounter there[47]' (Wright, Wallace and McCarthy, 2008, p. 18:7). Subsequently, the approach encourages continuous engagement and empathy between the design-researcher, wearer, and bra product, allowing each a valuable position to co-construct the experience of the D&DP. Through iterative and immersive engagement with participants, empathy and understanding can form. This form of empathy extends to the materials; as I created the bras, I continuously engaged in dialogue, questioning how the wearer might experience it while also empathising with the materials and design constraints (van Dongen, 2019).

5.4.2. Design and Emotion

Fig.5.4. Landscape of Human-Centred Design Research illustrating area this study occupies.
Source: Sanders and Stappers (2008) Adapted by (Postma *et al.*, 2012)



[47] This notion is essential to understanding the significance of reflection to the BWD&DP. Through the utilisation of the Bra Experience Framework and continuous reflection after multiple interactions with the wearers, I was better positioned to understand what the wearers were bringing to the D&DP and how they, in turn, experience the BW concept.

The study is situated within the smart fashion field, and as a result, it draws approaches and methods from the Human-Centred Design (HCD) landscape (**Fig.5.4.**). Notably, in Sanders and Stappers' (2008) HCD landscape, participatory design research employs the 'users as partners' and is either 'led by research' or 'led by design'. This study was 'led by design' and acknowledged the 'users as partners' (and 'user as expert') in designing *with* them and 'user as subject' in designing *for* them[48]. Furthermore, as highlighted by research Aim #2, (Section 1.6.), the study seeks to "improve the bra wearer's experience" by designing for a pleasurable experience with future BW. The study emphasised the wearers' experience and used the information to develop products that would, during the interaction, be experienced pleasurably, also situating within the Design & Emotion sector. Viewing the HCD landscape, it is evident that Design & Emotion is 'designer-led' but also part 'user as partner' and 'user as subject'. As such, the field utilises explorative and generative techniques to bring the wearer into the D&DP, beginning at the fuzzy front-end – the most crucial phase – and during the final usability testing stage (Desmet and Hekkert, 2009). Although Sanders and Stappers (2008) do not connect the field of Design & Emotion to the Participatory Design sphere in their HCD landscape, this study does through practice. The practice validates Stappers and Sanders' (2005) notion that co-design generative tools are equally valuable when investigating experience and emotion-driven design research.

Design & Emotion is a new discipline emerging around 1999 with the 1st International Conference on Design & Emotion (McDonagh *et al.*, 2004). The space of design and emotion is multiplex, including subfields such as design *for* emotions, experience-driven design, and empathic design. These subfields have different perspectives, approaches, and – often overlapping – methods. Fulton Suri (2003) explains that the overarching field has three classifications differentiated by approaches aimed at participant observation, interaction with participants through making and doing activities, and the third, through researchers attempting to understand participants through role-playing.

While researchers attempt to distinguish the subtle nuances amongst the subfields, Dewey advocates that they all intersect and connect as experience influences emotions[49] (Dewey, 1934). Bra wearers' emotional relationship to the bra is predicated on their extensive bra experience history. Fairburn, Steed, and Coulter (2016, p. 92) advise that smart clothing has 'the potential to change the meanings of clothes and create emotional relationships between garment and wearer'. Whether good, bad, or indifferent, bra wearers already have an emotional relationship with the garment. It is thus crucial to comprehend how the traditional bra is experienced, and the relationship wearers have with it, before attempting to design *for* a pleasurable experience with BW. Approaching the BW field without this understanding has detrimental effects, as the bra can negatively impact bra wearers emotionally, psychologically, and physically.

---

[48] During the BWD&DP, the wearers move in and out of the stages as experts and subjects (see Section 10.3., Fig.10.9.).
[49]Dewey argues that 'the intimate nature of emotion is manifested in the experience [...]. Experience is emotional [...]. [Moreover] emotions are attached to events and objects [...]' (1934, p. 42). Therefore, to investigate emotions is to also interrogate experience.

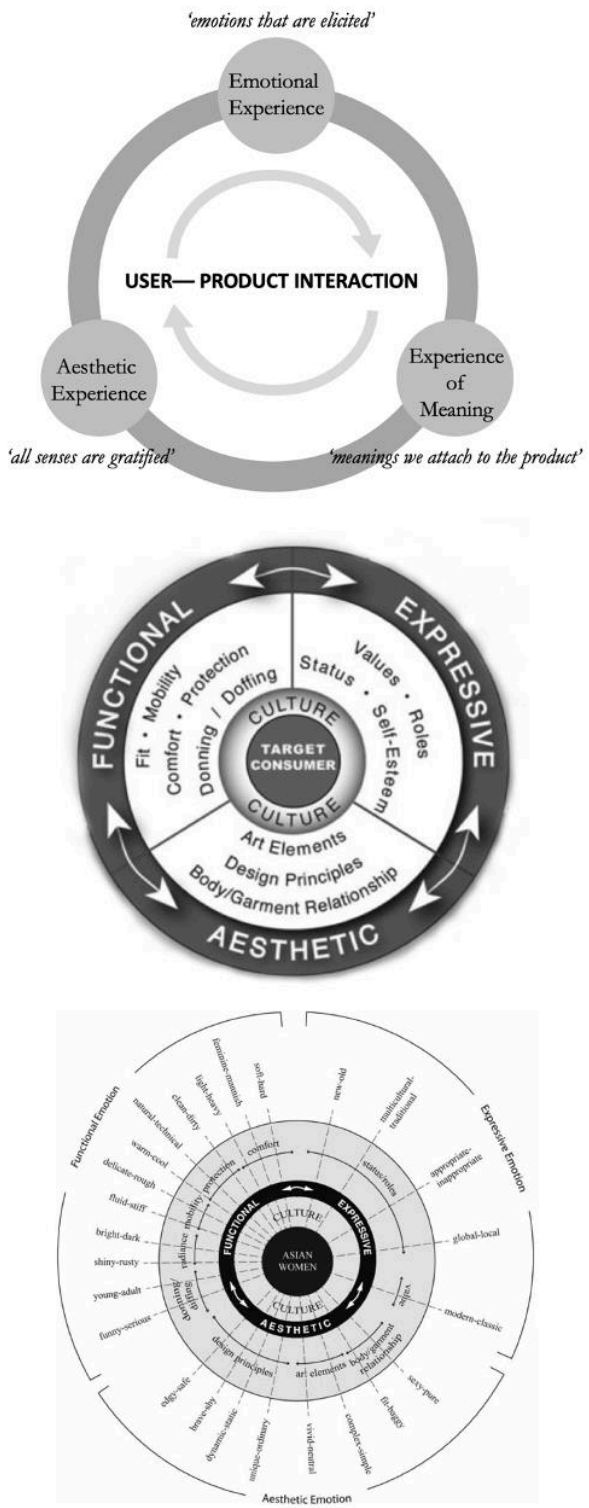


Fig.5.5. Models of Product/Garment Experience
Top: Product Experience Framework. Adapted from Desmet and Hekkert, 2007.
Middle: FEA Conceptual Model. *Source:* Orzada and Kallal, 2021.
Bottom: Emotional Needs FEA Model. *Source*: An and Lee, 2015.

To design *for* emotions, professor of Psychology Gerry Cupchik (2004, p. 6) asserts that design-researchers must 'place design objects, designers, and users in social context' to better comprehend the experiences during wear. To do so, the designer-researcher must consider the current social climate, information, materials, and wearers' disposition. At the time of this study there was a global pandemic due to Covid-19 which resulted in lockdowns in the U.K. During lockdowns, some women were excited not to wear a bra, and others wanted to dress up (Saner, 2020; Tsapovsky, 2021; *The Guardian*, 2021). Their vocalisations illustrated that rarely are women ambivalent in their emotions towards bra-wearing, predicated on their prior experiences. Therefore, it was essential to understand how the bra affects women's sense-of-self and its ties to their emotional experience (evidenced in Section 7.1.4.). Chapter 4 underscores that the bra-wearing experience is complex, intertwining with factors that make up the wearers' sense-of-self and is affected by psychological, socio-cultural, and physio-affective influences. Thus, understanding emotion within this prism is elaborate and extends beyond the limit of this research. Instead, the study seeks to comprehend the wearers' emotional assessment of BW during the D&DP.

Interaction Design researchers created frameworks to apprehend people's emotions with products. Desmet and Hekkert's (2007) product experience framework highlights that user-product interaction has three components: aesthetic experience, experience of meaning, and emotional experience (**Fig.5.5.**, top image). Although not attached in their framework, Desmet and

Hekkert (2007, p. 60) note that Overbeeke and Wensveen's (2003) *aesthetic of interaction*, 'the beauty one experiences when physically interacting with a product' is another aspect of the experience. These multiple experience facets influence each other.

Importantly, Desmet (2004) asserts that it is impossible to design for explicit emotions or experiences; instead, designers must concentrate on creating products that influence the emotions and experiences of the wearers through emotional assessments. He divides emotional product evaluations into five categories: instrumental, aesthetic, social, surprise, and interest. These evaluations are comparable to Lamb and Kallal's (1992) functional, expressive, and aesthetic (FEA) conceptual model for apparel designers (**Fig.5.5.**, centre picture), which was modified to include emotional, functional, expressive, and aesthetic needs – see **Fig.5.5.**, bottom image (An and Lee, 2015). Desmet's (2002a, 2002b) emotional assessment also informs An and Lee's FEA Emotional needs model. Collectively, the work of these researchers provided a model for assessing wearers' emotions regarding smart clothes during the D&DP (Section 9.5.2.).

5.4.2.1. Designing for Experience

Designing *for* experience is an attitude, I believe, which must include comprehending past and present experiences. According to HCI and Interaction Design researchers Peter Wright and John McCarthy (2010, p. 12), '…all experiences grow out of previous experiences and help shape future experiences, that is the experience of the process is both continuous and cumulative'. Wright and McCarthy's notion of experience, developed from Deweyan Pragmatism, is informed by Dewey defining experience as *continuity* (Dewey, 1997). Therefore, this research proceeded with the premise that bra wearers continuously learn from their past bra experiences and employ that knowledge to assess future experiences. Since participants will not have had experience with BW, comprehending their traditional bra experience becomes vital. Wright and McCarthy (2010) advocate for understanding the wearer-technology-interaction experience by comprehending the interaction's action, emotional, intellectual, and sensual aspects. Laddering theories combined these aspects addressing past, and current experiences in the Bra Experience Theoretical Framework (**Fig.5.6.**) developed from the literature review (Section 4.3.). Therefore, to design *for* pleasurable experiences with BW, the study firstly investigated wearers' previous bra-wearing experiences through interviews applying the experience grounded Bra Experience Theoretical Framework (Section 6.1.2.3.).

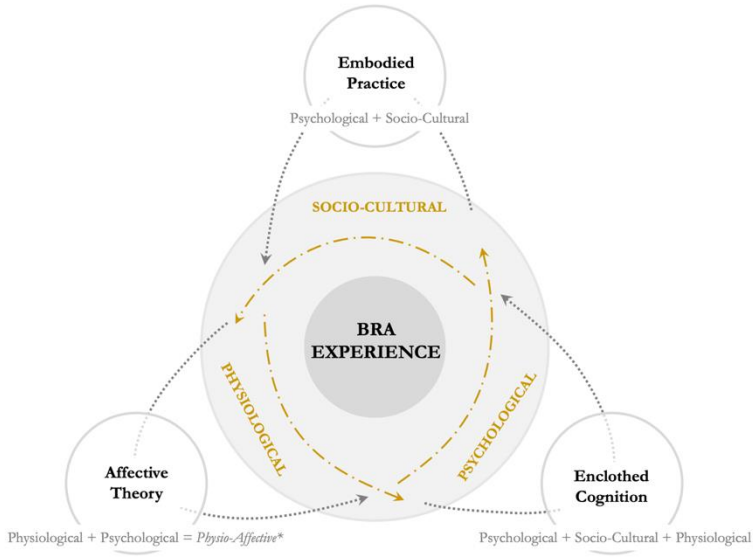


Fig.5.6. Bra Experience Theoretical Framework

To investigate designing *for* a pleasurable experience, the women's encounter with BW products[50] in the D&DP was assessed using Patrick Jordan's Four Pleasures framework containing physio-pleasure, socio-pleasure, psycho-pleasure, and ideo-pleasure – see Section 9.5.2. (Jordan, 2000; Koskinen, Mattelmaki and Battarbee, 2003). Wilkinson and De Angeli (2014) assert that the feeling wearers gain about themselves while wearing a product is as critical as its functionality. Thus, the Four Pleasure framework was useful for organising the ranges of pleasure that may be experienced with a product. By understanding the experiences of the women and the mature fit models through the D&DP, the wearer-technology-interaction experience materialises.

5.4.2.2. Empathic Approach

In designing *for* experience, an empathic design approach is necessary as the two entwine, with some researchers noting empathy is at the centre of experience-centred design (Wright and McCarthy, 2008). Contrastingly, others argue that 'designing *for* experience is an attitude' at the centre of empathic design (Postma *et al.*, 2012). Nevertheless, together they form the burgeoning field of Design & Emotion. According to Mattelmaki and Battarbee (2002 as cited in Wright and McCarthy, 2008), empathy is essential for designing products like BW, as the bra is experienced socially and personally beyond its functionality. This study centred empathy, humanising the participants from "users" to "wearers", to understand mature Black women's bra experience and utilised it as a tool in designing *for* and *with* them. Resultantly, I initiated the process of 'knowing the user' (Wright and McCarthy, 2008) by fostering a meaningful designer–wearer relationship throughout the BWD&DP, to acquire 'a rich understanding of [the womens'] experiences, dreams, expectations, and life contexts' (Battarbee and Koskinen, 2005, p. 7). To get to know the wearer, the D&DP was developed for multiple encounters with the women where their experience was reflected upon. An empathic approach from a pragmatist perspective maintains that 'knowing the wearer' also means understanding 'what it *feels like* to be that person', which involves interacting with the wearers and imagining their lived experiences through innovative methods (Wright and McCarthy, 2008). The D&DP becomes a vital space where the encounter and imagining of the other can be enacted through empathy methods such as body-storming (Buchenau and Fulton Suri, 2000) and drawing-as-seeing (Mida and Casey, 2020) utilised to navigate both the affective and cognitive components[51] of empathy (Sleeswijk Visser, 2009, p. 58).

Empathy extends into designing the product and developing the D&DP. The experience-centred approach advocates prototyping further mediating channels for constructing empathic experiences. This notion aligns with Sanders' (2002) belief that designing *for* experience is co-constructive with the design-researcher and wearer, bringing emotion and experience to the process. Empathy is a web that facilitates a relationship between the wearer, design-researcher, materials, and processes (Wallace and Press, 2004; Wright, Wallace

[50] It is essential to note that although the usability and functionality of the products are also assessed as it lends to the experience that they are not the focus nor goal.
[51] The affective component of empathy involves enacting what it feels like for the participants, while the cognitive component focuses on understanding the participants from the researchers' perspective (Section L.1.2.).

and McCarthy, 2008), which is associated with pragmatist aesthetics' multifaceted dialogical approach. The two approaches centre emotion, permitting a pluralistic angle where both the design-researcher and wearers' emotions – their co-experience – inform the product design and process (Battarbee and Koskinen, 2005).

5.5. Research-*through* and *for*-Experience-Centred Design

Dewey's experiential approach to inquiry, declares that knowledge is situated, being 'produced in and through experience' (Wright and McCarthy, 2008, p. 4). Hence, a practice approach is apt to develop an experience-centred D&DP where research is conducted through design, as discussed in Section 1.7. Research-*through*-design denotes 'research where design is used as the method for conducting a scholarly inquiry…' (Frayling, 1993, p. 5). It is suited for research that documents and analyses 'what happens and what can be learned from it' (Wright and McCarthy, 2008, p. 91). Reflections are inherent to this approach as the researcher must reflect on the insights created from their actions[52] – reflection-in-action and reflection-on-action (Schön, 1983)– and the outcomes of their learning to provide new knowledge. Research-*through*-experience-centred-design (RtXD) was utilised to execute the BWD&DP to access insights. The bra D&DP is highly skilled as it can be evasive since the 'design process is unique for each bra' due to fabrication, making it 'usual practice to design each new style of bra from first principles' (Hardaker and Fozzard, 1997, p. 313). In RtXD, BW artefacts are products of the exploration intended to inspire and advance understanding of the D&DP. Through designing and making BW products, I documented the D&DP providing awareness of the multiple facets involved with designing BW (Mäkelä, 2007; Mäkelä and Nimkulrat, 2011).

On the other hand, as this research sought to create an experience-centred BWD&DP, the wearers and design-researchers experience became essential to its development. An experience-centred D&DP required understanding the continuous nature of an experience, the multiple layers of an experience with a product, and the part emotions play within the experience. Wright and McCarthy (2010, p. 88) assert that when researchers seek 'insights into [their] participants' experiences, values, and relationships, [they are] doing research *for* design'. According to Frayling (1993, p. 5), 'Research *for* Design, denot[es] research that goes into the development of design products'. Therefore, by developing BW products and documenting the methods to access information, I better understood how to design *for* experience. Dewey argues that dialogue through multiple dimensions is essential to breed new knowledge (Dixon, 2020). By being in dialogue with the materials, designs, processes, and participants and reflecting on the knowledge created, I was better positioned to design BW for a pleasurable experience. Thus, the information gained from

[52] Therefore, the researchers' experience is placed as part of the process. Currently, UAL and the University of Westminster has teamed to develop a research network to better understand the role a designer's 'tacit experiential knowledge, emotion, and cultural perspective' has on the D&DP (Biagioli, Grimaldi and Ali, 2018). When utilising empathy in the D&DP, it becomes important to understand not just the strategies employed by the designer, but how their emotions impact decisions.

research-*for*-experience-centred-design (RfXD) provided novel input into the wearers' experience of a bra, methods, and frameworks to access the information within a D&DP and designing BW.

5.5.1. Validity/Applicability

Deweyan's Pragmatist philosophy does not engage with the notion of a single truth, instead contending that 'ideas and practices should be judged in terms of their usefulness, workability, and practicality' (Reason, 2003, p. 104). Dewey refers to this as warranted assertability, a form of knowledge evaluation where the solutions are grounded, '*valid* in relation to context of inquiry and *useable* in other contexts' (Dixon, 2020, p. 179). Moreover, Prochner and Godin (2022) advise that applicability in terms of transferability and impact for practice research utilising pragmatism is the focus rather than traditional validity. Thus, the findings should provide 'inspiration for research and practice approaches' (Prochner and Godin, 2022, p. 8). Dalsgaard (2014) informs that according to Deweyan Pragmatism, the transformation of a situation from an indeterminate one to one that is determinate accomplishes the resolution of the inquiry. Exploring the experience-centred BWD&DP transformed it from indeterminate to determinate. Therefore, the validity of the inquiry lies within the new knowledge gained about the situation – the BWD&DP, including participants assessments of their experience of partaking. The research results are co-validated by participants and myself in our reflections and transformations (Sections 8.5., 9.6., and Chapter 10). The phenomenon and actions were reported using rich data to limit validity threats (Maxwell, 2013). Moreover, the developed BWD&DP was validated for applicability in other contexts by contour and fashion technology experts (Section 10.1.2.5.), judging its novelty, practice approach, practice methods, applications, and industrial applicability.

5.6. Reflexivity

This section discusses the significance of reflexivity and its ties to the methodology and research approach. Reflexivity played a vital role throughout this research, as proposed by Dewey. Dewey argues that 'our experience is enriched by reflection, by thinking and talking about experience' (McCarthy and Wright, 2004, p. 117). By reflecting on the situation during the inquiry – the doing and thinking – sense-making occurred; thus, I could better understand my role and its effect on the research processes and outcomes (Haynes, 2012). Utilising reflexivity, along with journaling, guided me as I acknowledged how my professional design experience informed my assumptions and approach to developing the D&DP. It enabled positioning my experiential and tacit designerly knowledge (Cross, 2006) as a source of value at various stages. Subsequently, understanding the transformations occurring throughout the research required reflexivity – becoming essential to the inquiry. Section 6.1.4., *Reflect,* addresses the reflection applied throughout the study and the methods utilised.

Design processes require continuous reflection as they advance from '…the experiential learning cycle of theorising, action, observation and reflection and dynamics cyclical relationships of cause and effect' (Crouch and Pearce, 2012, p. 49). The symbiotic relationship between problem and solution is inherent in

design processes (Dorst and Cross, 2001) as the design-researcher reflects on past experiences to inform their current problem-solving approach (Schön, 1983). Several methods employed in the D&DP, such as sketching, prototyping, and material selection, require constant conversation, including reflexivity, to transform the situation (Hansen, 2016). Hansen (2016) expresses that design-researchers must critically reflect on the methods, materials, and applications exploited and how they affect the development of the design process. Reflexivity became routine as I scrolled through my repertoire of exemplars to navigate the stages of encountering problems and selecting older or new methods as solutions. Additionally, the design-researcher must reflect on the participants' inputs and their own, as the product design requires both perspectives (Hekkert and van Dijk, 2001). Dewey considers this 'evaluative reflection' which enables more significant insights about the situation to crystallise (McCarthy and Wright, 2004, p. 19).

Dunbar, Rodriquez, and Parker (2001) advocate that qualitative researchers must not neglect to discuss the subjective lenses utilised in their research; it is imperative to be reflective when working around the subject of 'race', conducting fieldwork, and establishing a relationship with participants. Therefore, I established my positionality in Section 6.4. 'Researcher Positionality'. Nevertheless, from the initial literature and contextual review phase, it was clear that continued reflection was imperative within this research. It became apparent that I was the first Black female researcher within the field of lingerie research and the first to bring Black women into focus. This meant I had to continuously reflect on the weight of this task and its effect on my decisions. Thus, selecting approaches with reflexivity as a critical methodological position, such as Feminist HCI and Black Feminist Thought Lens, was significant as they guided me while collaborating intimately with the women. Reflexivity aided my method selections, ensuring that they were not emotionally or mentally harmful to the wearers – placing significance on navigating a balanced, respectful, and mutually beneficial relationship. An accompanying reflexivity journal (**Fig.6.38.**) allowed me to navigate my own experiences with lingerie, my interactions with mature Black women, and how I approached and manoeuvred the research.

5.7. Summary

Fig.5.7. expands on **Fig.5.1.** demonstrating how the Deweyan pragmatist framework's tenets connect to the overarching woman-centred and pragmatist approaches and those that underpin them – guiding this study.

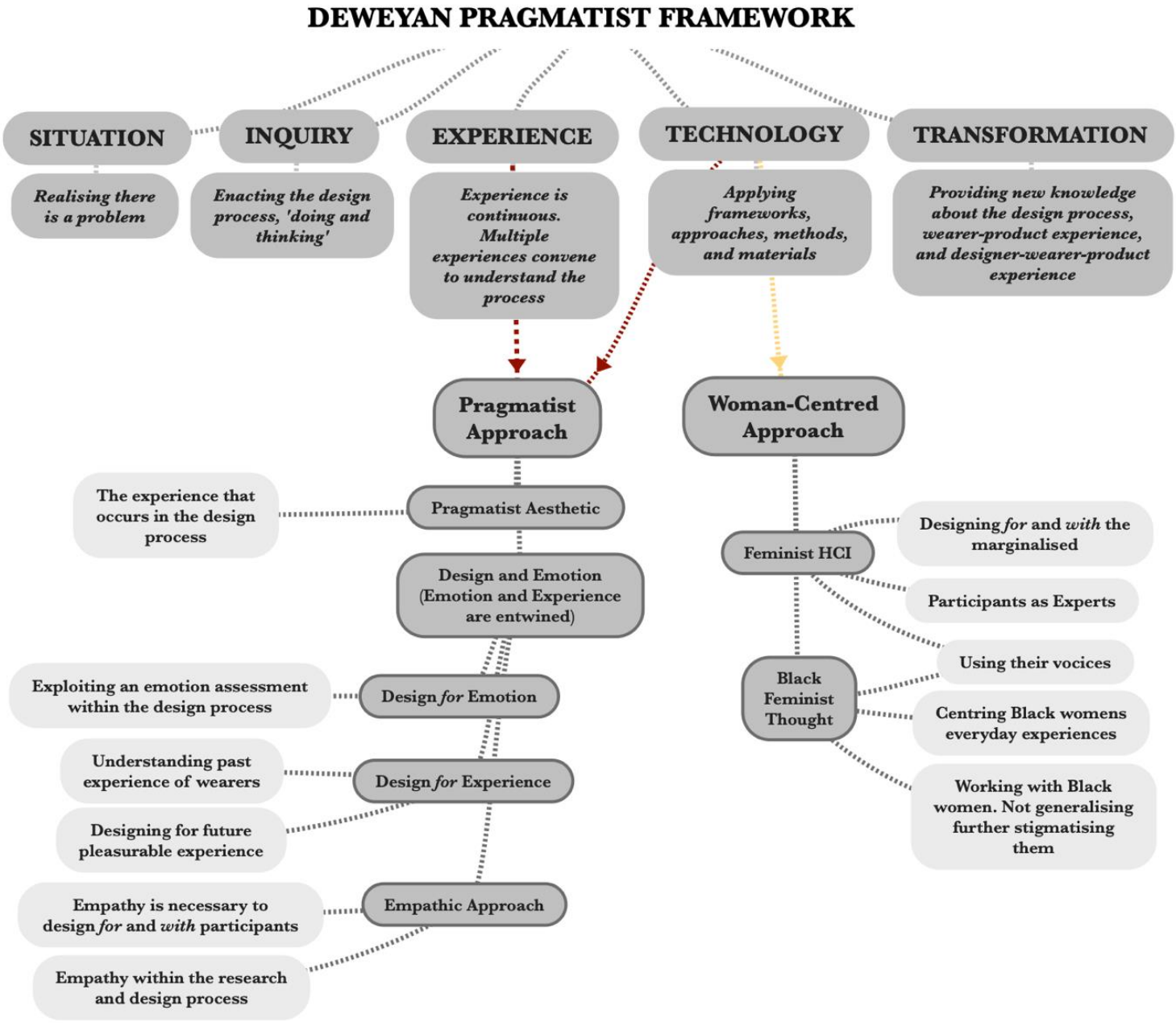


Fig.5.7. Research approaches and actions they facilitate.

Chapter 5

- ***Introduced*** the research methodology underpinned by a Deweyan Pragmatist framework enabling a research approach that is explorative, experience-centred, action-driven, and reflective (**Figure 5.7.**).

- ***Discussed*** the Deweyan Pragmatism tenets (i.e., situation, inquiry, experience, technology, and transformation) that provides the design-researcher with terminology and guideline to undertake this practice research.

- ***Informed*** on the multiple approaches, such as pragmatist and woman-centred approaches, that were selected which best suited the aims and needs of the research in line with pragmatism (Creswell and Creswell, 2018).

- ***Highlighted*** that the interweaving approaches and perspectives are multi-layered (see **Figure 5.7.**), advising the research – underpinning a woman-centred methodology.

- ***Emphasised*** the research methodology draws on experience and empathy to expand a woman-centred approach that places, as the nexus, the women's needs, emotions, and experiences across time (past, present, and future).

- ***Indicated*** that multiple methods are employed to target the wearers 'body, mind, thoughts and emotions' for an experience-based approach (Dixon, 2020, p. 40).

- ***Postulated*** that the approach endeavours to further humanise the BWD&DP by making aware the relationship-interaction between those involved.

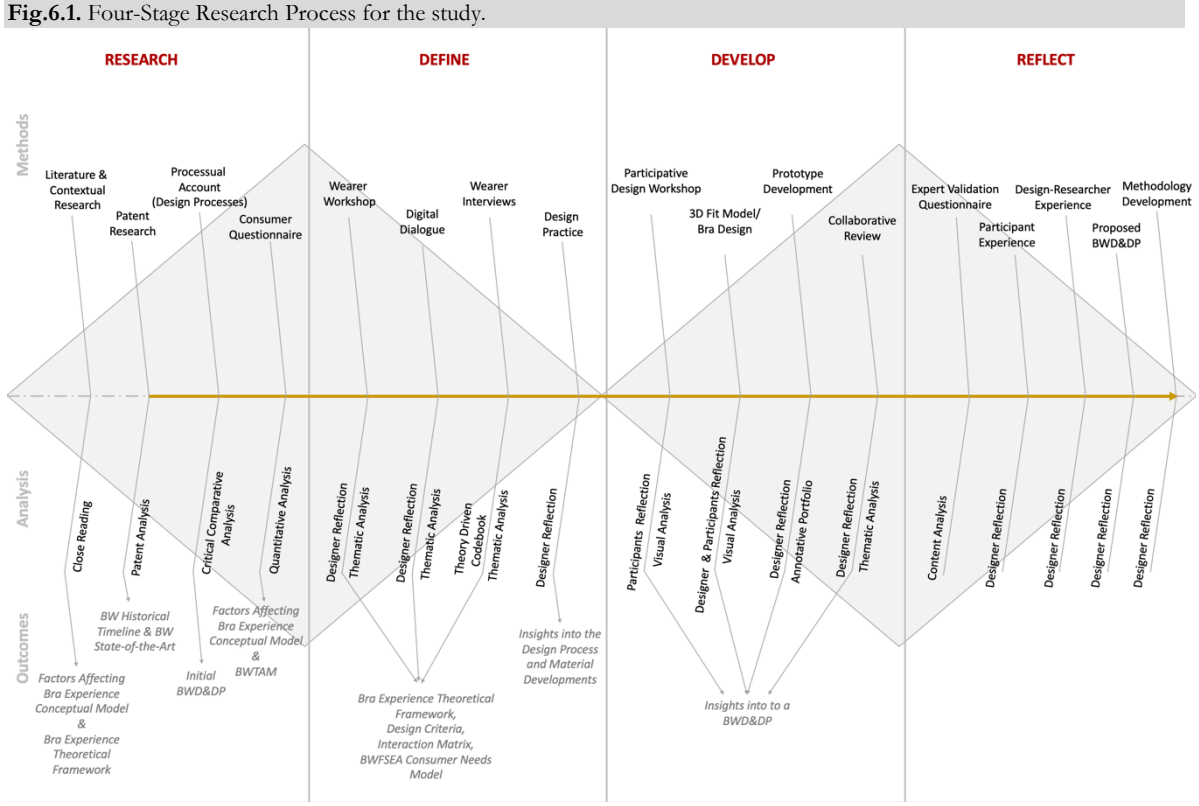
6

6. RESEARCH DESIGN

Chapter 6 details the research design and methods employed within this thesis. It begins by introducing the Four-Stage Research Process (6.1) – which structures the various stages of the study: research (6.1.1), define (6.1.2), develop (6.1.3), and reflect (6.1.4). Each section discusses multiple methods. The chapter progresses highlighting the participant selection (6.2.), ethics (6.3) and researcher positionality (6.4).

6.1. Four-Stage Research Process – Research/Define/Develop/Reflect

Fig.6.1. Four-Stage Research Process for the study.



This exploratory and experimental research follows a Four-Stage Design Process[53] (Fairburn, Steed and Coulter, 2016), grounded in creative and design thinking behaviours such as divergently exploring the situation for ideas, then converging, narrowing the specification and focus (Kara, 2015). Fairburn et al.'s process derives from the Design Council's 2007 'Double Diamond', which provides designers with a

[53] For simplicity and to reduce confusion between the D&DP being researched, the Four-Stage Design Process will be referred to as the Four-Stage Research Process.

framework to design, define, develop, and deliver innovative consumer products and solutions (Ball, 2019). Conversely, the Four-Stage Research Process (**Fig.6.1.**) differs, providing a framework for design-researchers to structure the stages, findings, and insights into practice research. Kelemen and Rumens (2008) affirm that pragmatism (Section 5.4.) centres selection of multiple approaches that support methods, such as those used throughout the Four-Stage Research Process. This process affords importance to reflection, fundamental to this design methodology, enabling the design-researcher to gain insights from their action and the outcomes.

AIMS	OBJECTIVES
AIM #1 To comprehend whether the wearers' bra experience is significant in developing a BWD&DP.	**1A.** Identify the factors that affect how mature women experience the bra. **1B.** Conduct a survey to answer whether Black and white women experience the bra differently. **1C.** Explore the current bra experiences of mature women. **1D.** Utilise the TAM to determine if being a part of the BWD&DP affects mature women's acceptance and purchase intention.
AIM #2 To investigate approaches that can be utilised to inform the design of BW that improves the bra wearers' experience.	**2A.** Scope the BW field to map the state of the art. **2B.** Examine various design processes to develop an initial BWD&DP. **2C.** Explore ways of integrating the bra wearer and their experience into the BWD&DP. **2D.** Investigate ways of integrating technology into the bra (i.e., new design elements, bra form, and composition.) **2E.** Develop BW products that allow for the exploration of designing for meaningful and pleasurable experiences.
AIM #3 To interrogate the different types of experiences (i.e., the design-researcher and wearer) that aid in informing BWD&DP.	**3A.** Demonstrate utilisation of a woman-centred methodology in the design process for understanding & developing BW products *for* and *with* the mature wearer.

Fig.6.2. Diagram representing the objectives, methods, and actions all situated within the Four-Stage Research Process and corresponding results chapters.
*Asterisk signals chapters (2 and 10) not a part of the BWD&DP

Fig.6.2. illustrates the research aims and objectives and their corresponding methods, which sometimes expand into the different sections of the research framework. Due to the research adhering to time constraints and the nature of practice research, methods overlapped and fed into each other, allowing the investigation to progress when obstacles arose. **Fig.6.3.** showcases the research's multiple mixed method (Creswell and Plano Clark, 2007) sequential process, enabling each stage to inform the next.

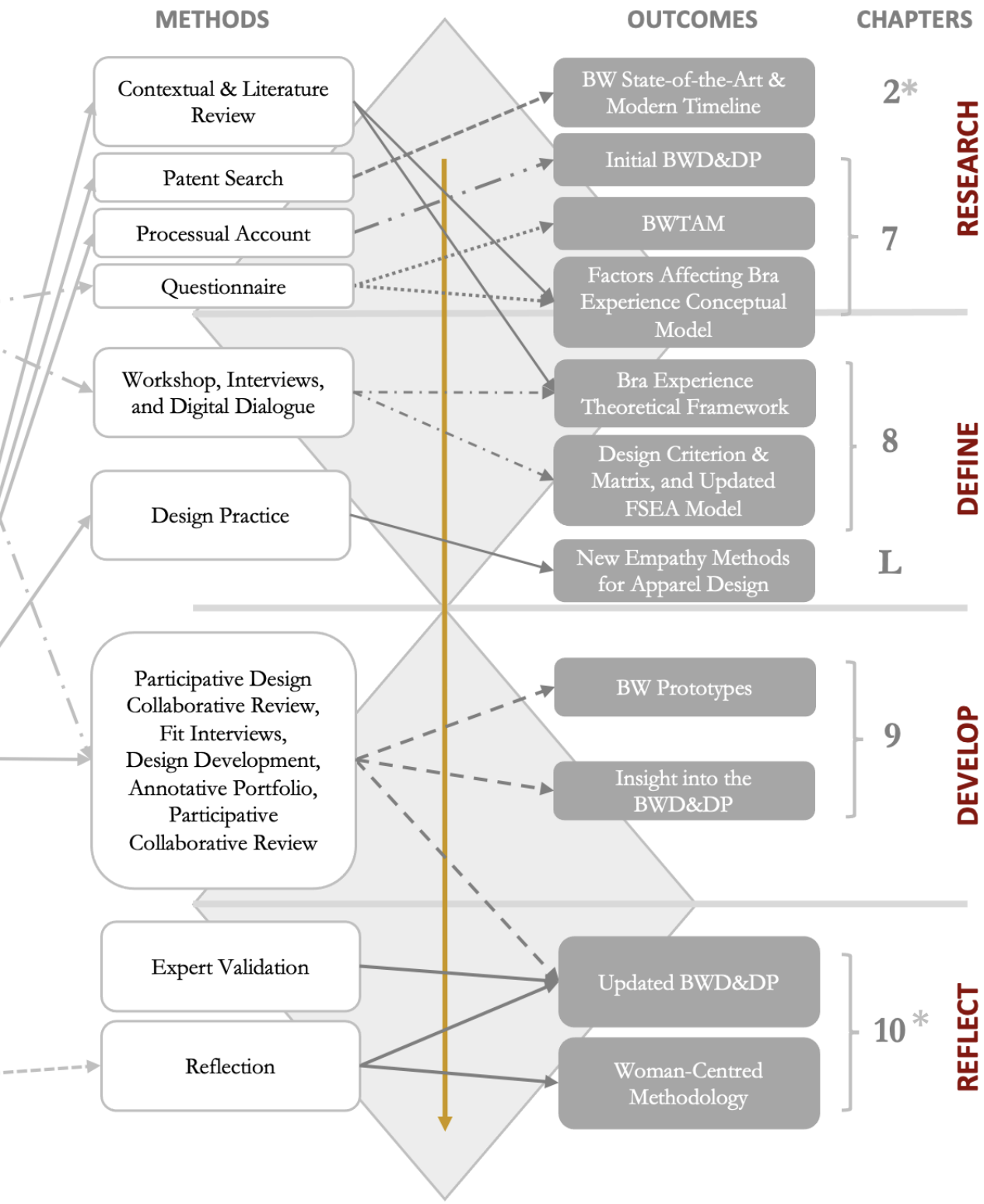
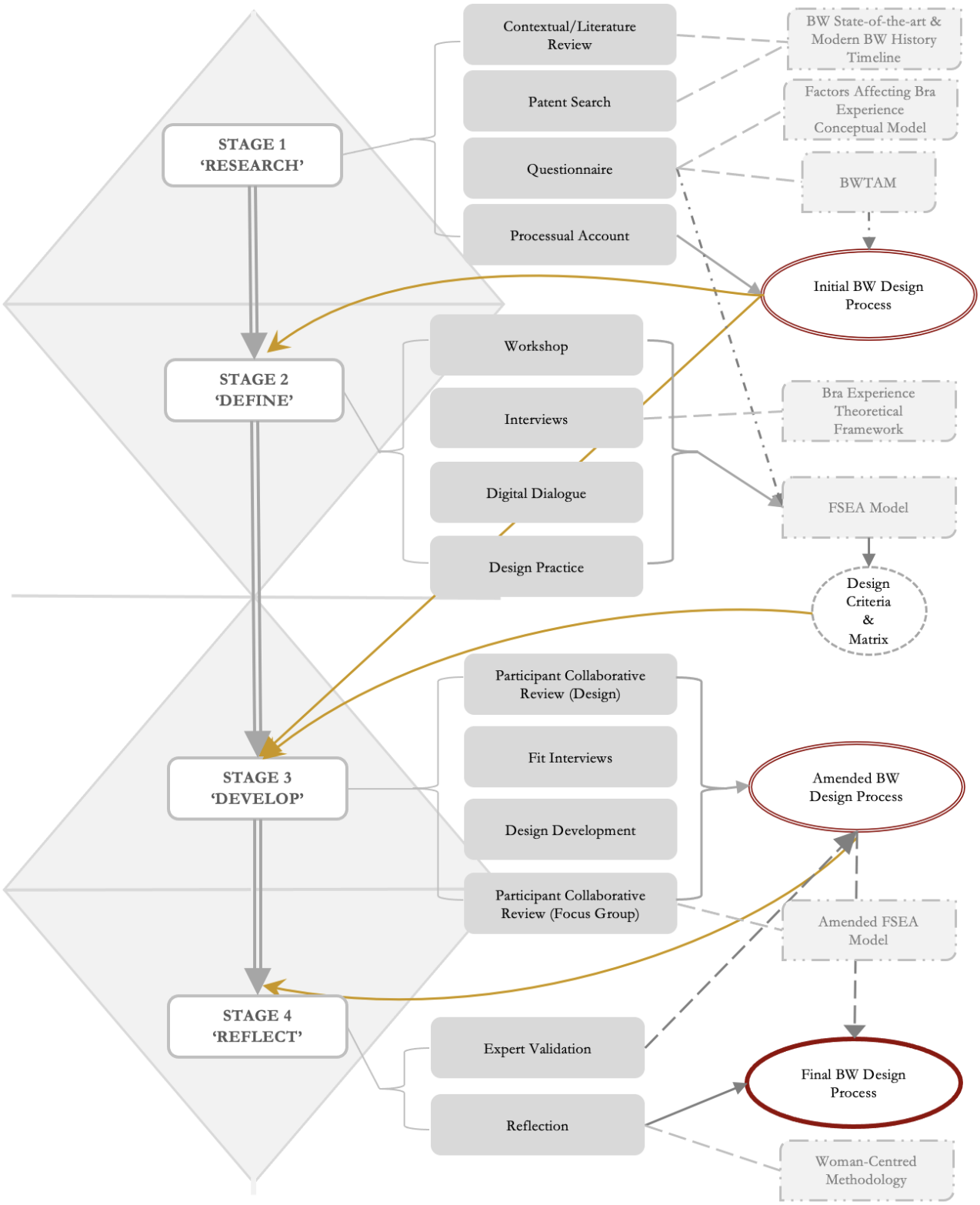


Fig.6.3. Mixed method Sequential Process



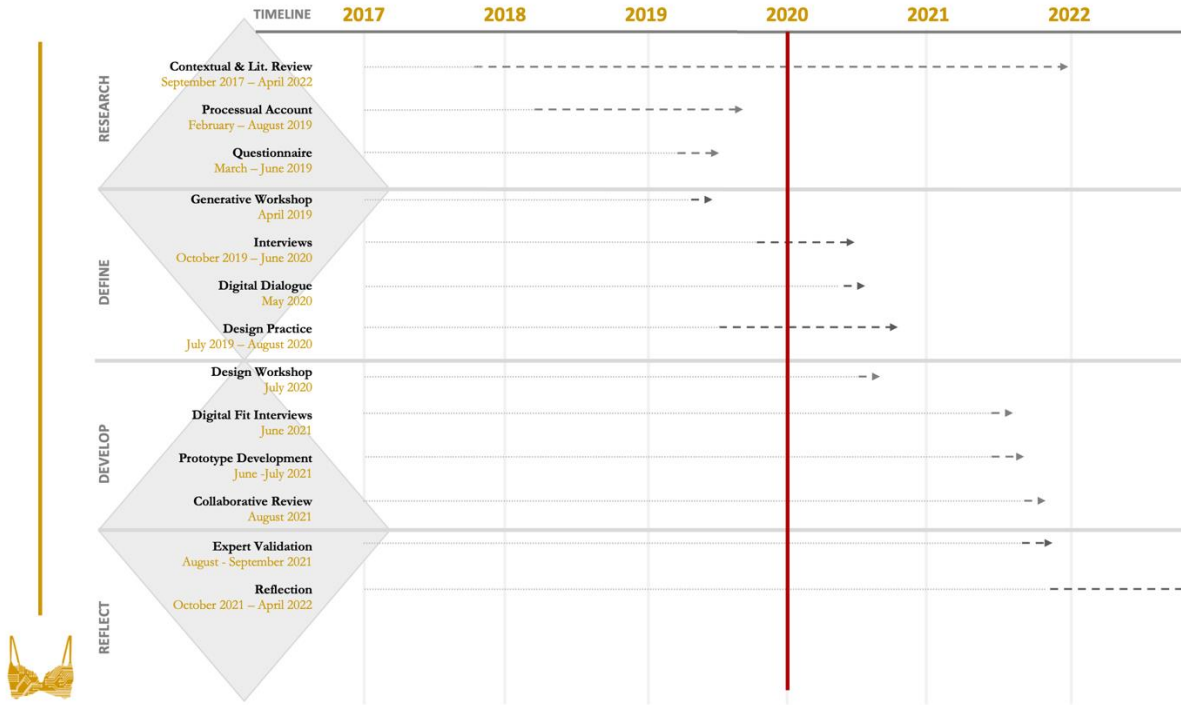


Fig.6.4. Research timeline
**Red line indicates start of Covid19 pandemic

The *Research* stage expands from the contextual and literature review to comprehend information about Aim #1, objectives 1A, 1B, 1C, 1D, and Aim #2, objective 2B. An extensive questionnaire (6.1.1.1.) was conducted to begin gathering data for objectives: 1A to 'identify the factors that affect how mature women (MW) experience the bra', 1B to 'investigate whether Black and white women experience the bra differently', 1C to 'explore the current bra experiences of MW', and 1D to 'utilise the TAM to determine if being a part of the BWD&DP affects MW's acceptance and purchase intention'. Additionally, in response to objective 2B, a processual account (6.1.1.2.) was undertaken to 'examine various design processes to develop an initial BWD&DP'. Chapter 7, Research, delivers the results from the two methods, concluding the stages' divergence.

Next is the *Define* stage, which converges, focusing on Aim #1, objective 1C, Aim #2, objectives 2C and 2D. Objective 1C concentrates on comprehending mature Black women's bra experiences and needs through workshops (6.1.2.1.), interviews (6.1.2.3.), and a group digital dialogue session (6.1.2.2.). The triangulation of the methods yielded the necessary information to address objective 2C, to 'explore transferring the experiences and needs into actionable design outputs'. Concluding the *Define* stage, a design practice (6.1.2.4.) element attended to objective 2D to 'investigate ways of integrating technology into the bra…'. As indicated by the timeline (**Fig.6.4.**), several methods overlap due to multiple factors such as difficulty reaching the target participants, Covid-19 and subsequent lockdowns, and limited access to the necessary machinery and resources. Nevertheless, by moving workshops to the digital realm, during the

Define and *Develop* stages, obstacles were overcome. Results from this phase are presented in Chapter 8, Define.

Following is the diverging *Develop* stage, endeavouring to chronicle objectives 2D and 2E through design practice. Objective 2D extends into the design development phase accompanying 2E to 'develop BW products that allow for the exploration of designing for meaningful and pleasurable experiences'. During the development stage, experimentation facilitated action and reflection, enabling the design-researcher to 'gain richer understanding of the situation' (Dalsgaard, 2014, p. 149). By enacting the initial BWD&DP's "Research & Concept" and "Pattern & Prototype" development phases (**Fig.6.10.**), knowledge was gained from the design workshop (6.1.3.1.), digital fit interviews (6.1.3.2.), prototype developments (6.1.3.3.), and collaborative review session (6.1.3.4.). Chapter 9, Develop, details the results from this stage.

Lastly, the *Reflect* stage converges, allowing the design-researcher to provide insights into the participants' and design-researchers' experiences, Aim #3, objective 3A, and inform the expert validations. Across the first three stages, 3A is implemented to 'demonstrate utilisation of a woman-centred methodology in the design process for understanding and development of [bra] wearable products *for/with* the mature female wearer'. However, it is within the reflection stage (6.1.4.) that its effects are crystallised. Finally, the *Reflect* stage culminates in Chapter 10, providing insights into the different types of experiences connected within the D&DP that aid in informing the experience-centred BWD&DP.

6.1.1. Research

The *Research* section investigated multiple aspects that delineate the study to improve understanding of the situation. **Fig.6.5.** illustrates the different methods, analyses and outputs applied within this stage. The multidisciplinary contextual and literature review situated the larger smart bra field and circumscribed the more distinct BW subfield – identifying areas for design opportunities (Section 2.3.3.). Furthermore, the study clarified the complexity and intricacy of bra design

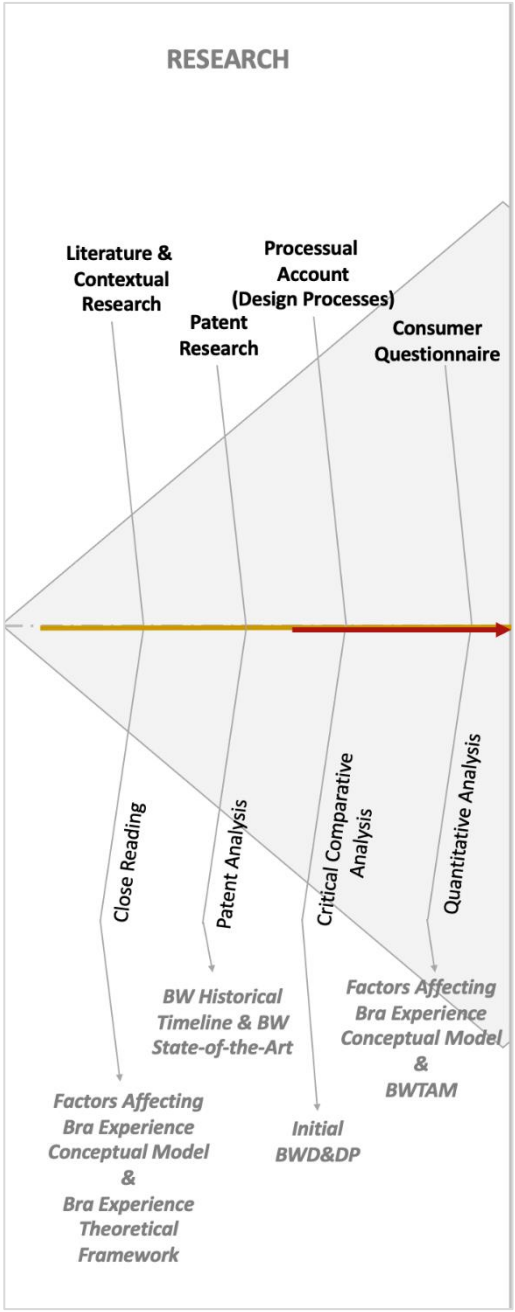


Fig.6.5. Research section of Four-Stage Process.

processes (DP) and explicated the importance of the mature wearer and their diverse bra experience. The outputs of the *Research* section are presented below.

Five valuable outputs were conceived through the *Research* stage. The first output is a BW Historical Timeline (**Fig.2.7.**, p.58) demonstrating BW research and design from 1989 to date and state-of-the-art emerging areas[54]. This output was employed as an information tool when introducing the participants to BW. The second output is the Bra Experience Theoretical Framework (**Fig.4.5.**, p.115), generated from secondary research scaffolding experience theories from disparate disciplines such as fashion studies, cognitive psychology, and social psychology (Section 4.3.).

The third output, a Factors Affecting Bra Experience Conceptual Model (**Fig.4.4.,** p.115), established links between the bra wearers' sense-of-self and bra-wearing factors that connect to bra experience, further substantiated by the consumer questionnaire. Furthermore, the questionnaire provided the fourth output, a BW Technology Acceptance Model (BWTAM) (**Fig.7.11.**, p.214), explicating the significance of the D&DP and BW interest to consumer attitude and purchase intention.

The fifth output is the development of the initial BWD&DP (**Fig. 7.19.** and **7.20.**, p.224) through a processual account (6.1.1.2.). Several processes were critically compared and reflected upon in developing the initial BWD&DP, providing direction for the practice.

The following two sections, 6.1.1.1. Consumer Questionnaire and 6.1.1.2. The initial BWD&DP addresses Aim #1, objectives 1A, 1B, 1C, 1D, and Aim #2, objective 2D (**Fig.6.2.**).

6.1.1.1. Consumer Questionnaire

Questionnaires are advised as the better method to elicit information when the goal is to differentiate among varying groups (Flick, 2014), access potentially sensitive information, and reach a broad audience (Gillham, 2008; Lavrakas, 2008). Therefore, an online questionnaire was deployed using convenience sampling. However, within HCD research, there are criticisms against the usage of questionnaires as 'the researcher prepares not only the questions but also the answers he or she expects to get, leaving little possibility for initiative on the part of the respondents' (Sanders and Stappers, 2012). Nevertheless, it was necessary to gather a large data set in this case. The design-researcher provided an open response section to each question to remediate presuming responses.

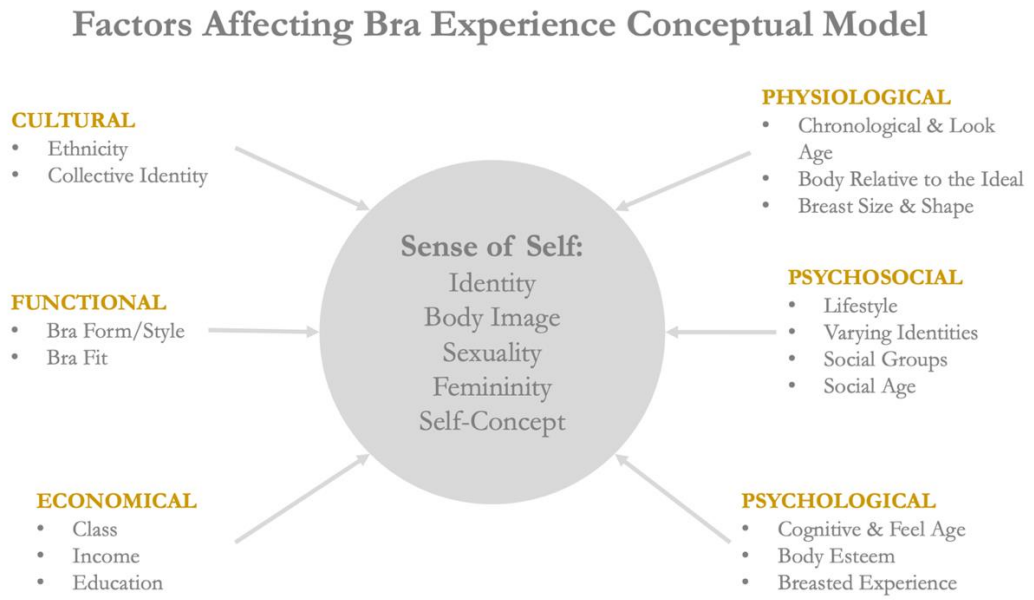
The questionnaire aimed to:

- gain insights into MW's diverse bra experience and factors affecting their relationship with the bra, validating the 'Factors Affecting Bra Experience Conceptual Model' (**Fig.6.6.**).

[54] These outputs are discussed in Chapter 2.

- comprehend the factors affecting MW's attitudes and purchase intention of BW using the Technology Acceptance Model (TAM) (Davis, 1989; Davis, Bagozzi and Warshaw, 1989).

Fig.6.6. Amended Factors Affecting Bra Experience Conceptual Model.



The TAM was developed to assist information systems and product designers in ascertaining the most effective variables – perceived ease of use and usefulness – affecting attitude and purchase intention. Although the TAM has been updated to the TAM2 (Venkatesh, 2000; Venkatesh and Davis, 2000) and the Unified Theory of Acceptance and Use of Technology model (UTAUT) (Venkatesh *et al.*, 2003), and the UTAUT2 (Venkatesh, Thong and Xu, 2012), according to Kalantari (2017) the TAM has primarily been applied for research into the acceptance of smart fashion (Ko, Sung and Yun, 2009; Chae, 2010; Schaar and Ziefle, 2011; Turhan, 2013; Hwang, 2014; Hwang, Chung and Sanders, 2016).

Instrument Development

Table 6.7. Questionnaire development.

Questionnaire Parts	Question Focus	Adapted From
Part 1 (Demographics)	• Location, age range, ethnicity, relationship status, educational level, income level, and menopausal status	• Hopwood et al., 2001
Part 2 (Current Bra & Breast Experiences)	• Menopause and ageing effects • Bras' impact on sense-of-self factors • Bra purchasing and wearing experience • Desired bra attributes • Societal influences on body-image and breast-image	• Kelch-Oliver & Ancis, 2011 • Cash, 2000 • Avalos et al., 2005 • Tylka & Wood-Barcalow, 2015 • Risuis, 2012 • Tsaousi, 2011
Part 3 (BW Interest & Acceptance)	• Introduction of BW through images and descriptions • TAM to BW acceptance	• Hwang, 2014

Due to the lack of research in this area, a lengthy questionnaire (Appendix I) was devised to access myriad unattainable information from secondary sources. A close-ended questionnaire with five-point Likert scales, multiple-choice questions with "other" options, and matrixes was employed. According to SurveyMonkey, using a mixture of question types allows for smoother progression and attention to be held during longer questionnaires. The questionnaire had forty-three questions across three parts: first, focusing on demographics and menopausal status; second, on sense-of-self concepts and bra experience; and third, on BW acceptance (**Table 6.7.**). Since many of the questions were adapted from qualitative studies and new TAM constructs were devised, the questions were piloted.

Pilot

The questions were piloted by two professionals who work with contracts, questionnaires, and proposals in their fields, to get the wording and meaning correct. Piloting is crucial during questionnaire development (Gillham, 2008; Lavrakas, 2008). Next, the questionnaire was piloted with four research colleagues, two of whom were a few years below the target age group, with their areas of concern edited before launching.

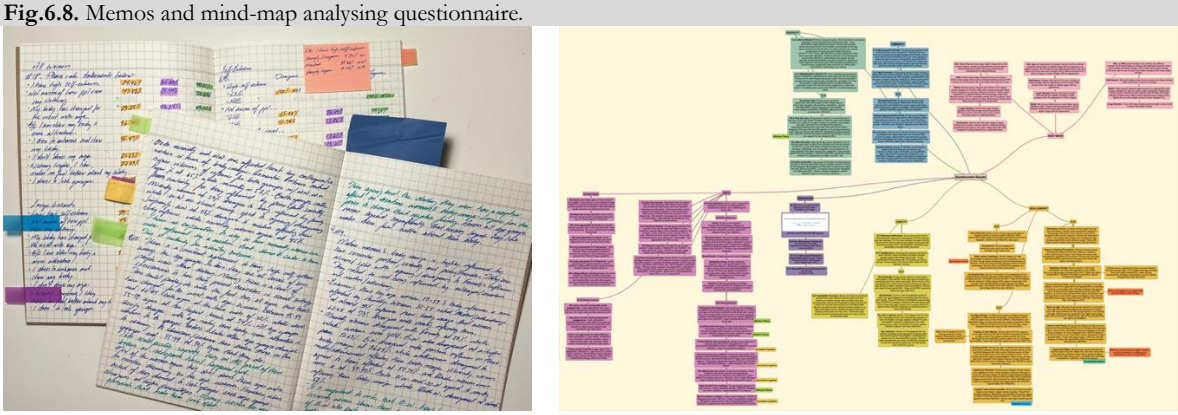
Implementation

A social media approach provides the best opportunity to engage with a broader audience and easily share the questionnaire. To access large numbers of women, the online questionnaire was deployed in mature women's Facebook groups, Reddit community forums dedicated to bra fitting, large breasts, and mature women 30+, Twitter and LinkedIn. Particular challenges and ethics must be considered when researching using social media (Gelinas *et al.*, 2017; Arigo *et al.*, 2018). Thus, care was taken to receive consent to post in each digital community from the moderators and group administrators and follow their guidelines. According to Social Scientists and Digital Technologies researchers Townsend and Wallace (2016), this step is vital for social media research. Similarly, the Twitter strategy – proving most successful – was to privately ask each woman to reshare the questionnaire link to their followers. This approach gave the women agency to decide if they wanted to participate and publicly become mediators. Lastly, the questionnaire was sent directly through email to women who fit the criteria in the design-researchers' circle.

SurveyMonkey, an online survey platform, was selected to house the questionnaire. The time estimated by the platform's algorithm was fifteen minutes, under the too-lengthy twenty-minute mark (Lavrakas, 2008). Participants were sent a link to access the questionnaire. Before beginning, a header introduced the questionnaire's purpose, voluntary nature, and confidentiality aspect. Additionally, it stated the necessary age requirement to participate. A separate link was provided below the introduction, leading to a downloadable participant information and consent sheet. Before partaking, participants were made aware that they provided their consent by clicking "enter" to begin. The questionnaire was active for four months, receiving a moderate number of responses (n=295).

Data Analysis

Fig.6.8. Memos and mind-map analysing questionnaire.



The questionnaire was analysed using a multi-method approach, mixing quantitative and qualitative methods. A multi-method approach is apt when the research question is answered interpretively to explicate patterns and connections through validity (Seale, 2012). In this case, the strength of the quantitative method allows for addressing a broader spectrum of issues among a dispersed group of women, and the strength of the qualitative method to capture the complexity was combined. The questionnaire's second portion on bra experience was first reviewed quantitively using response percentages provided through SurveyMonkey. The design-researcher then filtered the results to Black and white women from the western world (North America, U.K./Europe, and Australia). Then the responses were cross-tabulated amongst several criteria such as age group, breast size, self-esteem level, and 'race'. Next, the data were analysed qualitatively using sticky notes and memos, categorising information under the themes: body-image, self-concept, sexuality, femininity, identity, and bra experience. Last, a mind map was constructed to gain insights into each theme and explore relationships among them (**Fig.6.8.**). By analysing this portion using a multi-method approach, the researcher can qualitatively explicate patterns and verify connections from the quantitative data (Seale, 2012).

The qualitative data evidenced that although menopausal status and breast size affected the participant's bra experience, self-esteem was crucial[55]. As insights emerged indicating that Black and white women responded differently to societal influences and breast-esteem questions, it further highlighted the need to examine the data quantitatively.

[55] Due to the vastness of this study, this critical finding on self-esteem and bra experience was not further explored. However, as it continuously emerges, it is particularly ripe for further research.

Table 6.9. Statistical programs and analyses

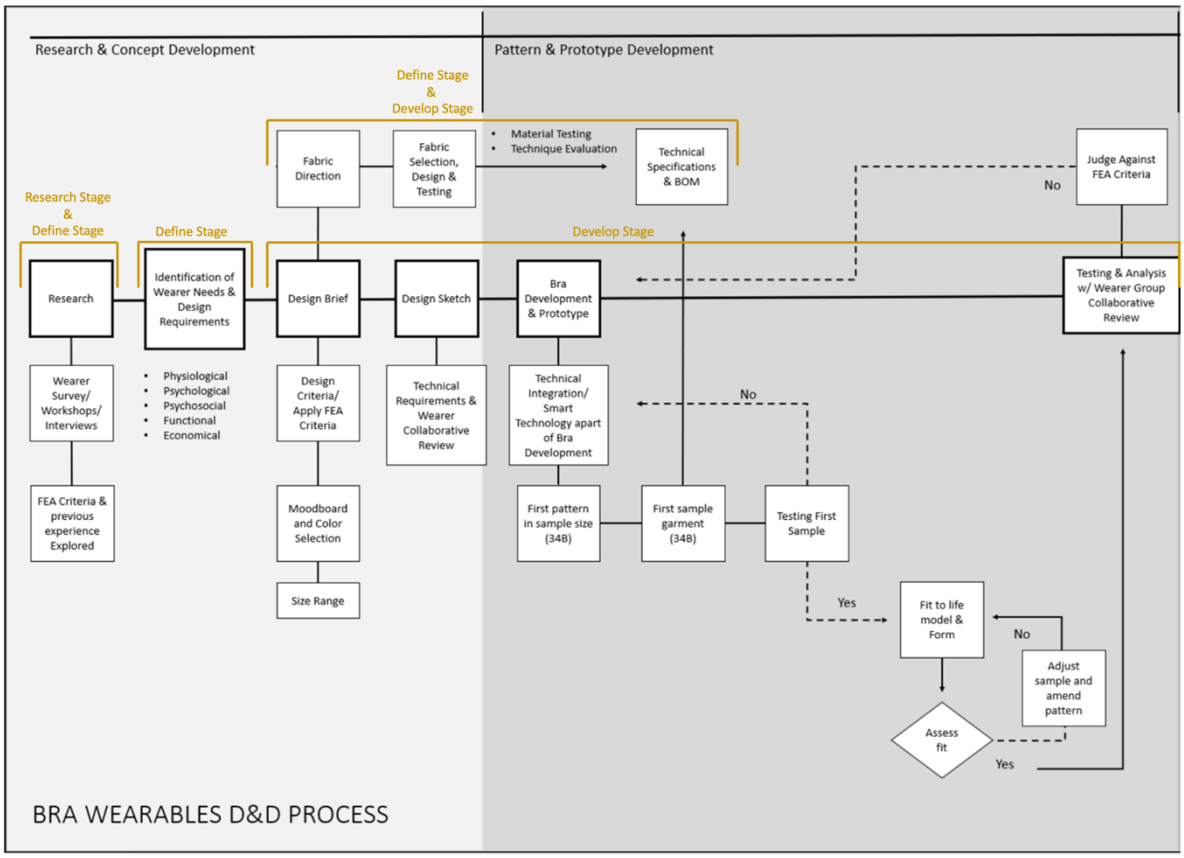
Program	Significance	Analysis
SPSS v26	• 'SPSS Statistics is a statistical software suite for data management, advanced analytics, [and] multivariate analysis…'	• **Descriptive Statistics:** used to 'describe the characteristics of your sample'. • **Reliability Analysis:** used to analyse that 'the values that make up the scale measure the same attribute'. • **Exploratory Factors Analysis:** used 'to identify the underlying relationships between measured variables'. • **Partial Confirmatory Factor Analysis:** is a 'data reduction technique' used to 'obtain more convincing information as to whether considering a CFA of the model in the future is justifiable'. • **Mann-Whitney U:** used to 'compare the differences between two samples when the sample distributions are not normally distributed and the sample sizes are small'. • **Assumptions of Normality**: used 'to test whether sample data is normally distributed'.
SmartPLS v3.3.2	• 'SmartPLS is a software with graphical user interface for variance-based structural equation modeling using the partial least squares path modeling method.' It allows for both a factor or path modelling analysis.	• **Partial Least Squares (PLS) Algorithm:** used to conduct a factor analysis, providing factor loadings for formative constructs. • **Measurement Model Assessment:** assesses the 'outer model focused on the relationships between constructs and their items'. • **Structural Model Assessment:** assesses the 'inner model and focuses on the relationship between constructs'.

Statistical software SPSS v26 and SmartPLS v3.3.2 were used to analyse the questionnaire quantitatively (**Table 6.9.**). Descriptive statistics were used in part one to provide participant profiles (i.e., location, race, age, ethnicity, education level), data on their menopausal experience, the factors affecting bra experience, and to provide information on the women's valuation of and interests in BW in part three. Furthermore, a reliability analysis using Cronbach's Alpha, an assessment of the convergent and discriminant validity using an exploratory factor analysis (EFA) and partial confirmatory factor analysis (pCFA), and a Mann-Whiney U analysis to gauge the relationships between the variables were all deployed. Lastly, to explore how the variables influenced each other for the Factors Affecting Bra Experience Conceptual model and the TAM, SmartPLS's structural equation modelling was exploited. Summarised findings are in Section 7.1. and 7.2.; however, detailed analyses from the questionnaire are available in Appendix J[56].

[56] Parts of the research finding were presented at the 2019 Fashioning Inclusivity Symposium.

6.1.1.2. Developing the Initial BWD&DP

Fig.6.10. Partial illustration of the devised initial BWD&DP.



As this study aimed to create a BWD&DP, various design processes (DP) were evaluated to achieve an initial BWD&DP[57] (**Fig.6.10.**). The selected DP (see Chapter 3 and Appendix C) ranged across apparel, engineering and product design, functional apparel, smart clothing, sports bra, and different bra DP. These DP were identified through secondary documentation and informal conversations with bra designers and technologists. Design processes[58] were investigated 'through constructing a processual account through the examination of documents' (Bryman, 2012, p. 403). Then a critical and comparative analysis method was exploited to construct the initial BWD&DP alongside the design-researchers' professional experiential knowledge.

Once the initial BWD&DP was developed (Section 7.3.), the following steps of this study ventured to implement and advance the process through enacting the first two phases, the "Research & Concept

[57] Larger images of BWD&DP are available in Section 7.3. (Fig. 7.19. and 7.20., p.224).
[58] Initially, during the authors' first year of the PhD program, she used Actor-Network Theory (Latour, 2004, 2005; Entwistle, 2016) to analytically develop in-depth accounts of the various stages, actors (human and nonhuman), components, and connections in the D&DP. However, this approach was meticulous, time-consuming, and placed all the actors in the D&DP at an equal level of importance, stripping away the emphasis on the humanistic value that the woman-centred approach requires (Elder-Vass, 2019). The initial developed process was presented to the researchers' peers during the UAL Summer Research Symposium 2018.

Development" and "Pattern & Prototype Development". **Fig.6.10.** showcases the four-stages of the research and their overlapping areas of the D&DP.

Due to Covid-19, digital methods allowing the design and research process to progress were added to the BWD&DP, namely digital dialogue (6.1.2.2.), digital participative design workshop (6.1.3.1.), and digital fit model session (6.1.3.2.).

6.1.2. Define

The *Define* stage began by gathering as much pertinent information as possible and then converged, narrowing insights to establish focus (**Fig.6.10.**). Spending considerable time in the *Define* stage amplifies the chances of attaining creative results (Christiaans, 1992, as cited in Dorst and Cross, 2001). Knowledge gained from this stage advanced outputs to develop an interaction matrix, design criteria, and BWFSEA consumer needs model (Section 8.4.). The goal of the *Define* stage was to:

- gain insights into MW's past and current bra experiences to substantiate the Bra Experience Theoretical Framework.
- acquire skills, knowledge, and empathy through experimental practice with the participants and materials.

The *Define* section triangulated data from multiple methods (**Fig.6.11.**) to explore the current bra experiences of MW, assisting in contextualising their needs according to Aim #1, objective 1C. Triangulation of multiple methods provides reliability (Hammond and Wellington, 2012; Denscombe, 2014) and enables the researcher to foster deeper connections of empathy with the participants (Sanders, 1992).

Additionally, the design-researchers' exploration into the design practice is elucidated in the *Define* section[59]. Aligning

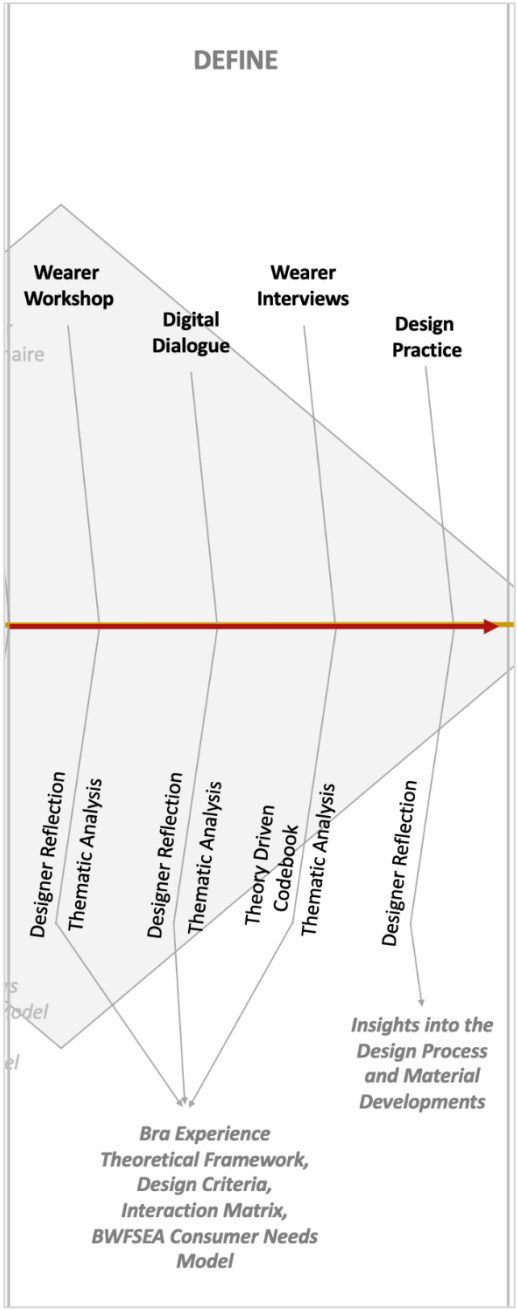


Fig.6.11. Define section of Four-Stage Process.

[59] While the design practice section occurs within the Define stage, the details from the practice are available in Appendix L. However, reflections from the practice are available in Section 8.4.

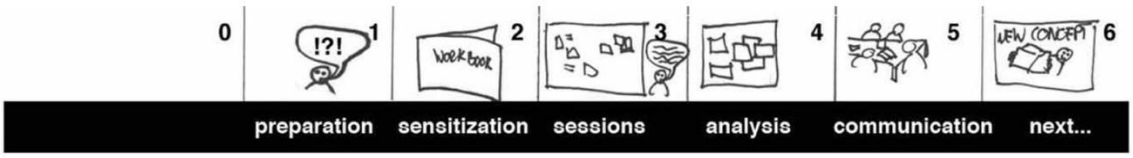
with Aim #2 objectives 2C, 2D, and 2E, the design practice bridged the theoretical. The following section presents the: wearer workshop (6.1.2.1.), digital dialogue (6.1.2.2.), wearer interviews (6.1.2.3.), and design practice (6.1.2.4.).

6.1.2.1. Wearer Workshop

The research used a generative workshop as part of a woman-centred approach (Section 5.3.) to access the women's experiences from their voices and create a dialogue with them. This generative workshop aimed to gain information on the wearers' bra experiences and 'feelings and aspirations' to use as creative inspiration in designing BW for pleasurable experiences (Desmet and Hekkert, 2009, p. 3). As a participatory method, participants in generative workshops are treated as experts in the explored phenomenon (Sleeswijk Visser *et al.*, 2005). HCI researchers have verified this method, gathering workshop-derived contextual data to inform design processes (Bødker, Nielsen and Petersen, 2000; Mattelmäki and Battarbee, 2002).

The workshop was developed using contextmapping, a generative co-creation[60] technique to understand wearers' needs and desires on a deeper level (Stappers and Sanders, 2003; Sleeswijk Visser *et al.*, 2005). This generative technique is helpful to 'discover as-yet unknown, undefined, and/or unanticipated user or consumer needs. In the generative phase, we are looking for ideas and opportunities to fill unmet user needs' (Sanders and Dandavate, 1999, p. 90). Moreover, contextmapping facilitates the development of empathy with the wearers. As part of the Design & Emotions purview (Section 5.4.2.), empathic relationships with the participants permit the design-researcher to share information about themselves and reflect upon their experience in the D&DP. The workshop followed the directives in the article 'Contextmapping: Experiences from Practice' (Sleeswijk Visser *et al.*, 2005). Sleeswijk Visser et al. established six sequential phases: preparation, sensitisation, sessions, analysis, communication/sharing, and conceptualisation (**Fig.6.12.**).

Fig.6.12. Contextmapping phases.
Source: 'Contextmapping: experiences from practice' (Sleeswijk Visser *et al.*, 2005)



[60] Co-creation 'refers to any act of collective creativity' (Sanders and Stappers, 2008, p. 5) used at various stages within the D&DP, for example, during the workshops and design sketch/participative creation stages of this study. Design and Emotion field allows for borrowing from Participatory Design as the attention is on the wearers, who are considered 'expert of their experiences' (Sanders and Stappers, 2008, p. 12), thus by continuously bringing them into the D&DP, more information on their needs is accessed.

Instrument Development

Following the article's recommendations, a workbook (Appendix F) was employed to sensitise the women, enabling them to think over their bra experience before initiating the interaction (Sleeswijk Visser *et al.*, 2005). The design-researcher spent four months from December 2018 to March 2019 in the preparation phase. During this phase, attention focused on constructing explicit goals for the workshop. A goal statement was created to guide the process: "to understand the MW's multifaceted experience of the bra from her encounters of wearing and purchasing". The goal statement helped shape the exercises developed for phase two sensitising workbook and phase three workshop[61] (Appendix G).

Pilot

The pilot was conducted with women (*n*=3) who were all early 40s. The women were given the workbook and a printout of the workshop's exercises. Rather than ask them to fill out the workbook, they were asked to review the questions for clarity and appropriateness. A few questions required rewording. Furthermore, the women were asked if the questions evoked uncomfortableness after thinking about their ageing breasts and bodies. The design-researcher was assured that they did not. Lastly, the workshop exercises were reviewed. Suggestions were provided to introduce more visual aid to the workshop, allowing the women to have some tactile functionality. The participants' recommendations were further reflected upon after the pilot and amended.

Recruitment and Participants

Sleeswijk Visser et al. (2005) suggest a three-week preparation period, including two weeks for participant recruitment; however, the researcher had to recruit for a month and a half. Posters were placed around the university campuses, and digital posters were emailed to colleagues and acquaintances. Additionally, an invitation to participate in the workshop was advertised on Eventbrite, an online event promotion and booking site. Women were requested to register for the event at minimum a week prior, so they had time to receive and complete the workbook. They were selected to participate if they were willing to undertake the workbook and partake in the workshop.

The second phase had two in-person workshops scheduled on a Saturday in April 2019. At this point, the research still sought information on Black and white women within the target age. Both workshops were scheduled for two and a half hours, with the morning for white participants and the evening for Black participants. Although four women signed up for the first workshop, none arrived. Three Black women in their late 50s/early 60s showed up for the second workshop. Two of the women, related through marriage, were in-laws. Both women had the same cultural heritage, Jamaican, and were raised in England. The last woman was of African ancestry but lived in England for over 25 years. Although the recommended number of participants is four to six, Sleeswijk Visser et al. (2005, p. 125) contend that three participants are

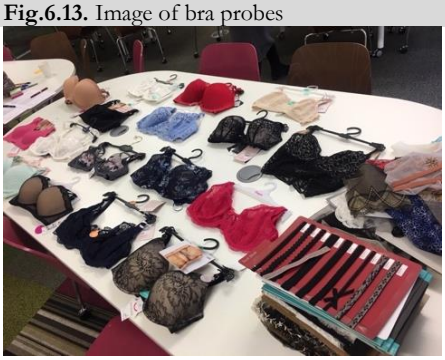
[61] See Appendix G for further information on phase 2 and 3 development.

sufficient; however, an impediment is that there may be 'less opportunity for the participants to reflect on each other's experience'. This was not the case as the women opened up to each other, providing rich data, and often stimulating new conversation paths. The smaller dynamic may have allowed for a more private session, providing the women with comfort as they divulged intimate details (Wilkinson, 2004).

Data Collection

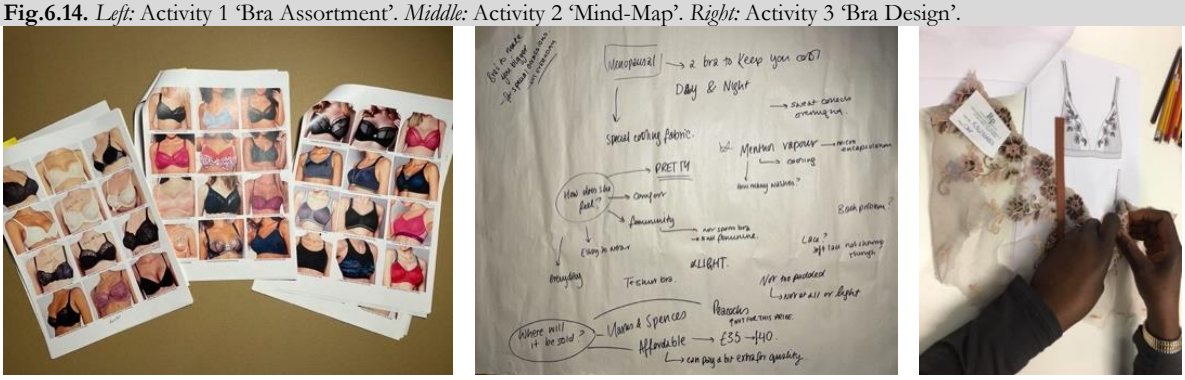
The workshop (see Appendix H for structure) event was held at the London College of Fashion. Tables were set up at the front of the room facing a presentation wall, which displayed the introduction to the workshop, the background of the research and workshop activities. The main table was set up with exercise packets and activity tools, while a second table featured a display of twenty-five purchased bras (**Fig.6.13.**). The bra samples were utilised as probes for inciting dialogue as an 'incentive to participation' (Mattelmäki, 2006, p. 63) – allowing the women to relate the stimuli to similar products they owned and discuss their 'concerns, memories, feelings, and experiences' (Sleeswijk Visser *et al.*, 2005, p. 120). The last table in the back of the room, set up as a communal space, was dedicated for snacks and drinks.

Fig.6.13. Image of bra probes



After introducing the facilitator[62], design-researcher, and the research premise – through a 10-minute presentation – three activities ensued following a script (Appendix G and H). The facilitator reviewed the consent sheets and collection of the workbooks. The workshop plan was created with exercises, activity instructions, and discussion points inspired by Sleeswijk Visser et al. (2005). **Fig.6.14.** illustrates images from the three main workshop activities (i.e., Assortment Activity, Mind-Mapping, and Bra Designer).

Fig.6.14. *Left:* Activity 1 'Bra Assortment'. *Middle:* Activity 2 'Mind-Map'. *Right:* Activity 3 'Bra Design'.

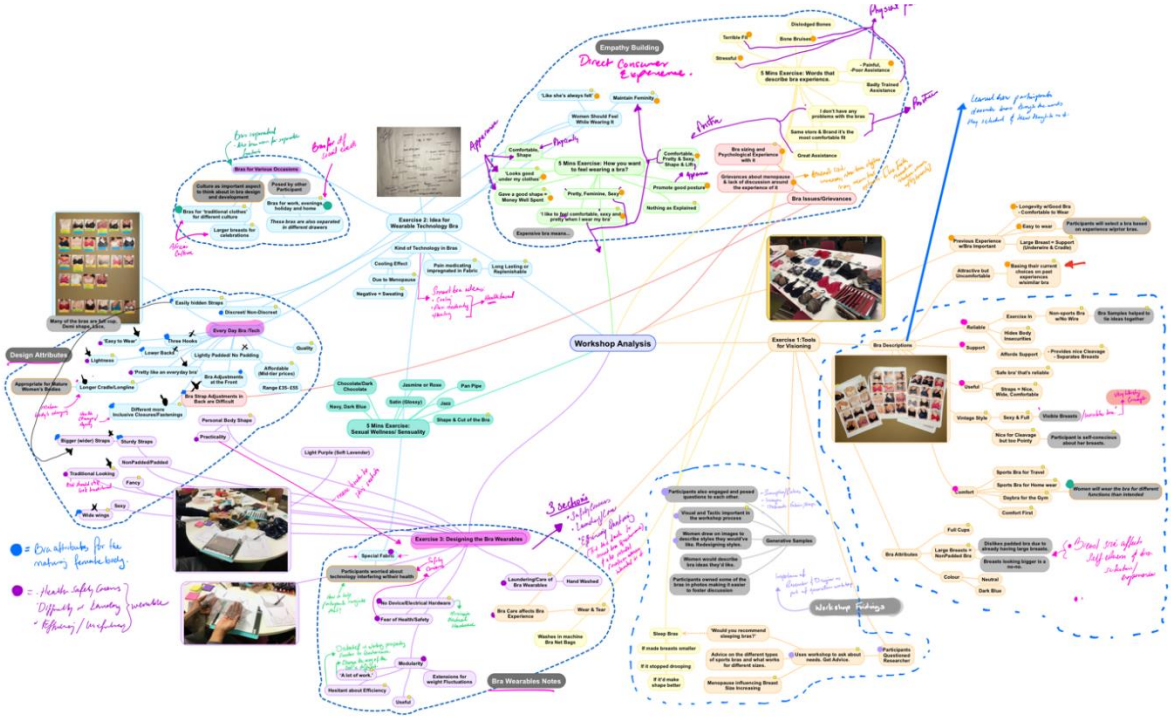


[62] As the design-researcher wanted to be on equal footing with the participants, an aspect of Feminist HCI, to minimise a sense of hierarchy (Seale, 2012), a facilitator was employed. The facilitator was a fellow PhD candidate who had experience facilitating workshops with elderly groups affected by dementia. As they valued compassion, care, and empathy practices, it made them suitable for this study.

Data Analysis

The workshop was audio-recorded and lasted two hours and thirty minutes. Transcription was conducted verbatim using a digital transcription program called Otter.ai, then transcribed manually in Microsoft Word, as the program did not capture specific phrases, emphasis, pauses, moments of laughter or hand gestures. Due to the sensitive nature of the workshop, very few photos were taken, occurring only when the women were in the last activity, which focused on their designs. The images did not include faces or identifying markers.

Fig.6.15. Mind map demonstrating part of the analysis to find patterns
**Image is for process not legibility.*



Sleeswijk Visser et al. (2005) suggest utilising a grounded theory approach (Corbin and Strauss, 1990; Charmaz, 2014) to analyse the rich and complex data generated. Data from generative workshops provide 'personal disclosure of attitudes, opinions, and intentions' (Wilkinson, 1998, p. 119, 2004). Following Sleeswijk Visser et al.'s (2005) three-phase analysis structure, in phase 1, 'Fixates on the data', the design-researcher reviewed and reflected on field notes from the session. Next in phase 2, 'Search and be surprised', the design-researcher made annotations and highlighted phrases in the transcript. Lastly, in phase 3, 'Find patterns and create an overall view', a digital mind map was developed with codes grouped into varying themes creating a more explicit visual depiction of the findings (**Fig.6.15.**). Results, including themes and quotations from the generative workshop session, are available in Section 8.1.

6.1.2.2. Digital Dialogue

The design-researcher employed the term "digital dialogue". Digital dialogue falls under the purview of focus groups as it similarly organises a target group to focus on a discussion topic (Kitzinger, 1994) to be

informed by the participants 'attitudes, feelings, beliefs, experiences, and reactions' (Gibbs, 1997, p. 2). Digital dialogue differs with its secondary aim of spreading the topic information to gain participants for follow-up activities. Initially, the digital dialogue was not a part of the research design. However, with the difficulty of finding target participants and the pandemic lockdowns increasing the need for online events, engaging potential participants in this manner seemed apt. The design-researcher sought participants for interviews and believed that by introducing potential participants to the topic, they would volunteer or spread the word to their network. Therefore, to engage prospective participants, the design-researcher decided to present the BW field to the target audience and utilised smaller exercises to engage in discussion rather than passive listening.

Development of Presentation

A digital presentation exploiting photo-elicitation as a dialogic technique (Goodman, Kuniavsky and Moed, 2012) was created to inspire discussion, spread interest in the topic, and prompt conversation on the types of experience participants desired while wearing BW. The PowerPoint presentation introduced the design-researchers' background, the overall sections of the research, and the BW History timeline. Throughout the fourteen-page presentation, five pages illustrated the BW state-of-the-art and three quick exercise-based slides. The five slides for the BW sectors focused on bras for health, fitness, safety, glamour, and a section comprised of various concepts. Each page featured the sector heading, a small detail about the sector, clear images of BW samples, and the bra's functions.

After being introduced to the modern BW timeline, the women were prompted to participate in exercises discussing their current bra experience. They were asked to think about their feelings when wearing, purchasing, and laundering the bra over the years; then share words that came to mind about those experiences. The second exercise focused on their bra shopping experience, prompting the women to discuss what they looked for, whether their focus was on the cost, style, experience, or emotions. The last exercise centred on the BW experience, asking the women their thoughts on the various subfields and if they would wear any of the designs.

Recruitment of Participants

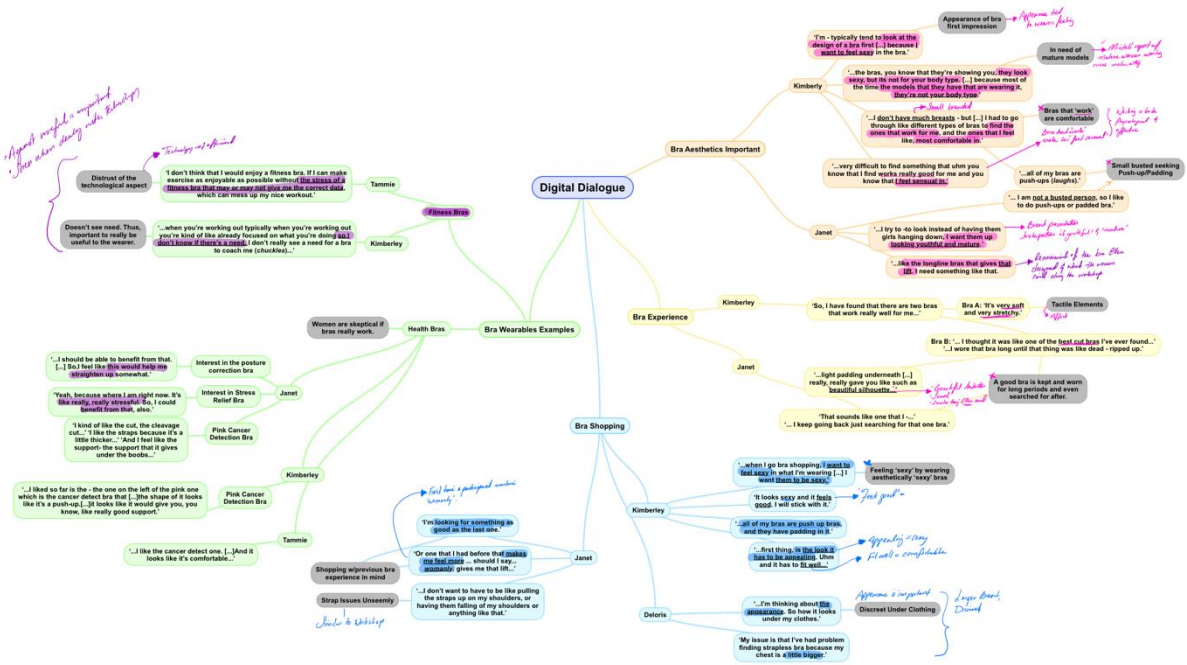
Fig.6.16. Banner featured in the Eventbrite listing.

An event page was created in May 2020 on Eventbrite, a free online event hosting and promotion website, where participants were recruited (**Fig.6.16.**). The webpage included details about the workshop, called for

Black women, and displayed links to the digital consent forms. Three questions were added before ticket collection, asking the participants to confirm they self-identified as Black women, were between 45-64, and consented to participate in the workshop. After a link was generated for the event, it was shared on the design-researchers' Twitter page, on Black women in menopause page, and emailed to Black women on the design-researchers' Facebook to share with their family members and friends. Five women participated (**Table 6.36.**, p.188) who were located throughout the United States. Two women worked together within the healthcare industry, and the other three were unacquainted.

Data Analysis

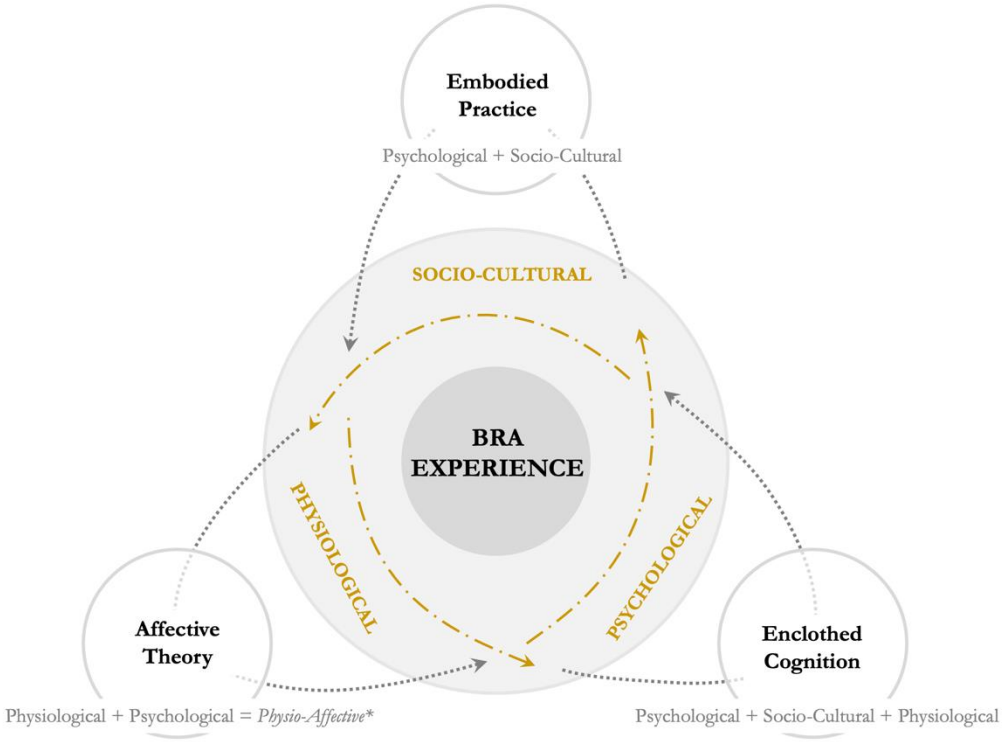
Fig.6.17. Digital Dialogue mind mapping analysis sample.
**Image is for process not legibility.*



The design-researcher presented the PowerPoint over Microsoft Teams; audio and video transcripts were obtained. The session lasted one hour, resulting in twenty-five transcription pages analysed thematically following Braun and Clark (2006, p. 87). First, the transcript was reviewed manually, highlighting insights, pertinent quotes, and noting memos. The quotes were then entered into a digital mind mapping program called SimpleMind Pro, then colour coded and grouped according to similar themes (**Fig.6.17.**). The design-researcher further defined and coded themes, adding annotations, resulting in the final themes discussed in Section 8.1.

6.1.2.3. Interviews

Fig.6.18. Bra Experience Theoretical Framework.



Qualitative interviews using purposive sampling were selected as the best method to access women's past and present bra experiences using their voices. Interviews are also beneficial for accessing emotional aspects of experience (Sanders and Dandavate, 1999). To be clear, the aim was not to compare the experiences among women, but rather to understand *how* women experience the bra through the Bra Experience Theoretical Framework (**Fig.6.18.**). Black Feminist researcher Patricia Hill Collins (2005) advocates that when studying Black women, the aim is not to generalise – further stigmatising them – but expound on the myriad of experiences within the group.

While some women may have had fantastic bra experiences and were willing to share, others might not. Therefore, due to the nature of the topic, a high level of sensitivity was required. Woodward (2007) shares, in her research conducting clothing interviews with women in their homes, lingerie was the one area the women were unwilling to show or discuss. However, interviewing the women over their chosen medium while in the comfort of their homes provided security, enabling them to share. When interviewing women about their bra experiences in a safe and secure space, it is possible to uncover insights that help them learn more about themselves (Reinharz and Chase, 2001). Feminist researcher Seale (2012, p. 213) 'advocate[s] proffering friendship and exchange' to enable the researcher to build trust and empathy. Moreover, Brinkman and Kvale (2015) warn to be aware of striking the right amount, as too much or too little hinders the process and subsequent data. To assist in striking the right amount, reflexivity is vital for the researcher to examine their impact on the interviewees (Seale, 2012). The design-researcher kept a journal recording

her experiences and thoughts after the interviews, utilising it as a reflective tool for understanding and contextualising her interpretations (Section 6.4.).

Participants

Participants were selected using purposive sampling. Five of the six women interviewed partook in previous activities (**Table 6.36.**, p.188).

Interview Development

The interviews were semi-structured; thus, instrument development focused on conversational topics with prompts rather than a set question-and-answer format. The aim was to record the women's bra experiences by having them recall specific and vivid events that would allow them to discuss those experiences thoroughly. Since the bra is a garment women wear most days of their adult lives, asking them broad questions about their experience may return general responses. Therefore, the experience-centred interview method called 'Directed Storytelling' was utilised, prompting the participants to recall specific events in detail (Saffer, 2010, p. 87). Directive questions were employed, encouraging women to recall through storytelling amazing, horrible, and every day – but memorable – bra experiences (Forlizzi and Ford, 2000; Wright and McCarthy, 2010). Thus, the interview began by asking the women to describe their favourite bra and discuss one of their favourite bra-wearing experiences. Once the women started recalling specific events, the questioning incorporated experience-centred elicitation style interviewing, encouraging women through sensorial questions to describe where they were, who they were with, and what the bra experience felt like, emotionally and physically (Light, 2006).

Pilot

Piloting allows the design-researcher to practice interviewing, discover nuances that may arise during the study, and is an opportunity to reflect on the engagement and their experience of it (Seidman, 2005). The interview was piloted (n=4) with two Black, one Middle Eastern, and one white woman. All were college-educated and in their 30s, except for the white woman who was mid-forties. Three described themselves as having medium to big breasts, and one as having small breasts. As the piloting unfolded, new aspects were added to the interview instrument. During the first pilot[63], the researcher realised how difficult it was to access detailed information from participant Nebula about how she felt while physically wearing the bra. Switching approach, the researcher asked her to describe the sensation of comfort. This line of questioning led to a more detailed dialogue. It reminded the design-researcher of what an earlier participant said, 'if the bra fits the way it is supposed to, she could not recall what wearing it felt like'. Conversely, when asked about their worst bra-wearing experiences, the participants described in detail how it affected them physically and emotionally.

[63] All participant names are pseudonyms.

Piloting allowed the researcher to connect with how empathy can be felt during the interview process and while transcribing and re-listening to the conversation. During Ballie's pilot interview, while transcribing, the design-researcher began experiencing a sense of sadness and familiarity as Ballie recounted how her family made her feel for buying new bras.

> *'I used to be made to feel uh guilty about buying a new bra because of finances [parts omitted]. I used to go to Victoria's Secret, and I had a part-time job. Uhm, I was working two jobs, really [chuckles]. When I was doing that, I had gone to Victoria's Secrets because I love the experience of them like doing the fitting and finding the right bra for you, stuff like that. Uhm, and I had bought a few but then when I spoke with uhm, I think was my mom or somebody, my mom… my sister and they kind of like guilted me by saying, 'oh, you have enough bras already. You don't need to get a new bra'. But the bras that I did have, they didn't support my breasts like they needed to'.*

In re-listening and hearing the change of tone in Ballie's voice, it was clear that this was a painful experience for her. The researcher realised that past experience could shape the new experiences Ballie has with bras, substantiating Deweys' notion of experience being continuous (Dewey, 1997). That feeling of guilt she noted rising when she attempted to treat herself to purchasing a new bra reminded the researcher of earlier times in her career where, although she had the income, purchasing items that others considered luxury made her feel guilty. The action of empathising in this manner is one way Wright, Wallace, and McCarthy (2008, p. 18:13) advocate for, as it allows the researcher 'to find threads that resonate with her own experiences'.

Developing Analysis Codebook

A theory-driven codebook was developed to analyse the data, employing the Bra Experience Theoretical Framework (Section 4.3., **Fig. 4.5.** and **6.18.**). DeCuir-Gunby, Marshall, and McCulloch (2011, p. 141) establish three steps to effectuate theory-driven codes: '(1) generate the code; (2) review and revise the code in context of the data; and (3) determine the reliability of coders and the code'. Before developing the line of interview questions, a codebook was created applying six components: 'the code, a brief definition, a full definition, guidelines for when to use the code, guidelines for when not to use the code, and examples' (MacQueen *et al.*, 1998, p. 32). First examples from the literature review were coded into the codebook. This allowed the design-researcher to refine the codes and further substantiate the feasibility of the theoretical framework. Then the piloted data was analysed through the theories, and the codes were revised.

Data Collection

Interviews were collected over ten months beginning from October 2019 to June 2020. The researcher found recruiting the target audience difficult – a disadvantage of interviews (Collis and Hussey, 2021). Academics have noted the difficulty in finding willing participants within this 'race' to participate (Aririguzo, Spencer and Freysteinson, 2022; Kracht *et al.*, 2022). Reinharz and Chase (2001, p. 228) highlighted from Cannon, Higginbotham, and Leung's 1988 research 'that women of color and working-class women may

be less able and less willing than more privileged women to volunteer for research because of their heavy responsibilities and their well-founded skepticism about the value of social research'. The design-researcher noticed that women mentioned they did not have time or suggested they would recontact her when they found time. Thus, extra care was taken approaching women for participation and ample time provided to follow up.

A call for participants was shared using a digital poster on Twitter and Facebook social media channels and printed posters placed around the university's campus before the lockdown. After two months with few responses, selected Black women were contacted directly and privately through their social media accounts. The message introduced the design-researcher, research subject, target age group and asked if they were interested or knew of anyone who might be. The message also included a digital poster of the call for participants (Appendix E) and a link to the design-researchers' website. One hundred twenty-five women were privately messaged on Facebook and twenty-one on Twitter. Word of mouth was also implemented, with women close to the design-researcher passing the information along. In the end, snowballing provided most participants with those who were previously interviewed or too busy, suggesting friends and family members. This method established trust between the design-researcher and participants (Esterberg, 2001).

Data Analysis

Interviews were conducted over the phone, Microsoft Teams, and Google Meets, lasting approximately thirty minutes to an hour and audio recorded. Transcription was performed using Microsoft Word and then sent to the app Notability. Notability is an application that allows for PDFs to be mocked up digitally with a pen for ease of handwritten memos and highlighting. Transcriptions were detailed with the design-researcher, including pauses, chuckles, trail-offs, and colloquialisms. The transcript analysis aimed to uncover bra experiences from the women's voices to be examined within the Bra Experience Framework. Passages of significance were then copied from the Word document and pasted into Microsoft Excel.

The Bra Experience Theoretical Framework is categorised into three groups: physio-affective, psychological, and socio-cultural (**Fig.6.18.**). Using the program Excel, this framework was developed into a coding frame to provide the rules for recording and interpreting the data from interviews (Benaquisto, 2008). First, the design-researcher examined the transcripts, highlighting the experiences that fell into the distinct categories using a colour code. Next, memos were written alongside phrases and ambiguous sentences, or those that possibly fit into multiple categories. Then highlighted passages from the transcripts were placed into the bra experience codebook within the correct code label (sample of codebook in Appendix V). A description of the experience was allocated along with qualifications for the code label, the design-researchers' memos, and themes.

McCarthy and Wright (2010, p. 90) advise that for an empathetic dialogue to occur, researchers must engage with participants' accounts of their experience by 'linger[ing] over their story and experience until an understanding is created'. Furthermore, through a credibility technique and prolonged engagement with

the data, the design-researcher could access a more profound understanding of the phenomenon being studied (Lincoln and Guba, 1985). After sitting with the data, the design-researcher created a mind map (**Fig.8.5.,** p. 243) – known for its exploratory capabilities – synthesising the experiences within the allocated categories. This enabled the design-researcher to visually examine and engage with the experiences further, make connections and develop nodes around positive, negative, and neutral bras experiences in its multifaceted form[64].

The design-researcher stepped away for two months and reviewed the codebook – to establish credibility and validity – with a colleague who had coding experience and minimal knowledge of the data within the study. Through peer briefing – a process of analytical discussions that challenged the researchers' assumptions and assisted in minimising bias (Lincoln and Guba, 1985; Spall, 1998) – the codebook, themes, and codes were assessed to determine reliability and trustworthiness. Codes not agreed upon were critiqued until a consensus or removed if an agreement was not met (DeCuir-Gunby, Marshall and McCulloch, 2011).

6.1.2.4. Design Practice

The design practice[65] section (Appendix L) addresses Aim #2, 'To investigate approaches that can be utilised to inform the design of BW that improves the wearers' experience'. As such, objectives 2C to 'explore ways of integrating the bra wearer and their experience into the BWD&DP', 2D to 'investigate ways of integrating technology into the bra', and 2E to 'develop BW products that allow for the exploration of designing for meaningful and pleasurable experiences' were all interrogated.

Objective 2C assisted in developing an interaction matrix, BW design criteria, and BWFSEA consumer needs model (Section 8.4.). The outputs created a bridge between the theoretical and practical nature of the study, assisting in lessening the effects of wicked ill-defined problems the design-researcher faced. The concept known as *wicked problems* is described as '…problems which are ill-formulated, where the information is confusing, where there are many clients and decision makers with conflicting values, and where the ramifications in the whole system are thoroughly confusing…' (Buchanan, 1992, p. 15). Objectives 2D and 2E combined to actualise the practice component, the experimental inquiry (Dalsgaard, 2014), which fosters knowledge through doing.

Undertaking the study required the design-researcher to creatively unfurl to innovative and future-facing bra ideas after working commercially for several years. This meant moving from designing commercially safe products, in terms of design aesthetics and profitably, to focusing on *futuristic* designs. Moreover, the design-researchers' background is in traditional intimate apparel design; thus, she approached this practice

---

[64] The physio-affective section of the Bra Experience Theoretical Framework was presented to peers at the 3rd Memory, Affects, and Emotions International Interdisciplinary Conference.
[65] The design practice section introduces the design-researcher to the practice of designing smart clothing. It enacts parts of the BWD&DP from concept development to prototyping. Due to space, this section is discussed in detail in Appendix L; however, reflections are discussed in Section 8.5. and Section 10.2.

without experience or knowledge in designing smart garments. Designers within the smart clothing space often lack 'all the necessary knowledge to make smart clothing'; therefore, they frequently rely on multiple methods to navigate challenges accessing new knowledge (Perry, 2017, p. 1). To gather information on smart technology, the design-researcher attended hands-on workshops, read project-specific books (Hartman, 2014; Genova and Moriwaki, 2016; Kettley, 2016; Pailes-Friedman, 2016), completed a Physical Computing short course at UAL, Core Electronics course on Udemy[66], referenced open-source Fabricademy[67] courses, Arduino courses on Lynda Learning[68], watched YouTube "how to" videos, and leaned heavily on teaching websites like Instructables[69] and KobaKant[70]. The learning was a specific facet of the research as I transformed into a hybrid-designer (Section 5.2.).

One of the design practice's aims was to develop prototypes allowing the design-researcher to reflect on the process of designing BW and her experience with digital and traditional materials. Hansen (2016, p. 41) contends, 'materials forms part of a problematic situation, and might also serve as the means of transforming the situation'. Within RtXD (Section 5.5.), prototypes and materials become explorative tools, enabling the designer to experience the situated process of making and reflect on the interdisciplinary facets (Stappers, 2007). The prototypes function as a guide to inform on challenges and opportunities in developing experience-centred BW as an outcome of RfXD. Additionally, prototyping enables the documentation and mapping of the stages for guidelines. While the goal was the development of prototypes, as an independent design-researcher working singularly, without a trained team or vast technology resources, she was acutely conscious of the limitations and adjusted her expectations accordingly. Owner Frederic Chanay of OmBra, an SBW, noted that their D&DP with multiple material scientists, engineers, and computing experts took three years and 1,633 prototypes before it was consumer-ready (E. E. Wood, 2016). Therefore, the focus was on concept development and integrating the materials and photographic documentation of initial look-like and work-like prototypes[71].

Design Practice Process

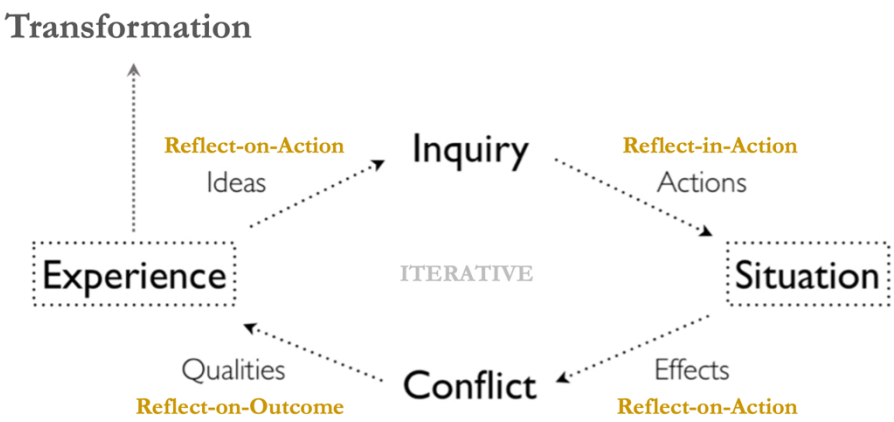
The goal of the design practice was to introduce the design-researcher through hands-on making to the practical portion of designing BW. Additionally, it provided information into the concept development phase in the initial BWD&DP. The design-researchers' approach to problem-solving included utilising her repertoire (Schön, 1983) from past experiences to inform the practice. This approach began a reflection loop where she continuously had '…reflective conversations with [her] situations which are experiments in

---

[66] Udemy is an online platform featuring paid courses in a range of topics. https://www.udemy.com/
[67] Fabricademy is a paid and open-source program intersecting digital fabrication, textiles, and biology. https://fabricademy.org/
[68] Lynda Learning is an online course provider in business, creativity, and technology available through the university's library system. https://www.linkedin.com/learning/
[69] Instructables is an online community where members show detailed "how to's" in the form of texts, images, and videos. https://www.instructables.com/
[70]Kobakant is a website featuring comprehensive DIY wearable technology documentation and information. https://www.kobakant.at/?page_id=475
[71] Looks-like and works-like are engineering terms denoting the initial introduction of a working or appearance ready prototype. It is also referred to as a representational prototype.

reframing' (Schön, 1983, p. 141). **Fig.6.19.** demonstrates the processes of reflection enacted for mood-board development, empathic approaches, design sketches, and materials exploration (Section L.1.). The following section introduces the methods undertaken.

Fig.6.19. Iterative model of inquiry and reflections.
Adapted from: 'Model of inquisitive use in which an experience of conflict in the situation triggers interaction, leading to a process of inquiry'. (Dalsgaard, 2014, p. 151)



Design Objective

The design objective was developed, within the concept development phase, from the design criteria (**Table 8.9.,** p.259), interaction matrix (**Table 8.10.,** p.260), and BWFSEA consumer needs model (**Fig.8.7.,** p.254). The methods were utilised to bridge the theory with the practice by creating a design brief which commenced concept development. Marchant (2016, p. 340) describes the design brief as 'a form of discourse… that design context and design intentions for the purposed project need to be conveyed'. The design brief stemmed from the aims and objectives of the research: to explore designing bras with technology, documenting the approaches and methods, and enacting the initial BWD&DP while noting obstacles and advantages. This portion of the practice feeds into the following stages. Due to the material exploration section below, it can be seen as part of the fabric direction phase of the BWD&DP.

Mood board

After setting the design objective, the next step was developing the mood boards (Section L.1.1.), which were created utilising various materials to assist in framing the design inspiration and concepts (Cassidy, 2008; Tracy Cassidy, 2011). Developing mood boards is a form of creative research designers undergo during the commercial process (Burke and Sinclair, 2015). The design-researcher often employed mood boards at the beginning of every season; they inspired forms, style lines, trimmings, and colours. A mood board was initially created by exploiting traditional art materials (**Fig.L.2.**, p.480). The mood board, inspired by the Baroque era, contained themes of movement, ornateness, and capturing a moment like an experience. To clarify, the design-researcher did not want to capture a moment through the design, but

facilitate the experience of change through the BW function. However, the traditional fashion mood board fell short, leading to the incorporation of an experience map tool from the HCI field.

To assist designers in developing experience-driven products, Camere et al. (2015) created an 'Experience Map' which focuses on the various facets of experiencing a product. The experience map and the traditional fashion mood board inspired experience-centred fashion. Bringing the two mood boards together, the design-researcher began experimenting with various materials like traditional embroidery and 3D embellishments, extending visual and tactile inspiration. The mood boards and tactile materials were a form of thinking-*through*-materials that fostered 'collaborative reflection' (Hansen, 2016, p. 40).

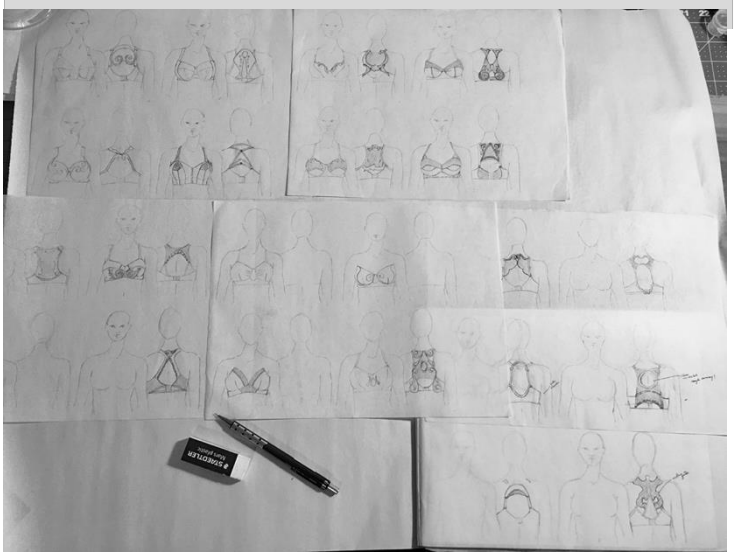
Empathic Approaches

Empathic approaches[72] commenced after the mood board development. As noted in Section 5.4.2.2., empathic approaches enable the designer to empathise with the wearers' needs, leading to a more in-depth understanding of their experience. Wilkinson and De Angeli (2014, pp. 623–624) inform that 'how a product makes a person feel and how a person feels about a product is as important as its' actual functionality'. Hence, the design-researcher must explore how the issues she is designing for make the wearers feel. The design-researcher found it advantageous to place empathy approaches in the concept stage before sketching, allowing her to comprehend the wearers' current position just as potential ideas form. Two empathic methods were trialled (Section L.1.2.); first, a body-storming technique (Buchenau and Fulton Suri, 2000), permitting the design-researcher to place herself in the participant's place as part of the affective component of empathy. Second, the cognitive component of empathy, drawing-as-seeing (Mida and Casey, 2020), enabled the design-researcher to intensely focus, connect readings and data from participant interactions, and triangulate subconscious information about the wearers while drawing. While the body-storming technique is from the HCI field, the drawing-as-seeing is from fashion history, placing it as an innovative approach to empathy.

[72] Aspects of the mood board and empathy approaches were presented at the 2023 Fashioning Experience Symposium.

Design Sketches

Fig.6.20. Initial BW design sketches



Design sketches (Section L.1.3.) are used to reconcile and capture the designers' ideas as visual recordings. Schön and Wiggins (1992) explicate that sketching is a method of seeing-moving-seeing that enables designers to experiment, discover, and work through concepts. Sketching is a form of being in conversation with the problem and, as such, is a navigation tool utilised by designers to facilitate thinking (Hansen, 2016). Initial ideas were drawn on pen and paper (**Fig.6.20.**); however, the design-researcher found it challenging to progress concepts without knowing the necessary number of electrical hardware, sizes, and placement requirements. The lack of familiarity created an obstacle. Dalsgaard proposed the importance of sketching to the progression of the design research,

> 'It appears to be a common trait across many design disciplines that design ability goes beyond intramental (i.e., "in the head") activities and extends into competent use of tools and techniques such as … sketching, prototyping and scenario development. Designers draw on these resources to understand the present situation, to envision and explore potential futures and to expose potential future users to their concepts to evaluate which course to take in the design process' (Dalsgaard, 2014, p. 145).

Notably, the design-researcher needed to move beyond the 'intramental' activities but was stuck as she could not envision the whole of the designs. As a way forward, she switched materials to drawing and recording designs on an iPad Pro with a digital pen using an illustration application called SketchBook. Multiple croquis were sketched (**Fig.L.7.,** p.487), with variations for the inclusion of electrical hardware. While sketching, she also incorporated material explorations. Swapping materials enabled her to amend concepts easier, which Hansen (2016, p. 31) contributes to the digital material facilitating 'rapid mental developments'.

Material Exploration

During sketching, the design-researcher encountered numerous conflicts, mainly the lack of knowledge about the electrical hardware needed for the designs. Therefore, sketching overlapped with material exploration (Section L.1.4.) to gain insight into the necessary components. Here she fused sketching, material exploration, draping and patternmaking – moving between activities to understand how to begin

designing ideas for BW (**Fig.L.1.,** p.477). This required her to experience many roles as a designer, technical engineer, textile technologist and more. Each role required a different level of experience; hence, the learning process was explorative and arduous. During this process, the design-researcher focused on two concepts selected by participants from the participative design workshop (6.1.3.1.), a bra with vibration functions (Section L.1.4.2.) and a cooling bra (Section L.1.4.3.), explored in tandem. Each concept came with parameters and obstacles, adding to the design-researcher's experiential knowledge. Moving across design areas permitted the 'materials [to] support the development of ideas' (Hansen, 2016, p. 40).

Reflection

At every stage in the design practice, the design-researcher encountered conflict as this process differed from her prior experience as a lingerie designer in industry. While there were stages that felt more familiar, aspects differed in ways that forced her to continuously reflect on her abilities, actions, and possible outcomes. The design practice required a constant back-and-forth of reflecting-in-action and reflecting-on-action to move through each stage. Hansen (2016, p. 40) asserts that the back and forth is a Deweyan inquiry strategy, 'consisting of what you do as well as the rationale for it'.

6.1.3. Develop

The *Develop* stage aimed to utilise the initial BWD&DP and information gathered from the design brief to lead the co-creation of BW samples. This stage consists of the "Concept Development" and "Pattern & Prototype Development" phases of the BWD&DP. During this stage, continuous reflection and reflexivity (Schön, 1983), individually from the design-researcher and participants, guided and informed the subsequent steps.

The design-researcher aimed to gather first-hand insights into the BWD&DP. Within this phase, Aim #3, 'To interrogate the different types of "experiences" (i.e., the design-researcher and the wearer) that aid in informing BWD&DP', is documented. Throughout the *Develop* stage, Aim #2 objectives, 2C, 2D, and 2E, are all effectuated by multiple methods (i.e., participative design workshop, 3D fit model development and review, prototype development, and collaborative review) (**Fig.6.21.**). These methods resulted in two prototypes and an updated BWD&DP (Chapter 9 and Appendix P).

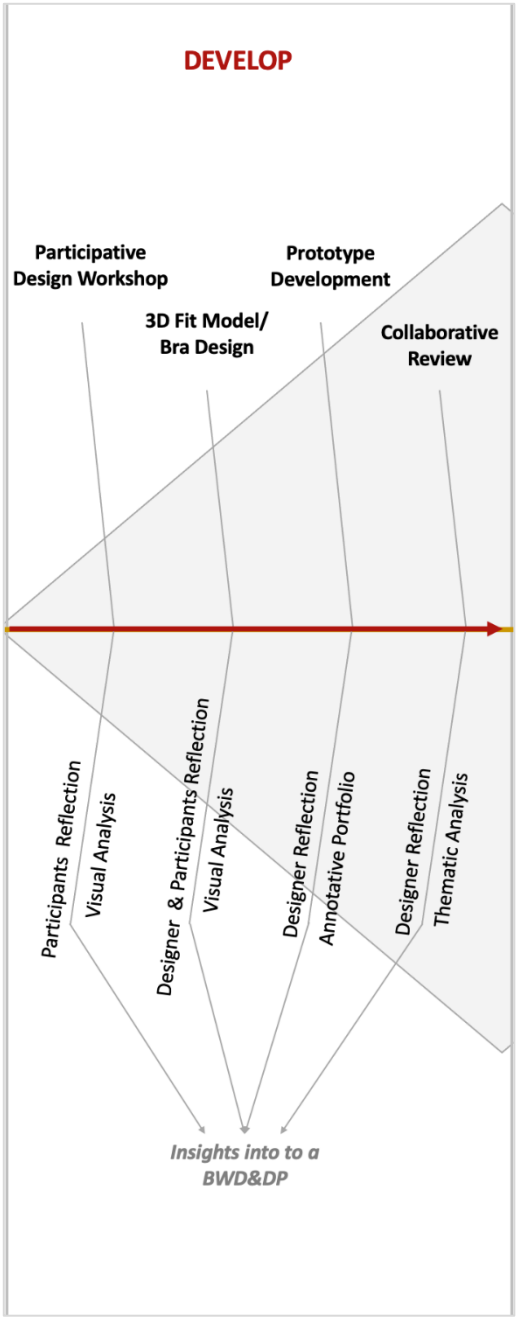


Fig.6.21. Develop section of Four-Stage Process.

6.1.3.1. Participative Design Workshop

The participative design workshop was inspired by a process called 'participative creation' in Patrick Jordan's 'Designing pleasurable products' (2000, p. 149). Jordan shares that this process differs from a focus group as the participants are creatively engaged, 'helping to set the product […] specification' (2000, p. 149), and hands-on in designing concepts based on aesthetics and functionalities. Although this method is beneficial at the beginning of the D&DP, enabling designers to gather information directly from the participants, Jordan advises that a disadvantage is the time commitment necessary from participants. The design-researcher encountered this issue as the workshop was scheduled for an hour and a half but lasted three hours.

Engaging the participants utilising a participative design workshop fits neatly within the experience-centred BWD&DP. It enables the designer to exploit various visual methods to directly share and communicate ideas, concepts, and possibilities with the participants. In turn, the visuals presented evoke participants 'sensory and affective engagements with […] [their] past, present, and anticipated experiences' (Pink, 2020,

p. 523), enabling them to share their wants and desires. This activity ignites convergent thinking, providing the design-researcher with rich data to inform designing analytically.

Design Workshop

Fig.6.22. Screenshots of the ideation activities.

The workshop, conducted online via Zoom, brought participants into the design stage, allowing them to act as experts sharing their experiences while aiding in ideation and creative concept design. To develop the workshop, the design-researcher used methods from her professional background, like showcasing collections and concepts to buyers in the lingerie industry. A packet for the session was developed to guide the workshop.

First, the participants were asked to partake in a 40-minute ideation session to develop useful BW concepts. Before commencing the activities, the women were reintroduced – through a slideshow – to the BW state-of-the-art, with images of different BW and their respective subfields. They were asked to discuss which subfields they were most interested in and wanted to pursue.

Next, three ideation activities were chosen that elicit creative concepts in a group setting: Brainstorm (1+1=3), Mash-up method, and Storyboarding (**Fig.6.22.**).

- Brainstorm (1+1=3) (Luenendonk, 2015) tasked participants with writing down an idea for a BW product on the stickies. Then they selected a concept that was not theirs and added to them. As a group, we discussed the best ideas and why.
- Mash-up (IDEOU[73]) method utilised the 'How might we', as a group, expound on an idea from the first activity – the brainstorm – if mixed with an extreme other category. Participants had two minutes to think of as many wild ideas as possible and type them anonymously on the whiteboard. We then discussed as a group the ones they most liked. Next, two ideas were selected that they all agreed on.
- Storyboarding (Cross and Warwick-Booth, 2016) required, together as a group, the selected ideas to be discussed working through how the BW will be experienced. A specific event was the focus for an imaginary wearer. Participants were asked to think about the physical (how does it feel to wear the design), social (how might others view her while wearing it and how might she view

[73] Mash-up cards and PDFs available. https://www.ideou.com/pages/ideation-method-mash-up

herself in social situations), psychological (what reactions might the wearer have), and ideo-pleasures (how has the wearer's life changed). Questions were derived from Jordan's Four Pleasures Framework (Jordan, 2000), see Section 5.4.2.1.

Once the activities were completed, the women were queried about their experience of the ideation process. The women provided their responses on a separate slide with five questions on each sticky.

Fig.6.23. Sample of one concept shown in the design stage.

After a 5-to-10-minute break, the participants entered the 35-minute design stage, which was intended to get them to actively engage in designing the visual aspects. They were introduced to the activity by reviewing three different design mood concepts derived from WGSN Autumn 22/23 trends. Each concept featured a page dedicated to a mood board, fabrication consisting of laces, elastics, and fabrics, and showcasing bra styles that fit within each concept (**Fig.6.23.**). There were nine pages in total. On each page, the women discussed the styles, colours, fabrics[74], and themes they liked and why. As the discussion progressed, the design-researcher highlighted what the women were saying through hearts, X's, and notes on the screen.

Fig.6.24. Slide showcasing multiple bra styles.

The final two pages of the design activity showcased a range of bra styles. The first page had eighteen images of various bra styles in black, numbered with the type of bra written beneath them (**Fig.6.24.**). Here the focus was just on the bras' form, with the women selecting which bra styles they liked and why. The second page illustrated thirteen front-facing bra designs and two back designs created in Adobe Illustrator and Photoshop by the design-researcher. The bra design concepts were like the previous page; however, they showcased a variety of creative forms and materials from which to select.

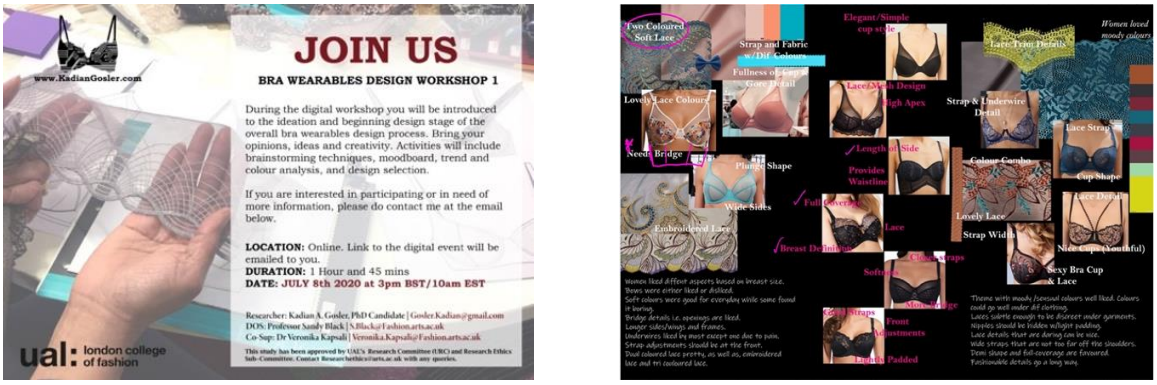
The final slide of the design activity asked the women to reflect on their experience of the design stage for three to four minutes. They were tasked with writing down their thoughts, focusing on which activities they enjoyed, found difficult, and areas they would have liked more time.

[74] Liao and Lee (2010) found that bra attributes women valued most were fabric, colour, neckline, lace, and style.

Finally, the workshop concluded with a slide called 'What's Next?' revealing the subsequent steps for the study. The top portion of the page highlighted the search for digital fit model volunteers to trial the designs as avatars. Additionally, the bottom introduced the final workshop to commence in three to four months.

Recruitment of Participants

Fig.6.25. *Left*: Participant recruitment poster. *Right*: Visual analysis.



Participants were recruited through Facebook, Twitter, and direct email. Previous participants were contacted to invite back and share the poster within their immediate circle (**Fig.6.25.**). Five women participated in the design workshop (**Table 6.36.**, p.149).

Data Collection and Analysis

The workshop was conducted via Zoom and lasted three hours and sixteen minutes. However, for almost twenty minutes, the women, who were strangers, stayed to chat with each other. Visual analysis was utilised to identify design features, colours, and bra styles participants favoured (**Fig.6.25.**). Analysis of memos and participant comments from each activity and the design workshop was collated and reflected upon.

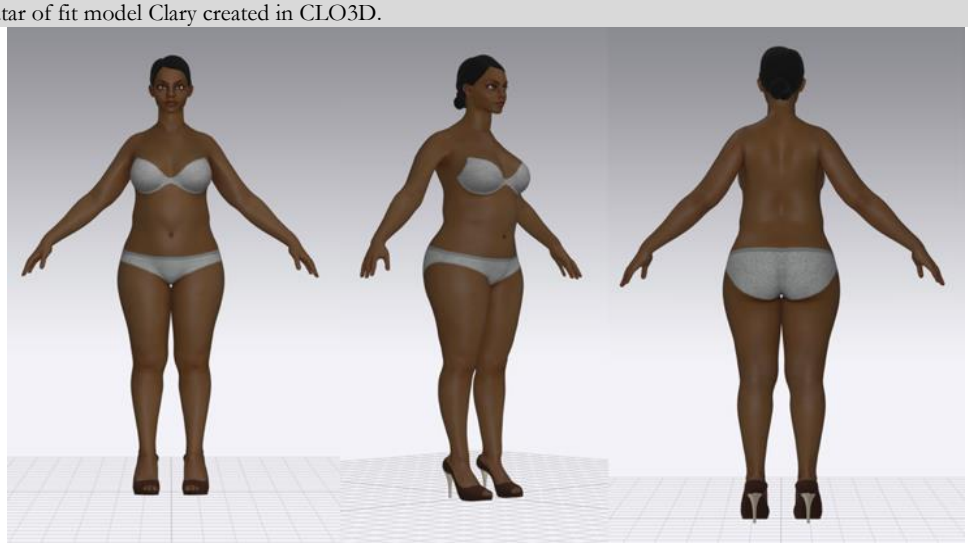
6.1.3.2. Digital Fit Model Sessions (3D Avatar)

After the design workshop the design-researcher created two BW CADs, Lavinia and Luisia, for further development (**Fig.9.6.**). Due to the lack of physical interaction with participants and Covid-19 restrictions, it was necessary to pivot to the digital realm. The goal was to use 3D avatars to aid participants in the fitting and garment review stage; additionally, gauging wearer perception (McCann and Bryson, 2014). 3D avatars have been used in bra research to help develop new shapes as a design and patterning method (W Yu *et al.*, 2006, p. 106) and exploited to examine the aesthetic and fit of sports bras for mature women (Hwang, 2017). Moreover, Choi et al. (2021) developed an avatar based on the scanned bodies of 42 mature Asian women between 50-59 to develop a physical bra that fits most mature women. However, Papahristou and Bilalis (2017) found that 3D avatars were utilised primarily by the fashion industry as a concept and design tool rather than a digital prototyping tool, attributable to the disadvantage of assessing fabric properties and fit. As the design-researcher employed the 3D avatar, issues arose, forcing her to shift from using it as

a standard fit prototype tool to a concept and visual perception of the fit and emotional design assessment tool. The two CAD designs were placed on to the digital fit models for review.

Development of Digital Fit Models

Fig.6.26. Avatar of fit model Clary created in CLO3D.



Three women, who also partook in other activities, volunteered to participate as digital fit models. A fit measurement sheet with a measuring guide using an avatar image was sent to the women. Their measurements were then transferred to digital avatars using the program CLO3D (**Fig.6.26.**). While designing the selected bra styles in CLO3D and reflecting-in-action, the design-researcher realised she was designing on a solid shape, like draping on a mannequin. This meant the garment needed to be actualised to assess fit on a soft human body. Informal conversations with Nadia Salt King and Trudy Gardner, bra designers utilising CLO3D, confirmed that the process still involved printing the patterns, making the samples, and fitting them on a real body multiple times. The conversations motivated the design-researcher to focus more on the bra design employing the digital fit model as a design aid rather than using CLO3D as a digital prototyping tool (Section 9.3.). The designs were visually enhanced using Adobe Illustrator and Photoshop.

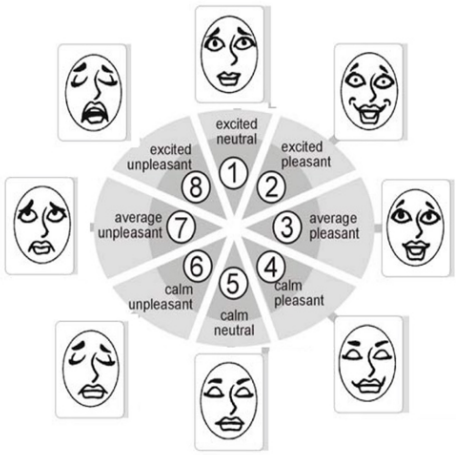
Three fit model avatars were created for the participant's Clary, Shelly, and Janet. Each avatar had a screenshot of three viewpoints (**Fig.9.9.,** p.276) – front facing, three-quarter side, and back view – showcasing two different BW styles, each in five colourways. Viewing the different body types of the fit model avatars was a humanising experience for the design-researcher. It concretised that the designs were for real women who differed from the croquis, and dress forms accustomed to by the design-researcher. Extra care was taken in developing the one-to-one interview sessions, as the women could become uncomfortable viewing themselves digitally.

Crafting the Digital Fit Sessions

Fairburn, Steed, and Coulter (2016, p. 5) posit that 'sensor-embedded garments (e-clothing) have the potential to change the meanings of clothes and create emotional relationships between garment and wearer'. Therefore, the fit session aimed to comprehend the potential emotional relationship and experience of the designs. The sessions centred on acquiring the participant's assessments of the overall design, colours, fit, material, emotions on the design's wearability, and experience of the digital fit process. Examples of questions on emotions, garment experience, and experience of the process are available in Appendix M.

Fig.6.27. Emotional Response Questions and EmoCards
Source: 'EmoCards' from Desmet, Overbeeke and Tax, 2001

1. How do you consider the overall design?
2. How do you consider the colours/colour combo?
3. How do you consider the fit?
4. How do you consider the materials?
5. How do you consider the design on the model's figure?
6. How do you think other mature women would consider the design?



Six questions were designed using emocards to measure the participants' emotional responses to the designs (Desmet, Overbeeke and Tax, 2001; Reijneveld *et al.*, 2003) and serve to facilitate conversation (**Fig.6.27.**). Emocards are cards with facial expressions used to assess initial emotions toward a product (Desmet, Overbeeke and Tax, 2001). The selected emotions and the participants' responses provided insight into their true feelings about the product.

The design-researcher developed questions eight through ten (Appendix M) to assess the participants' experience of the fit session. This line of questioning enabled reflection of the participant's experience in

Fig.6.28. Bra Wearables Adjectives
* Words have been amended
**Added Adjective Pairs

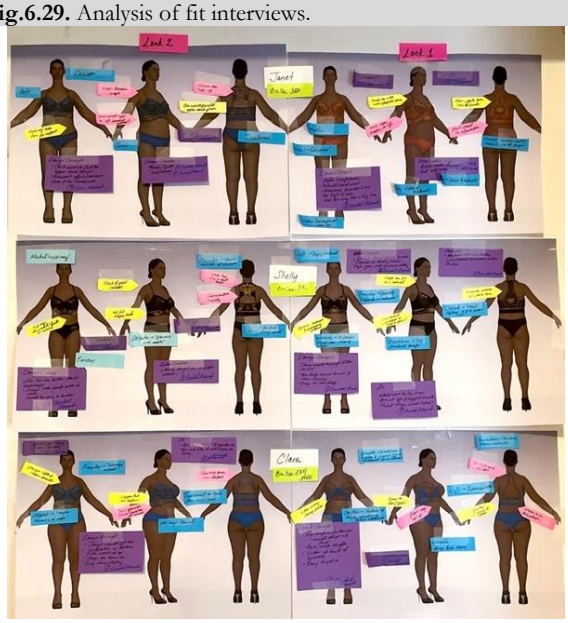
Adjective Pairs for Functional, Expressive, and Aesthetic Emotional Needs	
Soft – Hard Feminine – Masculine• Womanly – Girly•• Light – Heavy Warm – Cool Delicate – Rough Fluid – Stiff Funny – Serious	Comfort → Functional
Appropriate – Inappropriate Edgy – Safe Everyday – Specialty•• Discreet – Visible•• Modest – Ostentatious••	Social Lifestyle Values → Expressive
Sexy – Neutral• Complex – Simple Unique – Ordinary Dynamic –Static Traditional – Futuristic••	Aesthetic

this stage of the BWD&DP and facilitated comprehension of the usefulness of this method for designing BW.

Although a product emotion measurement instrument was available (Desmet and Dijkhuis, 2003), it was not suitable as it required a larger number of participants for quantitative assessment. Instead, a word selection exercise between two opposite adjectives was added, amending An and Lee's (2015) word pairings from the Emotional Needs FEA Model (Section 5.4.2.). The Emotional Needs FEA Model positions each adjective pair in functional, expressive, or aesthetic categories. Rather than utilising An and Lee's 25 pairs of adjectives for outerwear, the researcher adapted them for the bra garment and simplified to 18 pairs (**Fig.6.28.**).

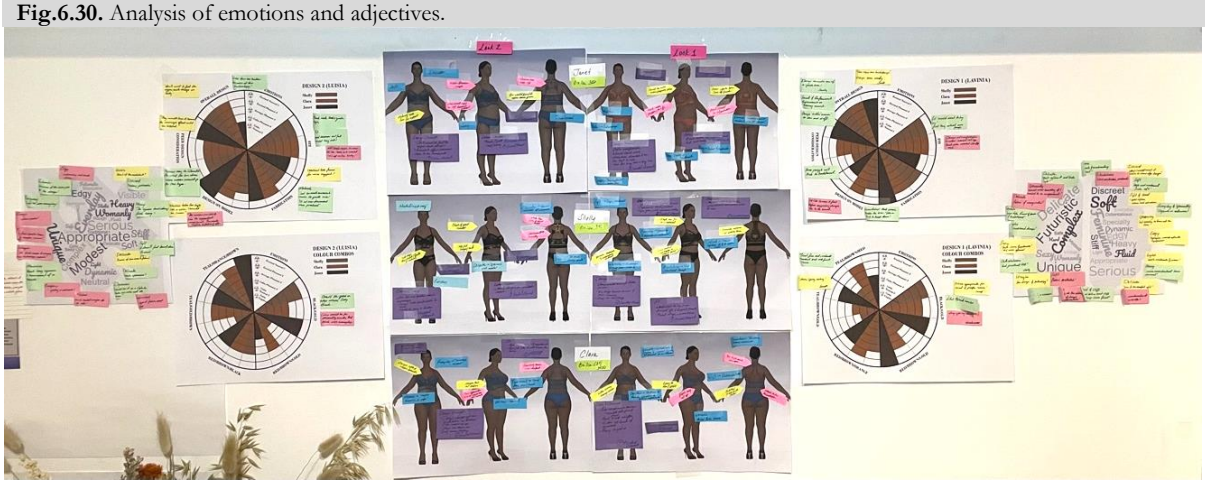
Data Analysis

Fig.6.29. Analysis of fit interviews.



All three fit interviews were one-to-one, occurring over Zoom, and lasted an hour. Following the interviews, the design-researcher reviewed her memos and began highlighting aspects pertinent to participants. The colourways of the two styles each woman rated highest were printed and displayed for analysis (**Fig.6.29.**). Positive facets the women noted were highlighted in yellow stickies and placed onto the areas the comments reflected. Negative aspects or areas of concern were written on pink stickies and placed facing the respective areas. Blue stickies were the adjectives selected by the participants to describe their assessment of the garments. Lastly, purple stickies contained essential quotes from the interviews. Visual analysis in this manner proved valuable, as it was more advantageous to implement and more discernible for a real-world D&DP.

Fig.6.30. Analysis of emotions and adjectives.



To analyse further the women's emotions, two radial graph charts (**Fig.6.30.**) were developed for questions one through six (larger images in Appendix N). Radial graphs were selected as they effortlessly delivered visual data, allowing information to be accessed swiftly. One graph focused on questions about the design, and the other on the women's responses to the colour combos. Positive emotions filled the portion, while depleted slices signified negative emotions. A specific colour demarcated answers for each fit model.

A word cloud was established from the 18 opposite-pair adjectives to visualise the emotional responses graphically. Sticky notes were added, with each colour representing a specific model's response. Responses for questions eight through ten were subsequently cross-examined with the results from the participant reviews in Section 9.5. to evaluate and reflect on the participant's experiences.

6.1.3.3. Prototype Development

Fit model assessments of the designs were used to amend and inform the prototype development. The prototype development stage aimed to develop the initial BWD&DP further by undergoing the "Pattern & Prototype Development" phase. Information from prior methods fed into this stage, supporting Aim #2, objective 2D, to 'investigate ways of integrating technology into the bra'. The design-researcher investigated the BWD&DP through design practice, materials, 3D printing, and development techniques (Section 9.4.). Hall asserts that (2020, p. 218) 'the researcher's experience of the design process [is] central to deriving insights' because of the first-hand knowledge gained. Therefore, meticulous documentation of the process provides rich data for reflection. Two prototypes were completed within two months (see timeline **Fig.6.4.**, p.149).

Design Production

Prototype development required a range of materials, tools, and machinery. When specific machinery was unavailable, it presented an obstacle that necessitated a unique design development approach. For example, the design-researcher did not have access to a 3D printer, so she explored 3D pen options, which changed the development process. Utilising a 3D printer would change the D&DP as it requires more time in the

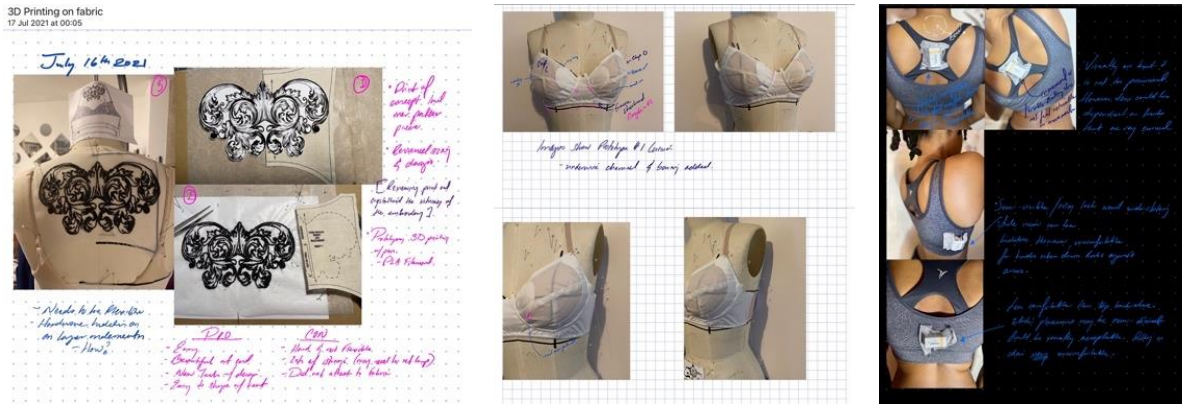
digital space, additional testing of filaments, longer print times, different approaches and skill sets. Nevertheless, it was essential for the design-researcher that the design aesthetics remained true to what the fit models were shown.

Part of prototyping essential to bra making is the fitting. Unable to fit on a live model, the designs were physically created to fit the design-researcher. In this manner, she became a *wearer*, reflecting on the garment-body experience using a first-person perspective. This step provided her with insights into the BW physical comfort.

The prototyping process consisted of designing, draping, cutting, digital and physical component layouts, wiring and testing, and many more explorative and iterative methods. To analyse the process, a method grounded in reflection was imperative.

Annotated Portfolio

Fig.6.31. Digital notes during product development.



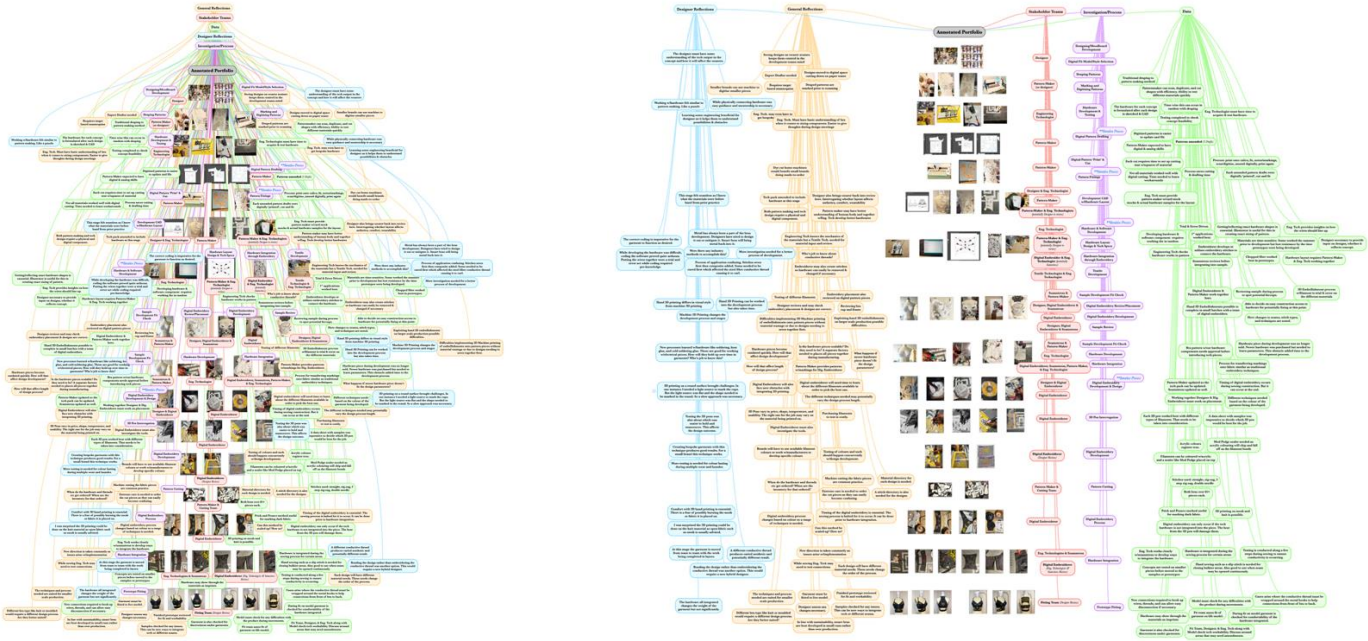
The 'Luisia' and 'Lavinia' BW prototype samples were developed in tandem. Pictures and digital notes were used to record the progression (**Fig.6.31.**). An experimental annotated portfolio (Hall, 2020) was utilised to analyse and reflect on the process. To 'create designerly insights from experience', Hall (2021, p. 45) amended Gaver and Bower's (2012) annotated portfolio approach. The original method, utilised in RtD, explicates groups of design objects that cannot speak for themselves; by conducting an annotated portfolio, designers can explain the choices that go into designing (Gaver and Bowers, 2012). Thus, accompanying notes – annotations – are necessary to help viewers understand the D&DP. Importantly, Gaver and Bower expressed that the annotated portfolio could take many forms. The annotated portfolio facilitated the development process documentation through the organisation of images and notes, providing 'a systematic record of [material] interactions and decisions' (Dixon, 2020, p. 187) by the design-researcher. This process facilitated meaningful reflection as the designer-researcher recounted what she did and why, to provide a sound textual argument for the proposed D&DP. The process mapping exemplifies Dewey's recommendation of 'holistic understanding' (Dixon, 2020, p. 194).

Fig.6.32. Three stages in developing an experience-centred Annotated Portfolio
Source: 'TAKING NOTE: Annotated Portfolio as a Method to Analyse the Experience of Design Research Practice' (Hall, 2020)

ANNOTATED PORTFOLIO THREE STAGES	
REFLECTIVE	Self-reflective information about what happened and why
THEMATIC	Themed insights from zoomed-in experiments
HOLISTIC	Over-arching conclusions

Hall (2020) established three stages for the experiential annotated portfolio (**Fig.6.32.**). In the reflective stage, images were organised vertically, with added visuals placed horizontally. Annotations in the form of coloured notes were made alongside the images. Next, the coloured notes were organised into themes in a table format in the thematic stage, providing more precise insights. Lastly, the images were combined to give an overview of the holistic stage. **Fig.6.33.** illustrates the first two stages from the BW design annotated portfolio (see Appendix O for all three stages).

Fig.6.33. Experience-Based Bra Design Annotated Portfolio Analysis.
Left: Image of reflective stage. *Right*: Image of thematic stage.
**Images are not meant to be legible.*



6.1.3.4. Collaborative Review Focus Group

During the "Pattern & Prototyping Development" phase, a collaborative review was used to re-engage the participants in the BWD&DP to critique the prototypes. Their integration at this phase is essential, as their feedback and critiques either progress the D&DP or trigger an iterative loop, returning to the beginning of the development phase. Ideally, this method would have occurred in person, allowing the participants to

interact with the prototypes. However, as this was not possible, a heavily visual presentation was necessary. The aim was to ascertain the participants 'attitudes towards the aesthetics and functional aspects, information about the context in which they will experience the product, and the types of pleasure[75] or displeasure' they believe the design will create (Jordan, 2000, p. 45). As discussed in the methodology (Section 5.4.2.), an assessment tool is necessary that combines the consumer needs and potential experience with the prototypes. Thus, the BWFSEA consumer needs model and the Four Pleasures framework were used to assess participants' feedback (Section 9.5.2.).

Collaborative Review Development

The collaborative review began by succinctly reviewing the BW field and participants' prior engagements from the *Define* stage. Due to the time between activities, it was necessary to remind participants about the research. As new participants were partaking, updating them on the field was best. Following the introduction, three sections for the collaborative review ensued (**Fig. 9.27.,** p.295 and **9.29.,** p.299). First, the women were introduced to one style shown on the digital fit models to review the designs on figures closer to their own. This was also an opportunity to introduce the various aspects of the design. Then images featuring close-ups of the technology hidden within the designs were shown before moving on to images of the finished garment on dress forms. Last, images of the garment on the design-researcher were shown with and without outer clothing, providing examples of the bras' discreetness beneath garments. Throughout each slide presentation, the women were asked to discuss their opinions, whether they liked or disliked certain features, if they would wear them, what they would change, and how they believed the designs would feel when worn.

Recruitment of Participants

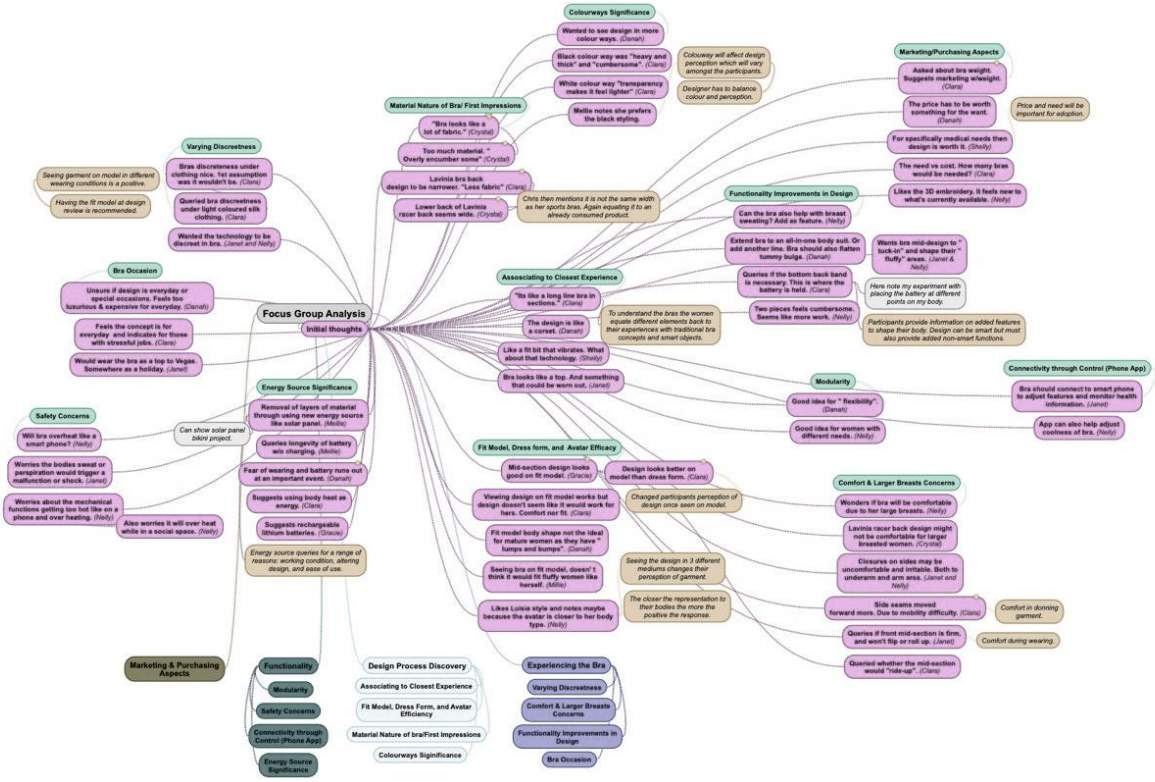
Previous participants were contacted and invited to participate or share the call for participants for the collaborative review (**Table 6.36.**, p.188). Nine participants partook in the review. For five of the women, this was their first activity in this study.

Data Analysis

The collaborative review lasted three hours and twenty minutes. Data were analysed using a visual mind mapping method (**Fig.6.34.**). Participants' comments were assessed and grouped into categories, with the design-researcher including notes made from the collaborative review. The data was evaluated further and subsequently composed into themes. Results are articulated in Section 9.5.1.

[75] Section 5.4.2.1. Designing for Experience discusses the need to understand the types of pleasures to be had with a product and how it affects the experience.

Fig.6.34. Collaborative review analysis using mind mapping.
**Images are not meant to be legible.*



6.1.4. Reflect

The *Reflect* stage addresses Aim #3, 'To interrogate the different types of 'experiences' (i.e., the design-researcher and the wearer) that aid in informing BWD&DP' (**Fig.6.35.**). As such, the design-researcher is placed within the research – having 'insider knowledge' (Gray and Malins, 2004, p. 23) – where their subjective and objective perspective becomes essential to its unfolding. Although the participants were centred in this study, their limited interaction with the materials made the design-researchers' experience with the materials essential. The design-researcher must reflect on their experience with the materials from the designers' and the potential wearers' perspectives. This way, she can provide the participants with the necessary insights during fit sessions and collaborative reviews to help frame their assessments.

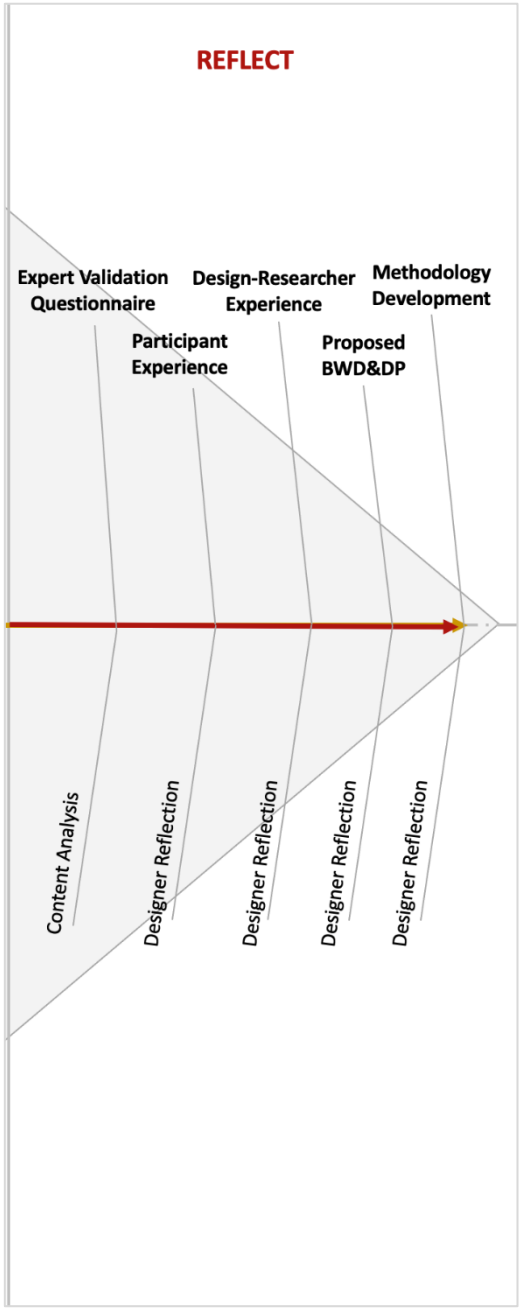


Fig.6.35. Reflect section of the Four-Stage Process.

This study's RtXD and RfXD approach is underpinned by reflection-in-action and on-action (Section 5.5.). Kimbell (2009, p. 12) affirms that 'in the practice approach design cannot be understood without people and their practices […]. In order to see the connections between design-as-practice and design-in-practice, researcher must go and look for them'. According to Deweyan Pragmatism, the situation is essential to inquiry and experience (Section 5.2.); thus, it must be accounted for within the reflection. The design-researcher's background, skills, access, and the participants are crucial to the research experience. Furthermore, undertaking the research without industrial or academic collaborations during a global pandemic placed the research in a distinct space. Dewey's notion of technology, inclusive of 'resources, means, or instruments', highlights that technologies can function as constraints or supports, enabling the researcher to transform the situation (Biskjaer and Dalsgaard, 2012, p. 69). Although seen as a constraint having to pivot processes and approaches, the available technologies equipped the research with a distinctive and incomparable perspective.

Designing *for* and *with* Women

In this section, the design-researcher reflected on designing *with* and *for* women. To reflect on designing *for* women, the design-researcher reflected on the women during the research phase of the BWD&DP. She reflected on how the wearers experienced the workshop, digital dialogue, and interviews. The workshop and digital dialogue became spaces where the women interacted with each other. They revealed details about their favourite bra and why they enjoyed it. Furthermore, they provided insights into themselves, such as personal life events, partners, and health situations. As such, the spaces became one of sharing, with frequent laughter. Similarly, in individual interview sessions, the women became insightful, often noting they never thought deeply about why they gravitated to specific bras or how their past experiences affected what they were now wearing.

To reflect on designing *with* women (Section 10.2.3.), the design-researcher reflected on the concept, prototyping, and development phases. The collaborative design, individual fit sessions, and collaborative review sessions had built-in questions to get the participants to reflect on their experience of the process. Those notes were utilised to interpret their experience as part of the BWD&DP.

Design-Researchers Experience

The design-researcher reflected on her experience with the materials, wearers, and the D&DP (Section 10.2.1.). Vital to the BWD&DP development is the researchers' experience, as she becomes the medium to interpret multiple points of experience. Since the field of BW is developing, scarcely many people have experienced marrying electrical hardware with delicate materials in bra design. As both fields are grounded in engineering and need technical expertise, they have inherent parameters that must be navigated. Therefore, the design-researcher journaled and reflected on the areas of tension between the two, from the understanding that happens as a lingerie designer, learning how the hardware and software work, and how the hardware and lingerie materials can be adapted for cohesion (Section 8.5.). Examination occurred by reflecting on the design practice portion and "annotations" of pictures and journaling. The design-researcher also reflected on balancing the needs of the wearer versus the needs of the materials through developing toiles and first-fit sample prototypes. Placing the wearers' bra experience as the pinnacle without their physical interaction with the process proved difficult. However, it provided an opportunity for novel digital approaches.

Developing a Woman-Centred Methodology

Within the *Reflect* chapter, through reflection, the woman-centred methodology is explicated (Section 10.3.2.). A review is presented of the multiple approaches that enabled centring the participants as experts and focusing on the value of their experiences. Throughout the process, empathy and experience intertwined (Section 10.2.4.), providing approaches that allowed for designing meaningful products.

Reflections on the BWD&DP Validation

Contour lecturers and fashion technology experts partially validate the amended BWD&DP (Section 10.1.2.5.). Lecturers were selected because they have industry and academic experience engaging with commercially viable products and fostering future thinking designers. The fashion technology experts had experience in outerwear and abstract concepts, but none in the lingerie field. Few experts have experience developing smart bras or BW, so it was best to gain insights from the two fields. A two-to-three-minute video was created explaining the amended BWD&DP (**Fig.10.3.**) and project-specific terms. Five questions were provided on the novelty of the D&DP, practice approaches and methods, application, and industry applicability (Appendix Q). Output from the validity interviews was reviewed and reflected on (Appendix R). The external expert validation was based on whether the BWD&DP could be generalised to the industry.

6.2. Participants Overview

Table 6.36. Participants throughout the study.

Participants *n* =15	Participative Workshop	Digital Dialogue	Interviews	Design Workshop	Fit Interviews	Collaborative Review	*Number of Activites Engaged In*
Clary	*		*	*	*	*	5
Ellen	*						1
Lilly	*						1
Janet		*	*	*	*	*	5
Kimberly		*					1
Deloris		*					1
Tori		*	*	*			3
Melly		*	*	*		*	4
Donna			*				1
Sherry		*	*	*	*	*	5
Nelly-Ann						*	1
Garcelle						*	1
Deena						*	1
Moesha						*	1
Crystal						*	1
Total Per Method	3	6	6	5	3	9	

The research was initiated to explore the bra experiences of mature Black and white women. Since most of the bra and lingerie research is based on white women, the literature review needed to branch out, employing interdisciplinary research to comprehend similar or dissimilar experiences of Black women. In doing so, the researcher was often questioned whether this was a comparative study, which was not the original intent. The aim was to ascertain the varied experiences and explore whether these experiences could be used as a launching point to design BW. After completing the questionnaire and receiving disproportionate responses from white (81%) and Black (10%) women, the researcher pivoted to a different approach. She conducted generative workshops, separated by 'race'. No participants showed up for the first workshop for white women, and three Black women came to the later session (6.1.2.1.). Listening to the Black women crystallised that their experiences were different and worthy of study without being

othered. The decision was then made to focus solely on mature Black women. **Table 6.36.** showcases the number of participants[76] within each activity and the number of activities they participated within.

6.3. Ethics

An ethics form from the university's guidelines was developed and reviewed by the college and the university's ethics department. A separate form was designed for each instrument, i.e., the online questionnaire, workshop, interviews, fit models, and focus groups. The ethics forms and research honoured six principles from 'The Research Ethics Guidebook'[77]: quality and integrity, informed consent, confidentiality and anonymity, voluntary participation, harm avoidance, and impartiality. Due to Covid-19, methods that directly engaged face-to-face were amended in the updated ethics forms and approved. This study received ethical approval from the University's Research Ethics Sub-Committee. Participants received an honorarium[78] for their time.

6.4. Researcher Positionality

'…all research is fundamentally grounded in the experiences of the authors and the research participants'. (Generett and Jeffries, 2003, p. xii)

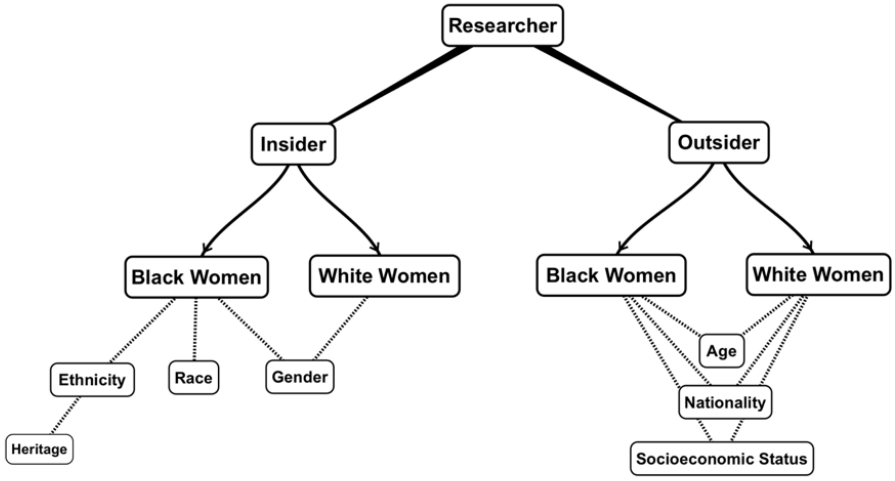
Practice research necessitates impartiality, requiring the design-researcher to demonstrate bias control (Prochner and Godin, 2022). As an objective and subjective design-researcher, I am placed in the research as an actor and co-interpreter. Collaborating with participants requires the researcher to question their subjectivity, which impacts their approach and understanding of the data. The researcher must locate themselves 'in relation to three areas: (1) the subject […], (2) the […] participants, and (3) the research context and process' (Holmes, 2020, p. 2). This meant knowing how my educational, professional, and personal background may impact my approach, the questions asked, and my interpretation of the data (Saldana, 2014). As Generett and Jeffries (2003) quote above identifies, this research entangled the participants' and my experiences as we co-created new experiences. Therefore, as Holmes (2020, p. 2) asserts, 'reflexivity […] is an essential part of […] positionality' and must occur when researching with participants. This section details my position as a design-researcher.

Fig.6.37. illustrates my position as an insider/outsider (Hayfield and Huxley, 2015). While the research eventually focused solely on Black women, the figure still indicates my position to white women as part of my reflexivity. Groves (2003, p. 109) acknowledges, 'only recently have we begun to ask questions that

[76] Out of the fifteen participants, seven worked in the health care field, two were furloughed, and two were able to work from home. Three declined further participation due to close Covid-19 related deaths, and two could no longer participate due to work.
[77] http://www.ethicsguidebook.ac.uk/Acknowledgements
[78] Honorarium was funded through the Bristol & Bath Fellowship Fund.

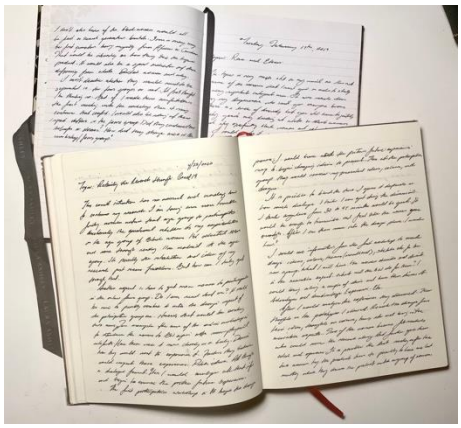
probe how our project would look differently if someone from a different race or ethnic background collected the data and analyzed it'. As I reflected on that notion, I also reflected on how the project would have been valued, received, and evaluated had white women been centred. Nevertheless, I reflected on how the women may see me and how I saw them, which could create bias.

Fig.6.37. Researcher Positioning Insider/Outsider



As a trained and experienced designer, I began the research to *fix* a problem by helping to design and develop better commercially suited BW for the future. My initial focus was on the product, as I was unsure of the study's target participants. However, once the decision was made to focus on this invisible age group (mature women), further inquiry brought to my attention the almost non-existent research on Black women and lingerie. While undertaking the contextual/literature review, I realised I was no longer attempting to *fix* the original problem. Instead, I found my experiences and guilt as a Black woman lingerie designer and researcher influencing my desire to transform the situation into one where those "invisibilised" were made visible and given voices. By centring and humanising Black women, there is potential for the 'positive stereotypes [to] bring better treatment' (Hill Collins, 1986, p. s17). This realisation allowed me to re-evaluate and critique the Deweyan Pragmatist framework, woman-centred and pragmatist approaches, and developed a design research approach where reflexivity and design-researcher introspection (Xue and Desmet, 2019) were continuous. Additional methods, like journaling my reflections, throughout were advantageous in assisting in limiting bias (**Fig.6.38.**).

Fig.6.38. Photos from reflective journals.



In researching with participants, I did not immediately register my position as an 'outsider' as a youthful Black Jamaican American woman studying mature Black women. Generett and Jeffries (2003, p. 3) remind us that 'Black women as researchers … are often, more so than any other researchers, learning and

experiencing for the first time how to view the world from the center'. During readings on ageing and body studies of MW, I noticed the researchers were mainly *insiders*, sharing similarities of age and 'race' with the participants. Prior research advised that 'how you look should be compatible with the world of the people you will interview' (Charmaz, 2014, p. 133). This led me to examine how sharing a similar 'race', and possibly Caribbean heritage, may influence how some women reacted to me and how I reacted to researching women of similar age to my mother and aunts — my elders.

A researcher's place within a study can oscillate depending on several factors throughout the study (Milligan, 2016). Within this study, I moved from an outsider to an insider and an 'inbetweener', a phrasing used by Milligan (2016) to note the researcher and the researched co-constructing knowledge and, in this case, experience. For example, in discussing physical bra-wearing experiences, I am an "insider" as a woman; however, I am also reminded of my "outsider" status as a designer when Clary asked me, 'Why are bra straps made to fit so uncomfortably?' It had not dawned on me that my background would come into play in a workshop around their bra experiences. They saw me as a designer with expertise, knowledgeable to answer their bra questions. Milligan advises that the researcher should examine their positioning from their own viewpoint and how the participants view the researcher. In this manner, I became conscious of how the participants would view me and how that would affect the research.

Bryman (2012) highlights that reflexivity includes the researchers' cultural and social context. During the first workshop, there were a few moments where I realised, I was censoring myself and holding back, unlike how I practised. It began with calling the participants by their first names — a practice unfamiliar and uncomfortable for me, as I was raised to refer to my elders as "Mrs Last-name". Reviewing the transcripts, I realised I rarely called the women by their names and fumbled over the few attempts. This is grounded in my Caribbean upbringing and consciously not wanting to engender a power imbalance that could restrict and influence how women opened to me. Reflecting on the experience, I realised that referring to them as "Mrs Last-name" was not just my way of showing them respect but imparting some gratitude during the interaction. Groves (2003, p. 109) reaffirms, 'the researcher is a part of the research process, and we, therefore, must be aware of how we influence the participants and how the participants influence us'. Throughout the research, I became cognisant of this mutual influence.

Although the women may have seen me as an "outsider" who is the expert, I did not have that perspective. In approaching this study, I viewed the participants as having expert knowledge of their own experiences with the bra (Section 5.3.1.). Furthermore, in facilitating dialogue with them through selected methods, we would co-construct new knowledge in a non-hierarchical research relationship that feminist research advocates. Dwyer and Buckle (2009, p. 62) assert that researchers can create a non-hierarchical atmosphere by 'bringing their personal role into the research relationship by answering participants questions, sharing knowledge and experience, and giving support when asked'. An example of this during the study is my self-disclosure, sharing my bra experiences, and informing that this experience and research topic is new to me.

Lastly, navigating this research through a Black Feminist Thought lens necessitates reflecting on the outcomes. Groves (2003, p. 107) declares, 'researchers must question who ultimately benefit from the project; how the research could possibly be interpreted and used when in the hands of the dominant'. This is an area I have toiled over as I intend for marginalised women to benefit from BW and smart bras developed *with* and *for* them. It bears repeating, as I do not argue that Black women should have separate bras designed for them. Instead, I argue that understanding their experiences should also be a part of designing bras.

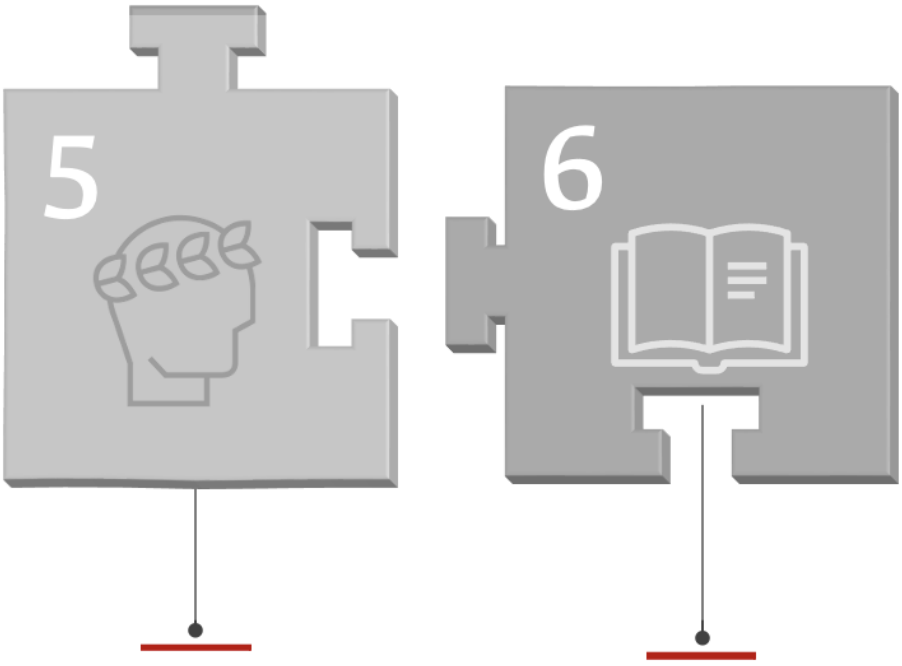
6.5. Summary

Chapter 6

- ***Introduced*** readers to the research design guided by the Four-Stage Research Process (**Figure 6.1.**), which provided a framework for practice following the initial BWD&DP (**Figures 7.19 and 7.20.**).
- ***Described*** the mixed-method sequential process with multiple fashion and HCD methods conducted within each research stage, underpinned by a pluralistic approach.
- ***Demonstrated*** reasonableness, explicating why each method was selected.
- ***Detailed*** the design-researchers' positionality as an outsider, insider, and inbetweener.

PART B SUMMARY

Part B presented the Deweyan Pragmatist framework and the woman-centred and pragmatic approaches that underpinned this study's methodology. A Four-Stage Research Process helped to frame the multiple methods utilised in actualising the BWD&DP.

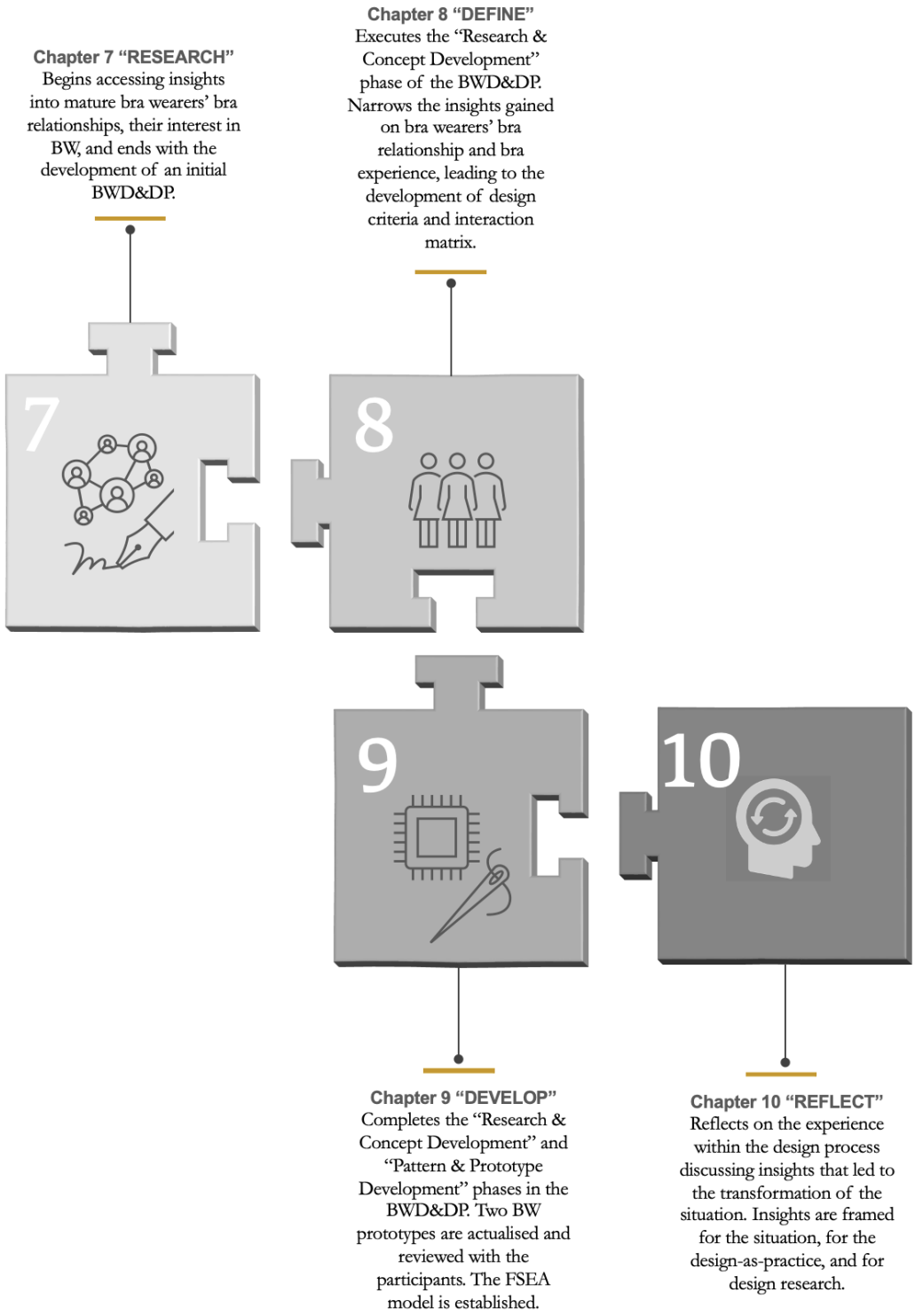


Chapter 5
"METHODOLOGY"
Introduced the Deweyan Pragmatist Framework underpinned by a pragmatist ontology that enabled a Woman-Centred and Pragmatic Approach facilitating research-*through*-design and research-*for*-design.

Chapter 6
"RESEARCH DESIGN"
Presented the explanatory sequential research design structured by the Four-Stage Research Process (Research, Define, Develop, and Reflect).

PART C: Research Findings

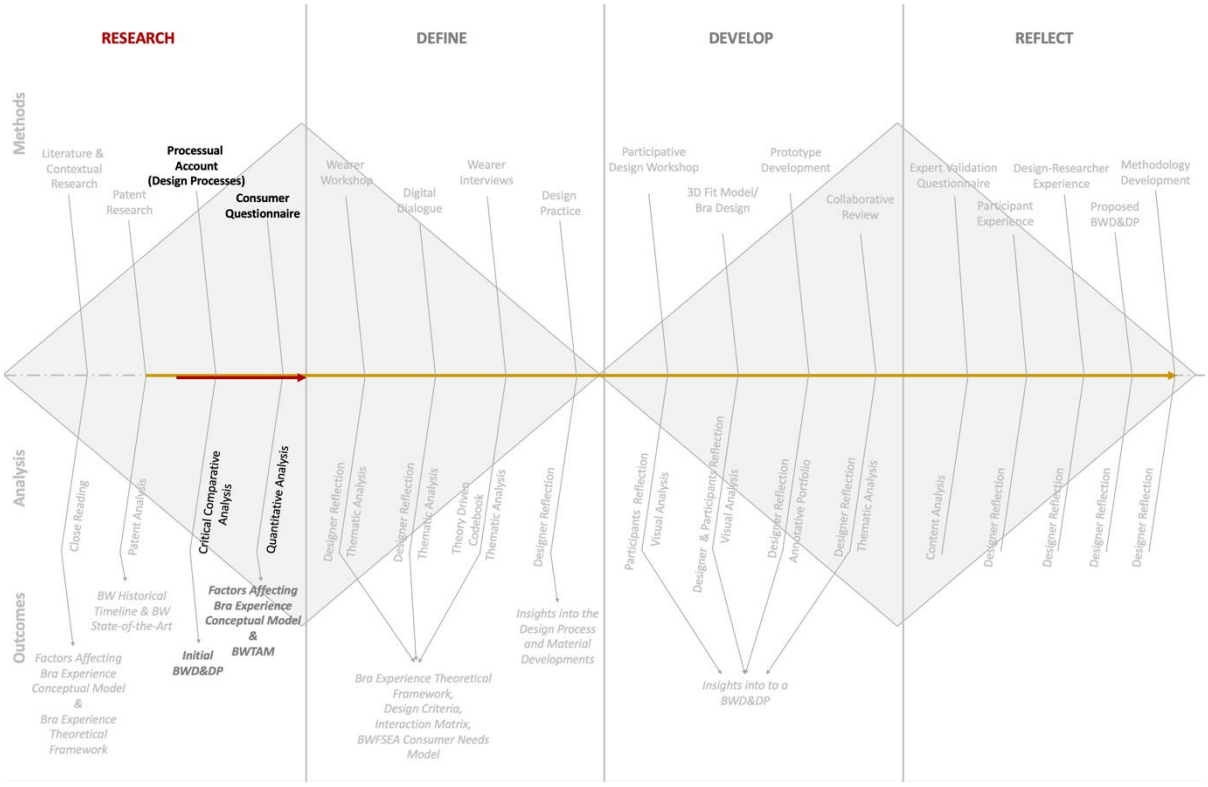
Part C comprises four chapters (Chapters 7, 8, 9, and 10) segmented utilising the Four-Stage Research Process discussed in Section 6.1. Each chapter provides the reader with insights into the transformation of the indeterminate situation following the initial BWD&DP.



7

7. RESEARCH

Table 7.1. Chart illustrates the *Research* stage and the corresponding result sections discussed in Chapter 7.



Chapter 7 is situated within the *Research* stage of the Four-Stage Research Process (**Table 7.1.**). This stage engendered to collect generalisable data from a large group of Black and white mature women (MW) on their bra experience and interest in BW. The questionnaire provided information that allowed the design-researcher to make sense of the research situation (Dalsgaard, 2017). While the questionnaire produced two valuable concept charts (**Fig. 7.7.**, p.208 and **7.12.**, p.214), it also encouraged 'emergent chains of thought and action' (Gaver *et al.*, 2022, p. 3) that influenced the study's progression.

This chapter is divided into three parts: 1) comprehension of the bra-wearing experience and Factors Affecting Bra Experience Conceptual Model (7.1.), 2) evaluation of BW acceptance by extending the Technology Acceptance Model (TAM) (7.2.), and 3) development of a BWD&DP (7.3.) – partially informed by findings from part 1 and 2. Together these sections contributed to the research aims:

- Aim #1: To comprehend whether the wearers' experience is significant in developing a BWD&DP.

- Aim #2. To investigate approaches that can be utilised to inform the design of BW that improves the wearers' experience.

Readers should note that the statistical analysis, including charts and extra findings, is available in Appendix J.

7.1. Mature Women's Bra Experience

This section produces an account from the questionnaire concentrated on Aim #1, objectives 1A through 1C:

Aim #1: **To comprehend whether the wearers' bra experience is significant in developing a BWD&DP.**

1a. Identify the factors that affect how MW experience the bra.

1b. Investigate whether Black and white women experience the bra differently.

1c. Explore the current bra experiences of MW.

The following section reports on the participants' demographic profile (7.1.1.), results from the questionnaire (7.1.2.), a summary of constructs (7.1.3.), the Mann-Whitney U test to examine differences between Black and white women, and the validation of the Factors Affecting Bra Experience conceptual model (7.1.4.). SPSS v26 was utilised to access descriptive statistics (J.1.1.), reliability analysis of constructs, assumptions of normality, conduct an exploratory factor analysis (J.1.2.), and Mann-Whitney U analyses. Mann-Whitney U test was used to explore the relationship between socio-cultural and physiological influences on bra-wearing experience, the effect of the bra-wearing experience on factors affecting sense-of-self, and statistical exploration of the Factors Affecting Bra Experience conceptual model. SmartPLS v3.3.2 was employed with Partial Least Square (PLS) analysis to develop the conceptual model. **Table 6.9**. explains the programs and analyses (Section 6.1.1.1.).

7.1.1. Demographics of Sample

The questionnaire received 297 responses, with a usable total of n =181[79] based on 74% of the questionnaire completion. Questionnaire results demonstrated that 52% of participants were between the ages of 45-49, 27% between 50-54, 15% between 55-59, and 6% between 60-64. The majority were based in the U.S. (41%), the U.K. (39%), Canada (7%), Europe (7%), and other (5%), attributed to Australia and New Zealand. Locations were in line with the focus on Western women. Women of "White/European" ethnicity represent the largest group at 81%, followed by women who are "Black/African/Caribbean" at 10.4%, "Mixed" at 7%, and the remaining ethnic groups at less than .5% each. Education level was selected by the

[79] Participants were not required to answer all questions; therefore, the number of responses varies. Participants who missed more than 15% of the questions were removed. Pairwise deletion was used for questions missing answers resulting in a fluctuation of n values.

highest achieved, with the women being educated, many receiving a bachelor's 33%, a master's 26%, and a doctoral degree 13%. Income varied from 23% 50-70K, 20% 30-50K, and 15% 100-150k, placing many participants between the lower and upper-middle-class range. Almost 70% were married or partnered, with 20% single. See **Table 7.2.** for the complete demographic statistics.

Table 7.2. Demographic Statistics

Demographics	Frequency (n)	Percentage (%)
Age (n=182)		
45-49	95	52.2
50-54	49	26.9
55-59	27	14.8
60-64	11	6.0
Location (n=180)		
U.S.A	75	41.2
Canada	12	6.6
U.K.	71	39.0
Europe	13	7.1
Other (please specify)	9	4.9
Ethnicity (n=182)		
Mixed (Please Specify)	12	6.6
East Asian and other Pacific Islander	1	0.5
American Indian/Native American	1	0.5
South Asian	1	0.5
White/European	148	81.3
Black/ African American/ African/ Caribbean	19	10.4
Relationship (n=182)		
Other (please specify)	4	2.2
Single	35	19.2
Partnered/Married	126	69.2
Widowed	1	0.5
Divorced	16	8.8
Education (n=181)		
Some High School/ GCSE	4	2.2
High School Diploma/ A-Levels	2	1.1
Some College	16	8.8
Certificate Degree	17	9.3
Associates Degree	11	6.0
Bachelors Degree	60	33.0
Masters Degree	47	25.8
Doctoral Degree	24	13.2
Income (n=181)		
Under 15,000	6	3.3
Between 15,000 and 29,999	15	8.2
Between 30,000 and 49,999	36	19.8
Between 50,000 and 74,999	41	22.5
Between 75,000 and 99,999	23	12.6
Between 100,000 and 150,000	33	18.1
Over 150,000	27	14.8
Menopausal Status (n=180)		
Pre-menopausal	90	49.5
Menopausal	44	24.2
Post-Menopausal	46	25.3

7.1.2. Results and Discussion Summarised

The questionnaire explored MW breasts and bra experience gathering current information to inform experience-centred BW design. Here a presentation of the findings is discussed on MW body-image (7.1.2.1.), breast perception (7.1.2.2.), perception of bras (7.1.2.3.), and unwritten bra rules (7.1.2.4.).

7.1.2.1. Mature Women's Body-Image

Clothing provides identifiers that can affect how the wearer is viewed (Roach-Higgins and Eicher, 1992), given that 'when we dress, we do so to make our bodies acceptable to a social situation' (Entwistle, 2000a, p. 81). Thus, body-image is significant for MW as their bodies change during this life stage, and clothing can affect their self-perception (Liechty, 2012). In this study, 54% of MW believed their bodies had changed for the worse with age, and because they were older, their bodies were less attractive (57%). Additionally, the women noted that their body-image was most influenced by romantic partners (60%), society (51%), peers/friends (47%), and family (38%). Szmigin and Carrigan (2006) similarly found that MW's style was informed by their friends and family. Society's role is significant as MW are invisibilised or stigmatised in media, signifying a need to 'redefine [them] in the eyes of the apparel industry' (Mohylsky, 2011, pp. x–xi). In lingerie advertising, mature bodies are still only marginally represented. MW noted that visual representations of themselves influence their purchasing (Borland and Akram, 2007; Kozar, 2010; Mohylsky, 2011). Regardless, in this study, 57% of MW agreed that wearing lingerie they liked made them feel better about their bodies – reaffirming that clothing affects wearers' emotions (Klepp and Storm-Mathisen, 2005; Klepp and Rysst, 2017).

Clothing is vital to the experience of ageing (Twigg, 2007), with many MW unable to resist conforming to societal ageing norms (Zeilig and Almila, 2018). This study's results illustrate that 49% of MW agreed that the appearance of their clothing was important to their identity. Although 76% believed a confident woman was beautiful no matter what she was wearing, others' perceptions played a role, as almost half (48%) noted being aware of how others viewed their clothing. The women were also aware of viewing others, with 48% agreeing they dressed similarly to women of similar ethnicity. While there are several papers on MW and clothing, there is still a gap in investigating Black mature women's fashion experiences. The women agreed that they did not dress their age (46%), dress to look younger (52%), or look to older women as inspiration on how to dress (55%), indicating further research on their clothing desires is necessary. Birtwistle and Tsim (2005) suggest that MW dress for their cognitive age, which tends to be 20 years less than their actual age[80]. MW desire clothing to help them navigate their ageing bodies (Mohylsky, 2011; Romans, 2018), as clothing affects their sense-of-self (Thomas and Peters, 2009).

[80] Section 4.2.2.3. provides more information on cognitive age vs chronological age.

7.1.2.2. Breast Perception

Risius et al. (2014) advocate for more research on MW's bra and breast experiences. This study's results were compared to their seminal study on MW's bra and breast perceptions. The findings show that breasts are an essential part of MW's identity (67%), sexuality (80%), and femininity (77%). Since turning 45, participants noticed breast changes, such as size increase (26%) and shape change (32%). In comparison, 51% of participants noticed a size increase in Risius et al.'s study. The percentage difference may be because 53.68% (*n*=146) of this study's participants had not experienced menopause which can change breast size (Chrisler and Ghiz, 1993). Even with the breast changes, 40% were happy with their breast appearance, while 30% were slightly unhappy, and 7% were really unhappy (**Table J.3.,** p.446). In Risius et al.'s study, only 7% were happy with their breasts, and 8% were unhappy. The women in this study were possibly happier with their breasts because a larger percentage had not undergone menopause. Nevertheless, 70% agreed that the appearance of their breasts made them feel feminine. The women's feelings about their breasts may inform how they purchase and experience bras.

7.1.2.3. Perception of Bras

The study shows 42% of MW purchased bras for function and comfort. Many noted that the reasons they wore bras were because they had large breasts (51%), they felt comfortable wearing one (47%), and because it made their clothes fit better (45%). In fact, 49% of women agreed that the bras they selected affected what outer clothing they purchased and wore. While clothing plays a vital role in their appearance, so do their bras. The women agreed that they purchase bras that reflect their identity (40%) and to feel sexy (33%). However, many found bras marketed to MW to be plain/functional (23%), too matronly (27%), unflattering and not stylish (18%). Sukumar (2007, p. 269) suggests, 'the brassiere is a mirror of the evolving identity of women and their bodies. It [symbolises] their changing self-image, their roles in society and their presentation of self'. The bra is still a significant garment for MW (Risius, 2012); however, without explicitly designed bras, they are forced to conform to societal expectations, rather than purchase or trial bras they like.

7.1.2.4. Unwritten Bra Rules

Sukumar (2007) posited that there are unwritten bra rules to which women adhere. These unwritten bra rules teach women what bra styles, colours, and materials, are appropriate and how they must be worn. Tsaousi (2011, 2016) contends that knowing the *right* bras to wear is part of a woman's cultural capital. This study aimed to understand what rules MW may be utilising to inform their bra practices. **Fig.7.3.** showcases the bra images and colours shown to the participants (see **Tables J.4.,** p.447 and **J.5.,** p.448 for responses). The study found that MW mostly wore non-padded T-shirt (37%) and non-padded plunge (32%) bras. Similarly, bra researchers found that MW preferred non-padded underwire bras (Liang, 2008; Risius *et al.*, 2014). In this study, non-padded plunge bras (25%) were selected as the most appropriate for social events,

while non-padded T-shirt bras (34%) were the most appropriate for professional events. Triangle bras were selected most for the style they would like to wear but do not. Triangle bras are marketed as comfortable wire-free options but provide minimal lift. Moreover, triangle bras were selected as the number two style least appropriate for professional events (26%) and believed to be inappropriate for MW to wear (28%). Sports bras were selected as the least appropriate for social events (40%) and professional events (30%).

Fig.7.3. Bra samples and colours shown in questionnaire.

The bra colour is also a part of unwritten bra rules. The women selected during daily social engagements they would not wear yellow (55%), red (33%), rich purple (23%), or pink (23%) coloured bras (see **Table J.5.**). During professional engagements, yellow (62%), red (44%), rich purple (29%), and pink (30%) were selected as the least appropriate. Three colours (yellow 46%, red 28%, and pink 26%) were selected as inappropriate for MW. The selection of these colours as inappropriate for MW could reflect why they were also not worn in social or professional engagements. Colours such as 'pink, purple, blue, [and] yellow' are seen as youthful and not for MW (Sukumar, 2007, p. 277). By way of contradiction, outside of the top three selections (black 70%, white 40%, and beige 48%), the colours they most wanted to wear were grey (37%), rich purple (36%), and red (34%). The selection of the latter colours, red and rich purple, suggests that MW limit what colour bras they wear due to social expectations.

The findings discussed within this section indicate that the bra is an essential garment in the lives of MW. The bra enables MW to present their ideal identity. Furthermore, the bra permits them to be comfortable physically and psychologically and allows them to present themselves as they desire. Although their breasts

have changed due to ageing, MW were still happy with them and desired bras for their mature breasts. Understanding the unwritten bra rules MW follow is essential as it informs the bra styles and colours, they select for professional and social events.

7.1.3. Summary of Constructs and Analysis

Here the constructs for the bra experience (**Table 7.4.**) and the descriptive statistics (**Table 7.5.**) are displayed to inform the readers for the following sub-sections. **Table 7.5.** illustrates the mean response from questions used to devise the constructs for the sense-of-self factors in the Factors Affecting Bra Experience Conceptual Model (**Fig.7.6.**). Briefly, the table showcases in the BODImag1 construct, that MW agree lingerie affects how they feel and perceive themselves. Furthermore, within the BRAFemSex1 construct, MW agree they view their bras as feminine and utilise it as a tool when engaging their partners. The BRAIden2 construct indicates MW breasts maintain an importance to them with their bras affecting their outer garment selection. For further information on the statistical analysis see Appendix J, Sections J.1.2. and J.1.5. to J.1.7.

Table 7.4. Constructs for Bra Experience.
The asterisk (*) constructs were amended to new constructs.

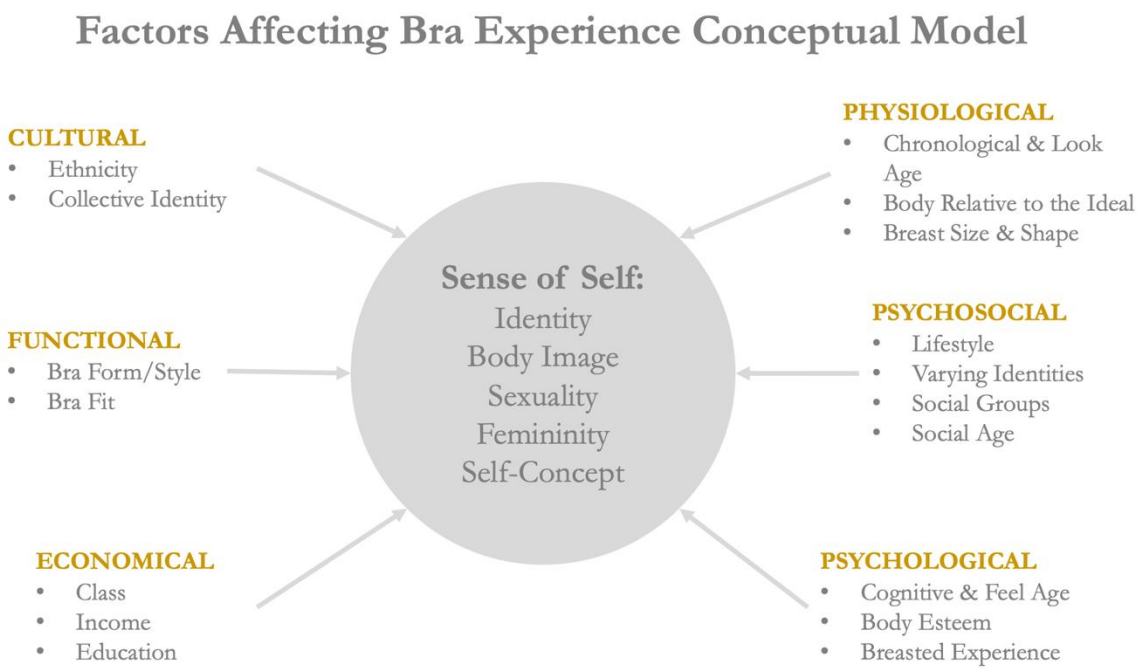
Construct	Short Hand	Definition	Sources
Age Experience	AgeExp	Construct to comprehend how ageing has affected sense of self.	Hopwood et al., 2001
Menopause Experience	MenoExp	Construct to understand how menopause has affected femininity, sexuality, and feeling womanly.	Hopwood et al., 2001
Body Image*	BodImag	Construct to understand how bra-wearing affects body image.	Kelch-Oliver and Ancis, 2011; Risuis, 2012
Body Image 1	BODImag1	A new construct combining other construct items that focuses on body image.	Newly developed construct.
Bra Femininity*	BraFem	Construct to understand how bra-wearing affects femininity.	Tsaousi, 2011
Bra Sexuality*	BraSex	Construct to understand how bra-wearing affects sexuality.	Tsaousi, 2011
Bra Femininity-Sexuality	BRAFemSex1	A new construct combining other construct items that focuses on femininity and sexuality.	Newly developed construct.
Bra Identity*	BraIden	Construct to understand how bra-wearing affects identity.	Tsaousi, 2011
Bra Identity 2	BRAIden2	A new construct combining other construct items that focuses on bra identity.	Newly developed construct.
Bra-Wearing	BRAWear1	Construct focused on understanding bra-wearing experience.	Risuis, 2012
Bra Influence	BraInflu1	Construct combining societal factors items to gauge influence on bra-wearing.	Tsaousi, 2011; Tiggemann, 2006; Grabe, Ward, Hyde, 2008

		Mean	SD	Factor Loadings	Chronbach's *alpha*	Composite Reliability	Collinearity Statistics (VIF)
AgeExp					**0.71**	**0.80**	
A45Femin	Since turning 45 has your perceptions of your femininity changed?	2.94	0.73	0.73			1.53
A45Sexu	Since turning 45 has your perceptions of your sexuality changed?	2.96	1.12	0.76			1.36
A45Wom	Since turning 45 have you felt more or less like a woman?	2.97	0.90	0.65			1.44
BIBodAttr	Because I am older my body is more attractive.	2.37	0.86	0.68			1.45
BIBodChanPOS	My body has changed for the better with age.	2.60	1.12	0.52			1.41
MenoExp					**0.68**	**0.78**	
MenoFemin	Since experiencing menopause has your perceptions of your femininity changed?	2.69	0.71	0.53			1.40
MenoSexu	Since experiencing menopause has your perceptions of your sexuality changed?	2.64	0.94	0.86			1.25
MenoWom	Since experiencing menopause have you felt more or less like a woman?	2.89	0.85	0.80			1.38
BODImag1					**0.70**	**0.82**	
Appear2e	Pretty lingerie could make a mature woman more beautiful.	3.38	1.08	0.66			1.33
BIFB	I dress to enhance and show my body.	2.93	1.13	0.85			1.41
BILing	Wearing lingerie, I like, makes me feel better about my body.	3.45	1.15	0.81			1.50
BRAFemSex1					**0.82**	**0.87**	
BBFem1c	Purchasing bras makes me feel more feminine.	2.98	1.10	0.76			1.84
BBFem1dPOS	My bras are feminine.	3.02	1.25	0.71			1.85
BBIden1d	I consider my bra collection to be more fun than boring.	2.70	1.24	0.65			1.60
BBSex1cNEG	The kind of bra I wear does not affects my sexuality.	2.66	1.19	0.81			1.54
BBSex1d	When trying to impress a romantic partner I think about the type of bra I wear.	3.41	1.15	0.81			1.76
BRAIden2					**0.74**	**0.82**	
BBFem1a	Having breasts makes me feel feminine.	3.90	0.80	0.78			1.64
BBIden1a	My breasts are a part of my identity.	3.68	1.04	0.67			1.66
BBIden1c	The bras I wear affects what outer clothing I purchase or wear.	3.11	1.18	0.53			1.20
BBSex1a	My breasts are a part of my sexuality.	3.97	0.88	0.90			1.57
BRAWear1					**0.89**	**0.88**	
WearBra3a	Wearing floral printed bras makes me feel more feminine.	2.83	1.17	0.69			1.78
WearBra3b	Wearing overly lacy bras or sheer designs makes me feel sexy.	3.16	1.21	0.90			2.22
WearBra3c	When I wear printed or 'girlish' bras I act more feminine.	2.14	0.98	0.62			2.37
WearBra3d	When I wear sexy/sensual bras I act more confident.	2.73	1.21	0.90			3.58
WearBra3e	The bra I wear affects how I act.	2.61	1.16	0.61			1.77
WearBra3f	If I am wearing a plain bra I don't feel as confident.	1.96	0.87	0.65			2.17
WearBra3g	When I wear a red bra, I feel and act more powerful.	2.18	1.01	0.64			1.88
				Outer Weights	**T Statistics**	**P Values**	
BRAInflu1							
BRAInflu1a	Family	1.63	0.81	*0.13*	3.30	0.00	1.43
BRAInflu1b	Romantic Partner	2.66	1.26	*0.44*	7.17	0.00	1.28
BRAInflu1c	Peer/Friends	2.09	1.05	*0.23*	5.93	0.00	1.66
BRAInflu1d	Media/Advertising	2.24	1.13	*0.31*	8.56	0.00	1.85
BRAInflu1e	Society	2.01	0.99	*0.23*	6.30	0.00	1.78

Fig.7.5. Descriptive Statistics

7.1.4. Bra Experience Structural Model – Discussion of Key Findings

Fig.7.6. Generic Factors Affecting Bra Experience Conceptual Model



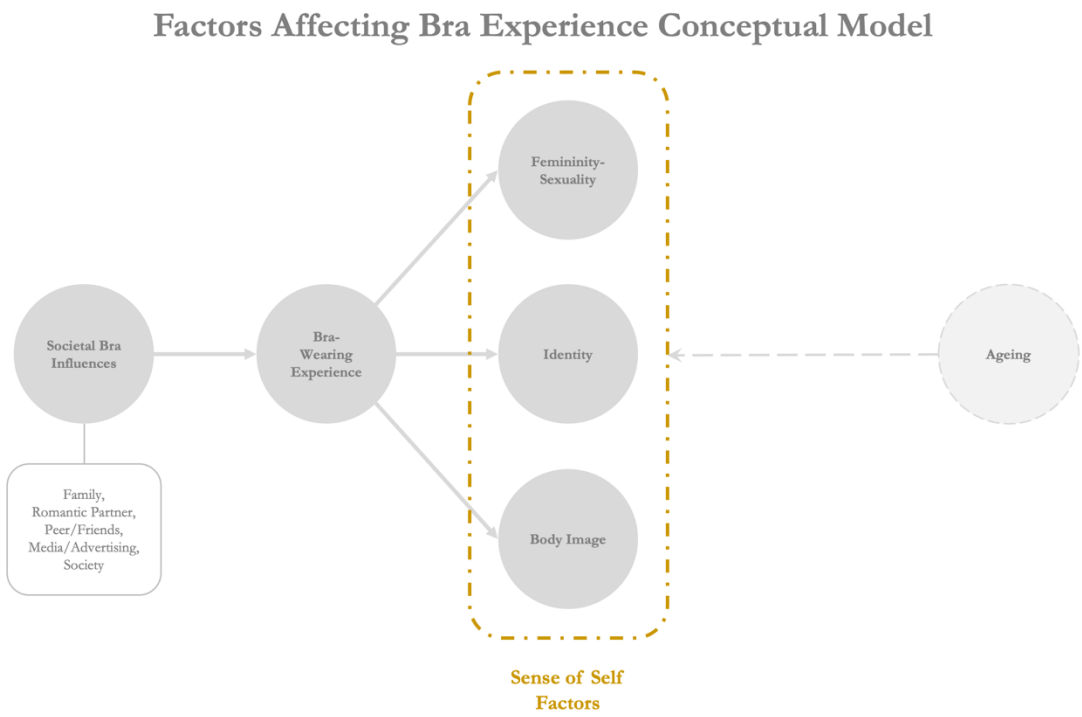
The generic Factors Affecting Bra Experience Conceptual model (**Fig.7.6.**) was developed through the literature review (Section 4.2.4.). Hart and Dewsnap (2001) surmised that the bra is linked to women's sexuality, body-image, and social image through its connection with the visibly presented breasts. These concepts, when commingled, define the sense-of-self. Humanistic Psychologist, Carl Rogers, notes that a sense-of-self is defined by the person's experiences (Greene, 2008). Therefore, the questionnaire examined whether societal bra influences affected the bra-wearing experience, and if the bra-wearing experience is statistically tied to the bra wearers' sense-of-self. Additionally, the questionnaire investigated whether there were any differences between Black and white women's bra-wearing experiences, and connection to the bra concepts of identity, femininity-sexuality, and body-image.

First, an exploratory factor analysis (EFA), Shapiro-Wilks test, Spearman's Rho, and Mann-Whitney U tests were conducted in SPSS (for analysis, see Appendix J, Sections J.1.2. – J.1.4.). Next, SmartPLS was utilised to develop the structural and measurement models and assess the structural model (Appendix J, Sections J.1.5 – J.1.8.). The findings are discussed below.

The results indicate that Black and white women experience bra-wearing differently. A Mann-Whitney U test signified that the bra-wearing construct was greater for Black women (M =85.66, n =16) than for white women (M =64.45, n =117), U = 638, z = -2.07, p =.04, r =.18. This suggests that Black women have a stronger connection to the cognitive and behavioural effects of the bra, resulting in them feeling or acting differently during bra-wearing. Black women also recorded significantly higher scores for the bra identity

(M =102.92, n =18) than white women (M =74.14, n =136), U = 767, z = -2.59, p =.01, r =.21. Additionally, Black women (M = 97.36, n = 18) had higher scores for the bra femininity-sexuality concept than white women (M = 76.62, n = 139), U = 921, z = -1.83, p =.07, r =.15. Scraton and Watson (1998, p. 126) argue that 'Differences between women can and do lead to different […] experience[s]'. Historically Black women's bodies were regarded as less feminine (Carby, 2000), outside the norm (Newton *et al.*, 2012) and not that of a woman (hooks, 2014). Davis (2015) found that outer garments were essential to mature Black women's embodiment of femininity and tied to their sense-of-self and self-esteem. Due to the bras' proximity to the breasts, it becomes a symbol of womanhood, femininity, and sexuality (Young, 1992; Latteier, 1998; Naugler, 2009), thus an object that Black women can utilise to embody those aspects – dispelling negative stereotypes.

Fig.7.7. Validated Factors Affecting Bra Experience Conceptual Model



Next, the Factors Affecting Bra Experience model was statistically validated (**Fig.7.7.**); for analysis, see Appendix J, Sections J.1.5. – J.1.8. Societal bra factors (i.e., family, romantic partner, peers/friends, media/advertising, and society) directly influenced the bra-wearing experience. Research has found that older women's fashion choices were influenced by family and friends (Hurd Clarke, Griffin and Maliha, 2009; Thomas and Peters, 2009; Peters, Shelton and Thomas, 2011). This study has linked societal factors to the bra and MW's sense-of-self (Section J.1.7.). A gap remains in bra research to understand *how* MW experience societal bra influences. It is essential to investigate how society portrays MW in lingerie and how it shapes MW's bra experiences. The bra-wearing experience influences MW's body-image, identity, and feminine-sexuality. As noted in Section 7.1.2.3., MW are conscious of what they want from their bras psychologically and functionally. While ageing does not directly impact the bra experience, it affects the

MW's sense-of-self (Section J.1.7.). Therefore, MW need bras that help them to identify with and navigate their maturing bodies. This study fills a gap in the literature on the significance of bras and clothing for MW. The findings indicate that the bra is just as important to MW's sense-of-self as their outerwear.

7.2. Factors Affecting BW Acceptance

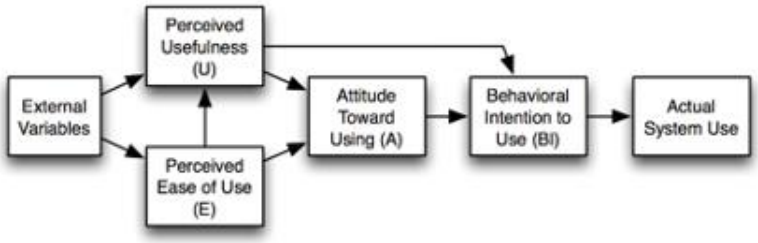
This section reports Part 2 and the last portion of the questionnaire, which concentrates on answering Aim #1, objectives 1D:

Aim #1: **To comprehend whether the wearers' bra experience is significant in developing a BWD&DP.**

1d. Utilise the TAM to determine if being a part of the BWD&DP affects mature women's acceptance and purchase intention.

This research did not intend to test a hypothesis but to explore the Technology Acceptance Model (TAM)[81] (Davis, 1989; Davis, Bagozzi and Warshaw, 1989), **Fig.7.8.**, applied to smart fashion, specifically BW, to understand relevant external factors for its acceptance (Section 6.1.1.1.). TAM has been used to test consumer acceptance of smart bras in Turkish women aged 14 to 57, with the majority, 41%, teens between 14 and 19[82] (Turhan, 2013). Turhan reports that attitude is significant to purchase intention with compatibility, perceived usefulness, and relative advantage, all predictive of attitude. However, as Turhan focuses on a broader range of women and obtained results skewing toward younger women, it was presumed that mature Western women would provide differing results due to contrasting attitudes and intentions for usage. Furthermore, external variables were added as this study aimed to understand the role of BW interest, the D&DP, and its significance in MW's acceptance.

Fig.7.8. Technology Acceptance Model
Source: (Davis, 1989; Davis, Bagozzi and Warshaw, 1989)



[81] The researcher is well aware this model has been amended to the unified theory of acceptance and use of technology (UTAUT) (Venkatesh et al., 2003) and UTAUT2 (Venkatesh, Thong and Xu, 2012). However, as several prior research into wearable technology (Chae et al., 2007; Ko, Sung and Yun, 2009; Turhan, 2013; Hwang, 2014; Hwang, Chung and Sanders, 2016; Li et al., 2016) have employed TAM, this research continues in a similar fashion.
[82] Only 12% of women in Turnhan (2013) were mature women between 40 and 57 years.

A total of *n*=141 participants partook in this questionnaire portion, with those not completing 30% of the questions removed. The following section reviews the factor analysis (Section J.2.1.1.), instrument reliability and validity (Sections J.2.1.2. and J.2.1.3.), descriptive statistics (Section J.2.2.), model assessments (Sections J.2.3.1. and J.2.3.2.) and results. SPSS v26 was operated to analyse the factor analysis, instrument reliability and validity, and descriptive. To analyse the data and explore the model, SmartPLS v3.3.2 was utilised.

7.2.1. Factor Analysis, Instrument Reliability, and Validity

The constructs within the BWTAM model are explained in **Table 7.9**. Construct abbreviations may be used moving forward. Additionally, **Fig.7.10.** informs on the Summary of Measurement Scale, providing information on the questions.

Table 7.9. Constructs for BWTAM.

Construct	Abbrev.	Definition	Sources
Bra Wearables Interest	BWInt	Construct to comprehend BW interest using multiple BW scoping items.	Newly developed construct for present study.
Perceived Usefulness	PUse	Construct to measure the perceived usefulness of BW.	Davis, 1989; Childers et al, 2001; Hwang, 2014
Perceived Ease of Use	PEoU	Construct to measure BW ease of use.	Davis, 1989; Childers et al, 2001; Hwang, 2014
Perceived Performance Risk	PPerR	Construct to measure the perceived performance risk of BW.	Grewal, Gotlieb and Marmorstein, 1994; Hwang, 2014
Perceived Comfort	PComf	Construct to comprehend perceived physical comfort of BW.	Hwang, 2014
Perceived Compatibility	PComp	Construct to understand perceived compatibility with BW.	Bradford and Florin, 2003; Ko et al., 2009; Hwang, 2014
Perceived Aesthetic Attributes	PAAtt	Construct to measure perceived intrinsic aesthetic attributes of BW.	Hwang, 2014
Attitude	Attit	Construct to understand attitude towards purchasing BW.	Hwang, 2014
Purchase Intention	PurIn	Construct to measure purchase intentions of BW.	Bower and Landreth, 2001; Hwang, 2014
Design Process	DProc	Construct measuring design process beliefs.	Newly developed construct for present study.

Fig.7.10. Summary of Measurement Scale

		Mean	SD	Factor Loadings	Chronbach's alpha	Composite Reliability	Average Variance Extracted
Bra Wearables Interest		**3.21**	**1.03**		**0.86**	**0.91**	**0.67**
BWInt1	Bra that detects and monitors heart disease.	3.30	1.25	0.900			
BWInt2	Preventative Breasts Cancer bra.	3.33	1.34	0.849			
BWInt3	Stress detection and relief bra.	3.31	1.29	0.873			
BWInt4	A bra designed for sexual stimulation.	2.83	1.31	0.477			
BWInt5	Bra that monitors health vitals.	3.33	1.21	0.912			
Perceived Usefulness		**2.74**	**1.05**		**0.92**	**0.95**	**0.81**
PUse1	I believe there is a need for Bra Wearables.	2.99	1.12	0.900			
PUse2	Wearing Bra Wearables would improve the quality of my overall health.	2.83	1.21	0.952			
PUse3	Wearing Bra Wearables would increase my sense of self.	2.35	1.10	0.868			
PUse4POS	Bra Wearables would be useful to me.	2.76	1.27	0.881			
Perceived Ease of Use		**3.19**	**0.81**		**0.76**	**0.86**	**0.67**
PEoU1	Understanding how to use Bra Wearables would not require a lot of mental effort.	3.53	0.90	0.791			
PEoU2	It would be easy to use Bra Wearables.	3.41	0.96	0.878			
PEoU3POS	Wearing Bra Wearables would be easier than wearing a regular bra.	2.71	1.09	0.789			
Perceived Performance Risk		**2.71**	**0.91**		**0.94**	**0.96**	**0.90**
PPer1	I am confident that Bra Wearables will perform as described.	2.65	0.95	0.966			
PPer2	I am certain that Bra Wearables will work to my standards.	2.73	0.96	0.921			
PPer3	I believe Bra Wearables will perform the functions that they are set to do well.	2.78	0.95	0.959			
Perceived Comfort		**2.61**	**0.68**		**0.88**	**0.91**	**0.67**
PComf1POS	Comfortable	2.50	0.93	0.839			
PComf2POS	Flexible	2.79	0.84	0.862			
PComf3POS	Easy to move in	2.68	0.86	0.830			
PComf4POS	Light Weight	2.74	0.83	0.738			
PComf5POS	Fitting	2.47	0.91	0.814			
Perceived Compatiblility		**3.34**	**0.94**		**0.89**	**0.92**	**0.75**
PComp1	Health & Wellness Bra Wearables may suit my needs.	3.05	1.25	0.902			
PComp2	Bra Wearables would be compatible if its discreet underclothing.	3.46	1.09	0.911			
PComp3POS	Bra Wearables would be appropriate for my lifestyle.	2.99	1.11	0.885			
PComp5	Bra Wearables should be made to be worn at any time.	3.86	0.86	0.752			
Perceived Aesthetic Attributes		**3.89**	**0.61**		**0.69**	**0.81**	**0.52**
PAAtt1	The aesthetics of Bra Wearables is important for my acceptance.	3.76	1.02	0.850			
PAAtt2	Bra Wearables should look like regular bras.	3.98	0.84	0.788			
PAAtt3POS	The longevity of Bra Wearables is important to me.	3.83	0.84	0.513			
PAAtt6	The technological elements should be hidden in the bra.	3.95	0.83	0.682			

Attitude		**3.00**	**0.83**		**0.91**	**0.94**	**0.75**
Attit2POS	Favourable	2.92	0.92	0.801			
Attit3	Wise	3.08	0.95	0.895			
Attit4	The Future	3.33	0.97	0.861			
Attit5POS	Beneficial	3.18	0.92	0.920			
Attit6POS	Staple Product	2.48	1.06	0.836			
Purchase Intention		**1.95**	**0.69**		**0.87**	**0.92**	**0.79**
PurIn1	I intend to try this type of product when made available.	1.77	0.68	0.890			
PurIn3	I would like more examples of Bra Wearables.	2.09	0.87	0.901			
PurIn4	If recommended by my peers I would be interested.	1.98	0.78	0.874			
Design Process		**3.69**	**0.71**		**0.82**	**0.87**	**0.63**
DProc1	Mature women should participate in the design process of Bra Wearables.	4.13	0.80	0.743			
DProc2	I believe as a bra wearer I have insight on what's best for mature female bodies.	3.92	0.87	0.678			
DProc3	I would be more interested in Bra Wearables if I were a part of the design process.	3.22	1.06	0.861			
DProc4	I would be interested in Bra Wearables if I knew my peers were involved in the design process.	3.30	1.11	0.878			

7.2.2. Findings

This section aimed to comprehend whether the added constructs design process and BW interest would have relationships with perceived values such as usefulness, ease of use, performance risk, comfort, and aesthetic attributes (**Table 7.9.**). Furthermore, whether those relationships would affect attitude and purchase intention.

Perceived usefulness was the strongest attitude indicator, previously substantiated by the original TAM (Davis, Bagozzi and Warshaw, 1989; Venkatesh *et al.*, 2003). Comparable to other studies on smart bras and clothing, perceived usefulness did lead to attitude and purchase intention (Chae *et al.*, 2007; Ko, Sung and Yun, 2009; Turhan, 2013; Hwang, 2014). Not shown in the model for clarity (see Appendix J, **Fig.J.28**), it was also proven significant that perceived comfort (PComf -> PUse, ß=.13) and perceived performance risk (PPerR -> PUse, ß=.21) also contributed to perceived usefulness. The combined design process, perceived comfort, performance risk, and BW interest led to 71% of the variance in perceived usefulness. Perceived ease of use did not affect perceived usefulness, as noted in the original TAM (Davis, Bagozzi and Warshaw, 1989) and Turhan (2013), with similar results from other smart clothing research (Ko, Sung and Yun, 2009; Hwang, 2014; Hwang, Chung and Sanders, 2016). Hwang's (2014) study on the acceptance of solar-powered clothing likewise indicated the importance of perceived comfort on perceived usefulness. Perceived usefulness was established as a significant construct for acceptance of BW purchase intention. Perceived ease of use was not significant, as Davis et al. (1989) noted.

Constructs perceived ease of use and perceived aesthetic attributes did not demonstrate a significant relationship to attitude or purchase intention. Comparably, Turhan (2013) found that perceived ease of use impacted perceived usefulness slightly for smart bras and was not significant to purchase intention or

attitude. In this study, women believed BW would be easy to use (*M* =3.19, *SD* =.81), although they did not believe it would be easier than a traditional bra (*M* =2.71, *SD* =1.09). Moreover, they noted that the aesthetics of BW was crucial for their acceptance (*M*= 3.79, *SD* =1.07), with similar results to Hwang (2014), perceived aesthetic attributes did not affect attitude or purchase intention. While both constructs, perceived ease of use and aesthetic attributes, did not prove significant in the model, we can surmise from the questionnaire responses that they are critical for BW acceptance.

Attitude was a significant indicator of BW purchase intention with a sizeable effect. Although it was updated and removed from the TAM as a variable that was unnecessary for purchase intention (Venkatesh and Davis, 2000), it was essential to understand what variables did affect the attitude of BW. Perceived usefulness, performance risk, comfort, and BW interest significantly affect attitude. Together they contributed to 74% of the variance in attitude. Both performance risk (*M* =2.71, *SD* = .91) and comfort (*M* =2.61, *SD* = .68) received less than favourable responses from participants. Women believed BW would not perform to their standards nor work as described. Furthermore, they imagined it would be uncomfortable, ill-fitting, and challenging to move in. Women must have a positive assessment of the performance risk and physical comfort for an optimistic attitude leading to the purchase intention of BW. A solution for positive assessment pre-purchase may be to invite women into the D&DP.

The D&DP was rated as extremely important for women (*M* =3.69, *SD* =.71), with many indicating they would be interested in BW if they were a part of the process (*M* =3.22, *SD* =1.06) or if they knew their peers were a part of it (*M* = 3.30, *SD* =1.11). While the D&DP did not directly affect attitude or purchase intention with significant values, it significantly moderated relationships to attitude and purchase intent through BW interest, perceived usefulness, and comfort. BW interest significantly influences attitude directly and indirectly through perceived usefulness, performance risk, and comfort, making it vital to the design process.

Not coincidentally, the design process has a 31% variance on BW interest with a high coefficient path (ß=.56) and a medium size (f^2=.34). The results are interpreted as the D&DP is important in influencing attitude and purchase intention by cultivating BW interest.

Fig.7.11. The BWTAM Structural Model

This model is similar in theory to the original and updated TAM (Davis, 1989; Davis, Bagozzi and Warshaw, 1989; Venkatesh and Davis, 2000).

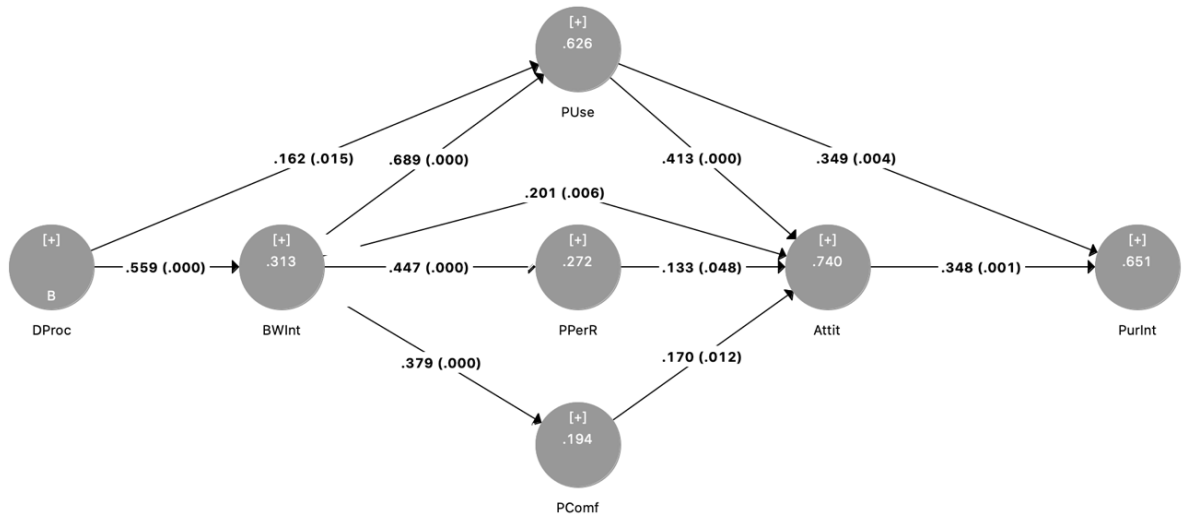
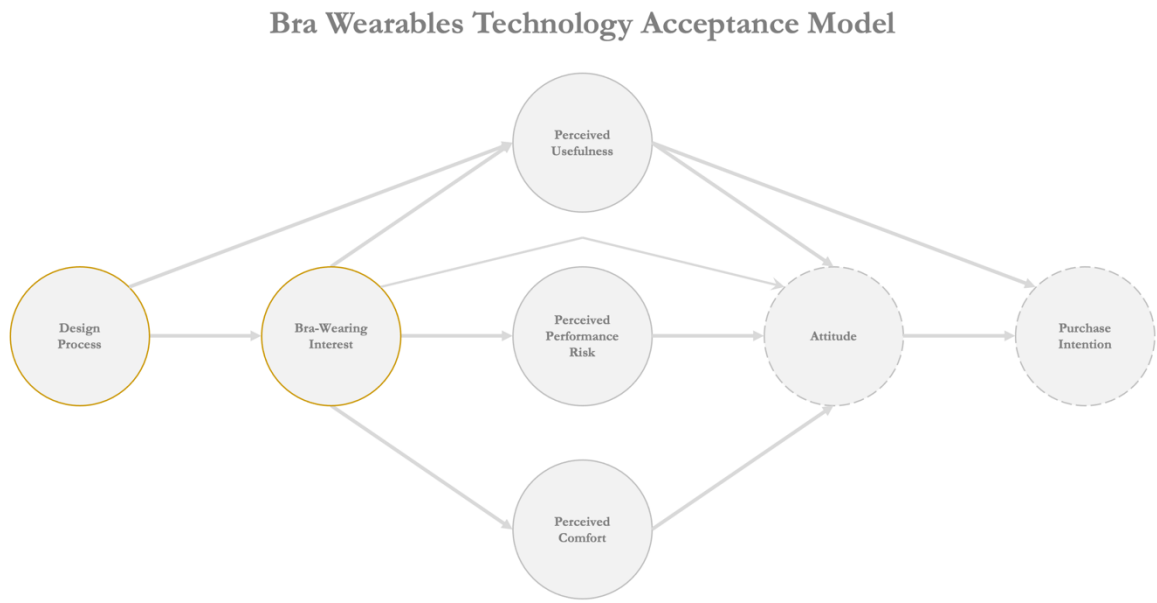


Fig.7.12. Confirmed BWTAM Conceptual Model



7.2.3. Contributions and Implications

Researchers have suggested that more insight into how women 'view themselves (i.e., identity and self-concept) is crucial to understanding the importance of marketing' (Peters, Shelton and Thomas, 2011, pp. 300–301). These findings advance the literature by providing essential information on how MW experience the bra on a more profound level. The key contributions from this questionnaire are:

- insights into current MW's breast and bra experiences. Moreover, new knowledge confirms that Black and white women experience the bra differently.

- original information into the unwritten bra rules adhered to by MW.
- a Factors Affecting Bra Experience model statistically confirms the connection between societal influences on the bra-wearing experience of MW. Furthermore, the conceptual model also informs on the relationship between the bra-wearing experience on MW's sense-of-self.
- a BWTAM that accentuates the significance of the D&DP to BW interest, perceived attitude, and purchase intention.

This portion of the study has several limitations. First, most of the participants were white, thus not allowing comparisons between them and Black women in Section 7.1.2. Second, most participants skew towards the younger side of the age range, so the older groups' responses may be underrepresented. Future research is recommended to focus the questionnaire on a larger group of mature Black women. Moreover, future research can widen the age range by concentrating exclusively on Black women from 18+. Doing so may provide added insights into how age and society affect bra experience within a specific 'race'.

The findings have implications for the bra industry. For designers and marketers, it is recommended that they investigate further the unwritten bra rules as it provides greater insight into the bra experiences of MW. Additionally, it may enable them to design bras that are occasion specific. Designers and marketers must consider MW's sense-of-self in designing and marketing bras for them. Age alone is not enough of a determinant. It is recommended that MW be a part of the D&DP to effectively design bra products and develop a suitable marketing strategy.

7.3. Development of the BWD&DP

This section reports on Part 3, the development of the initial BWD&DP, which responds to Aim#2, objective 2B:

- **Aim #2. To investigate approaches that can be utilised to inform the design of BW that improves the wearers' experience.**
    - 2b. Examine various design processes to develop an initial BWD&DP.

There was no BWD&DP[83] available for researchers or practitioners to enact. Several small brands and researchers were investigating and developing products; however, their procedures were not well documented or were proprietary. Therefore, this study aspired to create a BWD&DP through a processual account, employing a comparative analysis of various design processes (DP). A comparative analysis of DP enables the researcher to compare similarities thoroughly to gain insights into developmental stages (Collier, 1993). Dawson (2014, p. 65) argues for using the processual approach 'to identify patterns and "deviant" activities that shape the underlying process'. Thus, the design-researcher applied a processual approach to

[83] While Haffenden and Smith (2015) developed an SBW D&DP; it is inadequate for the traditional bra design (Section 3.3.).

gather and comprehend patterns in D&DPs, allowing in-depth chronicles to validate the development of an initial BWD&DP. Documents, archives, interviews, and tacit knowledge are all essential to implementing a processual approach (Dawson, 2014, 2019). Pettigrew (1997, p. 346) asserts that 'process research is a craft activity full of intuition, judgement and tacit knowledge'; thus, the design-researcher can use their experiences and extensive knowledge base as a reference and guide. Furthermore, Hardaker and Fozzard (1997) inform that the bra D&DP is improved and advanced by designers' heuristic knowledge. With an extensive educational and professional background in lingerie design, the design-researcher employed tacit knowledge and reflection to direct the study through the processual approach. As a living document, the BWD&DP was continuously updated throughout this study.

The Western bra research field is fragmented, with little research conducted on the bra from a design perspective (Shin, 2009). The most esteemed and cited paper on the bra was conducted in 1997 by Hardaker and Fozzard, in which they investigated the professional bra D&DP. Twenty-five years later and the process is still cited. Although much has changed in the industry with the addition of fast-fashion, the findings are still relevant. Therefore the structure of Hardaker and Fozzard's (1997) bra D&DP was utilised as the foundation for the various processes (discussed in Chapter 3) within the processual approach.

7.3.1. Processual Review of Bra, Functional and Smart Clothing processes

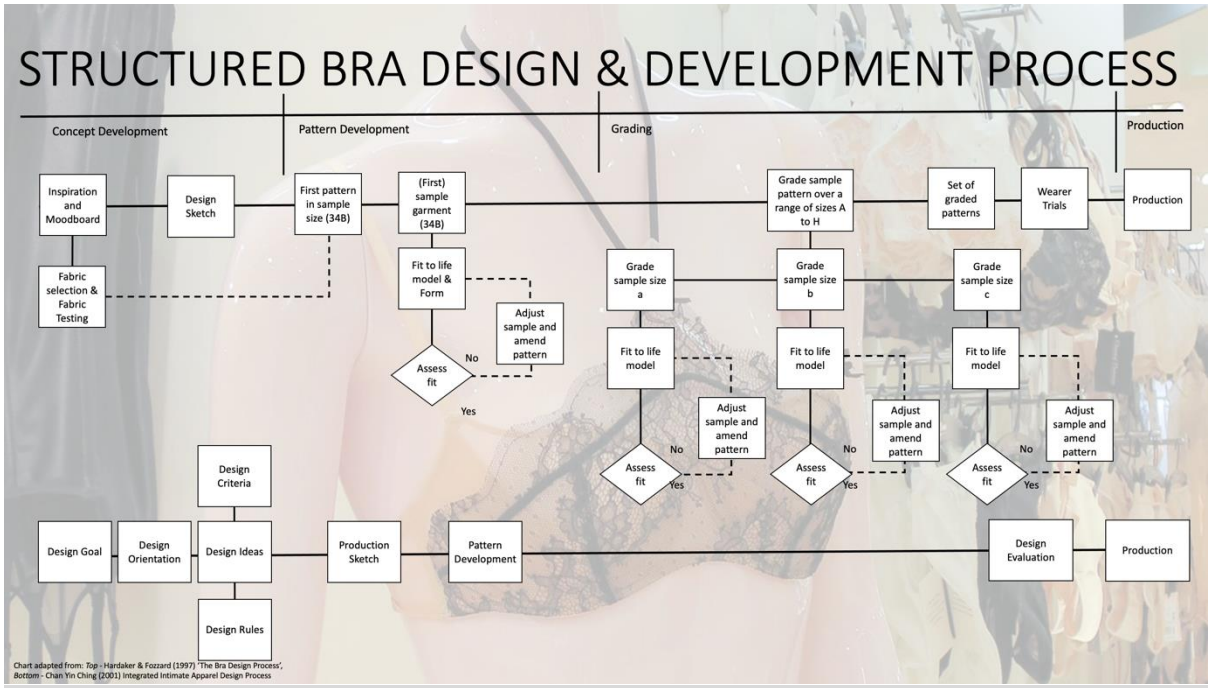


Fig.7.13. Structured Bra D&DP from Research.
Top: Hardaker & Fozzard (1997); *Bottom:* Chan (2002)

Structured Bra D&DP from Research. Hardaker and Fozzard's (1997) process was compared to Chan's (2002) intimate D&DP. The processual account of structured bra D&DP in **Fig.7.13.** led to the following insights:

- DP can begin with a buyer, company brief, or inspiration from the design team.
- Sketches may be influenced by previously established, or newly developed criteria and rules.
- Pattern development is an iterative multi-step stage involving several fittings (Luk and Yu, 2016) and sample developments.
- Grading is the most time-consuming portion of the process, consisting of numerous samples and fittings lasting between two and eight months (Hardaker and Fozzard, 1997).
- Prior to production, a design evaluation is conducted where styles are trialled with wearers.

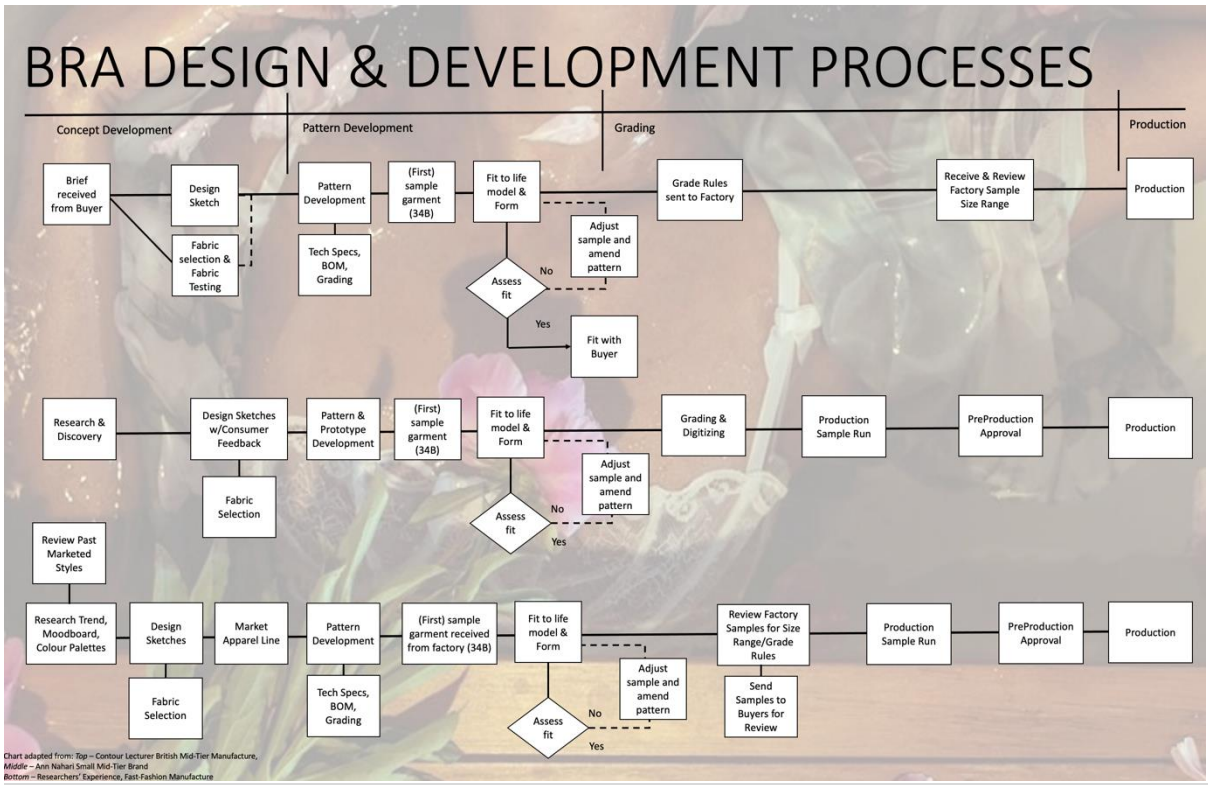


Fig.7.14. Real-world Structured Bra D&DP.
Top: British High Street Manufacturer (2018); *Middle:* Ann Nahari Speciality Mid-Tier Brand (2016); *Bottom:* American Fast-Fashion Lingerie Manufacturer (2018)

Three real-world structured bra D&DP. Exploiting experiential knowledge, I compared my professional American fast-fashion (AFF) bra D&DP to an LCF contour lecturers' British high-street bra manufacturer (BHSM) experience (Gosler, 2020, personal communication) and a small speciality bra brand called Ann Nahari (Rashed, 2016). Each D&DP varied. The processual account of real-world structured bra D&DP in **Fig.7.14.** led to the following insights:

- DP began differently for various tiers, either from a buyer brief, a review of past marketed styles or from the designers' ideas and trend boards.
- Sketches coincided with fabric selection, which was then reviewed with, marketed to buyers, or reviewed with consumers in the speciality brand's case.

- Pattern development is either conducted in-house as per the BHSM, and speciality brand or the technical specifications were sent overseas (AFF).
    - If conducted in-house, brands can spend more time generating and fitting the first-fit sample before grading.
    - If overseas, brands review first samples from factories before approval, then factory grades and return graded samples for brand approval (AFF).
- Samples may be fitted on a live model or form.
- Grading rules were digitised and sent overseas or developed in-house.
- After pre-production approval came production, meaning designs were potentially not trialled by wearers.
- Processes varied in timing, with the AFF process lasting between three to eight months (Berg *et al.*, 2018), the BHSM between nine months to a year, and the small speciality brand up to eighteen months (Rashed, 2016).

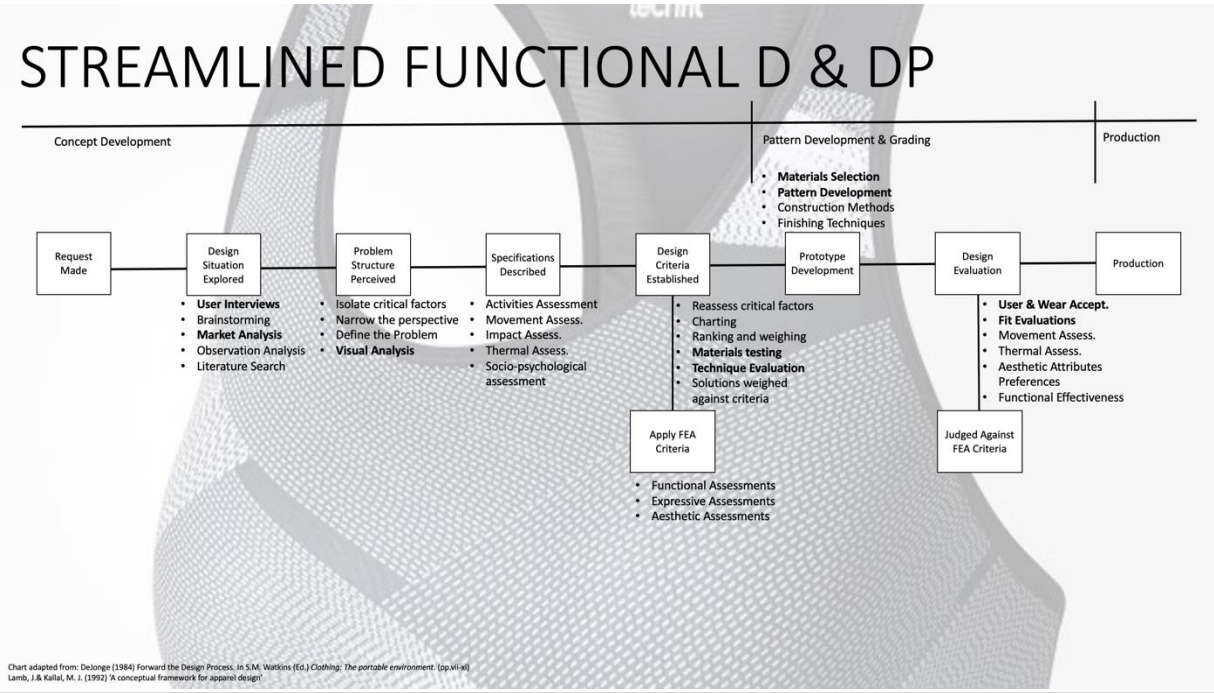


Fig.7.15. Functional Sports Bra D&DP
Source: DeJonge (1984) Forward the Design Process in S.M. Watkins (Ed.) Clothing: The portable environment. (pp.vii-xi), and Lamb and Kallal (1992) 'A conceptual framework for apparel design'.

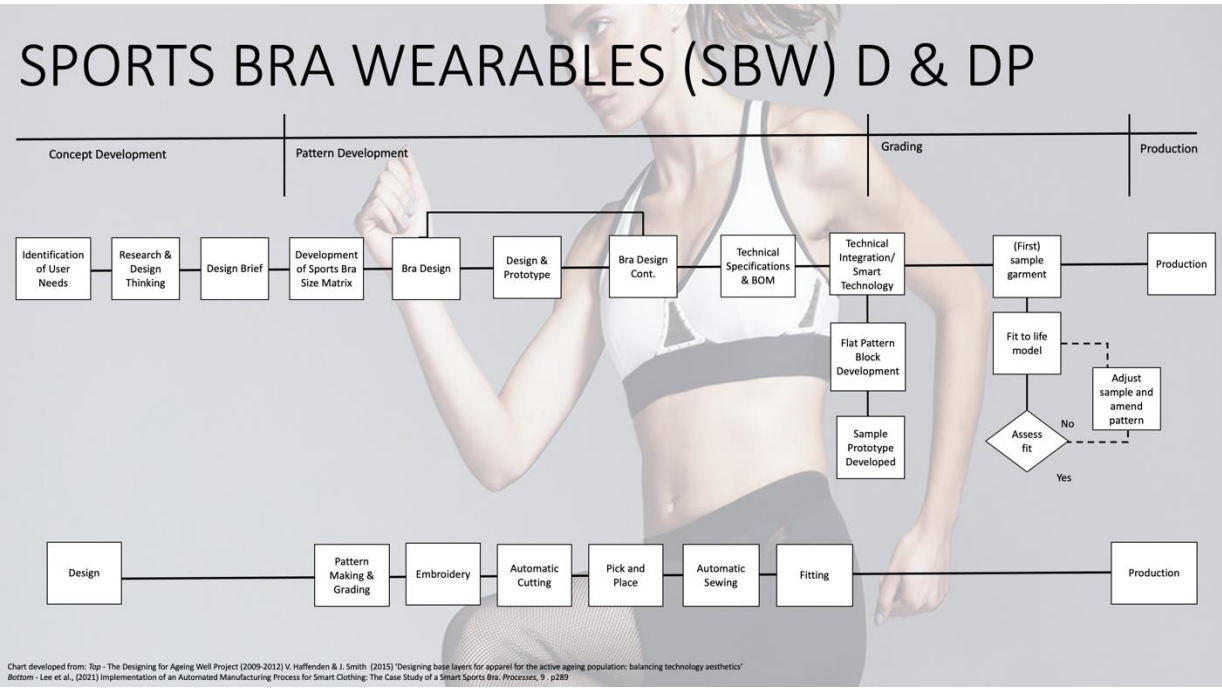


Fig.7.16. Sports Bra Wearables (SBW) D&DP
Top: V. Haffenden & J. Smith (2015) 'Designing base layers for apparel for the active ageing population: balancing technology aesthetics'.
Bottom: Lee et al., (2021) 'Implementation of an Automated Manufacturing Process for Smart Clothing: The Case Study of a Smart Sports Bra'.

Sports Bra Wearables (SBW) D&DP. As discussed in Chapter 3, the sports bra D&DP is derived from the functional D&DP (**Fig.7.15.**) and differentiates from the structured bra D&DP (**Fig.7.13.**). To understand SBWD&DP, two projects were compared (Section 3.1.3.2.). The Designing for Ageing Wellness (DAWSBW) (Haffenden and Smith, 2015) project is based on McCann, Hurford, and Martin's (2005) critical path for smart fashion D&DP. The DAWSBW co-developed SBW with women aged 60 to 75. Lee et al. (2021) developed an Automated Sports Bra Wearables (ASBW) D&DP. The processes differ fundamentally, as DAWSBW intends to create a holistic procedure that brings various experts and the target consumer together on equal footing. Contrastingly, ASBW aspires to minimise 'human intervention' (S. Lee *et al.*, 2021, p. 14) throughout the operation. The processual account of SBWD&DP in **Fig.7.16.** led to the following insights:

- Like the functional D&DP, the DAWSBW D&DP spends considerable time in the concept development phase focused on understanding the wearers' needs to develop a design brief.
- Ideas were co-designed, with participants assisting in selecting designs, fabrics, and accessories.
- DAWSBW pattern development phase was extended as designs were iteratively developed to fit each participant.
- After the first sample was developed and approved for fit with participants, like the functional D&DP, technical integration occurred where the prototyping ensued again.
- Grading process was iterative and minimised as the prototypes were developed for each participant before proceeding to production.

- Unlike DAWSBW, the ASBW design process began with designing concepts using CAD programs.
- Automated designs were minimised stylistically for ease of producing quicker visual prototypes, reduction of material waste and cost, ease of facilitation between multiple departments, and immediate technical specifications and bills of materials (Papahristou and Bilalis, 2017).
- Due to the automation, the pattern development phase was streamlined, requiring several advanced machineries.
- After fitting on a mannequin, ASBW sent designs to production.

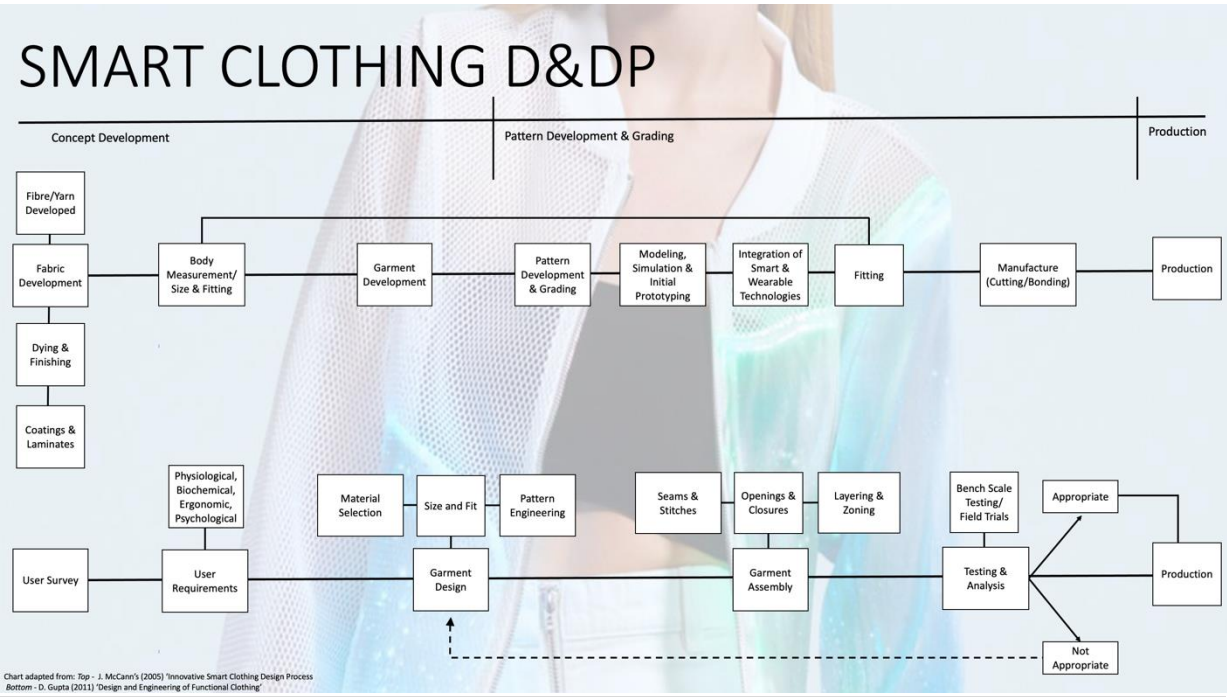


Fig.7.17. Smart Clothing D&DP
Top: McCann, Hurford, and Martin (2005) 'A Design Process for the Development of Innovative Smart Clothing that Addresses End-User Needs from Technical, Functional, Aesthetic and Cultural Viewpoints'.
Bottom: Gupta (2011) 'Design and Engineering of Functional Clothing'.

Review of Smart Clothing D&DP. Smart clothing D&DP were interrogated to discern how they evolved and integrated technology. Two smart clothing processes were contrasted, McCann, Hurford, and Martin's (2005) 'Critical Path', referred to as Critical Path Process[84] (CPP), and Gupta's (2011) smart clothing design process (SCDP). Both processes are generalisable, enabling their usage for various clothing and constructed from the functional apparel D&DP (**Fig.7.15.**). The processual account of smart clothing D&DP in **Fig.7.17.** led to the following insights:

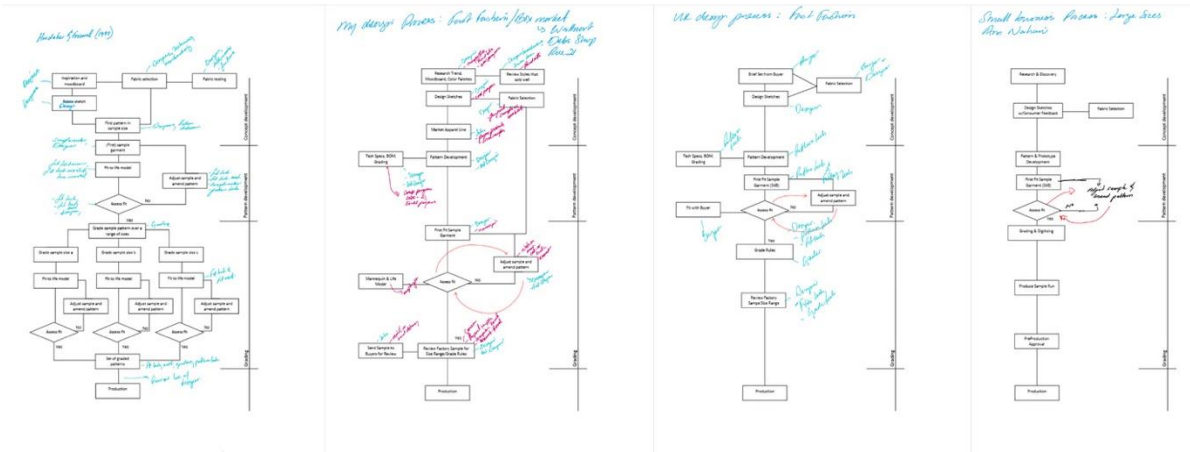
- Both DP argue for an astute understanding of the wearer to inform design decisions and directions through apprehending their physiological, biochemical, ergonomic, and psychological demands (SCDP) or the technical, functional, aesthetic, and cultural facets (CPP).

[84] The CPP is both a tool and a process to guide smart clothing development.

- Prior to garment design, the CPP and SCDP argue for fabric research and development – i.e., smart, e-textiles and biomimetic – emphasising the significance of understanding material properties according to the body, environment, and usage.
- The CPP advocates for implementing 3D body scanning technology, 3D virtual designs and fitting, patternmaking, and 3D cutting techniques to develop the initial prototype.
- After the initial prototype, wearable facets were integrated and then fitted on a live model for wearability, comfort, and functionality before production in the CPP.
- Comparatively, SCDP integrated technology during the garment assembly and then tested and analysed the garment in lab environments and on the body before production.
- Not included in the Fig.is the CPP's inclusion of the end-of-life stage, which was examined at the beginning of the process at the fabric development and garment design stages and again after production.

7.3.2. Initial BWD&DP Developed

Fig.7.18. Image illustrating a comparative process analysis.
Image is not meant to be legible; it illustrates the analysis method.



The previously analysed D&DP, in Section 7.3.1., were further investigated (**Fig.7.18.**) and streamlined to inform the development of the initial BWD&DP. Each process and its phases were critically examined for positive and negative attributes with the wearer, technology, and production aspects considered. As different market tiers necessitate distinctive processes, the BWD&DP was created for mid-tier positioned brands marketing directly to consumers or retailers. Evaluation of these processes supports the following developments for the five phases in the initial BWD&DP (**Fig. 7.19.** and **7.20.**):

- **Research & Concept Development**
    - Inspired by the functional and smart clothing D&DP, the BWD&DP begins by exploring the design situation and applying multiple research methods to define and understand the wearer.

- FSEA (Section 3.1.3.1.) criteria are established to identify wearer needs and design requirements centred on the physiological, psychological, psychosocial, functional, and economic facets.
- Design brief is developed from the FSEA criteria, along with a size range, and links to the mood board, colour, and inspiration board.
- Fabric and technical direction commence with the design brief but branches off, developing and testing smart and traditional materials simultaneously as the process continues (inspired by steps in **Fig.3.5.**).
- Initial design sketches are developed by the design team and then collaboratively reviewed with wearers, narrowing the design, functional and technical requirements.

- **Pattern & Prototyping Development**
  - Patternmaker, sewists, designer, and textile and engineering technologists collaborate in the bra development to create a prototype using industry sample size.
  - First sample is developed and fitted on a mannequin and live model following the iterative structured bra process until approved.
  - Technical integration ensues after fit sample approval with the addition of smart materials.
  - Testing and analysis occur with a wearer group with the fit sample and is judged against the FSEA criteria and Four Pleasures framework (introduced in Sections 5.4.2. and 5.4.2.1.) in order to move on to the grading phase.
- **Grading**
  - Technical specifications and bill of materials (BOM) are developed and reviewed for a range of sizes.
  - Samples are graded, prototypes developed and fitted on live fit models over a wide size range.
  - If approved, testing and analysis transpire with wearers of all sizes.
  - Approval of graded patterns and samples initiates the development of pre-production samples to be utilised in wearer trials.
- **Testing & Pre-Production**
  - Prior participants and the target group are utilised in wearer trials for feedback on comfortability, wearability, functionality, and care.
  - If wearer trials are positive, then pre-production approval follows with a range of samples assessed for appropriateness.
- **Production**
  - Production requires multiple types of machinery and skilled labourers as structured bra manufacturing contain manual operations.

This process was utilised as the base to which new stages were added, amended, or removed to construct the BWD&DP. Although smart clothing D&DP promote the inclusion of several 3D technological elements such as body scanning, virtual design and fitting, and novelty manufacturing approaches, traditional bra brands tend to be averse to including these. They often do not have personnel with the technical knowledge or financial resources to obtain and learn how to merge these technologies into their existing process efficiently (Ariyatum, 2005; Perry *et al.*, 2017). Furthermore, limited information illustrates the effectiveness of designing well-fitted structured bras using 3D technology, such as digitally fitting bras on avatars. This initial BWD&DP is not fixed and may be amended to include 3D technological elements, which can shorten and change the process.

Fig.7.19. Part 1: The Initial Bra Wearables Design and Development Process (BWD&DP)

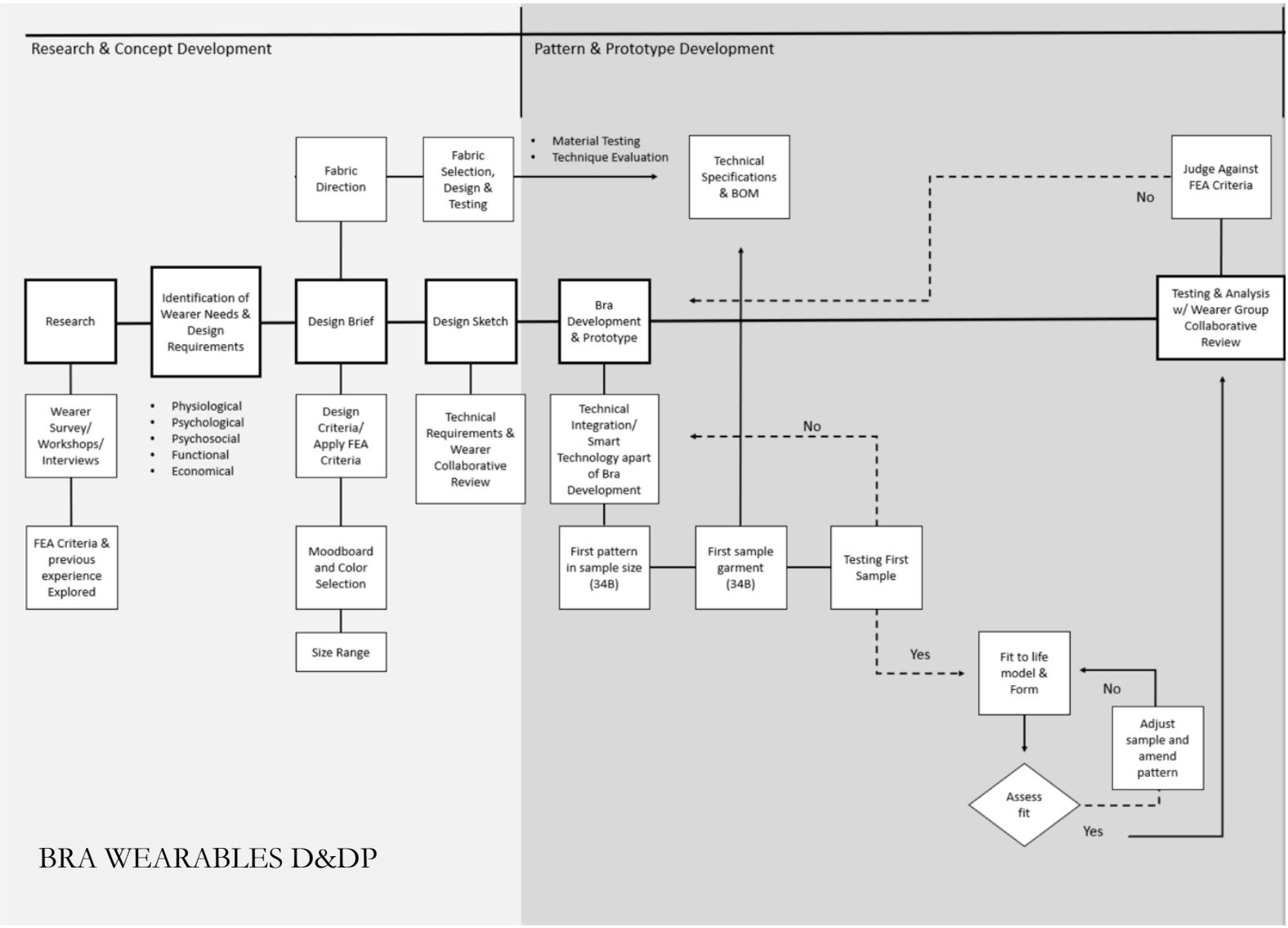
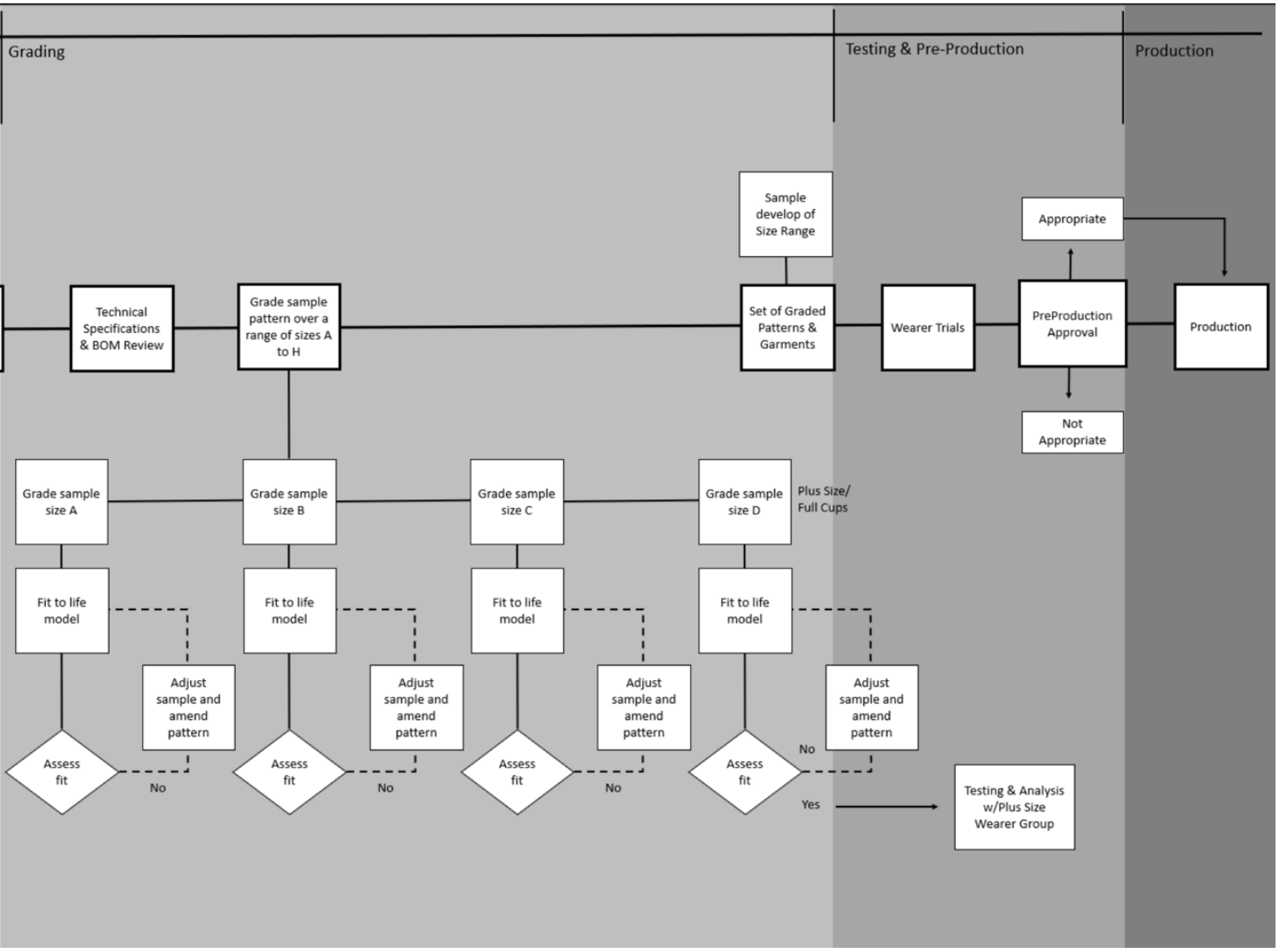


Fig.7.20. Part 2: The Initial Bra Wearables Design and Development Process (BWD&DP)



7.4. Summary

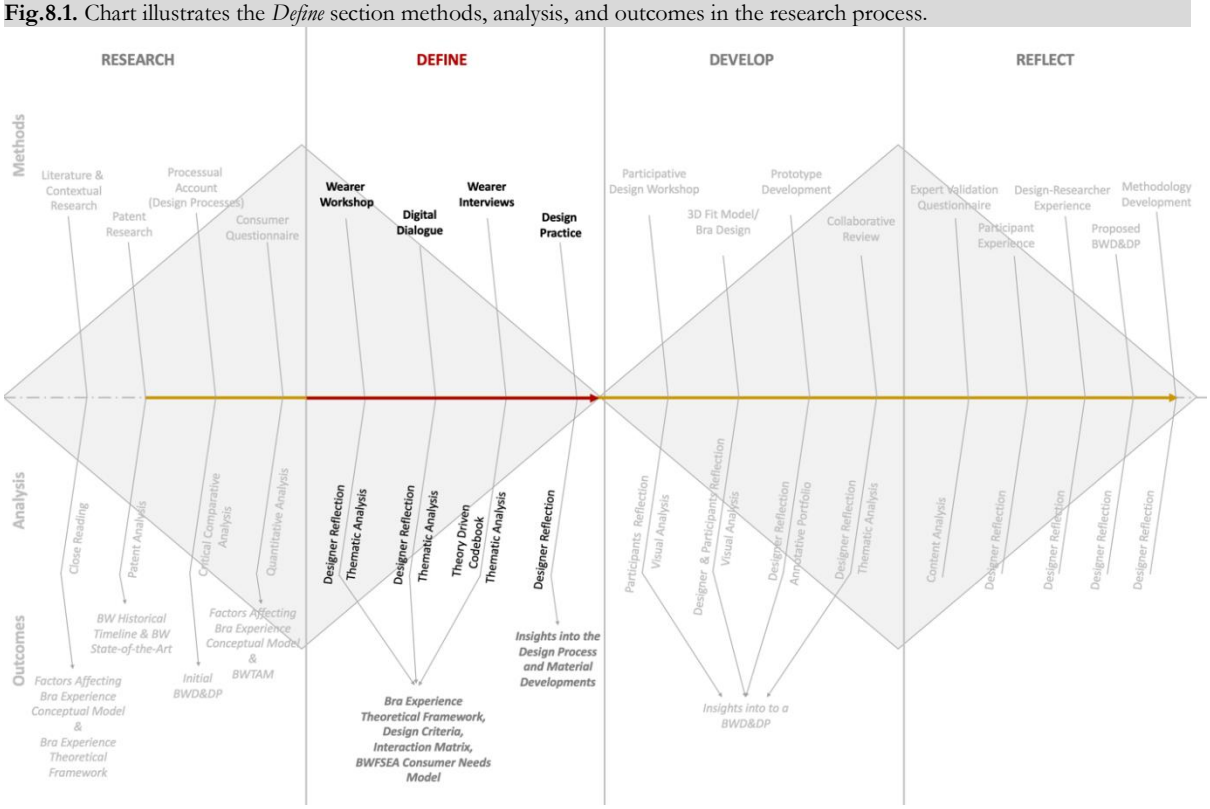
Chapter 7

- ***Introduced*** the reader to the results from a questionnaire and processual account.
- ***Provided*** insights into MW's bra and ageing experiences, substantiating that Western MW's bra-wearing and ageing experiences influence their feminine-sexuality, identity, and body-image.
- ***Confirmed*** that Black and white women differed, with Black women having a more significant relation to the bra-wearing experience, feminine-sexuality, and identity factors.
- ***Validated*** the Factors Affecting Bra Experience conceptual model (**Figure 7.7.**) was validated, illustrating that social factors influence MW's bra-wearing experiences, which is tied to their sense-of-self through identity, body-image and feminine-sexuality factors.
- ***Substantiated*** the BWTAM (**Figure 7.12.**), revealing that the D&DP is significant for BW interest, favourable attitude, and purchase intention – confirming that if women perceived BW to be interesting, useful, comfortable, and work to their standards, their attitude might be favourable towards purchase intention.
- ***Evidenced*** that the design process significantly impacts BW interest, signifying the noteworthiness of developing a D&DP that includes the wearers in meaningful ways while also being transparent to potential consumers.
- ***Created*** the initial BWD&DP (**Figures 7.19. and 7.20.**), to be participatory and woman-centred by focusing on the wearers' needs and introducing them throughout.

8

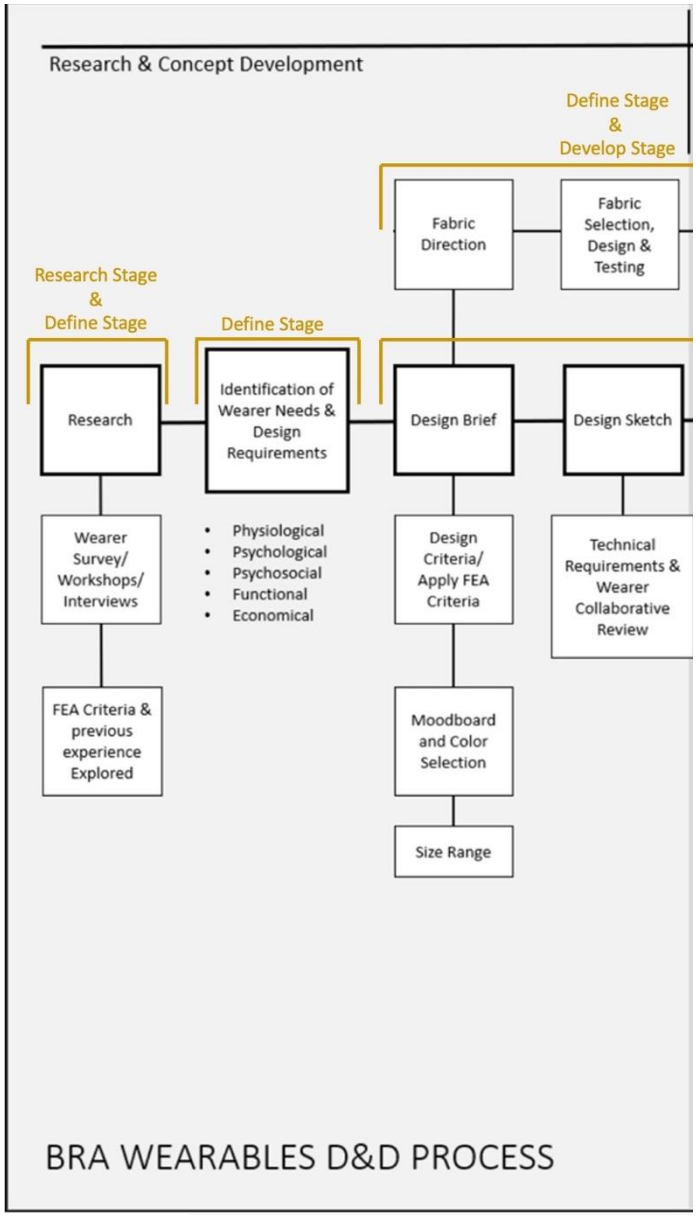
8. DEFINE

Fig.8.1. Chart illustrates the *Define* section methods, analysis, and outcomes in the research process.



Chapter 8 is positioned within the *Define* stage of the research process (**Fig.8.1.**). Corresponding to the BWD&DP, the activities within this chapter initiated research, collecting data in the "Research & Concept Development" phase (**Fig.8.2.**). During the BWD&DP research stage, the aim is to gather information about the participants' bra experiences while introducing them to the BW field. As noted in Section 7.2., a D&DP that includes and centres the wearers is advantageous for BW interest and generates a favourable attitude. Moreover, to design BW that elicits pleasurable wearing experiences (Section 5.4.2.1.), the D&DP must prioritise user experience by empathising with wearers to understand their latent needs (Sanders and Stappers, 2008). However, as Niinimäki and Koskinen (2011, p. 182) highlight, 'It is especially difficult to capture meaningful past experiences and include them in the design process'. Therefore, this chapter engendered to capture information from bra wearers on their bra experiences and turn it into applicable information within the D&DP. The chapter addresses research Aim #2, objectives 2C and 2D:

Fig.8.2. BWD&DP covered.



Aim #2. To investigate approaches that can be utilised to inform the design of BW that improves the wearers' experience.

2c. Explore ways of integrating the bra wearer and their experience into the BWD&DP.

2d. Investigate ways of integrating technology into the bra (i.e., new design elements, bra form, and composition).

Chapter 8 is divided into three parts: the first portion centres around the research stage of the BWD&DP, providing results from the workshop (Section 6.1.2.1.), digital dialogue (Section 6.1.2.2.), and interviews (Section 6.1.2.3.). The second portion identifies the wearers' needs culminating in design requirements for BW for mature women (MW). The third portion provides the design-researchers' reflection on the initiatory practice element. Due to space within this thesis, the design practice portion – coinciding with fabric material selection, design, and testing – was moved to Appendix I.

Part 1 (8.1. and 8.2.) is dedicated to identifying the wearers' experiences and needs, and BW interest through multiple methods. First, results from the wearer workshop and digital dialogue provide insights into MW's past, current and envisioned future bra experiences. Next, the results of semi-structured interviews in which participants were prompted to recall their best and worst bra experiences are analysed and discussed using the Bra Experience Theoretical Framework. This section presents the participants' voices (*n*=11) (**Table 6.36.**, p.188) as they discussed their bra experiences. Part 1 concludes with the design-researchers' reflection on collating the multiple strands of the bra experience (8.3.).

Part 2 (8.4.) combines the wearers' needs and experiences into design elements necessary for BW. The data obtained from the triangulation of the multi-method approach (questionnaire, workshop, digital dialogue,

and interviews) was employed to update the BWFSEA[85] consumer needs model, compose a BW interaction matrix, and establish design criteria. Moreover, the BWFSEA consumer needs model and design criteria were used to inform practice in Appendix L.

Part 3 (8.5.) reflects on investigating the design requirements when integrating the various design fields in the preliminary practice portion. Appendix L sequentially details the applied methods, such as mood board creation, empathy activities, sketches, and design practice, including fabric direction and technical requirements. This section highlights my reflection on the experience as I grappled with the learning required to transition into a hybrid designer working with and integrating electronic functionality into the design of the bra and balancing the needs of the wearers, design aesthetic and hardware.

8.1. Mature Black Women's Bra Experience

Wearer workshop and digital dialogue analysis are in Section 6.1.2. The data from the methods were collated and presented in an abstract way, using the participants voices to assist in retelling their experiences, to inspire and inform a professional design team (Sleeswijk Visser, 2009). The resulting four themes for design deliberations are bra use knowledge (8.1.1.), bra experience (8.1.2.), design attributes (8.1.3.), and BW considerations (8.1.4.).

8.1.1. Bra Usage

The analysis uncovered the wearer's various bra usage as part of their bra experience, exhibiting two different themes: bras segregated by occasions and bras worn outside the intended function. The women agreed that they separated their bras by events such as work, evening festivities, home, and holidays. Clary revealed she separated her bras by occasion in her bra drawer, having a work and evening/social section. Lilly agreed to have a similar separation, elucidating that the bras were further categorised by design features. She shared, '*For occasions, I like the padded push-up bras. But for the job, I like the padded with light* [slight pause], *you know, lightly padded for the work'*. The separation by design feature, the padding, is a cultural aspect that Lilly, of Nigerian descent, informed is important for traditional celebratory engagements. Lilly explained, *'I have a lot, many! For like when we wear our traditional clothes. […] we dress up to push our bras up like* [gestures with hand] *to make our breasts big. You know some people they wear like two to three bras. To make it push up to become big'*. Ellen offered another perspective surprising the group by separating her bras with a section solely for going on holidays. '*I've got my holiday drawer. Because every time you go on holiday, you don't have to keep buying all these new bras. […] and they last for years, a long time. […] They're the expensive ones'*, she added. The questionnaire results (Section 7.1.2.4.) highlighted that women believed there were appropriate/inappropriate bra styles and colours for professional and social events. These findings are analogous to prior studies indicating that women wore separate bras for social occasions such as evening or daytime events (Dewsnap and Hart,

[85] The Functional, Expressive, and Aesthetic (FEA) consumer needs model was amended to include the structural aspect of a garment, thus altering the acronym to FSEA (Davis, 1996). Moving forward, the FSEA acronym is utilised.

2004; Risius *et al.*, 2014). The women's experience demonstrates that bras may also be separated by events such as holidays and doctor visits[86].

Fig.8.3. Images from activity booklet with participants marks

The results also revealed that women wore bras outside the design's intended functions. Clary explained, '... *I always travel in a sports bra because I just find they're that much more comfortable'*. The sports bra, intended for sports-based physical activity, offers her large breasts support while still being comfortable enough for long travelling journeys. Ellen emphasised the sports bra's comfortability, admitting she only wore them in the house as loungewear. She disclosed, '*I wear them in the house. I put them on when I come home cause when I've been wearing a bra for so many hours... It's comfortable to do my housework in and stuff like that. […] comfortability in the house, but I still get that little bit of support*'. According to Marketing Report specialist Mintel 2020**,** more women seek non-wired bras for comfortability, with sports bras being a replacement when non-wired everyday bras are unavailable. Unexpectedly, Ellen shared that when she exercised, she wore structured bras. She explained, '*even though I do go to the gym, I don't particularly go out and buy sports bras for the gym. I use normal bras to go to the gym'*. Picking out an image from the activity booklet (**Fig.8.3.**), she noted, '*I mean, this is the bra here* [referring to another image in the booklet]. *I put reliable here because I think that is a bra I could wear to my Zumba and exercise in. […] It's not a sports bra, but I would still get the support from it'*. Ellen's experience highlights that women make personally informed decisions when purchasing bras. The women's experiences confirm that the bra, a feminine technology (Section 5.3.1.), imparts them with embodied knowledge to decide on its best usage based on their comfort and support needs.

[86] In the following sections, we will hear from one participant who has specific bras for visiting her doctor.

8.1.2. Bra Experience

This section details the various sentiments of the women when discussing their bra experience. Three areas were most prominent: breast size affecting experience (8.1.2.1.), bra-wearing and comfort (8.1.2.2.), and bra shopping (8.1.2.3.).

8.1.2.1. Breast Size & Bra Experience

Breast size and its effect on bra experience emerged from the discussions. The women would casually mention their bust size while discussing their bra wants or experiences. Kimberly mentioned, '*...I don't have much breasts - but [...] I had to go through like different types of bras to find the ones that work for me, and the ones that I feel like, most comfortable in'*. She added, '*…all of my bras are push-up bras, and they have padding in it'*. Kimberly's experience illustrates the problems she faces, even though small-busted, in finding suitable bras. Although mature in age, Kimberly shared her desire for padded push-up bras. Janet voiced similar sentiments relating, '*... I am not a busted person, so I like to do push-ups or padded bra[s]'*. Regardless of age, in this study, smaller-breasted women preferred bra styles that enhanced their size.

Prior research reports that having larger breasts affects MW's body-image, leaving them less satisfied and embarrassed (Fernandes, 2016; Spencer *et al.*, 2020). This could be due to the limited bra choices available, as larger-breasted women are forced to purchase bras for functionality due to the lack of fashionable styles in their size (Filipe *et al.*, 2015). Ellen voiced her concern about larger breasts and menopause. She posed the question, '*Why is it that women, when they go through the menopause, their breasts get bigger? Because I used to be like a 34DD back in the day, you know, when I was young* […]. *I was a size 12 forever. And then once I started going through menopause, these things just grew* [emphasis on grew]'. Black women in the questionnaire noted that their breasts had changed since turning 45 years old, with 36.8% seeing a size increase. Moreover, Ellen mentioned not wanting bigger breasts due to her problems finding 'nice' bras in her size. Agreeing, Deloris exclaimed that her dilemma was finding specific bra styles for her large breasts. '*My issue is that I've had problem finding strapless bra because my chest is a little bigger*', she shared. Clary reported a similar problem, along with participants from the questionnaire, with one writing, '*Being top heavy limits selections and are expensive. It is more about the quality and support, but I choose attractive style*[s]*'*. Ellen contributed that she often forgoes bras with padding, not wanting to appear any larger – further limiting her choices.

Moreover, larger-breasted women have conflicting relationships with their breasts. It can make them feel feminine, attractive and sexy, while also feeling as if their breasts are constantly visible leading to discomfort and self-consciousness (Millsted and Frith, 2003). Koff and Benavage (1998) establish that women's breast size satisfaction affects their self-esteem. Ellen did not explicitly mention how having larger breasts affected her psychologically, whereas Clary was aware of the tempestuous relationship with her breasts. She revealed, '*…what I didn't like when I got reduced was the fact that they've changed the bra sizes. Cause I thought, ohh, good, I've gone back to a DD. Psychologically, that was important for me'*. Their bra choices further exemplify the dissimilarity

between Ellen and Clary's large-breast experience. Ellen prefers non-padded lacy bras, while Clary does not want to draw attention to her breasts, frequently noting she prefers a discreet bra. Clary shared, '*I don't want to see lace showing. I think I'm really conscious, especially with the size of my breasts, conscious of attracting the wrong attention'*. Retorting, Ellen countered, '*I never think like that. I always wear the lacy ones if I try. I never think about, oh, I must wear a plain bra under this because, oh, it's going to show that I've got a lace bra under this'*. The bra's discreetness is a personal choice; however, the questionnaire highlights that discreetness was important to mature Black women. The results illustrate the importance, with 27.8% extremely important, 22.22% very important, and 22.22% somewhat important. The significance of discreetness is possibly tied to the hyper-sexualisation of Black women, and their reaction to it by not wanting to appear improper. Davis (2015) explicates that Black mothers strive to teach their daughters proper appearance, based on respectability politics, as a source of pride and a strategy to navigate marginalisation from Black women stereotypes.

As the findings show, whether large or small-breasted, MW have difficulty finding suitable bras. These women illustrated the significance of breast size in understanding bra experience. As this research did not focus on specific breast sizes, further research is needed to examine the difference in bra experience between larger and smaller-breasted bra wearers. Both Risius's (2012) research on mature bra wearers and Sharland's (2018) on larger-breasted bra wearers indicate similarities in desired areas such as comfort, support, aesthetic and fit. However, as Risius's participants were also larger-breasted the experience of smaller-breasted bra wearers are missing.

8.1.2.2. Bra-Wearing Experience

The bra-wearing experience[87] is complicated and an area the women described in obscure terms. Kimberly divulged that when a bra is satisfactory, it '…*works really good for me and, you know, that I feel sensual in'*. She mixed the functional and psychological nature when describing an ideal bra experience. In contrast, Janet was more aware of what she did *not* want in her bra-wearing experience: the physical and functional bra strap troubles. She shared, '…*I don't want to have to be like pulling the straps up on my shoulders or having them falling off my shoulders or anything like that'*. Bra straps showing were unacceptable for many of the participants. For Janet and the other women, what was essential and acceptable was the appearance of the bra under clothing. Although several women from the questionnaire indicated that it did not matter how their bras looked as no one would see them, speaking with different women illustrated that they make preferences based on this awareness. Janet disclosed, '...*I try to – to look instead of having them girls hanging down; I want them up looking youthful and mature'*. Despite the juxtaposition of Janet's 'youthful and mature' description, she was conscious of how her bra must function for her breast presentation. Deloris was also mindful of her bra choices; she informed, '…*because my chest is a little bigger. […] I'm thinking about the appearance. So how it looks under my clothes'*. She spotlights her larger breasts and selected bras that did not draw negative attention to her. Kimberly

[87] Section 7.1. and 7.2. expounds on the myriad of ways the bra experience affects MW. Moreover, Section 8.2., further details in-depth specific bra experiences by mature Black women.

also emphasised the social aspect of appearance for a suitable bra experience and further denoted the affective tactile sensation. Describing her favourite bra, she explained, '*It's very soft and very stretchy. […] really, really gave you like such as beautiful silhouette'*. The women's critique indicates that the bra must be personally and socially acceptable.

This portion introduces themes around positive and negative[88] bra experiences and areas that influence particular grievances. The women were asked to write a few words on a post-it about how they wanted to feel while wearing a bra. While discussing their notes, it became clear just how entwined the bra experience was with the women focusing on comfort and the emotional aspect. Clary coalesced comfort within an emotional, psychological, and social aspect by wanting to 'feel great' and 'look good' by appearing aesthetically pleasing. She shared, '*When I first put it on, I want to... feel like... it fits my clothes underneath, and I look good. And that's that for the rest of – forget it for the rest of the day*'. She followed this up with, '*I've put nothing. Yeah. I want to feel like I've put my clothes on and I feel great. And I don't even think about my bra*'. Clary adamantly centred on feeling comfortable in her social self-presentation, which meant the bra functioned according to her standards without attracting her attention.

Ellen discussed comfort in the physical aspect by not wanting to be aware of the bra on her body during wearing. She clarified, '*Comfort. That's what I meant by nothing*'. Yu (2011) emphasises the intricate facets of comfort in bra-wearing, being psychological and physiological intermixing components such as sensorial, thermal, motion, aesthetic, and hygienic. Ellen explained the emotional and economic element by stressing that she is paying for the enhancement or experience of feeling 'sexy and pretty'. She elucidated, '*You want to forget it because you're wearing the bra it's not wearing you. I want to feel pretty as well. You've already gone and spent £45 on a bra. [...] So, you want to feel... sexy and pretty too. After all, I've spent all that money*'. Ellen faced difficulty finding beautiful bras as a large-breasted woman, thus spending more money shopping at higher-end retailers, such as Rigby and Peller, where a bra can be tailored. She reasoned that the expensive bras, '… *gave me a very nice shape. And for me, that's money well spent'*. Again, the bra enables her to present as she desires; thus, she is consciously paying for that experience. Like Clary, Ellen highlighted the importance of the bra as a foundation for producing their sought-after image. As validated in Section 7.1.4., the bra is connected to the wearers' sense-of-self. Clary exemplified this sharing; a good bra is '… *something to [help] maintain your femininity*'. She firmly added, '*I think it's really important to have pretty underwear. And if you're big busted, you never used to be able to get pretty bras*'.

During the workshop, comfort came up often – mentioned forty times – with the women agreeing it was one of the most significant facets when selecting a bra. This is expected as, commercially, more than three-quarters of bra shoppers (Sender, 2020), specifically mature women (Risius, 2012; Risius *et al.*, 2014), opined

[88] The women shared elements of negative bra experiences by similarly jotting a few notes on a post-it. Unfortunately, they did not elaborate on these negative experiences, but clear themes around ill-fit and bra pain were expressed – similar to those noted in Risius (2012).

that comfort is more vital than fashion. During the questionnaire, MW were asked to select reasons for wearing a bra. Over 50% responded because they have large breasts (51.4%), followed by them feeling comfortable wearing one (47.4%), and it making their clothes fit better (44.6%). Hence, physical, and mental comfort in social presentations is vital in the bra-wearing experience.

8.1.2.3. Bra Shopping Experience

Next, the women discussed their bra shopping experience deliberating over what they looked for during the process and the issues they encountered. Janet explained, '*I'm looking for something as good as the last one. Or one that I had before that makes me feel more ... should I say...womanly, gives me that lift'*. She mentioned the bra's physical lift function and the psychological sensation of feeling 'womanly' or feminine by wearing a bra that is in harmony with her desires. Janet also communicated that her past positive bra experience informed her new bra desires[89] and requirements. Tsarenko and Lo (2017) confirm that MW tend to be loyal to bra brands that have previously met their needs. Kimberly mentioned the psychological and physio-affective connection when shopping, selecting bras that appear 'sexy' to feel 'sexy'. She expressed, '*...when I go bra shopping, I want to feel sexy in what I'm wearing [...] I want them to be sexy. […] I'm – typically tend to look at the design of a bra first [...] because I want to feel sexy in the bra. ...first thing is the look; it has to be appealing. Uhm, and it has to fit well…*'. Although the bra fitting well seems like an afterthought, it is not, as Kimberly further explained, '*…because most of the time the models that they have that are wearing it, they're not your body type'*. Since 2015, lingerie retailers have slowly introduced mature models; however, as Kimberly pointed out, it should be required to help women select the appropriate product. Mintel's lingerie report (Sender, 2020) contends that 49% of MW ages 45-64 agree that seeing lingerie on different body types would make shopping easier. Additionally, 73.5% agreed that showcasing solely slim models was 'outdated' (Mintel, 2020)[90].

8.1.3. Design Attributes

One of the objectives was to collect information on women's bra wants and needs; therefore, it was essential to investigate their desired bra design attributes. The women were highly vocal and knowledgeable about their bra wants, concentrating on features appropriate for MW's bodies. Although they differed on whether the bra must be discreet or non-discreet, or padded versus non-padded, they agreed firmly on the following attributes. Clary requested adjustments at the bra's front, with Lilly and Ellen agreeing. The desire for bra adjustments to the front was also pointed out in the questionnaire, with an anonymous participant writing, '*Give me front-closure, it's the ONLY things that's changed for me, getting those damn hooks is harder'*. Zhang et al. (2020) confirm that bras for MW should have adjustable straps at the front with front closure for easier donning and doffing. Therefore, front closures, rings, and slide attachments pose valuable design attributes for MW.

[89] Desires referring to the social image of herself she wants to portray.
[90] To produce bras that fit MW in the retail stage, products must be designed to first fit them in the development stage. Thus, utilising mature models in the design process becomes pivotal.

Without elucidating, the women noted wanting bras with lower backs, three hook or innovative closures, wider wings, and under bands. These features have been argued as appropriate design elements for MW (Zhang, 2020). Ellen signalled the advantageous feature of a longer cradle or longline bra to shape and keep the bra in place for her maturing body. After showing her designs, she shared, '*Yeah, because I have a bulge here* [gestures to the abdomen just below breasts]*, it would have to be stiffer and stay down'*. As women age, their body shape changes, often increasing in BMI, which affects bra size and fit (Shi *et al.*, 2020). Bras with wider under bands become beneficial in shaping the upper stomach bulge (Zhang, Yick, Yip, *et al.*, 2020). To help shape their body, Lilly and Clary put forward the wish for wider wings at the side of the bra. Lilly exclaimed, about her design, '*Yeah, it's wider. I want it sexy, like sexy'*. Clary added, '… *and that wouldn't allow the back fat to show*'. Bra research for older women confirms that a wider and more rigid wing would help prevent the bulging under the arm and back that MW experience (Zhang, 2020; Zhang *et al.*, 2021). Subsequently, the women introduced ageing health problems and the obstacles they placed for bra wearers. Lilly suggested using snaps as an easier updated bra closure instead of the typical hook and eyes. Clary added, *'The snaps may also be good for people with arthritis and stuff. That's the other thing bras don't always take into consideration that you're not always fit. You're not always fit, and you don't always have both hands'*. Based on this premise, design-researchers Zhang and Yu (2018) patented a magnetic bra closure after research with mature Asian women.

The bra straps were another area the women agreed upon, wanting straps that are 'sturdy', 'bigger' and easier to adjust. Hidden straps were an attribute the women agreed upon, with Lilly clarifying she did not mind if her bra showed, but her straps must be concealed. Risius (2012) similarly corroborates the importance of the strap staying in place, and it slipping down as a common problem faced by many MW during wearing structured (Lim and Cho, 2013; Zhang, 2020) and sports bras (Bowles, Steele and Munro, 2012). As women age, their shoulders slope and round forward, causing bra straps to slide off easily (Ashdown and Na, 2008). Wider bra straps designed higher up on the shoulders are recommended for MW and those with larger breasts to prevent slippage and create a better bra fit (Coltman, McGhee and Steele, 2015; Coltman, Steele and McGhee, 2018; Zhang, Yick, Chen, *et al.*, 2020; Zhang, Yick, Yip, *et al.*, 2020).

8.1.4. Bra Wearables Interest

The first time the women had heard of BW, or its wider smart bras field, was during the workshop and digital dialogue. Therefore, they were introduced to the BW state-of-the-art through a PowerPoint to capture input of their interest and wishes. Four concepts arose: materiality (8.1.4.1.), BW aesthetic (8.1.4.2.), modularity (8.1.4.3.), and BW usefulness (8.1.4.4.).

8.1.4.1. Materiality

The hardware components and electrical materiality of BW were an issue for participants. Ellen shared, '*I think I'd want the wearable in the material. I don't think I'd wear a bra with a device in it. Unless it was something invisible. […] I don't want to think about that I have a battery in my bra. Something like that'*. Clary brought up concerns about the electrical elements interfering with women's health. '*I think if you have a heart condition, you'd maybe*

have to be careful around batteries and things like that', she commented, with Ellen revealing she had a heart condition. Laundering was another area of concern. Clary questioned, '*If you put a battery in the garment, you'd have to think about the aftercare, won't you? […] if it gets accidentally thrown in the wash?*' Ellen mentioned that laundering by machine created wear and tear; therefore, she would not mind hand-washing her BW. However, 62% of women in the questionnaire noted that caring for BW impeded their interest.

8.1.4.2. BW Aesthetic

Next, the women provided insights on their preferred BW attributes. Their consensus was that BW should be traditional looking. This is consistent with the questionnaire results, with 83% of the women agreeing that BW should look like regular bras. The women were clear they wanted it to be 'pretty like an everyday bra'. Moreover, 74% of questionnaire participants agreed that the aesthetics of BW was important for acceptance. Through the provided bra samples, images, fabric, colour chips, and design tools, the women in the workshop pieced together their BW concepts. Ellen mentioned, '*Yeah, I'd say I want something a bit more traditional looking like this here.* [Gesturing at a design]'. Additionally, the women came to a common consensus that BW should be 'easy to wear'. Based on the questionnaire, almost half (47%) of women believed wearing BW would be more difficult than wearing a regular bra. The notion of what *difficult* entailed is still unclear, as the workshop's women did not clarify. The women identified that the wearing sensation of BW should be comfortable and 'light'. Clary suggested, '*...a bra should be light. So, you don't feel like you're being holstered'*. While they did not comment on the BW examples in the PowerPoint presentation, the prototype images may have influenced their viewpoints. Having preconceived perceptions about the products, 40% of questionnaire participants believed BW would not be lightweight.

8.1.4.3. Modularity Feature

The design-researcher introduced and discussed modularity as a feature in the bra design (see Section L.1.3.). Then the women delivered feedback. They were hesitant about the modularity and whether it would work properly. This notion is similarly displayed in the questionnaire, with 41% of women believing technological enhancements would not function as described. The women's first perceptions were filled with concerns. Clary queried, '*It just seems like a lot of work.* […] *Would that support you efficiently though? Because if you're slipping bits in and out, would that weaken the bra?*' Ellen agreed, believing it would be too much work decreeing, '*But I'd have bits here and there. I couldn't. I just really couldn't get it. No way'*. Her statement illustrates the belief that a learning curve is necessary for new types of bras. After demonstrating the modularity concept with bra samples, the women adjusted their perceptions. Clary shared, '*I could see the use in it though. I'd have to get used to it. The only time I think it might come in handy is if I was going on holiday'*. Ellen agreed, '*Yeah, it would make a great holiday bra for me'*. The women felt the modularity concept was beneficial for them only when on holiday as it would alleviate the need to pack multiple bra options.

8.1.4.4. BW Usefulness

Different BW sectors received more interests than others due to perceived usefulness. During the questionnaire, 41% of women believed BW would not be useful to them. Nevertheless, breast cancer detection bras received higher interest during the generative workshop and digital dialogue, while SBW received less. Tori professed, '*...I like the cancer detect one. [...]And it looks like it's comfortable'*. Although she mentioned physical comfort based on the design, she also shared that her sister had breast cancer signalling a personal connection. Kimberly and Janet also found the breast cancer detection bras beneficial and expressed interest in the design specifications. Janet disclosed her enthusiasm for the EVA breast cancer detection bra, '*I kind of like the cut, the cleavage cut... I like the straps because it's a little thicker... And I feel like the support – the support that it gives under the boobs'*. Kimberly echoed similar sentiments, '*…the shape of it looks like it's a push-up. [...] it looks like it would give you, you know, like really good support'*. Both women mentioned the support and alluded to other design elements they perceived as significant. Despite being beneficial, the women emphasised the importance of the BW aesthetic for their interest. Therefore, based on their responses, both the bras' functionality and aesthetics are essential for acceptance.

The women were not interested in the SBW sector. Tori sharply insisted, '*I don't think that I would enjoy a fitness bra. If I can make exercise as enjoyable as possible without the stress of a fitness bra, that may or may not give me the correct data, which can mess up my nice workout'*. For Tori, the SBW were not useful hinting that it would be stressful and may not function properly. Navalta et al. (2020) provide supporting evidence after investigating three SBW[91] that they may only work accurately during certain activities such as walking or rest. Thus, wearer distrust may have merit. Kimberly's disinterest was due to her belief it was unnecessary contributing, '*...when you're working out – typically when you're working out, you're kind of like already focused on what you're doing, so I don't know if there's a need. I don't really see a need for a bra to coach me* [chuckles]*'*. Based on the discussion, for MW to be interested, BW must be considered useful, beneficial, and suitable to their standards.

8.2. Insights into the Multi-Level Bra Experience of Black Women

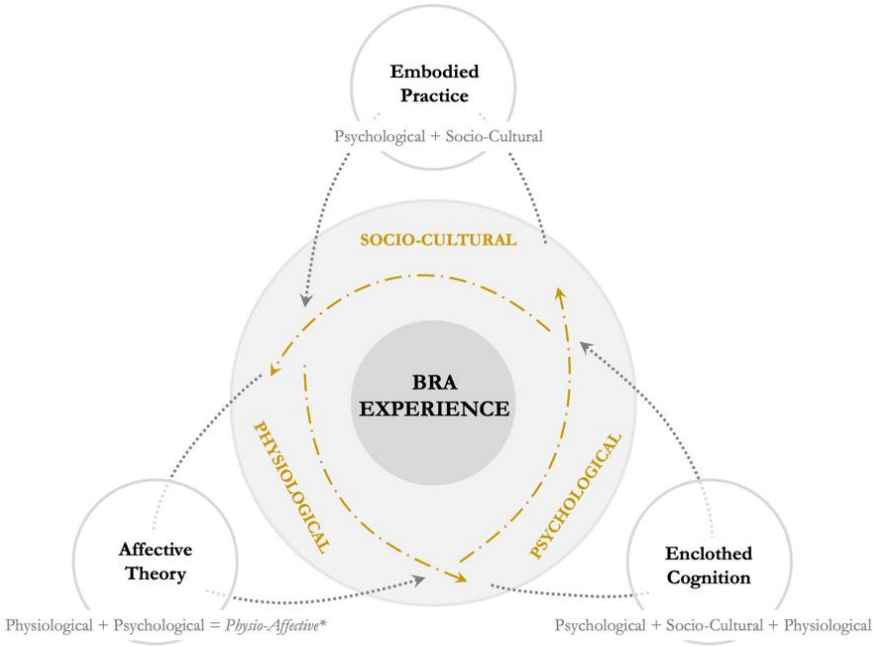
'Becoming aware of or constructing a self is a particularly salient feature of making sense of experience'. (McCarthy and Wright, 2004, p. 106)

This section introduces the results from semi-structured interviews (*n* =6, see **Table 6.36.**, p.188) to elicit further information on MW's bra-wearing experiences. Their experiences were examined through an interdisciplinary Bra Experience Framework developed from the literature review (Section 4.3.). The framework ladders three theories built on the psychological (Enclothed Cognition), socio-cultural

[91] SBW investigated were the Adidas Smart sports bra, Berlei sports bra, and Sensoria Fitness sports bra (Navalta et al., 2020).

(Embodied Practice), and physio-affective (Affective Theory) experiences of bra-wearing (**Fig.8.4.**). Employing a theory-driven codebook analysis (Section 6.1.2.3.), the women's experiences were interrogated and coded using the framework to guide comprehension. Once the codes were created, a mind map was developed to further assess and group codes into categories within their corresponding thematic frameworks (**Fig.8.5.**).

Fig.8.4. Bra Experience Theoretical Framework.



The overarching finding of this section is that the bra-wearing experience is complex involving the wearers' physical, sensorial, aesthetic and emotional contemplations (Norman, 2005) informed by prior bra-wearing occasions, socio-cultural norms, ageing and the women's bodily presentation desires. Sukumar (2007, p. 267) imparts that there are certain bra rules that 'is learned unconsciously, and spoken by every woman; a societal code that has its own language'. This implicit knowledge of the bra rules is acquired through their interactions with their mothers (Tsaousi, 2011) and society. As indicated in Section 7.1., societal bra influences impact the bra-wearing experience[92]. Although the women identified as Black, 'race' did not directly influence how they physically experienced the bra; however, they mentioned thinking about their 'race' when deciding how to present themselves socially[93]. Assessments from data triangulation suggest the most significant factor was breast size and self-esteem, which are intertwined.

Fig.8.5. illustrate the Bra-Wearing Experience Mapping resulting from the interviews. Embodied practice (8.2.1.) resulted in five themes demonstrating the significance of social presence to bra-wearing. Affective

[92] The Factors Affecting Bra Experience Structural Model (Section 7.1.4.) illustrate that bra influences – inclusive of (society, media, peers/colleagues, friends/family, and partner) – has a substantive and significant effect on the bra-wearing experience.
[93] Black women and fashioning self-presentation is a rich subject area illustrating that 'race' plays an important part in how they clothes themselves (Franklin, 2003), teach their daughters how to dress (Davis, 2015), and use dress to interact within the dominant society (Matthews, 2020). More research should be conducted on the influence of 'race' and fashion/presentation for Black women.

theory (8.2.2.), similarly, resulted in five themes indicating the complexity of the physio-affective aspects. Lastly, enclothed cognition (8.2.3.) resulted in three themes signifying that women wear the bra to access perceived attributes of the garment. The following sections, named after each experience-based theory, will expound on the multiple themes and categories. Although placed within specific themes, the categories often intersect and apply to more than one theme.

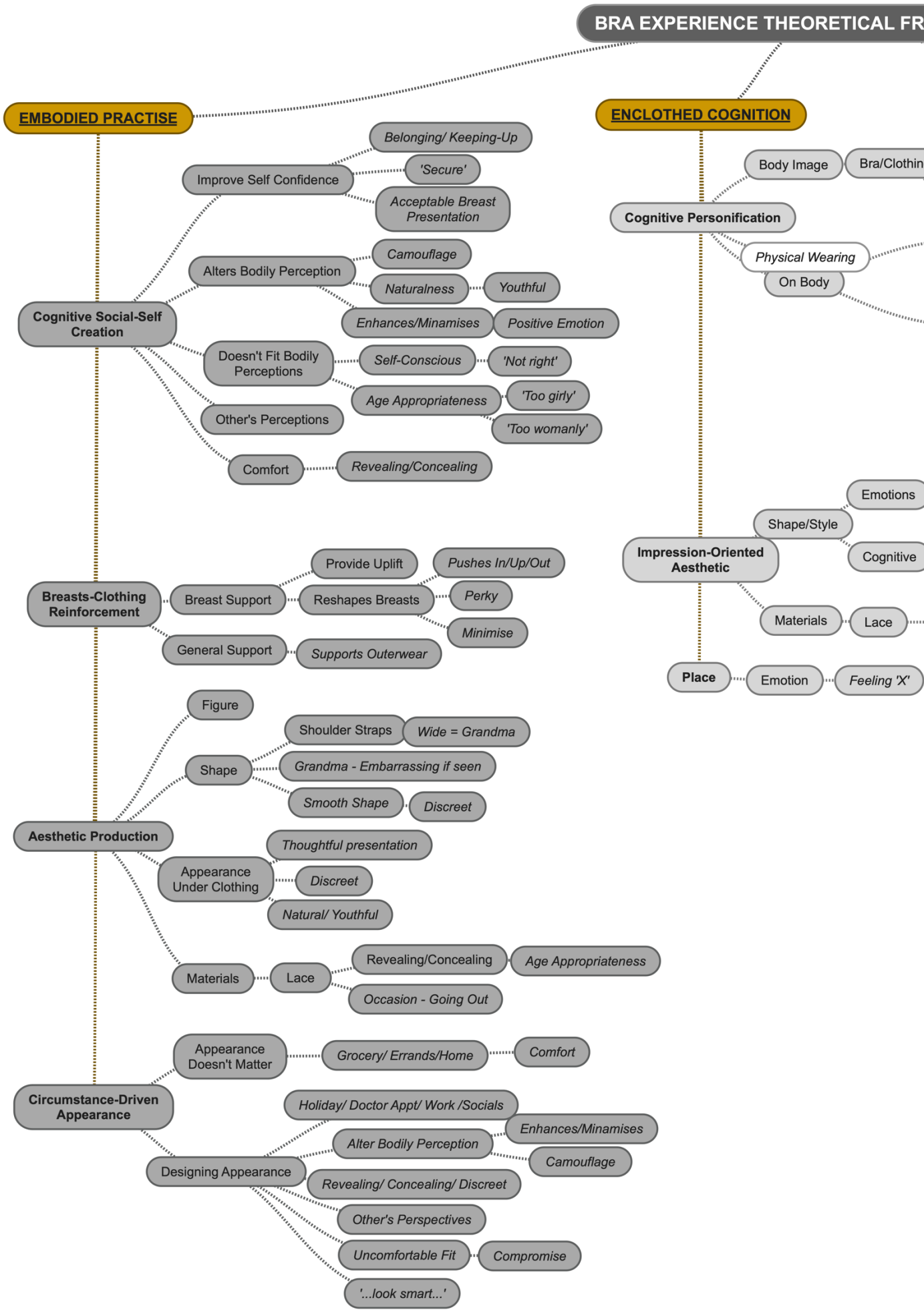

BRA EXPERIENCE THEORETICAL FR
EMBODIED PRACTISE
ENCLOTHED COGNITION
Cognitive Social-Self Creation
Improve Self Confidence
Belonging/ Keeping-Up
'Secure'
Acceptable Breast Presentation
Alters Bodily Perception
Camouflage
Naturalness
Youthful
Enhances/Minamises
Positive Emotion
Doesn't Fit Bodily Perceptions
Self-Conscious
'Not right'
Age Appropriateness
'Too girly'
'Too womanly'
Other's Perceptions
Comfort
Revealing/Concealing
Breasts-Clothing Reinforcement
Breast Support
Provide Uplift
Reshapes Breasts
Pushes In/Up/Out
Perky
Minimise
General Support
Supports Outerwear
Aesthetic Production
Figure
Shape
Shoulder Straps
Wide = Grandma
Grandma - Embarrassing if seen
Smooth Shape
Discreet
Appearance Under Clothing
Thoughtful presentation
Discreet
Natural/ Youthful
Materials
Lace
Revealing/Concealing
Age Appropriateness
Occasion - Going Out
Circumstance-Driven Appearance
Appearance Doesn't Matter
Grocery/ Errands/Home
Comfort
Designing Appearance
Holiday/ Doctor Appt/ Work /Socials
Alter Bodily Perception
Enhances/Minamises
Camouflage
Revealing/ Concealing/ Discreet
Other's Perspectives
Uncomfortable Fit
Compromise
'...look smart...'
Cognitive Personification
Body Image
Bra/Clothin
Physical Wearing
On Body
Impression-Oriented Aesthetic
Shape/Style
Emotions
Cognitive
Materials
Lace
Place
Emotion
Feeling 'X'

Fig.8.5. Bra-Wearing Experience Mind-Map.

8.2.1. Embodied Practice Exemplars

Embodied practice is 'concern[ed] with bodily experience and social practice' (Entwistle, 2000a, p. 333). By examining the bodily experience and social practices of bra-wearing, we can gain a deeper understanding of its social aspect. Entwistle (2000a, p. 325) establishes 'dress as both a social and a personal experience', which also applies to the inconspicuous bra (Tsaousi, 2011) and continues throughout ageing (Twigg, 2013). Women made conscious decisions when selecting a bra to wear as it supports the outer garment providing them with their desired appearance (Risius, 2012) and construction of various social identities (Tsaousi, 2011). Investigating the embodied practice of bra-wearing produced four themes: cognitive social-self creation (8.2.1.1.), breast-clothing reinforcement (8.2.1.2.), aesthetic production (8.2.1.3.), and circumstance-driven appearance (8.2.1.4.).

8.2.1.1. Cognitive Social-Self Creation

Cognitive social-self creation encapsulates how the women described their negative and positive bra experiences. Perception is critical, whether it was others' perception or attempting to alter their bodily perception; the women applied forethought in their bra selection. Sherry explained, '*I think I do unconsciously because – because I do with other people. So, if I see somebody at a function, and I think that their bra doesn't suit the outfit, I automatically [...]. But so, if I notice it about other people, I assume they would notice it about me. So, I think about how I'm going to look to other people when I'm – when I'm dressed*'. Thus, because the women are aware of other women's presentation – acceptable and unacceptable – they select their bras following social norms. Results (**Fig.8.5.,** p.243) suggests that they utilise the bra to camouflage, enhance, and present a natural youthfulness by lifting and reshaping the breasts. Tori assigned this increased awareness to ageing, sharing, '*So now as I'm older a bit more self-conscious, uhm a bit more reserved, then I've moved to different things*'. Ageing was often discussed in obscure ways; the women described bras they would not wear as either too girly or too mature, thus not fitting with their social self-presentation. Presentation was essential as the women employed the bra to improve their self-confidence in social situations. When sharing one of her favourite bra experiences, Clary divulged, '*I felt secure. I felt I could do anything, really. I didn't feel, uhm, restricted. […] But I – I didn't feel like I had to hide myself. I felt like I could be quite comfortable, comfortable to be out front with everybody*'. For women like Clary, the bra enables them to be comfortable by fitting in through socially acceptable breast presentation.

8.2.1.2. Breasts-Clothing Reinforcement

The breast-clothing reinforcement theme encloses the bras' functional facet, such as providing uplift, reshaping the breasts, and general support to the outerwear. When selecting a bra, the women rated it as being equally important as outerwear. '*I think that plays an important part, uhm, because if I want you to get the full effect of this dress and all its beauty, I definitely want to put that best bra on*', emphasised Melly. The bra reinforces and normalises breast presentation in society (Young, 1992), enabling proper social appearance. Moreover,

as a foundation, the bra supports outer garments. Tori reaffirmed this notion, stating '*I want [the bra] to be comfortable, and I want it to look nice with my outfit. I don't want my – I want my bra to make my boobs look perky. And look nice under my clothes. That's what's important to me*'. Tori consciously separated the bras' dual roles in supporting her outer garment and making her breasts presentable by providing an uplift. The women were cognisant of the bra's multiple capabilities in reshaping their breasts and using them to navigate different outfits based on social occasions. Sherry informed, '*Because it might be that – that I'm wearing it uhm with something that is figure-hugging, and I might feel that maybe I should wear, uhm, a bra that – that pushes me in or pushes me up a little bit*'. The bra was selected not solely based on the dress but the unspoken social stipulations. Sherry could not articulate why her breast needed to be presented that way; however, as the literature shows, it is likely that her decisions and the decision of other women are grounded in their embodied knowledge of acceptable socio-cultural breast presentation (Woodward, 2007). Flynn and Fitzgibbon (1998, p. 21) posit that for Black women, presentation is not solely about beauty but 'includes grooming, dress, posture, and whether she walks and moves as though she is proud of herself and culture'.

8.2.1.3. Aesthetic Production

The aesthetic production theme is quite varied as the women exploit the bra's material culture to design their social identity. Although the bra is an inconspicuous garment, women consider concealing or revealing it depending on certain circumstances. The bra's fabrication plays a vital role in the production and experience of the bra. Some women use lace bras as extra decoration for their outer garments, satisfied with its exposure. Janet recounted allowing the straps and back designs of her colourful lace bras to show during the summer, only when wearing summer dresses. She shared, '*Yes, I like them in the lace, like because I want them to show. So, I want – I use those in the lace, so it looks prettier*'. Similarly, Sherry acknowledged allowing her lace bra to be revealed only for a special occasion like a date. Sherry added, '*And I had some that had like a lace cup. So, they would be – they wouldn't be the thing that I'd wear if I was wearing this smooth dress or top. They'd be the sort of thing that I'd wear if I was maybe going out. Going on a date or whatever*'. As such, the women utilise the lace bra to illustrate different aspects of their identity, whether playful or sexy.

Other materials, such as the bra straps, were concealed or deliberately avoided as it was deemed embarrassing and improper to showcase. Some women in this study linked the wider bra straps to an older grandma identity. Tori acknowledged, '*And not wide – I don't really like very wide straps. I like not like super thin, but I don't like the big wide straps.* [...] *even though I know I'm older, I just feel like my grandmas probably would wear that.* [Laughs]' Although the bra strap would be concealed, Tori is adamant that she would not wear it as it does not fit her identity. Melly concurred, explaining, '*But uhm, I do like to feel glamorous when I have – like I feel when you have a good bra on under your clothes. It's not grandma-y-ish. It's not full of flowers or these big, humongous straps. And you know your shirt can't fall over today because if it does, everybody will see these humongous straps*'. Researchers have highlighted implementing wider straps for MW due to their bodies' changes, such as sloping shoulders and a curved back (Risius, 2012; Zhang, 2020); however, this may not fit with the women's identity causing

insecurity and distress. As noted in Section 7.1.4., the bra wearers' experience is linked to their identity and influenced by the aging experience.

8.2.1.4. Circumstance-Driven Appearance

Woodward (2007, p. 19) postulates that women exploit clothing based on the 'occasion-specific identity' they desire to create to fit in or stand out as individuals. This concept is reaffirmed in the circumstance-driven appearance theme, with the women selecting their bras based on whether they were designing their appearance or felt their appearance did not matter, depending on the occasion. Sherry shared,

> '*Well, if I'm going to uh uhm, let's say an evening function, a party, and my top is slightly lower than I would wear for the daytime, I would probably wear a bra that pushed me in and up. Because I don't want my breasts to sort of disappear down there. You know, I don't want everyone to be looking down uh the uhm between my breasts. I'd rather they were present where I could see them – where everyone else could see them.* [...] *giving them a better presentation. So, I'm not, not the kind of person that pushes my breasts up all the time, but for an occasion and certain garments, I would expect to wear a different bra that would present me better.*'

As uncovered in the questionnaire and workshop, women usually separate their bras for work and social events, indicating socially acceptable ways of presenting or concealing breasts in different spaces. Interestingly, Sherry added that she was not a specific type of woman who pushed her breasts up '*all the time*', acknowledging that she understood the bra rules and social norms, unlike the type of woman who did not. Tsaousi (2011) explains that women learn the importance of knowing when to wear the *right* bra and how that can factor into their social capital. Janet enthusiastically explained that she has bras for various occasions based on how she wants to exhibit her breasts. She expressed,

> '*Based on the looks – based on how they fit me. And the look, if – if the push-up bra, if – if I'm wearing like a jacket or I'm going to church based on what I'm wearing, I would wear those just to enhance me so I would look more* [slight pause] *more sexier than the – the regular padded bra. I would wear those to work under my scrub. So, I would look not too flat-chested, I would look like more bustier.* […] *Even if I'm going to the doctor, I make sure that my bra is nicely put together. If I'm going to events, I have my event bras that I would wear when I'm going out, different from the ones that I wear regularly to work.* […] *Like my – my doctor bra [laughs] has to be nice and intact*'.

Melly also mentioned feeling awkward if she wore a bra with a bow and her doctor saw it. A doctor's office is another space where women are cautious about how they present their bras.

On the other hand, there are events where women are indifferent about designing their breast appearance, for instance, when grocery shopping or running errands. Melly proclaimed, '*I really don't care if I have the jingle. Or if I'm trying to hold back the jingle, and I'm just getting up, and I know I need to just run to the store real quick. Um,*

I'll just grab whatever bra …' Tori confirmed this sentiment, '*...so, if I'm home, just lounging which I'm going to have on one, I may just pick like a bra that has no support, nothing it doesn't matter or nothing*'. When asked if she would wear her home bra out, Tori responded, '*...I would if I'm like running to Walmart, you know? Somewhere simple, but not to church. No, not if I'm going to be meeting someone for – for lunch*'. Although the women indicated their home bras were decent, it was regulated to a divergent identity, one related to their private life, which involves safe social spaces where they do not feel they must alter their bodily presentation.

8.2.2. Affective Experience Exemplars

> *'Emotions and the tactile senses are inextricably linked, and as a result fabrics' texture, surface and tactility are a significant part of the experience of wearing clothes.' (Quinn, 2012, p. 32)*

Affective theory is described as the 'mutual becoming' that occurs when the garment is worn on the body affecting the physiological and bodily sensations (Ruggerone, 2017, p. 580). Ruggerone emphasises the significance of studying 'the feeling of being dressed' using affective theory. Wearing the bra on the body, women can firmly decide whether it fits any of their multiple identities, deciding 'whether it is the right or wrong choice' (Neto and Ferreira, 2020, p. 7). The affective experience is understood through whether the wearer and the bra have become one – if the experience is positive, pleasurable, and even unnoticeable during wearing; or whether a negative experience, one that causes the body discomfort or pain, forces the wearer to alter their bodily behaviour. For the bra, specifically, the affective experience may begin pre-wearing due to the significance of its tactility. While shopping, women often touch the bra, examining its materiality before moving forward (Wood, 2015). During the workshop, women would pick up the bra samples and comment on whether they would suffice, referring to similar previous material encounters. MW's bra experiences were examined employing affective theory, producing five themes (**Fig.8.5.**, p.243) sensation-based affect (8.2.2.1), somatic-informed affect (8.2.2.2.), sentiment-oriented affect (8.2.2.3), aesthetic perception (8.2.2.4.), and evocative-situated affect (8.2.2.5.), which are discussed below.

8.2.2.1. Sensation-based Affect

Sensation-based affect develops around the concept of a positive and comfortable encounter with the bra divided into two categories: physical sensation and the lack of physical sensation. Within the physical sensation category, the women discussed the bodily feelings of the bra. While conversing about her favourite bra, Tori shared, '*...the underwire is not hard to dig into my skin. It's soft enough on the skin … so it feels nice against the skin*'. The perception of the bra's multiple material make-up on the wearers' skin combines to enable a positive encounter. On the other hand, the absence of that sensation also facilitates a positive circumstance. Sherry explained,

> '*Uhm, I'd say I could just forget – forget that I have a bra on. Because it doesn't pinch or uhm rub in any place. And so, I actually forget I'm wearing it – I'm wearing it sometimes.* [short pause] *It's just perfect.* [short pause] *It – it just makes me feel uhm free. (Giggles)* [short pause] *I don't know why for some reason, maybe because I'm getting older, uhm it just – it just makes me feel happier. Uhm… and comfortable*'.

Sherry struggled to define the positive sensation from the lack of physical feeling, instead providing numerous examples. Comparably, both Clary and Ellen, during the workshop, described a positive bra experience as one where the bra had no bodily sensation. Ruggerone (2017, p. 584) refers to this as the 'confused embodied feeling', which can be difficult to verbalise. Donna attempted to verbalise by drawing out the scenario,

> '*Well, it's not a bra that I'd actually wear to go uhm cause its quite – it's a few years old actually.* [short pause] *Uhm, so uhm, when I do wear that, I sometimes wear it to the gym, uhm, and it's just really comfortable. Like if I'm, like if my breasts is sore so I'm coming to a menstrual cycle, I like to put that on because it just – kind of feels like I've not really got much, you know. That I haven't got a bra on*'.

Similarly, Donna described the sensation as invisible, with the other women using terms such as 'natural' or 'like a second skin'.

8.2.2.2. Somatic-informed Affect

Somatic-informed affect encompasses the haptic relationship between the garment and the body composed of two categories: bodily shaping and discomfort. The women spoke about this theme regarding fit, emphasising negative and positive facets. Favourable dimensions include the bra behaving the way the wearers intend, like lifting the breasts and its visual element. Melly commented, '*...the material is breathable, and it'll be able to fit flat in between your breasts, which is going to give you the lift…*' Similarly, Clary related, '*It fits my cleavage very well. It gives me a good shape. And I can actually see my waistline'*. Both women focus on the bras' functional shaping attributes while on the body. Clary also coupled it with the visual aspect of seeing the desired outcome. Ruggerone and Stauss (2022) argue the significance of the mirror to the becoming for wearers' analysis and affective experience of the garment. Donna furthered this point, '*So basically, if you look in the mirror and then, you know, it's fitting in all the right places, uhm – and doesn't make your breasts look bumpy. That's what I was looking for. To make sure my breasts didn't look bumpy in the outfit and it kind of went with the – the shirt'*. The mirror extends the somatic experience of the bra as it verifies the wearer's desired effect compounded with the fit.

Conversely, the negative facet of the somatic affect includes the physical pain exhibited through marks on the body and bodily modification. Clary elucidated, '*But uhm, I didn't feel comfortable. And that probably showed on my face, because just a simple thing like holding on to the rails in the tube. It would shift, or you would – you'd feel like it*

was stuck to you. And so, you start to feel the pain, and you can feel it digging into you more and more'. The discomfort extends, altering how the wearer moves as the *becoming* was unsuccessful. '*I find that the wires just used to irritate and stick into the side of me. [...], it turned back, and it has a rough, uhm not rough but maybe a seam that would rub on my skin, so when I take off my bra, I'd have like a red line around my body. [...] Because I know what's on the inside can really irritate me when I'm wearing a bra*,' shared Sherry. Thus, from the findings, the bodily sensation of bruising or pain from specific bras is then avoided as the women indicated and stored as information used to judge and assess future encounters.

8.2.2.3. Sentiment-oriented Affect

The theme of sentiment-oriented affect relates to the emotions or feelings women engage in while wearing the bra, including past experiences. The emotions are either positive or negative, with little ambivalence. After countless years of wearing a bra, the women were decisive in their positive bra experiences and how they felt emotionally during wearing. Janet recalled wearing one of her favourite bras, '*There's a specific feeling with it. It makes me feel super feminine. Younger – makes me feel very attractive, feminine, and attractive'*. Likewise, Melly added about her favourite bra, '… *this was just how amazing this bra is, and I put on my dress, and I just felt so beautiful and so classy'*. Donning the bra elicits favourable or unfavourable emotions that become memorable only after the interaction, whether pleasurable or disagreeable. Donna expounded, '*Uhm, so I've noticed that there's, you know, a bra can make you feel comfortable, or it can make you feel – you can feel insecure wearing the wrong bra. […] it's more about me and how I'm feeling inside'*. Each woman brings their previous experience with them when wearing the bra, contributing to their emotions. Clary informed on one of her negative bra experiences, '… *especially if I'm going to be, uhm out in a situation like that. I think it's unsightly to be tugging at your clothes. It doesn't – it doesn't feel right'*. She spoke from multiple bad interactions with that bra. While Clary did not give it a direct emotion, she did indicate malapropos coupled with the improper clothing adjustment. This links to the somatic-informed affect with the wearers' emotional discomfort evidenced in their physical reaction.

8.2.2.4. Aesthetic Perception

Aesthetic perception is another theme that emerged. It encapsulates the ornamental interpretation of the bra during the on-body encounter with categories like materials, shape and style, and bodily appearance. From the interviews, the materials were acknowledged concerning their tactility, aesthetics, and on body sensation. Janet communicated, '*The material inside were like soft against my skin. The material was soft against my skin. And the straps were like just perfect. They weren't falling down my shoulder, falling down in my sleeves. I have nothing sticking or anything. It just gives me that comfortable feeling. And the material was nice and smooth against my skin'*. The positive encounter with the materials was mentioned frequently, registering as one of the most significant aspects of memory. Contrastingly, Melly disclosed a negative experience with the materials, '*I hate to wear that bra, especially in the summertime, I hate to wear them. Because you got sweaty boobs, and then you got this wick thing that's supposed to be lifting you up instead of the wire –. And it's just the combination and this smell is horrific'*. Both women's experiences of the material, positive and negative, were such that they made a notable impression.

When the wearer views or senses the garment on their body, with its materialistic qualities, a *becoming* occurs that concretises the wearer's emotions. Sherry verbalised,

> *'I think – I think it's almost like you're a different person. So, when I'm looking in the mirror, I see a kind of uhm a sexier look. Uhm, you know the bras – that the lace in the bra it kind of… covering but showing things at the same time because – because it's lace. So, and, and also the silhouette its putting your breasts in makes your breasts look fuller and sexier. Uhm and because I've seen that in the mirror, I know I then start to feel sexier and happier and… yeah, I don't know, it changes the way you feel about the way you look'.*

She revealed the seeing of the lace on her breasts and the sensation of it was a part of her becoming 'sexier'. The findings suggests that the mirror solidifies the wearer's expectation by facilitating the becoming (Ruggerone and Stauss, 2022).

8.2.2.5. Evocative-situated Affect

The theme of evocative-situated affect is one of the most difficult to elucidate. After years of bra-wearing, women developed embodied bra knowledge which they employed to shape future bra interactions. During discussions of their bra-wearing experience, the women would refer to past occasions that advised what they wore. However, their previous experiences also informed their comprehension of their current bra-wearing habits. When sharing how she knew she was selecting the correct bra, Janet articulated, '*I think about past occasions – past occasions where my chest wasn't as full as I wanted it to be. So, I know that bra enhances my boobs enough. That bra gave me that lift. And like a size – a size up'*. Sherry responded similarly, affirming, '*So, if that bra worked, then I would try and wear that same bra again. If it didn't work and I didn't feel happy wearing it, I would just look for a different bra in my drawer'*. The women shared the significance of past encounters, comprised of the functional and emotional, that informed current and future experiences. If the past bra encounter facilitated a positive becoming, it was stored to recall for future experiences.

8.2.3. Enclothed Cognition Exemplars

Enclothed cognition theorises that wearing specific garments influences our thoughts and actions (Adam and Galinsky, 2019). Adam and Galinsky (2019, p. 157) specify that 'the two basic factors underlying enclothed cognition are the symbolic meaning associated with an article of clothing and the physical experience of wearing it'. Therefore, enclothed cognition was utilised to comprehend how the participants experienced the bra yielding two themes (**Fig.8.5.**, p.243): cognitive personification and impression-oriented aesthetic.

8.2.3.1. Cognitive Personification

The theme of cognitive personification comprises the on-body experience, and the psychological and physical body-image concept manifested. The women verbalised the bodily changes they enacted based on how they felt while wearing their favourite bra in a social situation. Melly explained,

> '*But uhm, I feel like when I have a great foundation on, I do feel glamorous. It makes me make sure check my shoulders, "oh, wait a minute, put your shoulders back". Or sometimes I find myself walking different.* [Laughs] *Because like, I know I look good today like it's a straight definition between my boobs, and my waist, and my stomach, and I want to use that!*'

Her consciousness of how she felt – 'feeling glamorous'– manifested in her deliberate change of bodily behaviour. Notably, from the findings, the seeing of themselves and knowing that they will be seen facilitates this alteration. The physical, behavioural change is not always intentional; the wearer may become aware of their corporeal gestures only once wholly dressed in the bra and outer garment. Once the bra is on the body, the women divulge feeling 'sexy', 'complete', and 'taller', the emotional sensation of confidence. Clary imparted, '*I actually think I walk straighter. I stand straighter. It probably has something to do with my high-heeled shoes as well. Those two things always makes you look tall and feel tall. Uhm, so I know that uhm I'm going to uhm… yeah, I just felt good, and I know that I was standing tall, my shoulders back'*. This recurrent statement of 'feeling good' applies to both the accomplishment of looking the way the women intended and being physically and socially comfortable in the bra and outer garment. Tori elucidated, '… *it's like a feeling you just look – you feel nicer when your clothes fit nicer. I think your undergarments make your clothes fit better. And you just maybe walk a little taller because your boobs are where they're supposed to be.* [Laughs]' The women connoted the bras' ability to lift the breast into the desired position affects them emotionally and psychologically, linking to their walking or standing straighter.

8.2.3.2. Impression-oriented Aesthetic

The impression-oriented aesthetic is a theme constructed from the wearers' perception of the bra's material culture consisting of the fabrication and overall shape or style. When conversing about their bra experience, the women would emphasise the significance of the material, intendedly to embody the sentiment they placed upon it. Sherry explained,

> '*Uhm, the loungewear – the loungewear is lovely and comfortable, but it's not looking… it's not – it's not a sexy look. And if you want a sexy look, you need to wear a different type of underwear. And so, therefore, that's why I – I do have some type that are lacy underwire bras so that I can dress up, and it makes me feel different. It puts a different spin on how I feel for that evening*'.

For Sherry to embody sexiness for an event, she needed to wear the right type of material in her bra – such as lace. The findings indicate that lace has a symbolic perception of sexiness, which women use to embody

the sensation. By wearing lace, women may think about themselves differently. Therefore, Sherry used lace to symbolise the sexiness that she wanted to embody. Cotton was discussed relative to comfort, with the women wearing cotton bras at home to stimulate relaxation. It is not solely the fabrication that is vital for the embodiment, but also the style, which affects women's perception. Clary reported,

> '*Sometimes – uhm – bras can give you a round look which tends to make you look a bit more aged as well. I think if it fits well where its shape and* [slight pause] *can give you a nice breasts shape, then you actually feel younger. It doesn't give you a grandmother look, so to speak.* [...] *Uhm, but if it looks shapely, even if people do look at your breasts, you don't feel self-conscious about it because you know it looks good*'.

The rounded bra shape Clary self-identified with as being older; therefore, she avoids wearing it not to look or *feel* older. Separately, there were bra shapes that surprised the women once on the body, influencing their cognitive viewpoint – what they thought. Melly explained, '*I found these full coverage bras; they was exactly what they made me feel like, "huh, I'm a full-grown woman". Look at my boobs and look how they just sit so nice underneath my clothes, like that was when my perspective changed on a whole lot of things*'. Wearing the bra and viewing it on the body shifted Melly's concept of herself, affecting how she thought.

8.3. Reflection – Collating Bra Experience

This section includes various practices that typify how MW experience and employ the bra to alter others' and their own perceptions and improve their thoughts and moods. Western culture has made the breast synonymous with being a real woman; thus, the bra enables women socially to enact the *right* womanhood as it makes the breast more visible (Young, 1992; Gannon and Müller-Rockstroh, 2004). Woodward (2005, p. 38) explains that in selecting clothing, women contemplate their various identities 'from social roles, their femininity, whether they look fashionable, their sense-of-self, their relationships and family'. While this study differs from Woodward's as it centres mature Black women and their bras, not outerwear, from the findings, it is evident the bra is experienced comparably. The bra symbolises femininity and a way for women to share and reinforce their identity to others.

Section 8.2. demonstrates that although the scaffolded experience-based theories are separate, the experience of them informing and during bra-wearing is intertwined and complex. The developed Bra Experience Theoretical Framework (**Fig.8.4.**) illustrates the interconnectedness, while the Bra-Wearing Experience Map (**Fig.8.5.**) shows its intricacy. Moreover, the methods applied in this section also overlap, producing insights that build upon and contextualise the results. The socio-cultural influences the psychological and physical affect, each occurring at different times within the bra experience as illustrated by the following fictional yet apt example:

The wearer is headed to a party and intends to meet a partner. She selects the bra that will fit the occasion, which differs from her home and work bras. As she intends to meet someone, she finds a bra that she believes is glamorous. In selecting this bra, she wants to access the sensation of 'glamour'. Wearing this bra enables her to imbibe this social concept which influences how she thinks and acts. While on her body, the softness of the rich lace design against her skin and seeing the correct fit in a mirror, she feels and looks glamorous.

Fig.8.6. Wearer Methods Results Linked

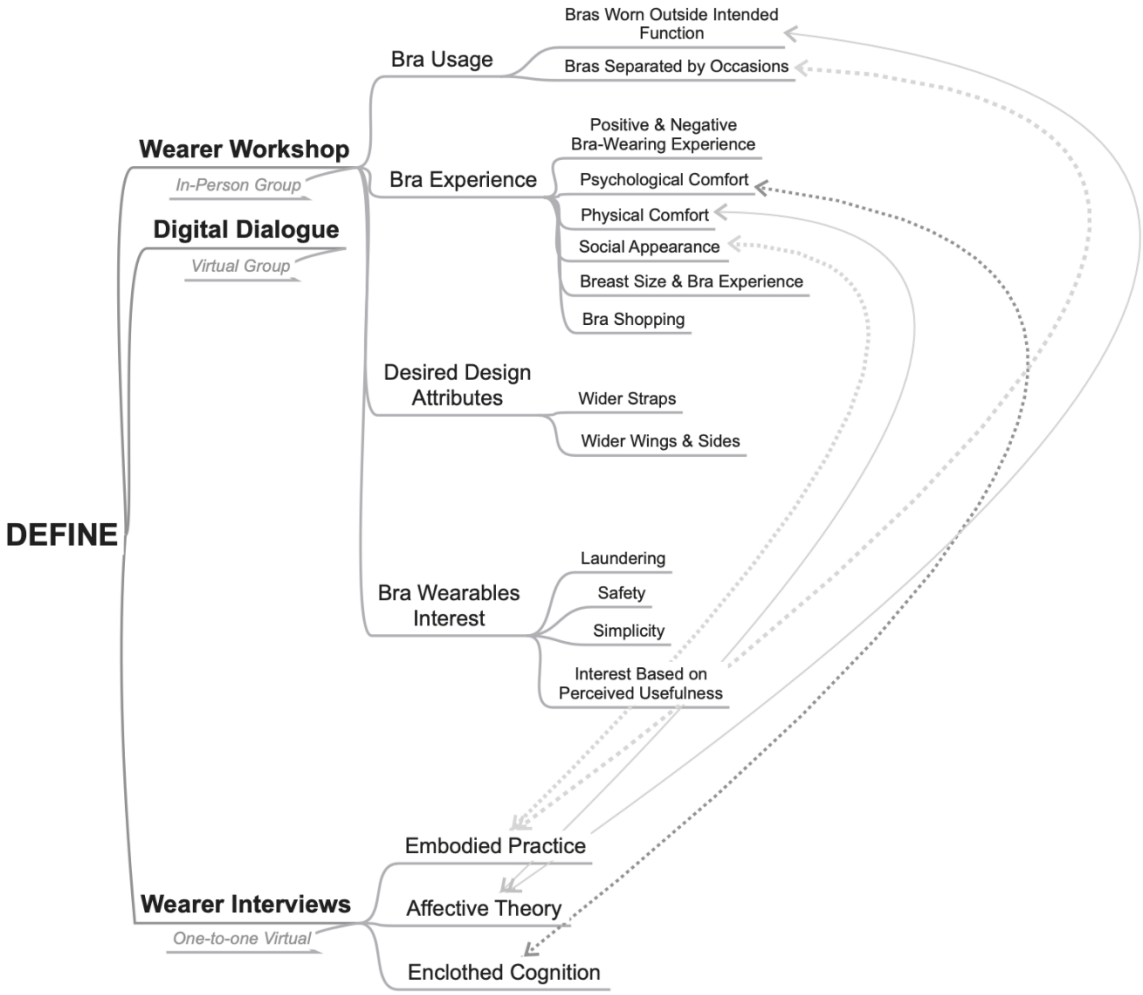


Fig.8.6. demonstrates the linked results from three methods: wearer workshop, digital dialogue, and interviews. Each method differed in approach, location, and participation (group versus one-on-one), providing triangulated insights into the women's past and present bra experiences. The group dynamics restricted how much and what kind of information each woman provided, while the interviews allowed them to provide more in-depth and sensitive information. The figure's arrow illustrates that the information from the methods interconnects with similar themes. For example, affective theory from the interviews can be linked to bras worn outside of intended functions and physical comfort discussed in wearer workshop and the digital dialogue. Significantly, the data and themes from the workshop and digital dialogue are

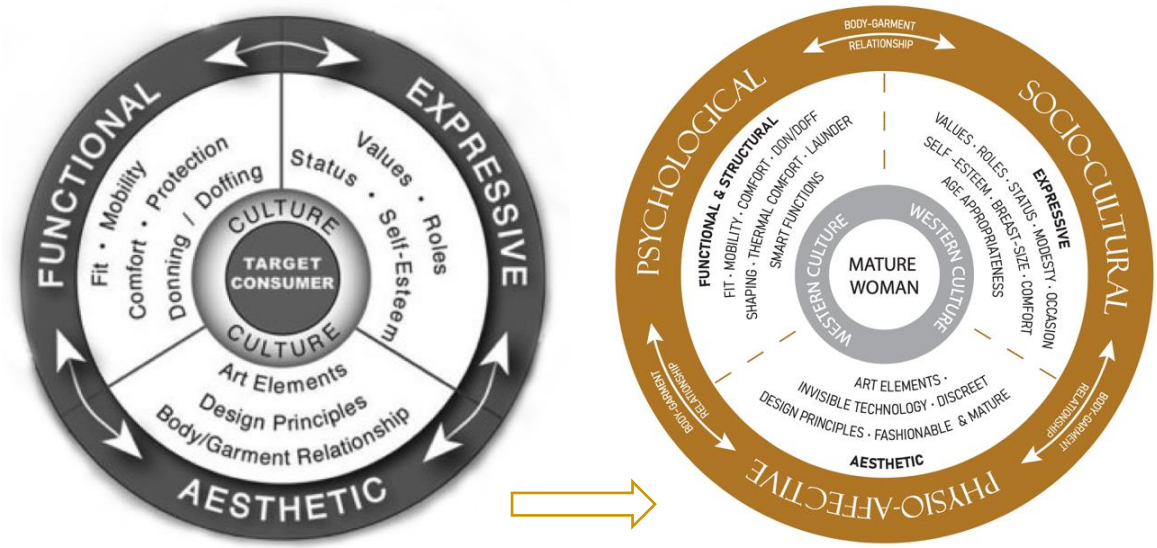
connected and can be expanded within the Bra Experience Framework. However, due to the storytelling interview and analysis method utilised, only that information was examined through the framework. The array of information from the multiple methods exemplifies the approach's adequateness.

8.4. Identification of Wearer Needs and Design Requirements

Part 2 of this chapter links the qualitative and quantitative data from the research stage to the concept development and practice within the BWD&DP. This portion aids the advancement of a design brief enabling progression from contextual research to concept development. Data from the digital dialogue, workshop, interviews, and questionnaire are triangulated to identify wearer needs and design requirements utilising the Functional, Structural, Expressive, and Aesthetic (FSEA) model (Lamb and Kallal, 1992; Davis, 1996). The FSEA model is geared toward problem-solving and targets consumers, 'demographic and psychographic information, physical characteristics, activities and preferences' (Lamb and Kallal, 1992, p. 42). The FSEA is most useful during the pre-generative phase in a D&DP to assist with problem identification and within the evaluation phase. The following sections discuss using the FSEA consumer needs model towards developing BW for MW, resulting in a BWFSEA model, design criteria, and interaction matrix.

8.4.1. Updating the FSEA Model with the Bra Experience Theoretical Framework

Fig.8.7. FSEA model updated with the Bra Experience Theoretical Framework.
Source: (*Left*) Original FEA Consumer Needs Model (Orzada and Kallal, 2021). (*Right*) Revised FSEA Model with requirements for mature women's BW design



Lamb and Kallal's (1992) FSEA model aids designers in understanding and evaluating consumer needs pre-design, throughout the D&DP, and as an appraisal tool with prototypes (Orzada and Kallal, 2021). Within this study, the FSEA model was placed throughout the D&DP, aiding in comprehending bra wearers' requirements and needs, leading to the development of the design criteria. The Bra Experience Theoretical Framework utilised within the interviews established that the FSEA model alone was inadequate for

supporting experience-centred BW design. Although the FSEA model allows designers to gain insight into the target consumer's wants, it overlooks how their past and present experiences can inform the development of new products. Therefore, a revised FSEA model was created, which places the wearers' experience as a distinct part of the model surrounding the outer layer and adds principles to each FSEA structure (**Fig.8.7.**).

The Bra-Wearing Experience Map (**Fig.8.5.**, p.243) established the significance of the body-garment relationship, with it appearing multiple times within the themes: sensation-based and somatic-informed affect (Affective Theory), cognitive social self-creation and breast-clothing reinforcement (Embodied Practice), and cognitive personification (Enclothed Cognition), see Section 8.2. The theories were simplified from their theoretical names to centre on their body-garment experience: affective theory to physio-affective, embodied practice to socio-cultural, and enclothed cognition to psychological (see gold outer ring in **Fig.8.7.**). Rather than keep the body-garment relationship as a minor component within the aesthetic compartment, it was removed and positioned around the model. Similarly, Stokes and Black (2012, p. 185) argue that 'the body-garment relationship involves aspects of functional, expressive and aesthetic considerations'. Since the body-garment relationship is influenced and affected by physio-affective, socio-cultural, and psychological factors, they are placed within the model's gold outer ring. It is important to note that the psychological, physio-affective, and socio-cultural factors also impact how the wearer experiences the functional, expressive, and aesthetic elements, as exemplified in **Fig.8.5**.

Lastly, the new FSEA model employs dotted lines to demonstrate that the functional, structural, expressive, and aesthetic elements are all interrelated (Stokes and Black, 2012). Previous research (Miller, Davis and Rowold, 1982; Cho, 2006; An and Lee, 2015) establish the ease of blurring between the elements, specifically aesthetic and expressive. For example, the expressive items of breast size and self-esteem will impact the wearer's functional desired fit and structural shaping of the bra, and alter the discreetness and fashion aesthetic elements.

Based on this study, the updated FSEA model includes new factors within each section. The functional and structural category encompasses the utility facet, introducing shaping, laundering, and smart functions, and separating comfort into physical and thermal. The expressive category includes the symbolic and communicative facets, including mental and emotional comfort, modesty, occasion, breast size, and age appropriateness. The aesthetic category comprises the beauty and physical characteristics of the product and on body, adding invisible technology, discreet, fashionable, and mature.

The updated model builds upon Hwang's (2017) factors influencing design requirements for female boomer active wear. Hwang's model highlights the essential ageing factors such as body changes, body shape, attitude towards ageing and changing social status that affects the design and wearing intention of sports bras for mature women. However, the model misses the importance of how the garment is experienced in

the different need's facets. This updated FSEA model can further be utilised to investigate the relationship between MW experiences, the traditional bra, and various clothing.

8.4.2. Analysis and Triangulation of Results

This section introduces multistage data triangulation. Qualitative methods are triangulated to aid the FSEA model (**Fig.8.7.**). The quantitative data is triangulated with the updated FSEA model supporting the design criteria and interaction matrix development in Section 8.4.3. Below, the qualitative and quantitative data analysis is briefly discussed, resulting in the development of the FSEA Mapping of Codes (**Table 8.8.**).

Table 8.8. Functional, Structural, Expressive, and Aesthetic (FSEA) Mapping of Codes

	Functional and Structural Aspects									
Participant	Lift/ Support	Shaping Excess Fat	Straps Stays/ Pain Free	Long Lasting	Comfortable on Body	Separation & Definition	Extended Bra Closure	Bra Adjustments in Front	Easier Bra Closure	Breathable
Clary	✓	✓	✓		✓	✓	✓	✓	✓	✓
Ellen	✓	✓		✓	✓	✓		✓	✓	
Lilly	✓	✓			✓	✓		✓	✓	
Janet	✓	✓	✓	✓	✓					
Kimberly	✓	✓	✓	✓						
Deloris	✓									
Tori	✓	✓	✓		✓					
Melly	✓	✓			✓	✓		✓	✓	✓
Donna			✓		✓					
Sherry	✓		✓		✓					

	Expressive Aspects							
Participant	Soft Material	Smoothing/ Discreet	Feel Comfortable In	Breasts looking presentable	Feel Sexy /Sensual/ Womanly	Wear Bra at Home	Feel Confident	Bras for Different Occasions
Clary	✓	✓	✓	✓	✓	✓		✓
Ellen				✓	✓	✓		✓
Lilly					✓			✓
Janet	✓		✓	✓	✓	✓	✓	✓
Kimberly	✓	✓	✓	✓	✓			
Deloris		✓						
Tori	✓	✓	✓	✓		✓		✓
Melly						✓	✓	✓
Donna		✓	✓	✓			✓	
Sherry	✓	✓	✓	✓		✓		✓

	Aesthetic Aspects							
Participant	Push-up/ Padded	Light Padding	Non-Padded	Lower Cup Bra	Full Cup	Thicker Straps	Long Cradle/ Frame	Lace Design
Clary			✓	✓		✓	✓	✓
Ellen			✓		✓		✓	✓
Lilly	✓	✓			✓			✓
Janet	✓			✓		✓	✓	✓
Kimberly	✓	✓						
Deloris								
Tori		✓			✓			✓
Melly			✓		✓		✓	✓
Donna		✓			✓			✓
Sherry		✓		✓			✓	✓

8.4.2.1. Qualitative data analysis (Workshop, Digital Dialogue, and Interviews)

The data collected from the workshop, digital dialogues, and interviews were analysed using an open coding process (Creswell and Plano Clark, 2007; Creswell, 2014). The transcripts from each method were carefully reviewed, with the generated codes highlighted if they were relevant within the FSEA needs model. As discussed in Section 3.1.3.1., the original FEA model has three needs categories (Lamb and Kallal, 1992): Functional encompassing fit, mobility, comfort, and the donning and doffing of the garment. Expressive

encapsulates the wearers' values, roles, status, and self-esteem. Aesthetics comprise the art elements, design principles, and body-garment relationships (Orzada and Kallal, 2021). An additional add-on, structure, consists of the construction, design details and accessories, shape, materials, and 'interaction with the body' (Davis, 1996; Ghalachyan and MacGillivray, 2016, p. 225).

Three separate tables were developed to organise the codes within the respective FSEA needs categories (**Table 8.8.**). All the participants, ten in total, from the triangulated methods were listed with check marks signalling codes they discussed. Four of the participants participated in two methods. Clary was a part of the workshop and interviews. Janet, Melly, and Tori participated in the digital dialogue and interviews. Multiple participation points enabled these women to discuss different in-depth facets of their bra-wearing experience.

In the functional and structural aspects table, more than half of the women mentioned the need for the bra to lift and support the breasts, be comfortable on the body, and shape excess fatty areas around the upper torso. Many women also discussed their issues with the bra strap, desiring it to be pain-free and fastened in place when worn. Four women specified the need for a bra that defined and separated their breasts, had easier closure, and could be adjusted in the front. Interestingly, those women all considered themselves to have a medium to large bust. Two of the women communicated wanting a long-lasting bra with breathable material and extended bra closure.

In the expressive aspects table, many of the codes were mentioned by multiple women. Seven or more women indicated they wanted their breasts to look presentable and had bras for different occasions. Six women also mentioned wearing a bra while at home due to breast size or comfort. Comfort is not merely physical but also psychological, with six women voiced their desire for a bra they can feel comfortable wearing, with part of that comfort being in the bras' discreetness under clothing and the materials' softness against their skin. Seven women discussed how they wanted to feel while wearing the bra with words such as sexy, sensual, womanly, and glamorous connected with feeling confident. Although the women did not always have a perfect bra in mind, they emphatically knew the pleasurable feeling it should provide them.

The aesthetic aspects table coded the women's ornamental or practical desires. Eight women specified liking or loving lace bras, while seven indicated they would prefer lightly padded bras, full coverage, and a longer frame. Three of the women who were small-medium breasted revealed they only wore padded or push-up bras, while three of the women who were larger-breasted desired only non-padded bras. The larger-breasted women intimated that they did not want their breasts to appear any larger. Three women discussed wanting lower cup bras with thicker straps as the thinner ones dug in and caused them shoulder pain or constantly fell off their shoulders.

8.4.2.2. Quantitative data analysis (Questionnaire)

Data from the questionnaire (Chapter 7 and Appendix J.), precisely questions on bra colours, styles, and BW interest, were applied to the design criteria development. Questions that addressed menopausal symptoms the women wanted to be managed by BW and their interest in the various smart functions were placed within functional needs. Questions that concentrated on the women's perceived compatibility, such as BW being discreet under clothing and designed to be worn at any time, were positioned within expressive needs. Lastly, questions that attended to the women's opinion on the appropriate bra colours for MW, bra styles for social and professional events, and perceived BW aesthetic attributes were arranged within aesthetic needs.

The coding mapping differed from prior research on MW's bra wants. Although previous research suggested that MW in their 50s and 60s want full-cup bras and wider wings, similar to this study, the women differed as they did not want a U-back bra, narrow straps or bras without underwire (Kim, Kim and Ashdown, 2014; Park and Jang, 2014). This difference in style may be cultural, as the participants were of Asian descent. The findings indicate that MW's bra desires may vary culturally; however, more research is necessary. On the other hand, the findings were similar to Risius' research (2012), with mature British women in the study also selecting underwired, non-padded T-shirt bras as their most worn style. Additionally, the top bra colours (black, white, and beige) have remained the same across multiple bra studies (Risius, 2012; Kim, Kim and Ashdown, 2014; Park and Jang, 2014).

8.4.3. Defining the Design Criteria and Interaction Matrix

Design criteria for BW were generated and evolved from the mapped codes from the data triangulation of the interviews, workshop, digital dialogue, and questionnaire (**Table 8.9.**). Employing the FSEA model (Davis, 1996), smart functions need (Hwang, 2017), and the wearers' psychological and social needs, 31 criteria specifications were established. The criteria are listed with a description or design approach that details what was needed and the necessary guidelines for progression. Following the descriptions is the needs category indicating whether the needs are Functional (F), Structural (S), Expressive (E), Aesthetic (A), Psychological (P) or Social (So). The criteria specifications fit into multiple categories demonstrating the significance of comprehending the bra wearer's complex desires and needs.

Table 8.9. Design Criteria

	Design Criteria	Description/Design Approach	Need Category
	Functional & Structural Needs		
1	Lifts & Supports Breasts	Extended cradle w/wider straps placed higher on the shoulder or cups with slings	F, S, & E
2	Removable Pads	Place in cup design pockets for removable breast pads	F, S, P, So
3	Shaping Excess Fat	Employ a longer frame w/nylon backing and using power mesh in the wings	F, S, P, So
4	Straps Stay in Place	Position straps higher up on shoulder	S, So
5	Comfortable on Body	Wires, straps, and materials should be comfortable against skin	F, S, P, So
6	Separation & Definition	Design deeper cups and higher gore	S
7	Bra Adjustments in Front	Rings and slides moved to front of bra straps	F, S, A
8	Easy Bra Closure	Bra closure made easier through magnets, snaps, or moved to sides or front of bra	F, S
9	Breathable/Cooling Material	Utilise natural materials and light weight materials such as lace or mesh	F, A
10	Longevity of Bra Wearables	Design for repair, employing durable, stain resistant, and anti-bacterial materials	F
11	Higher cups & Gore	Bra cup hook up placed higher and gore edge moved up	F, S
12	Easy to Care for/Launder	Easy to mainatin and launder by hand or if accidently thrown in wash still works	F
	Smart Functions		
13	Addresses Menopausal Symptoms	Bra designed to address hot flushes, night sweats, and weight gain	F
14	Heart Disease Detection	Bra designed to detect and monitor heart disease	F
15	Breast Cancer Detection	Bra designed to detect breast cancer by being worn periodically	F
16	Stress Detection and Relief	Bra designed to detect and relieve stress. Bra designed to be worn daily so must be versatile	F
17	Sexual Stimulation	Bra designed for sexual stimulation and can be worn at anytime. Must be connected to app	F
18	Monitors Health Vitals	Bra designed to monitor health vitals and connected to phone application. Must be versatile	F
	Expressive Needs		
19	Soft Material	Material is soft against the wearers skin. Allows for an invisible feeling	E, S
20	Discreet Under Clothing	Bra can be made discreet so as not visible or drawing attention from viewers	E, A, F, S, P, So
21	Feel Comfortable In	Bra should fit various occasions, outer garments, and provide youthful breast lift and shaping	E, A, F, P
22	Bras for Different Occasions	Bra can be worn for different occasions with modularity being a option	E, F, P, So
	Aesthetic Needs		
23	Appropriate for Social Event	Bras for social events should lift breasts and allow for wearer to reveal or conceal	A, E, P, So
24	Appropriate for Professional Event	Bras for professional events should be discreet and not draw attention to breasts	A, E, P, So
25	Appropriate Colours	Black, beige, jewel tones like berries and burgundies	A, E, P, So
26	Not too 'Girly' or 'Mature'	No balconette cups, overly floral or graphic prints, satiny materials, or too thick/ wide straps	A,E, P
27	Lace/Sheer/Solid Materials	Materials that are smooth solids, mesh, and lace designs	A, E, F, S
28	Wearables Aspect Hidden in Bra	Use embellishments, pockets, layering, and opaque materials to hide electronics	A, E, F, So
29	Full Coverage	Utilise cup shapes Demi or Plunge with full coverage	A, S
30	Wider Straps	Apply plush back straps between 12mm -15mm width	A, F, S
31	Longer Cradle/Frame	Cradle at side seam between 3 1/2" to 5", and beneath princess line 1 1/2" to 2"	A, F, S

Table 8.10. Interaction matrix of design criteria – O= No Conflict, ✓ = Accommodations, ✕ = Conflict

Design Criteria	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Functional & Structural Needs																															
1 Lifts & Supports Breasts																															
2 Removable Pads	O																														
3 Shaping Excess Fat	O	O																													
4 Straps Stay in Place	O	O	O																												
5 Comfortable on Body	O	O	O	O																											
6 Separation & Definition	O	O	O	O	O																										
7 Bra Adjustments in Front	O	O	O	O	O	O																									
8 Easy Bra Closure	O	O	O	O	O	O	O																								
9 Breathable/Cooling Material	O	O	O	O	O	O	O	O																							
10 Longevity of Bra Wearables	O	O	O	O	O	O	O	O	O																						
11 Higher cups & Gore	O	O	O	O	O	O	O	O	O	O																					
12 Easy to Care for/Launder	O	O	O	O	O	O	O	O	O	O	O																				
Smart Functions																															
13 Addresses Menopausal Symptoms	O	O	O	O	O	O	O	O	O	O	O	✓																			
14 Heart Disease Detection	O	O	O	O	O	O	O	O	O	O	O	✓	✕																		
15 Breast Cancer Detection	O	O	O	O	O	O	O	O	O	O	O	✓	✕	✕																	
16 Stress Detection and Relief	O	O	O	O	O	O	O	O	O	O	O	✓	✕	✕	✕																
17 Sexual Stimulation	O	O	O	O	O	O	O	O	O	O	O	✓	✕	✕	✕	✕															
18 Monitors Health Vitals	O	O	O	O	O	O	O	O	O	O	O	✓	✕	✕	✕	✕	✕														
Expressive Needs																															
19 Soft Material	O	O	O	O	O	O	O	O	O	O	O	O	✕	✕	✕	✕	✕	✕													
20 Discreet Under Clothing	O	O	O	O	O	O	O	O	O	O	O	O	✓	✓	✓	✓	✓	✓	O												
21 Feel Comfortable In	O	O	O	O	O	O	O	O	O	O	O	O	O	✕	✕	O	O	O	O	O											
22 Bras for Different Occasions	O	O	O	O	O	O	O	O	O	O	O	O	O	✓	✓	✓	✓	✓	O	O	O										
Aesthetic Needs																															
23 Appropriate for Social Event	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O									
24 Appropriate for Professional Event	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O								
25 Appropriate Colours	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O							
26 Not too 'Girly' or 'Mature'	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O						
27 Lace/Sheer/Solid Materials	O	O	O	O	O	O	O	O	O	✓	O	O	✓	✓	✓	✓	✓	✓	O	O	O	O	O	O	O	O					
28 Wearables Aspect Hidden in Bra	O	O	O	O	O	O	O	O	O	✕	O	✓	✓	✓	✓	✓	✓	✓	O	O	O	✓	✓	✓	O	O	✓				
29 Full Coverage	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O			
30 Wider Straps	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	✓	O	O	O		
31 Longer Cradle/Frame	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	✓	O	O	O	O	

An interaction matrix was established from the design criteria specifications to investigate and assist in developing BW (**Table 8.10.**). The interaction matrix[94] facilitates identifying conflicts and accommodations amongst the design specifications, which is critical to the product's design (Bergen *et al.*, 1996; Tan, Crown and Capjack, 1998; Hwang, 2017). Within the interaction matrix, design specifications are noted with marks indicating whether they conflict with one another (✕), contain no conflict (O), or must be accommodated for a singular design (✓). Many of the criteria have no conflict; however, there are 24 marked conflicts between the design specifications, all-inclusive of wearable technology facets. Most smart functions conflict as the hardware and electrical materials needed for each concept may not be compatible. Furthermore, as the technological facet introduces electrical hardware, achieving the material's desired softness is difficult. While the smart functions can be designed for physical comfort, the psychological aspect is needed for wearers to *feel comfortable* in the breast cancer and heart disease detection bra conflicts. The women noted they wanted the bra to be invisible and not think about it during the day. However, due to the seriousness and possible anxiety related to the illnesses being detected[95], it is probable that women may feel distressed during wearing. Thus, more research is necessary to rule the two specifications as not conflicting. Lastly,

[94] The interaction matrix is not related to the TRIZ contradiction matrix in Section 3.1.2.
[95] According to the Centers for Disease Control and Prevention (CDC), as of 2017, the leading causes of death for women were heart disease at number one and cancer at number two. https://www.cdc.gov/women/lcod/2017/all-races-origins/index.htm Similarly, Cancer Research UK indicates that as of 2018, breast cancer is also the 2nd most common killer of women. https://www.cancerresearchuk.org/health-professional/cancer-statistics/statistics-by-cancer-type/breast-cancer

the hidden aspects and longevity of BW conflict as it is challenging to discreetly integrate the electrical components while also enabling the ease of removing and repairing the components for longevity.

Table 8.10. shows that forty-three design criteria (X) need accommodations, including extra considerations, for the designs to be feasible. The smart function concepts must be adapted to permit longevity, easy care, and laundering. As the women want their bras to be discreet beneath clothing, most smart function concepts must inconspicuously integrate the electrical hardware. With the current hardware being sizeable, the bra's design must accommodate it in new forms and styles. The material selection of lace, sheer, and solid must be amended with thoughtful placements to cater to the smart functions and hide the technological components. Smart functions also conflict with bras for various occasions, suggesting the designs must be amended to allow for wearing to multiple events with various garments. Concealing the technological components also needs adjustments to coincide with utilising lace and sheer materials and for different occasions, social, and professional events. Lastly, the wider straps and longer frame aesthetic conflict with the women's want for bras not to be 'too girly or mature'. Therefore, the straps and frame must conform to suitable measurements.

8.5. Design-researcher Reflection

As noted in the *Define* section (**Fig.8.1.**), the design practice narrows this stage, aiding to focus information for the *Develop* stage. This section reflects on the initial design practice, which oversaw the mixing of HCD methods within the bra D&DP (Section 6.1.2.4.). In the "Research & Concept Development" phase of the BWD&DP, the designer/stakeholders must move from research to concept development, which can prove challenging. Information from the design criteria, interaction matrix, and FSEA mapping (Section 8.4.) were used to inform the design practice. I undertook the process, reflecting on applicable techniques and workflows. **Fig.8.11.** showcases a portion of the design-researchers' workspace to situate the environment. Appendix L details in-depth the methods and approaches reflected on below. Readers should review Appendix L before continuing.

The methodology selected required me to reflect-on-action to gain insights into the situation (Section 5.5.). The research situation contains elements like technology inclusive of the materials, frameworks, and tools utilised in the inquiry process (Section 5.2.). In reflecting on the actions of the design practice – from a burgeoning hybrid-designer perspective, I will focus on the technical facets. Discussed below are the five methods conducted which are crucial in the concept development stage: mood board, empathy activities, sketching, material exploration, and physical hardware and software development.

Developing the mood board (Section L.1.1.) established that traditional fashion design mood boards are not enough to inspire an experience-centred design. By incorporating an experience map from Interaction Design (Camere, Schifferstein and Bordegoni, 2015, 2018), specifically focusing on the garment's haptic sensations (textual, tactual, shaping, force and vibration feedback), a more comprehensive understanding

of potential experiences of a BW design emerged. This innovative application not only expanded the dimensions of experiential quality but also facilitated a nuanced consideration of and empathy for potential wearers encountering various haptic sensations.

The examination of empathy methods (Section L.1.2.) provided a distinctive perspective, delving into the cognitive and affective dimensions of connecting with participants (Kouprie and Sleeswijk Visser, 2009; Sleeswijk Visser, 2009). In contrast to the fashion industry's implicit empathy during design, the absence of recorded, shared, or examined processes prompted the adoption of the drawing-as-seeing method (Mida and Casey, 2020) from fashion history and material cultures. This facilitated a focused exploration of empathising with MW and their evolving bodies, offering a deliberate shift from idealised industry figures to a contemplative examination of real, mature bodies. The affective method of body-storming (Buchenau and Fulton Suri, 2000), while not conventionally applied in the bra D&DP, allowed for a profound empathetic connection by immersing in the experience of a hot flush, shedding light on the emotional and social aspects of the wearer's experience. However, further insight is warranted through the application of body-storming techniques in a practical field setting to discern the stakeholders involved and understand the potential impact of these methods on the DP.

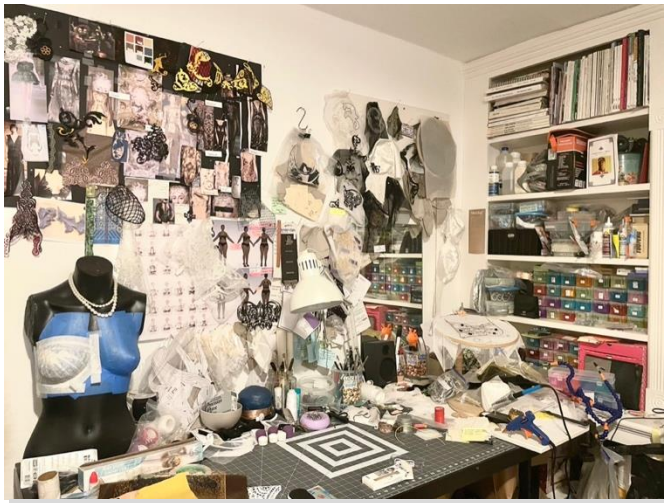


Fig.8.11. Designers' work desk

Sketching activities (Section L.1.3.) underscored the critical link between hardware knowledge and the ideation of the bra form, echoing the insights of Islam Molla (Islam Molla, 2020). The transition from traditional pen-and-paper sketches to digital design not only streamlined the iterative process by accommodating frequent conceptual changes but also aligned with Van Donegan's (2019, p. 110) observation that digital sketching facilitates quick impressions and supports continuous design progression. This reflective exploration illuminates the cyclical nature of the sketching process, highlighting the interplay between digital ideation, hardware understanding, and material experimentation, underscoring the dynamic and evolving nature of innovation in BW design.

The integration of material investigations (Section L.1.4.) with digital sketching and hands-on fabric manipulation exemplified a departure from the conventional separation of material design and sketching, fostering a symbiotic relationship between the two processes. This interdisciplinary approach not only facilitated the exchange of information but also introduced novel materials, exemplified in the exploration of a chemical-based elastic stretch sensor detailed in Section L.1.4. The iterative layering of sketching and

material development emerged as a dynamic practice, encouraging reflection on critical aspects such as placement, safety, laundering, and scalability, thereby enhancing the efficacy of sample development in BW design.

My investigation into the design stages illuminated a nuanced understanding of the iterative and reflective nature inherent in the concept development process. This innovative approach involved a cyclical engagement with reflection-for-action (to determine steps), reflection-in-action (to move forward), and reflection-on-action (to understand what was done and potential options), providing a comprehensive comprehension of the skills, knowledge, and collaborative dynamics essential for seamless transitions between stages. The insights gained underscore the imperative for a structured process that not only informs the specific steps but also delineates requirements, identifies opportunities, and anticipates potential obstacles during the concept development stage.

From my experience, the development of both the traditional mood board and the experience map creates a collaborative opportunity for diverse design teams to converge, particularly emphasising the pivotal role of the fabrics/textile development team in crafting the experience map. By integrating their insights into state-of-the-art materials and material feasibility, the collaborative process becomes an intersection of inspiration and practicality, transforming sketching and material research into a cohesive and team effort.

In my transition from a trained traditional designer, a heightened awareness of collaborative needs emerged, particularly in exploring hardware during sketching. This shift prompted a new approach to ideation, necessitating input from multiple stakeholders and fostering a holistic view of the bra design from diverse perspectives. The evolving process became a journey of learning to navigate and integrate varied insights, blurring the lines between individual concept development and collective ideation.

Simultaneously, as a developing hybrid designer, I recognised stages demanding an expansion of my skillset, exemplified in the creation of the stretch sensor. The multifaceted nature of this task, requiring a blend of academic and contextual research from diverse sources, compelled me to operate simultaneously as both a designer and researcher. This transition, underscored by experimentation with novel materials like silicone, carbon black, and chopped graphite, represented a departure from my past experiences in industry and marked a pivotal moment in embracing a hybrid role.

The assertion presented is reinforced by Hoonhout's (2007) endorsement of innovative-based DP, advocating for the dissolution of barriers that traditionally separate diverse teams and fostering a more integrated collaboration (see Section 3.1.2.1.). This perspective suggests a departure from rigidly defined stages in the DP towards a more fluid and cyclical model, encouraging iterative interactions among teams. Moreover, it underscores the potential for stakeholders to broaden their expertise beyond traditional boundaries, cultivating a more holistic understanding of facets that extend beyond their conventional domains.

8.6. Summary

Chapter 8

- ***Provided*** insight into Black MW's multifaceted and complex bra experiences, from the women in their own voices, with quotes throughout to humanise their varied lived experiences.

- ***Validated*** the Bra Experience Theoretical Framework (**Figure 8.4.**) by expanding it into the Bra Wearing Experience Map (**Figure 8.5.**), illustrating that the bra experience is intricate and interconnected by social, psychological and physio-affective factors.

- ***Demonstrated*** how capturing meaningful participant experiences could be transferred into actionable outputs for a design team through the BWFSEA consumer needs model (**Figure 8.7.**), design criteria (**Table 8.9.**) and interaction matrix (**Table 8.10.**).

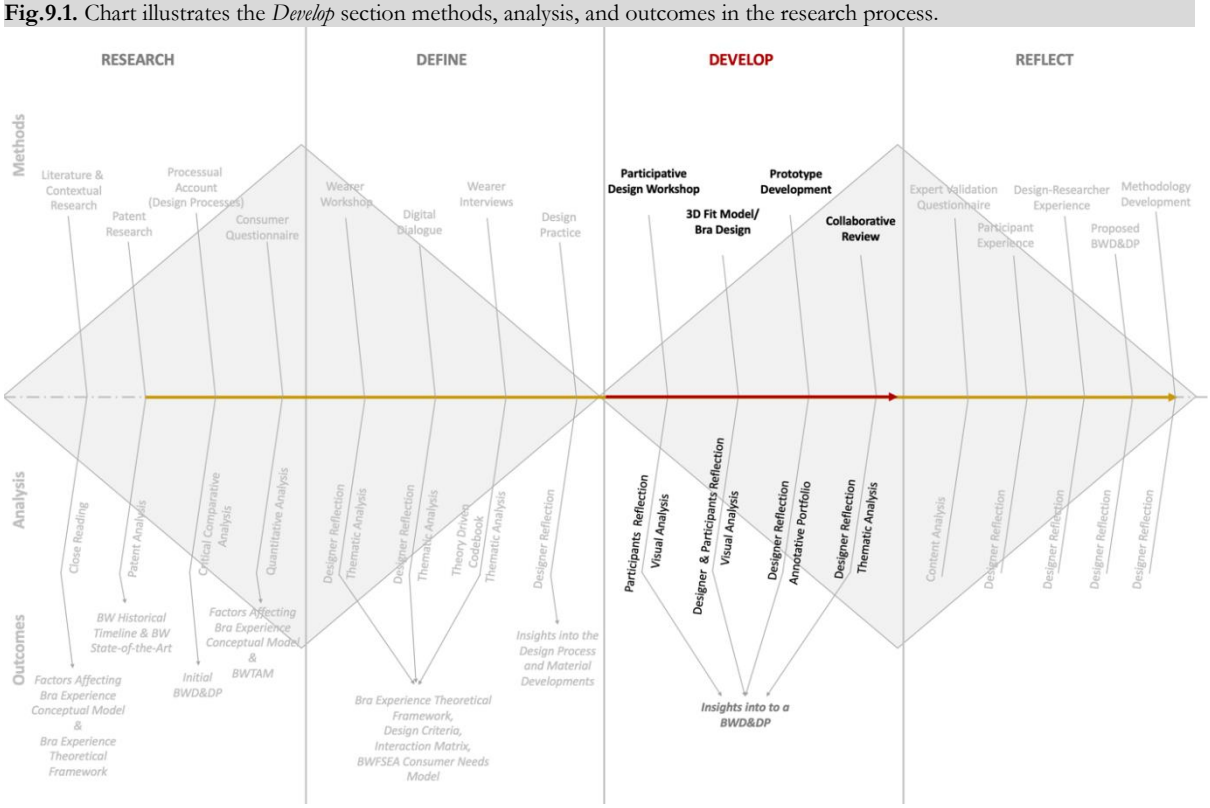
- ***Reflected*** on the initial design practice (see Appendix L), revealing that the concept development phase is iterative and experimental, requiring the collaboration of multiple members from several design teams.

- ***Expressed*** that empathy methods and material investigations are essential in creating a woman-centred experience-driven design process.

9

9. DEVELOP

Fig.9.1. Chart illustrates the *Develop* section methods, analysis, and outcomes in the research process.



Chapter 9 encompasses the *Develop* stage of the Four-Stage Research Process (**Fig.9.1.**). Within this stage, participants were reintroduced into the D&DP. Furthermore, practice was undertaken to explore and situate an experience-driven woman-centred approach to designing and developing BW. This chapter reflects the work undertaken within the "Concept Development" and "Pattern & Prototype Development" phases of the initial BWD&DP (**Fig.7.19.**, p.224), thus advancing on the practice from Appendix I.

The focus is on reviewing the design-researchers' actions and discussing the outcomes addressing research Aim # 2, objectives 2C, 2D, and 2E.

Aim #2. To investigate approaches that can be utilised to inform the design of BW that improves the wearers' experience.

2c. Explore ways of integrating the bra wearer and their experience into the BWD&DP.

2d. Investigate ways of integrating technology into the bra (i.e., new design elements, bra form, and composition).

2e. Develop BW products that allow for the exploration of designing for meaningful and pleasurable experiences.

9.1. BWD&DP

'Design knowledge is knowledge-in-action, revealed in and by actual designing'.
(Schön, 1992, p. 131)

The initial BWD&DP (Section 7.3.2.) outlines this practice section underpinned by Dewey's experiential approach to inquiry into the situation[96]. Rather than a field, referring to an industrial setting, the process was enacted within a lab setting, referring to a private atelier (Koskinen, Binder and Redström, 2008). The setting affects what resources are available to the process, thus changing the inquiry's situation (Dalsgaard, 2014). In this case, due to the pandemic and nature of the practice – being conducted almost in a silo – products were developed on non-industrial machinery affecting the process, design elements, and materials. Furthermore, with the social climate[97], the design-researcher and participants were working under abnormal circumstances, which may have impacted their emotional mindset and how they responded.

Wright and McCarthy (2010, p. 109) elucidate that 'the process of inquiry […] is continuous and the knowledge generated through this inquiry is situated, action-oriented, and revisionary'. Therefore, reflecting on the actions and outcomes is essential to access insights. Throughout the process, as Schön (1983) acceded, I was continuously engaged in conversation with the situation ranging from environmental, resources to practice availabilities. Engrossing in constant conversation forced me to reflect on the possibilities using my educational and professional experience to sense-make and guide progression – knowing-in-action (Schön, 1995). As the *develop* stage progressed, I moved between roles as a researcher and designer, oscillating between reflecting-in-action and reflecting-on-actions. Through my interaction within the D&DP and with the participants, co-constructed knowledge was formed and reflected upon.

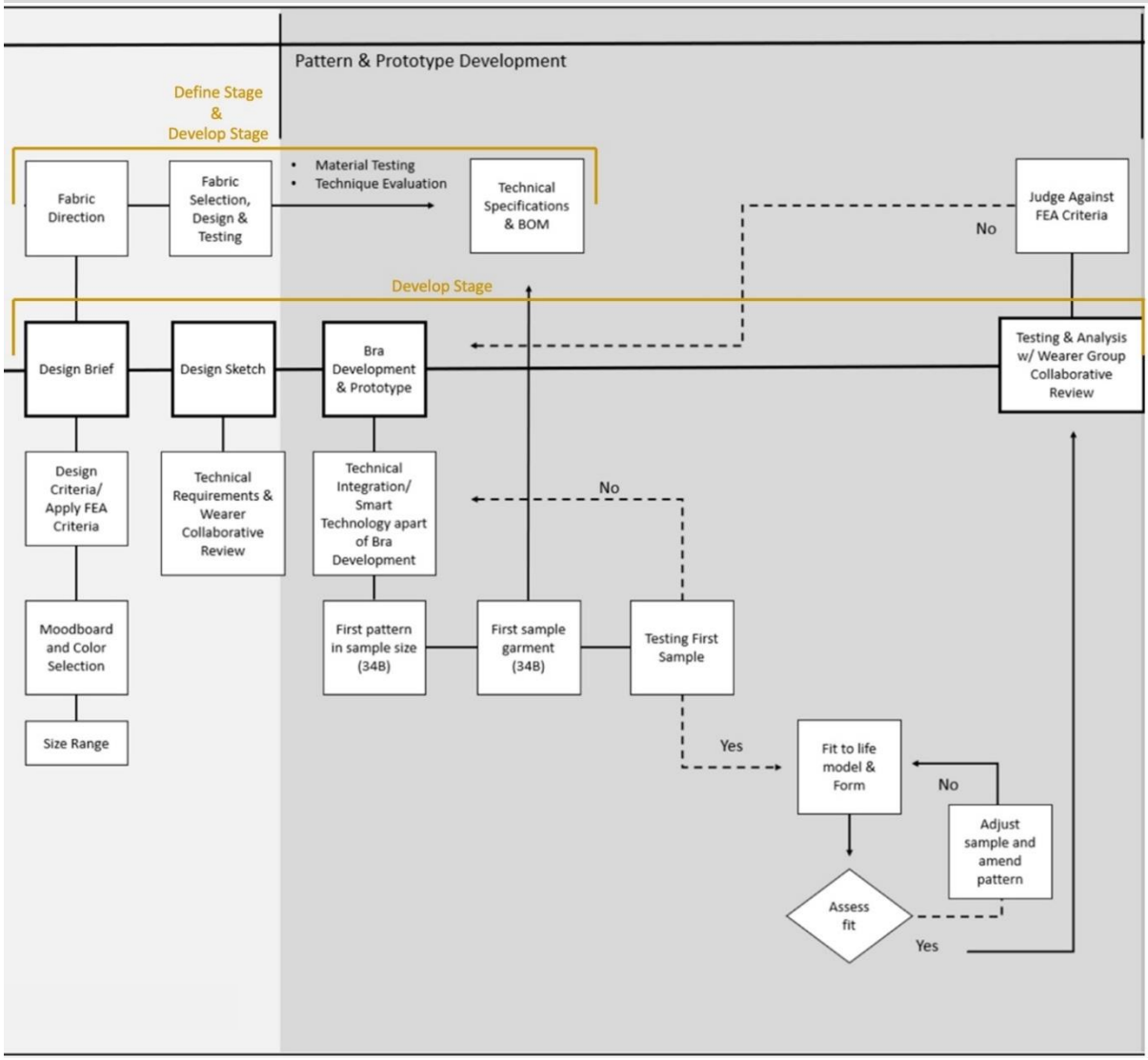
Lastly, the goal was to further develop the D&DP by undergoing it and producing prototypes. The prototypes became essential as it allowed the design-researcher to access insights into the D&DP and the development of BW. Therefore, throughout this chapter, prototype development is discussed in detail with participants assessments discussed during the "Fit Model Design & Emotion" and "Participants Review" (Sections 9.3.3. and 9.5.). Due to the research's subjective and objective nature (Section 5.3.2.), this chapter is written in both the first and third-person. When I am objectively interrogating information, the third-

[96] Dalsgaard (2014, p. 147) notes that according to Dewey 'neither the subject nor phenomena in the world can be understood outside of a situation. For this reason, human thought and action as well as objects and events must always be understood in the larger frame of the situation'.
[97] In addition to the global pandemic, there was also social unrest due to the unarmed killing of Black men and women, sparking Black Lives Matter protests.

person is used. However, I use the first-person when subjectively purveying information based on direct experience.

9.1.1. Initial BWD&DP Review

Fig.9.2. BWD&DP covered.



This area of the BWD&DP began after identifying wearer needs and design requirements within the "Research & Concept Development" phase (**Fig.9.2.**). Continuing in this phase required applying the design criteria (**Table 8.9.,** p.259) and interaction matrix (**Table 8.10.,** p.260) developed from the prior needs identification stages (Section 8.4.) to inform the practice (Appendix I.) and creation of new designs. Within this phase, the participants were involved in the ideation. Then the research progressed into the "Pattern & Prototype Development" phase, where participants were involved during the digital fitting, concepts review, and design evaluation stage[98]. The following sections discuss insights from the

[98] Fig.9.2. demonstrates the initial BWD&DP and is missing these stages. However, Fig.10.3. illustrates the amended BWD&DP with these stages added.

participative design workshop and concept development (9.2.), digital fitting interviews (9.3.), prototype developments (9.4.), and collaborative group review (9.5.).

9.2. BW Concepts Development

The participative design workshop aimed to bring the participants into the D&DP within the concept development phase. Despite the recommendation by scholars (Hoonhout, 2007; Gemser and Candi, 2010) to omit participants in the creative stages of an experience-driven innovative DP due to perceived limited design understanding, the design-researcher chose to include them, acknowledging their expertise stemming from lived experiences with contemporary bra offerings. Together with the design-researcher, the women ideated the bra silhouettes, colours, trimmings, and functions. The women were introduced to various activities to generate concepts, provide insights into their likes, and reflect on being a part of the design process (Section 6.1.3.1.). The following sections introduces the workshop activities (9.2.1.) then the concept development (9.2.2.).

9.2.1. Introduction to Workshop Activities

The workshop began with a brief introduction to BW. Introducing the women (*n*=5) to BW concepts before ideating enabled them to ponder desired design features and functions. Using brainstorming techniques (**Fig.6.22.**), the women developed two concepts they were interested in as a group. By allowing the women to write their thoughts on stickies in a digital group setting, while being in the comfortable confines of their personal space, they were provided agency to discuss sensitive topics without embarrassment (Clancy and Barry, 2022).

Once two bra concepts were selected, the participants reviewed four creative themes, each containing mood boards, trend boards, and fabrication pages (**Fig.6.23.**). This activity boosted the women's energy as they assessed and discussed the elements of each page. The mood boards aided in setting the themes for the following design elements. Trend boards mirrored mood boards, depicting related bra styles featuring similar design details. During the review of the trend boards, the women provided insights into bra styles and features they experienced, liked, or disliked. Thus, the design-researcher could identify desirable design elements. For instance, the women were either indifferent or disliked bows on their bras. Following the trend boards were fabric pages showcasing lace swatches, bra straps, bow designs, and Pantone colour swatches. Again, the women discussed and selected their favourite elements. Lastly, the women were shown a bra chart featuring numerous styles to appraise (**Fig.6.24.**).

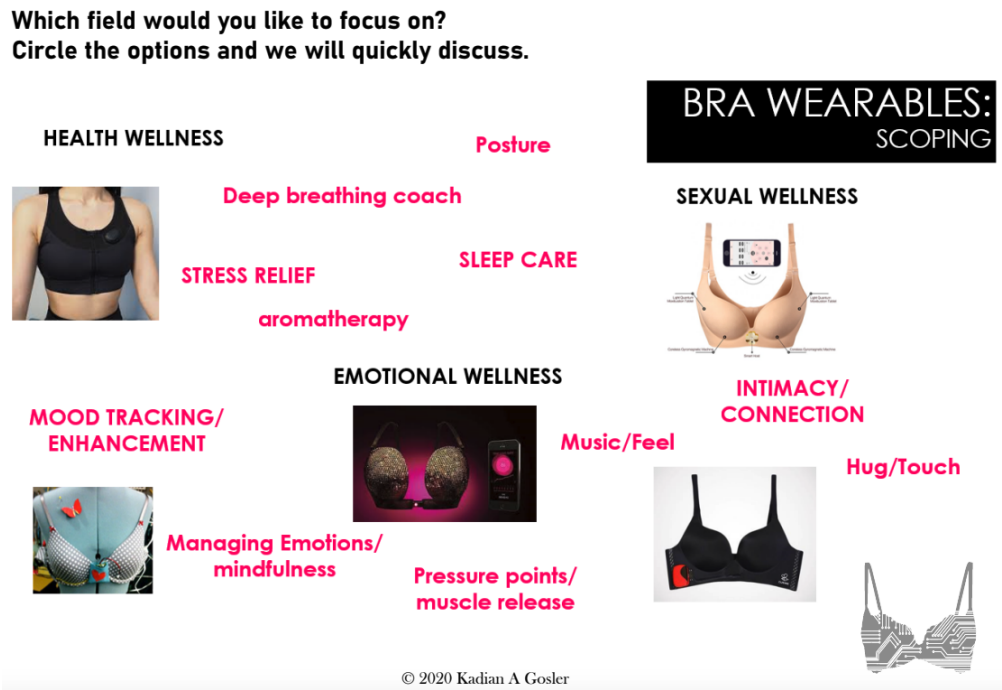
In this study, the women favoured the dramatic bondage theme (**Fig.6.23.**). The richer colours, such as bronze, slate grey, merlot, and jewelled teal, were discussed positively. Comments shared were 'the colour would look nice against my skin' and 'I always look for richer colours like that'. Decadently textured laces were selected, with the women opting for two-toned rather than single-coloured. Often the women chose

the two colours they thought would work best and sought the groups' opinion. Even in an online setting, the women attempted to relate to and engage each other. The women were tasked to select bra styles from the bra chart providing more insights on desirable bra forms.

Participants tended to favour different bra styles. One liked non-wired, two wanted padded, and four chose full coverage. The women were consistent in their preferred shapes and elements, such as full coverage cups, wide straps, lengthened frames, and wide wings. Their desires were consistent with data from the generative workshop, digital dialogue, and interviews (Section 8.4.).

9.2.2. Design Conceptualisations

Fig.9.3. Concepts presented in design workshop



From concepts presented (**Fig.9.3.**) and ideation activities, the women ideated two BW concepts.

The massage bra, later named Luisia, was one concept. The bra would relax the wearer as they tend to their daily lives (see **Fig.L.11.,** p.492). Participants noted their desire for a bra that would de-stress them while providing all the functions of a traditional bra. Besides massaging them, the women wanted the bra to release scents for relaxation. Both features would be controlled via an app on their phone.

A bra for cooling the body, the Lavinia, was the second concept. The bra would cool the wearer whenever they had a hot flush (see **Fig.L.16.,** p.497). Additionally, it would have a pain-relieving gel release, such as a menthol and eucalyptus substance. Lastly, the women wanted the bra to help eliminate odour. Similarly, the bra would be controlled via an app on their phone.

Due to limitations in time, skills, and technological availabilities, both concepts were pared down to achievable designs. The smart concepts focused on one functionality and were self-contained.

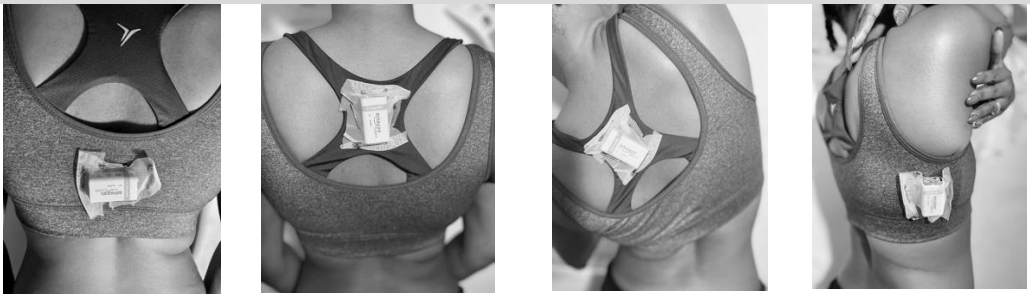
9.2.2.1. Technology and Why Selected

For both concepts, the massage and cooling bra, the technologies selected were based on availability, cost, and most effective materials. The design practice overlapped with the design workshop (**Fig.6.4.**, p.149) enabling experimental insights into the concept development, materials, and technical aspects (see Section L.1.4). The massage bra – the Luisia – required small vibration motor coins, Mosfets, and ATtiny45, all purchased for their capabilities and miniature size. The bra's trigger, a stretchable flexible conductive composite (**Fig.L.14.,** p.494), referred to later as a stretch sensor, was created rather than purchased.

For the cooling bra – the Lavinia – a Peltier, Trinket M0, DC/DC converter, a mini fan and multiple copper heat sinks were purchased. The Peltier was difficult to acquire in a smaller size; thus, what was accessible was utilised. Both designs employed flexible and soft conductive threads as a channel rather than relying on chunky insulated wires (Islam Molla, 2020).

9.2.2.2. Design Elements

Fig.9.4. Testing battery placement on the body.
(Viewing left to right) Battery placement at mid-back, upper back, testing battery sensation while moving, and side seam.

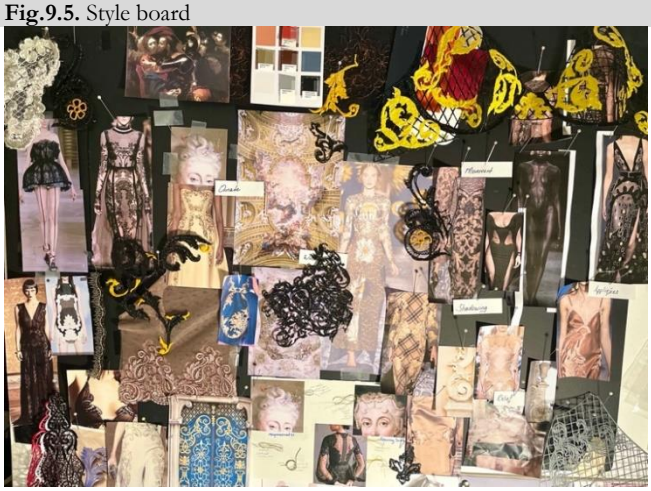


Certain aspects of BW design, such as the battery placement, must be investigated before designing. Timmins and McCann (2015, p. 190) calls this investigation 'body mapping', where designers must 'address requirements such as the size, shape and fit, and predominant posture and movement of the wearer for the optimal positioning of the wearable technologies'. The battery placement was interrogated for comfort, discreetness, and aesthetics. Using the first-person[99] method of experience prototyping (Buchenau and Fulton Suri, 2000), I pinned a 9V battery to a donned sports bra and traditional bra (**Fig.9.4.**). The battery was placed onto areas that could be concealed within the design of a bra. When placed at mid-back, the feeling on the body was invisible until in a seated position. Additionally, the battery would be visible under clothing, thus drawing attention to the wearer. When placed at the upper back, the battery was physically

[99] First-person method in HCI, according to Desjardins et al., (2021, p. 37:1), means 'to rely on first-hand experience as a mode of knowing'.

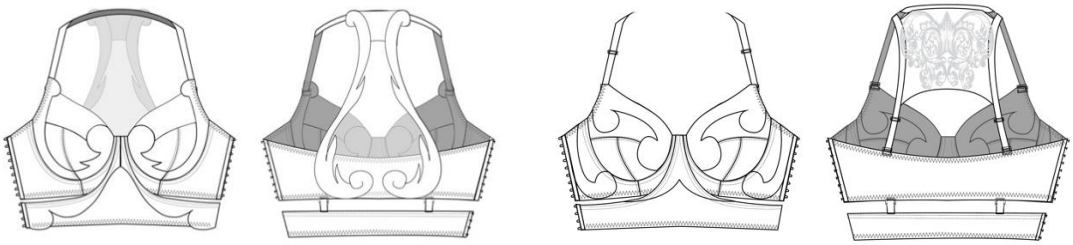
comfortable, and easy to move and sit in. Unfortunately, a bra with battery placement at the upper back would be neither aesthetically pleasing nor discreet which participants required. The battery was then moved to the side where the arm would conceal it. This placement hindered arm movements and distracted from the wearers' outline. While reviewing the images, I realised the lower back would be a viable placement option due to the natural indentation of the back. Furthermore, it is an area where clothing is usually worn loose and would not attract attention. This line of reasoning supported the idea of extending the bra by modifying its traditional appearance.

Fig.9.5. Style board



The mood and style boards, a living design tool, became essential to concept design and development. Cassidy (2011) suggests that designers should iteratively engage with the mood and style boards to develop innovative concepts and better understand the design's focus. Therefore, the style board was amended throughout the process, with images and samples added (**Fig.9.5.**). The mood and style boards, coupled with the experience map, inspired the designs for the Luisia and Lavinia bras (see Section L.1.1., **Fig.L.2.,** p.480). The bras employed numerous criteria discussed in Section 8.4.3. Namely, wider straps, front adjustments, side closures, wider wings, full cups, breathable materials, and more (see **Tables 8.9.** and **8.10.,** p.259). **Fig.9.6.** depicts bra CADs, inspired by the mood and style boards, which aimed to be luxurious and evocative of the Baroque period, yet comfortable and unobtrusive, using the design elements to hide the technology. Moreover, the concepts were designed to be modular[100], potentially extending their longevity, facilitating ease of repair, and allowing customisation.

Fig.9.6. Design concepts are shown as flat CADs.
(Left) Lavinia Cooling Bra. *(Right)* Luisia Massage Bra.



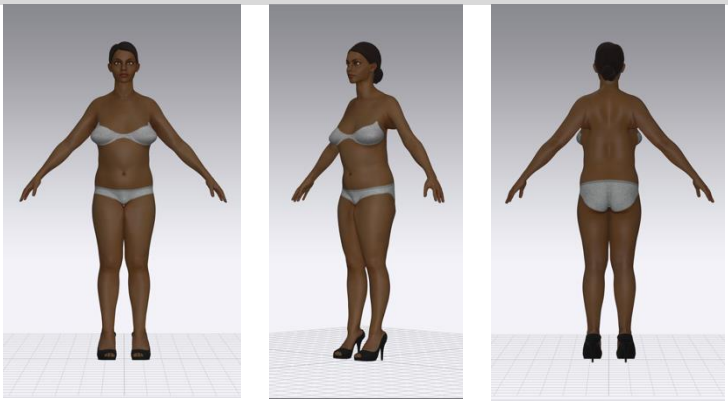
[100] The modular concept is a design feature the design-researcher studied during her Masters (Section 1.1.1.). She believes there is potential for creating easier closures that would make the concept accessible to a wide range of bra wearers.

9.3. Fit Model Developments

Due to the lockdowns, collaborating directly with fit models was not possible[101]. Instead, women were invited to function as digital fit models (Section 6.1.3.2.). Researchers advise the usage of digital prototyping to assess participants' perceptions (Park and DeLong, 2009; McCann and Bryson, 2014). Three participants volunteered (**Table 6.36.**, p.188), and their physical measurements were transferred to digital avatars using CLO3D, a virtual 3D prototyping system. The BW designs were placed onto the avatars enabling the women to evaluate the concepts and provide insights into emotional perceptions and potential experiences. This section reviews the process of making the participants into digital fit models (9.3.1.), digital prototyping the designs (9.3.2.), their assessments of the designs (9.3.3.), and their inclusion in this design phase.

9.3.1. Making the Participants Digital

Fig.9.7. Digital fit model measurements in CLO3D with model measurements without a bra.

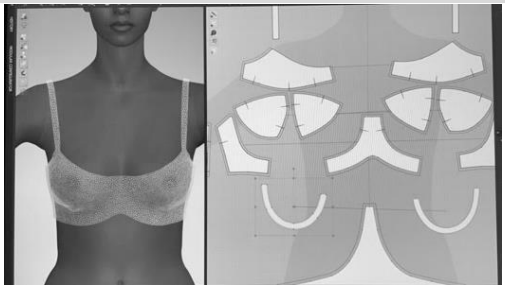


The CLO3D program enables avatars to be seen from multiple directions allowing viewing the model and garments from different angles. Moreover, CLO3D provides options for models to be nude or wearing breast covers and knickers. Janet, Shelly, and Clary's measurements were placed into the fit model dimensions, providing varied avatars. One of the first issues encountered was designing a bra on an avatar with pendulous east-west facing breasts (**Fig.9.7.**). As the digital figure is a solid object, the fabric used will not lift or change the natural soft breast tissue (Buyukaslan, Baytar and Kalaoglu, 2020). Therefore, the models had to provide measurements while wearing a fitted bra. The design-researcher could not see the physical bras the models chose to fit in and assess the *correct* fit; thus, the actual fit measurements may be slightly off. Moreover, the programmed avatars are developed to evenly distribute the weight, showcasing an in-shape model. The bulbous areas, such as the stomach, sides, and back, were not depicted. Thus, realistically evaluating the digital fit required some tolerance. Riewes' (2022) study on a bra developed utilising CLO3D reveals inaccuracy in the avatar breast shape and resulting bra fit. They concluded that CLO3D could not reconcile breast shape and volume.

[101] Since it was not possible to collaborate with fit models to develop the physical prototypes, the design-researcher created the prototypes to fit herself, utilising a first-person method. Unfortunately, as she is not a mature woman and has small breasts and a slender frame, she was not an ideal fit model for this demographic.

9.3.2. Digital Prototyping (AI, PSD, CLO3D)

Fig.9.8. Bra design attempted in CLO3D.

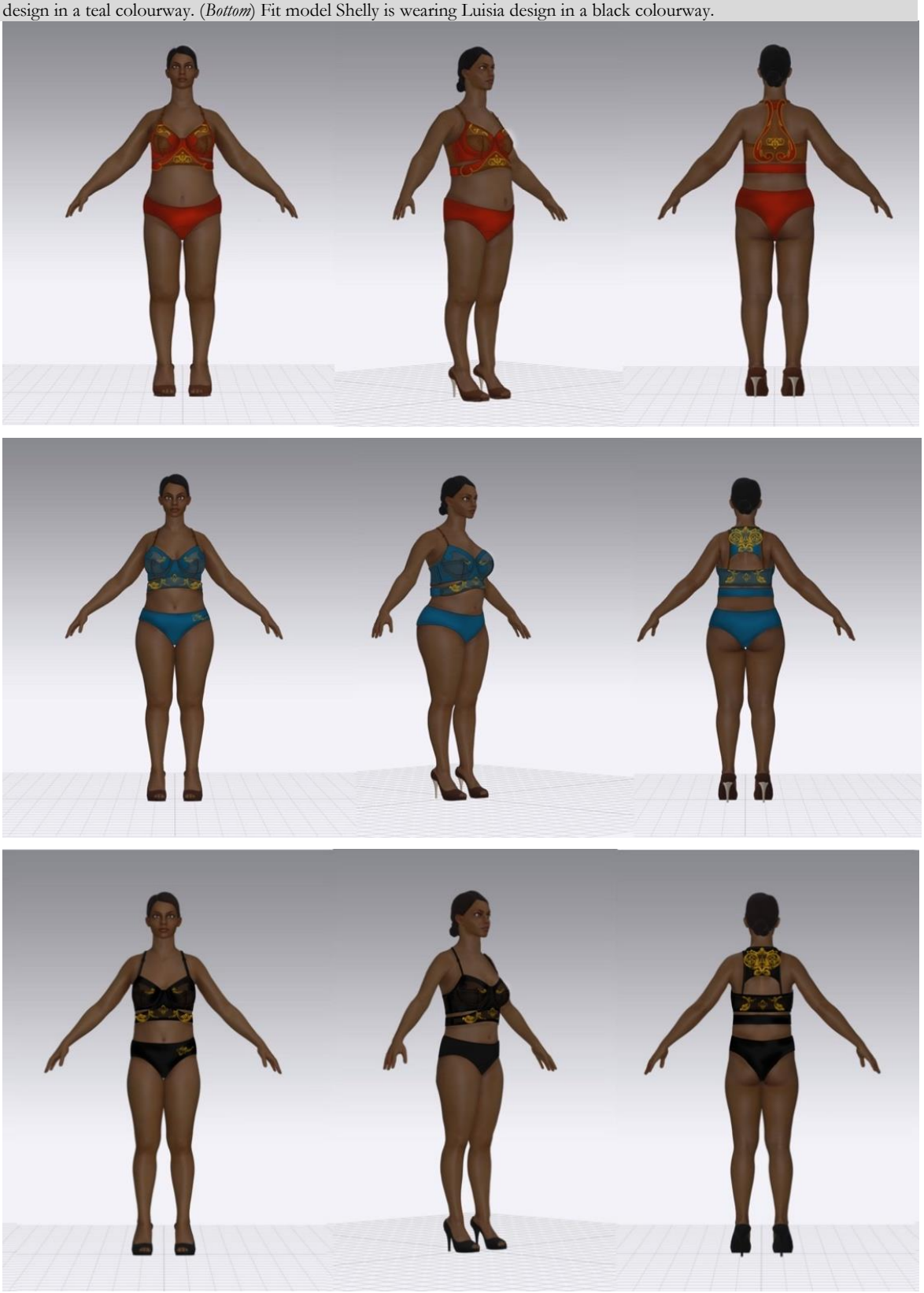


Initially, I began designing the concepts in CLO3D. The essential bra pieces included three-piece cups, frame, gore, wire channel, and mid-section (**Fig.9.8.**). While designing on the avatar, many obstacles arose attributable to my lack of knowledge of the program. Firstly, placing design lines on the avatar did not always provide the correct tightness and shape essential to a bra. It was advised to develop the patterns in Adobe Illustrator and export them into CLO3D. However, due to the complexity of the designs, patterns needed to be physically developed on a dress form first, then brought into Illustrator. Once this was completed, new obstacles arose, such as *sewing* – digitally piecing the garment together – the design and getting a proper tightness. Certain patterns on the cups were appliquéd atop others – this was difficult to achieve in CLO3D. Even with the suggested stiffening method, the underwire that pulls the bra close to the body was challenging to achieve. Developing the designs on the avatar in this way proved time-consuming and arduous.

Realising the goal was to show the fit models in the designs, which could be achieved the same as viewing products in different flat views, like online shopping, I shifted my approach reverting to designing in a manner professionally innate to me. Schön (1983, p. 138) refers to this as the design-researcher utilising their 'repertoire', including past experiences and knowledge acquired. The avatars were loaded into Illustrator, and the concepts designed directly onto them. Next, the files were brought into Photoshop, and the designs were executed with colours, fabric fills, stitches, and embroidery designs. The bra styles Luisia and Lavinia were recreated in five different colourways, resulting in ten completed looks to show to the participants. Three of the primary body colourways are shown in **Fig.9.9.**

This method enabled me to reflect-in-action on how the pieces would be assembled, as my focus was not on learning the program but on creating the designs. I focused on the bra back pieces, contemplating ways to integrate the hardware while using the patterns and embellishments to conceal them. Significantly, I recognised how different the bra fit would be on each fit model. Although the avatars did not accurately capture soft bulging body areas, they gave a general view of body shapes (**Fig.9.9.**). As the bra needed to fit a variety of mature body shapes, this method provided an opportunity to visualise several kinds.

Fig.9.9. Participants as Avatar Fit Models.
(*Top*) Fit model Janet is wearing Lavinia design in a red and brown colourway. (*Middle*) Fit model Clary wearing Luisia design in a teal colourway. (*Bottom*) Fit model Shelly is wearing Luisia design in a black colourway.



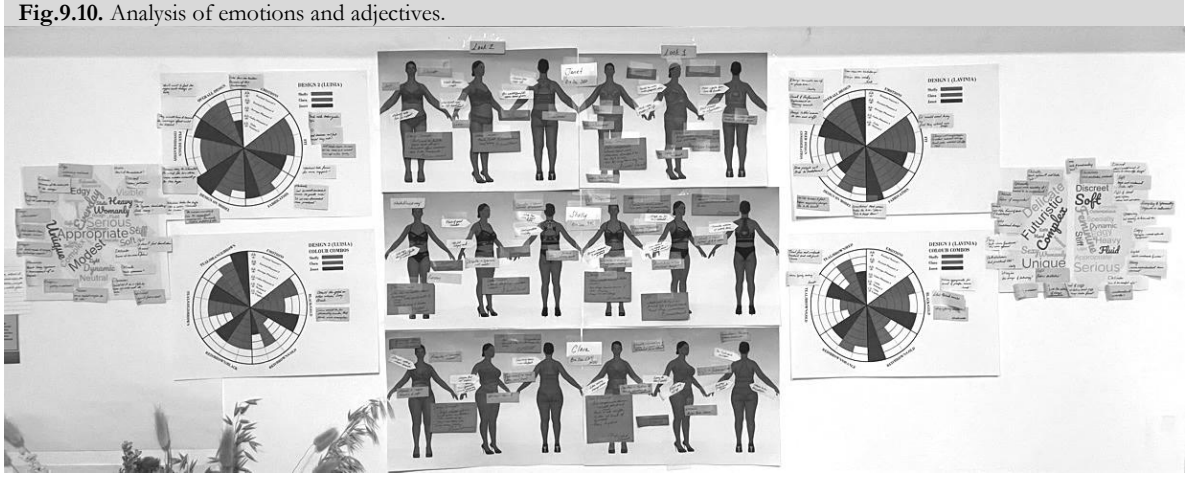
9.3.3. Fit Model Design & Emotion Experience

'Wearing a garment can open up a wide spectrum of emotions, which, in turn, provide gateways for a new range of experiences.' (Quinn, 2012, p. 32)

Examining the participants' emotions about the designs provides the design-researcher with inspiration and insights into the potential future emotional experience of the garment (Desmet and Schifferstein, 2012). To design clothing for a 'positive use experience', designers must understand attachment and emotional values (Niinimäki and Koskinen, 2011, p. 167). In this section, emotion-driven research (Section 5.4.2.) was executed through engagement with the fit models utilising assessment interviews as a source of information in developing BW concepts. Additionally, the approach of integrating participants as digital fit models and their reflection on participating in the process was investigated (Section 6.1.3.2.).

Eliciting emotions within bra design can present obstacles that further research is needed to evaluate. Desmet and Schifferstein (2012, p. 157) posit that 'products may elicit multiple (mixed) emotions simultaneously'. As shown from the validated Factors Affecting Bra Experience Conceptual Model (**Fig.7.7.**, p.208) and the Bra-Wearing Experience Map (**Fig.8.5.**, p.243), women carry a complex emotional relationship with the bra from vast prior experience — this study has just scratched the surface. Instead of interrogating this relationship further, due to time and space within this study, the fit models' emotions were assessed to illustrate how emotion can be used in the BWD&DP.

Fig.9.10. Analysis of emotions and adjectives.



Interviews with the fit models provided a wealth of data; thus, a diverse array of visual analyses was utilised (**Fig.9.10.**) [102]. The top colour selections for each of the two bra designs, selected by the fit models, were printed out and employed in the analysis. Coloured post-its reflecting positive and negative emotions based on participants' quotes were used to visually highlight the areas of concern and interest. A range of emotions

[102] Larger images in Appendix N.

chart accompanied the analysis, which showed each model's emotion for fit, materials, overall design, and design on models' figures. A second chart illustrated the participant's emotional responses to the bra colourways. The charts effortlessly displayed the data from the three fit models. Lastly, a word cloud was printed with the dual words selected by the fit models to illustrate the emotions selected often.

9.3.3.1. Applying Emotion Response to the Design

Emotions Assessed. Evaluating the fit models' emotions required reflecting on their bra experience from interviews (*n*=6). The insights and the fit models' design assessment provided a more profound understanding. Nevertheless, a balance must be drawn, and the design situation carefully evaluated. If the D&DP aimed to develop bespoke pieces, then appraising the interviews and fit model assessments to create tailored experiences would be apt. However, in this case, where the D&DP sought to develop pieces for a wider audience, materialising results focused on these women's experiences may not be the most beneficial. Instead, the emotions were reviewed from the fit model interviews and appraised to fit a broader target audience.

The radial graphs presented a straightforward approach to evaluating the participants' emotions. Many of the graph slices evaluating the design indicated intense pleasure from the excited neutral (1), excited pleasant (2), and average pleasant (3) categories. Accompanying the graph were quotes from the women further elucidating their selections. For example, on both designs, Luisia and Lavinia, Clary and Shelly noted the fit looked adequate on the model, but they would have liked to try it on themselves. The graphs provided a striking visual for the colour combos. Five different bra colour combos were shown to the women; their emotions varied from intense pleasure to calm unpleasant. The colours the women found most appealing were easy to discern and varied between the two designs.

Analysing the word clouds provided an additional avenue to evaluate the emotional responses of the women. This approach revealed the intricate nature of their perceptions and sentiments towards a design. For the Lavinia design, the women felt the style was soft and delicate but also edgy and heavy. Clary and Shelly focused on the fabric seeming soft, while Janet added that the gold design appeared soft. Again, in terms of delicate, Shelly and Clary mentioned the materials, with Shelly stating, *'… the mesh softens it, and it looks light'*. Janet referred to the bra's function as delicate due to the added technology. Although they selected the same words, they brought along different interpretations. Concerning the word edgy, which contrasts with soft and delicate, Janet shared the design's possibility of malfunctioning due to *'…sweat affect[ing] the equipmen*t'. While Shelly commented on the design appearing heavy because it looked '…*more substantial than normal'*. Shelly was not contradicting herself, although earlier, she noted the design looked soft. Instead, she emphasised the interconnectedness and intricacy of evaluating the design.

The word cloud provided an extensive overview of the various emotions; however, the women's explanation and direct quotes gave it substance. Reviewing the word cloud with the emotions radial graph and the fit model visual layout was essential to better understand the women's assessments.

Designers' Reflection. Bringing the fit models into the concept and prototype development phases illustrated their ability to provide useful information. Specific alterations, including the lowering of neck-back designs, the extension of side openings to both sides of the bra, and the incorporation of removable bra padding, demonstrated not only feedback enhancements for the fit models but also improvements for a diverse audience of MW. While critiquing based on subjective experiences, the fit models demonstrated exceptional empathy by suggesting modifications that could benefit other MW, such as Janet's recommendation for openings on both sides for left- and right-handed wearers. During the BW questionnaire (**Fig.J.24.**), 46% of women agreed they would be more interested in BW if they knew MW were a part of the DP. In this instance, the fit models exemplified their utility, showcasing their ability to consider and project aspects beyond their own needs, reflecting on their needs and others.

The participants' selection of emotions from the word cloud matched my design intentions from the experience map for the massage and cooling bra (Section L.1.). Participants selected words such as 'ostentatious', 'everyday wear', 'comfort', 'relaxing', 'fluid', and 'dynamic', confirming the experience map can aid with designing *for* emotions. The experience map can exist as inspiration and an assessment reference throughout the DP.

It is imperative to acknowledge the study's inherent limitation in its reliance on three fit models, each representing diverse body and breast types. This introduces a potential confounding variable in bra needs. Recognising this constraint, the study posits the necessity of employing a similar approach with a larger sample of participants sharing more homogenous body and breast sizes to unveil potential variations in outcomes.

9.3.3.2. Mature Fit Model Feedback on Experience

To understand their fit model experience, the women were queried at the end of the fit session on partaking in the D&DP. This section reports their responses.

Responses, while positive, varied on their digital selves. Clary enjoyed commenting on the model and pointing out similar curvy features; she remarked that the model is '*pretty much accurate. But I'm more rounded at the tummy'*. Clary would have liked seeing the model in movement to assess the fit better when '*bending down, reaching up, or stretching*'. Similarly, Shelly felt the virtual avatar looked like her, noting, '*I quite recognise her. Looks fine; I'm not offended'*. The way the avatar was depicted was enough for Shelly. She expressed it, '*…helps better to visualise fit like on my body'*. Janet, too felt the avatar reflected her body sharing, '*I think I need to run around the track. Just looking at the chunkiness. The design looks good though'*. Clary and Janet would have liked

to see the avatar in motion to assess better wearing aspects. Viewing their digital bodies reflected at them made the women more aware of dissimilarity in certain areas. However, it did not detract from evaluating the designs.

Engaging in the D&DP as fit models changed their interests. Clary noted, '*The fact that the designs are more discreet and easy to put on and take off changed my mind some'*. For Shelly seeing the BW design and hearing more about how it works made her more interested. She noted, '*Because traditionally we think of bras as just the thing we have to wear. But there's so much more you can do than just wearing it now*'. Janet reflected a similar sentiment, sharing, *'…seeing where I could benefit from it, and seeing the designs and where technology goes'*. As reflected by the BWTAM (Section 7.2.), participants' interest in BW was altered by bringing them into the D&DP.

The women believed their input as fit models were valuable, attributable to their long-term bra-wearing experience and knowledge. Clary mentioned, '*What I want from my bra now is different from what I wanted from my 20-year-old self*'. Janet expressed that by having MW a part of the D&DP, '*…we would be able to benefit with comfortable bras for us'*. Shelly clarified, '*…customer is the client, and their feedback is valuable'*. Therefore, engaging MW as digital fit models during the BWD&DP proves advantageous.

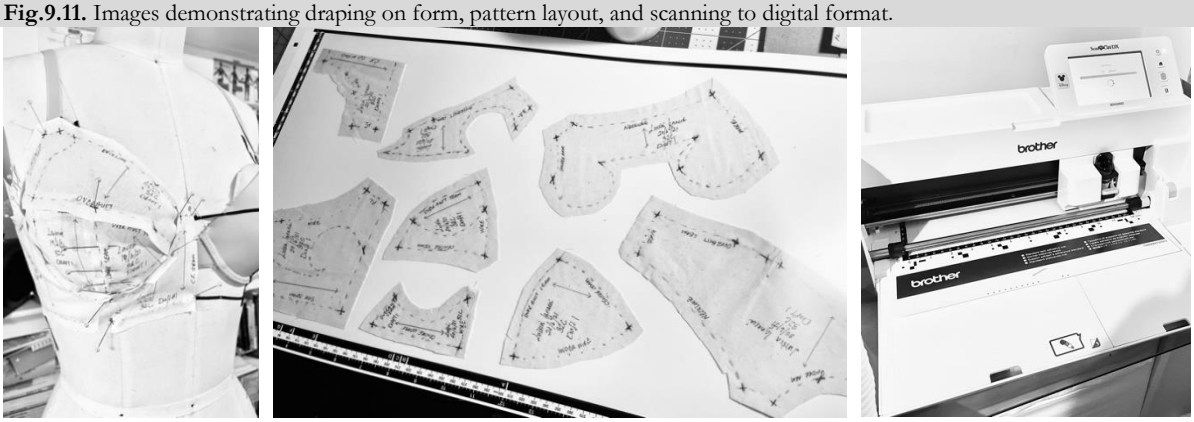
9.4. Prototyping BW

This section introduces the prototyping development, focusing on the engagement of the designer-product experience (discussed in Section 5.4.1.). The process sought to document the methods, techniques, and ways of thinking in actualising the BW samples. Moreover, the process sought to adhere to the initial BWD&DP while recognising that adjustments had to be made due to several limitations. For example, as the sole constant stakeholder, I made many decisions from a fashion designer's perspective. The proposed BWD&DP is a guide and a way of thinking that should be amended for different industry situations; the presented practice illustrates one situated example.

9.4.1. Pattern & Prototype Development

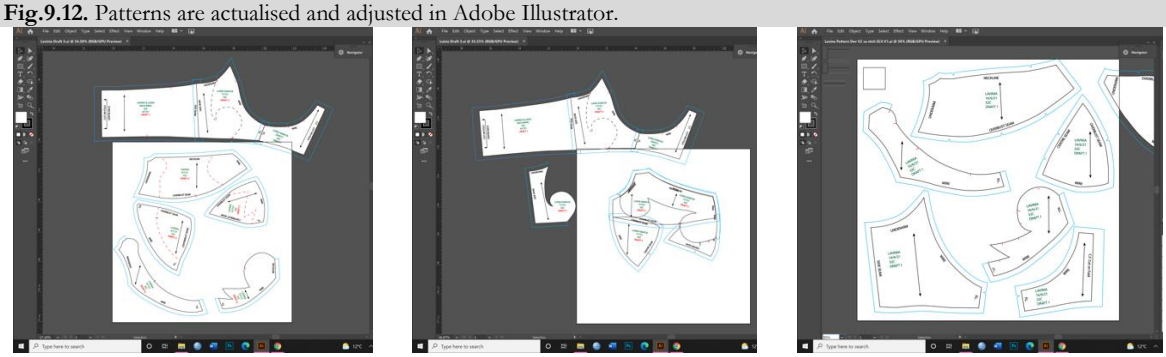
This phase aimed to actualise two bra concepts (see Sections 9.2.2. and L.1.4.). The process was documented through images, videos, and journaling. An image-based presentation style is employed to communicate the D&DP chronologically. As the two designs, Luisia and Lavinia, were developed in tandem, some areas for one style are discussed in detail and omitted for the other.

Fig.9.11. Images demonstrating draping on form, pattern layout, and scanning to digital format.



To materialise the designs, I draped the front cups and bra frames using a lightweight calico (**Fig.9.11.**). Some designers may begin with patternmaking; however, I prefer visualising the shapes that come together on a dress form. Schön (1992) argues that designers design utilising their senses which involves the sense of touch. Touching the materials fosters creative thinking and problem-solving, working through potential obstacles. According to Schön (1992, p. 133), the action of draping results in a seeing-moving-seeing method enabling 'reflective conversations with the materials of a situation'[103]. Once the designs were draped, they were laid flat and scanned into the computer using Brother SDX2200D ScanNCut – a home die-cut machine employed to cut complicated shapes for appliqués.

Fig.9.12. Patterns are actualised and adjusted in Adobe Illustrator.

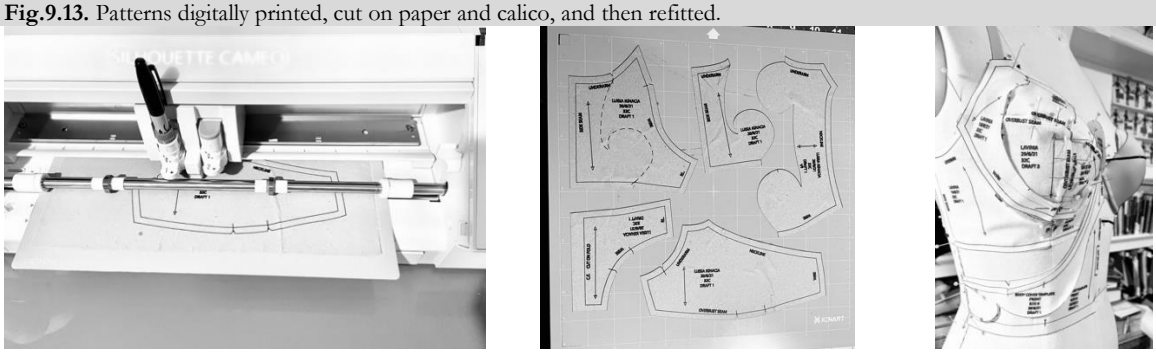


After scanning, the patterns were made digital and adapted in the computer program Adobe Illustrator 2019 v23 (**Fig.9.12.**). The lines of the patterns were reshaped, curves smoothed, matched, and notched. Due to the complexity of the cup pattern pieces, extra care was spent ensuring the curved seams and appliquéd pieces matched. Patterns were marked with the style name, pattern piece, size, date, and draft number. Further information was added, such as fabric direction, essential line names, and seam allowances. All new draft versions were saved separately due to the highly iterative process. During the patterning, I reflected on the sewing of the pieces – the procedure order, stitch type, and how to simplify the

[103] At each stage moving between the digital and physical, from fabric to hardware, I was continuously engaging in conversation with the materials. It was only through this action of seeing-moving-seeing that I could progress.

development process. By reflecting-in-action, 'unintended consequences' are recognised and rectified (Schön, 1992, p. 140).

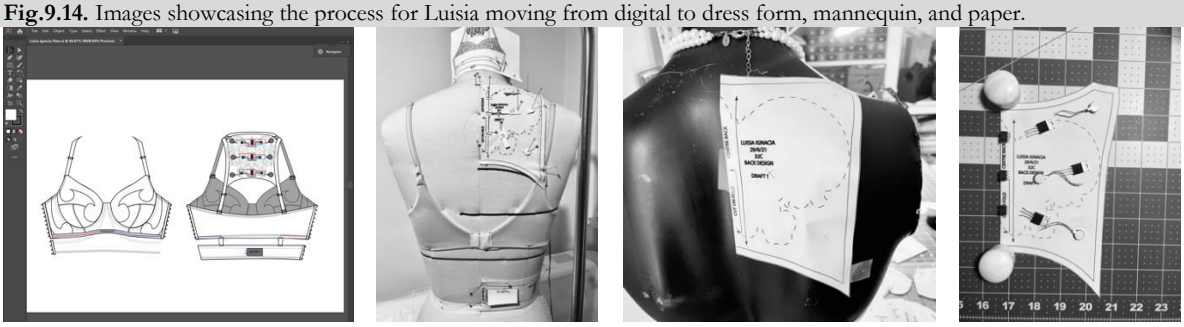
Fig.9.13. Patterns digitally printed, cut on paper and calico, and then refitted.



The amended digital patterns were transferred to the computer program Silhouette Studio to be printed and cut. The Cameo Silhouette 4 is a die-cut machine that prints through marks made by a pen and digitally cuts the patterns. First, the digital patterns were marked and printed on paper patterns and then on calico (**Fig.9.13.**). Toiles were drafted from the calico to test and revise on the form. Once reworked, the calico patterns were scanned and modified in Illustrator, printed, and refitted. This iterative process was repeated until the toiles fit on the mannequin was acceptable.

Both dye-cut machines saved time in hand copying and physically cutting patterns. Furthermore, I could quickly and easily alter patterns during the pattern development process by digitising the amendments.

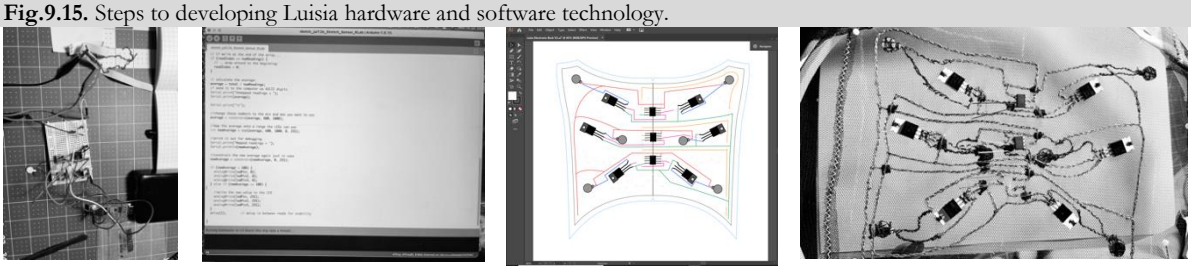
Fig.9.14. Images showcasing the process for Luisia moving from digital to dress form, mannequin, and paper.



The development process for both bras was similar, produced in tandem, and differing at the hardware stages. Once the toiles were complete and the basic bra shape patterned, I introduced the hardware. Dunne, Ashdown, and Smyth (2005, p. 9) assert that CAD software can be advantageous for layout of 'conductive pathways' and hardware. Using Illustrator, CADs were created in both styles to lay out potential hardware placements (**Fig.9.14.**). Options were limited due to the sensors requiring specific body placements and the bra having limited spatial possibilities. Illustrator enabled the development of various potential placements, including wiring layouts. Placements were then reviewed physically on the dress form, a method called 'body mapping' (Timmins and McCann, 2015, p. 192). Card stock was exploited to develop true-to-size patterns of the hardware. These hardware patterns were placed at similar locations, referencing the CAD, with few alterations. The dress form lacks slight variations of an actual body, such as the backbones and

spinal indentation. Utilising the paper pattern, the design was reviewed and updated on a mannequin with a curved back, bones, and muscle positioning. Next, the physical hardware was placed onto the paper pattern to view dimensions and potential obstacles due to proximities.

Fig.9.15. Steps to developing Luisia hardware and software technology.



After experimentation with the vibration motors (Section L.1.4.), the electrical hardware was tested again. Therefore, the knowledge developed from prior practice was brought into this activity. First, the hardware was hooked to an Arduino and breadboard to test the vibration motors (**Fig.9.15.**). Then the stretch sensor was added as a trigger[104]. The software code for the sensor was adopted from a textile lecturer's blog. Through trial-and-error, the ranges for the stretch sensor to register and react were amended. This was an iterative process between amending the software code and testing the hardware. After almost a year since the stretch sensors were developed (**Fig.L.14.**, p.494), only one conductive substrate worked. Thus, two more practice samples were developed, and two additional ones for the prototypes. ATtiny85 were selected to function as mini processors to run the software codes. Once the hardware and software ran adequately, a comprehensive, accurate-sized digital layout was mocked up in Illustrator. The wiring was colour coded, laying out directions, and then printed. The print was a pattern for chalking outlines onto the mesh fabric and was copied onto tissue paper to be used in the hand embroidery process. A chain stitch technique was applied utilising stainless steel fibre conductive thread, acting as conductive wiring, and connecting the hardware pieces. Nonconductive thread encased intersections to protect from cross-wiring. Before continuing, the sample was tested to ensure it operated.

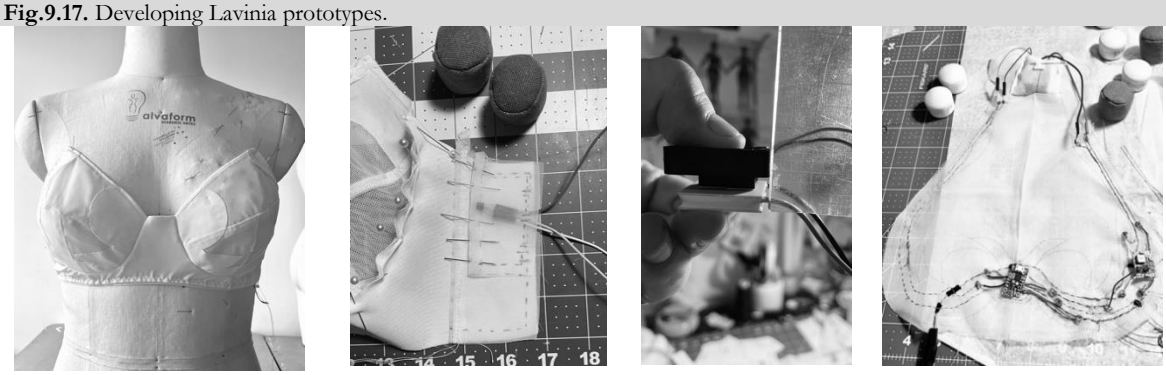
Fig.9.16. Developing the Luisia prototypes.

[104] Fabricademy's tutor Liza Stark's wearables blog was used to inform this portion. Within the blog's process section under tutorials, she demonstrates through text, images, videos, and linked codes how to achieve developing a stretch sensor with an output. http://thesoftcircuiteer.net/projects/soft-sensors/

The prototypes for each design, Lavinia and Luisia, were developed twice in white, utilising similar fabrication for the final samples. The fabrics used were white mesh, nylon tricot, and matte jersey. Due to the complexity of the designs, I had to interrogate sewing the appliqués to the cups since using iron-on fusible bonding was inefficient. Sewing the appliques brought many problems as the order of sewing operations proved challenging, requiring several bra cup iterations. Next was creating the mid-section design piece. Embroidery design options were printed and placed on the form before selecting the best placement (**Fig.9.16.**). For the second prototype, the frame and the length of the mid-section design were extended. Boning was added to keep the frame and mid-section from flipping.

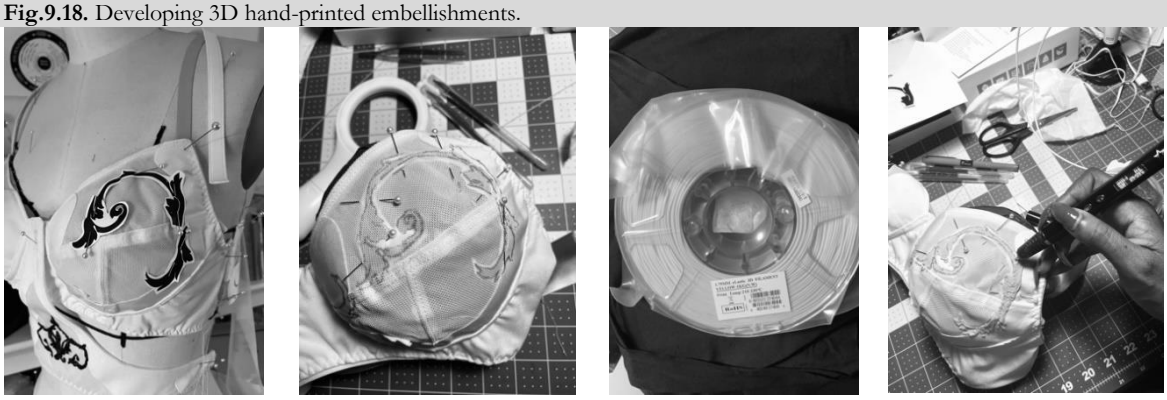
The stretch sensor in the front frame triggers Luisia's input, with the output being the vibration motors at the upper back. Therefore, I had to interrogate ways to connect the conductive thread between the front, upper back, and battery in the lower back band. This was achieved by channelling the conductive thread through the elastic bands, which is explained later in this section. The vibration motors were housed on a separate mesh material sandwiched between the upper outer and inner fabric. As the 3D embellishment designs could not adhere to the finished pattern with the motors beneath, they had to be designed onto the top pattern; the pieces were sewn together.

Fig.9.17. Developing Lavinia prototypes.



The Lavinia samples were sewn similarly to the Luisia. Sewing curved seams into a concave fashion utilising stretch material proved arduous. Therefore, the solid knit fabric on the cups was lined with a non-stretch heat bonding material and sewn onto the mesh cups. Issues from the first sample were amended for the second sample. The second sample included pockets in the frame where the temperature sensor could be housed (**Fig.9.17.**). A similar technique was used for the Peltier and electrical hardware in the back pattern pieces. At the top back neck, a pocket was designed to house a Peltier, heatsink, and micro-fan. As shown in **Fig.9.17.** (third photo from left), the depth of all those layered pieces was approximately less than an inch and a half. The pieces were connected to the lightweight mesh material using Adafruits' stainless steel thin 2-ply conductive thread. Small metal wires were hand-wounded into circular connections so the hardware and conductive thread wires could be linked.

Fig.9.18. Developing 3D hand-printed embellishments.



The integration of 3D-printing in bra designs (Section 3.4.5.), while theoretically promising, encountered practical challenges during experimentation with 3D embellishments as it slowed the process down, requiring a different approach. Nevertheless, it proved that 3D hand-printed embellishments could be a part of the BWD&DP. Baroque scroll designs were created and sized in Illustrator, printed, and then cut out in various sizes to be trialled onto the prototyped samples (**Fig.9.18.**). Once the desired size and placements were selected, marks were made so the designs could be traced onto the white fabric using removable heat pens. Flexible TPE[105] filaments were loaded into the 3D pens, and designs were embellished onto the pieces. Care needed to be taken as the heat from the 3D pens would erase the marks before completion and, in some instances, burn the fabric. A new tool had to be devised so 3D prints could occur on the pre-sewn bra cups[106] – indicating that BW created an opportunity for innovation.

Fig.9.19. Investigation of TPE filament colouring.

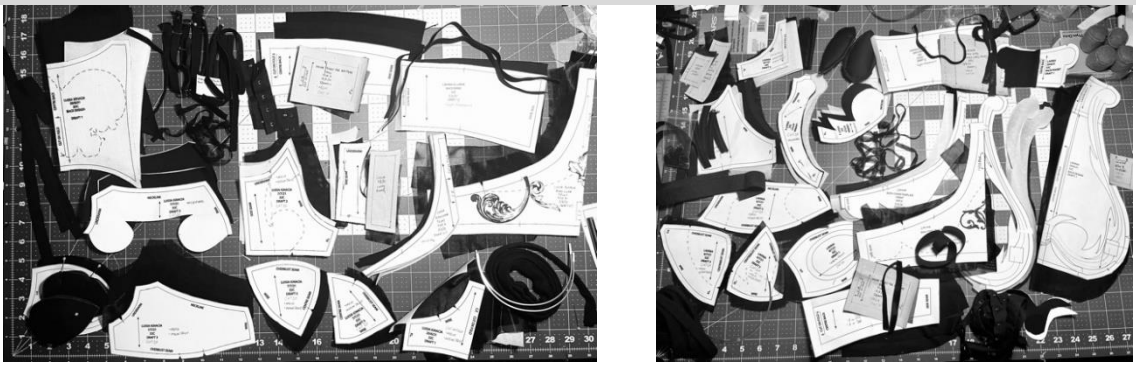
I aimed to match the sketched designs using gold-coloured TPE filaments for embellishment, but preferred brands were unavailable within the development timeframe. Instead, I experimented with a yellow TPE, testing acrylic paints like metallic gold from Americana and bright gold from Craft Smart (**Fig.9.19.**). The

[105] Thermoplastic elastomers (TPE) are soft, flexible filaments made from a rubber and plastic polymer blend. https://www.allthat3d.com/tpe-filament/

[106] A four-inch circular metal finial was padded with scrap fabric then covered in blue painter's tape. This ensured heat could be applied without damaging the garment's shape. The traditional tool is referred to as a bust ham.

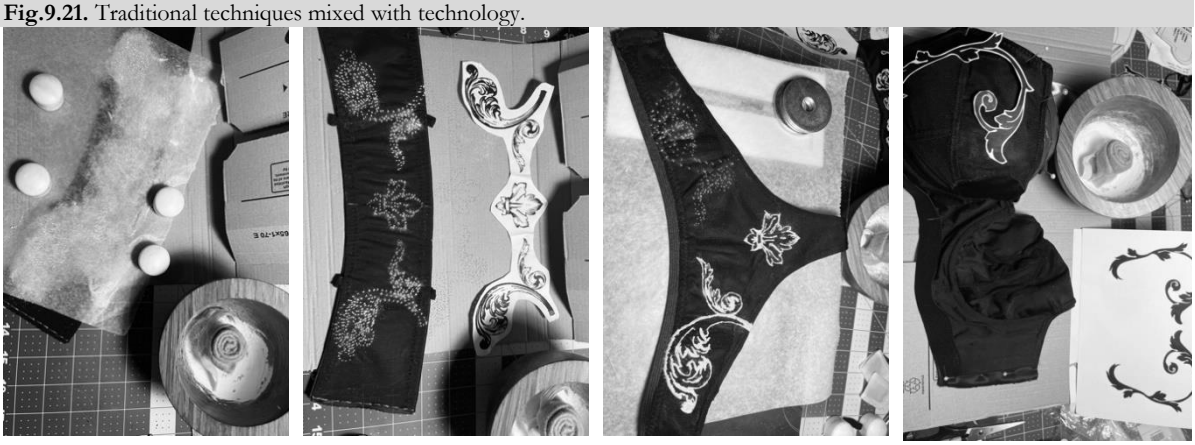
Americana brand proved effective when painted directly onto the TPE, and this method was selected for the final samples.

Fig.9.20. Images showing the pattern pieces, fastenings, and closure for the Luisia and Lavinia bra prototypes.



After the toiles were completed, it was time to cut out and prepare the sew packages for the Lavinia and Luisia bra samples. **Fig.9.20.** illustrates the pieces laid out for each design minus the electrical hardware. The Luisia and Lavinia bras each contained over 85+ pieces. Each bra was designed to conceal the electrical hardware through pockets or between seams. Additionally, all electrical hardware was designed to have a layer of fabric between the bra and skin[107]. These precautions increased the number of pattern pieces, a potential limitation for BW.

Fig.9.21. Traditional techniques mixed with technology.

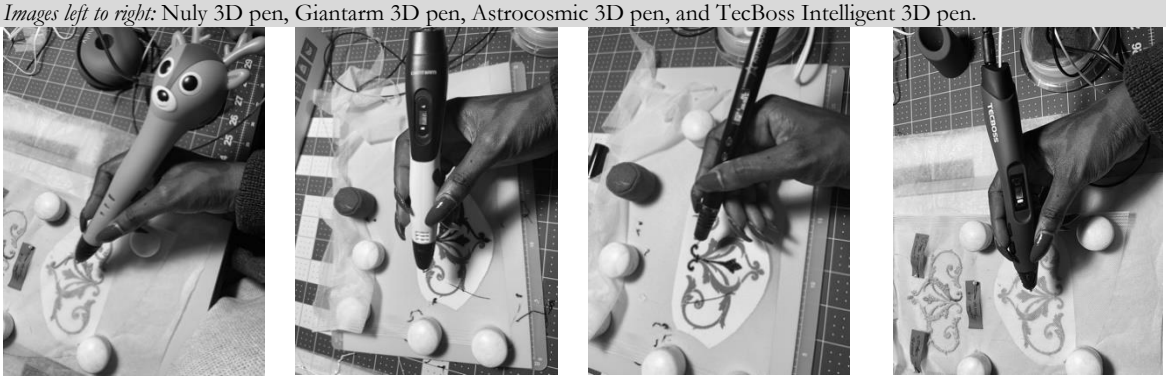


The white toiles proved easier when embellishing the designs using 3D printing. Unfortunately, marks using removable heat pens could not be made onto the black mesh or jersey knit. A different approach was required. The prick and pounce technique usually applied in embroidery was chosen. White chalk was grounded into fine dust using a pestle and mortar (**Fig.9.21.**). A pouncer was composed of scrap felt. The printed baroque scroll designs were placed beneath the wax paper; then, the design was pricked into the wax paper using a tambour hook needle. Removing the printed design, the felt was dabbed into the chalk and worked onto the wax paper with the black patterns underneath. Once completed, the designs were

[107] During production the conductive threads must be insulated with seam tape or fusible film to protect the thread and its ability to sense on body (Brueckner and Freire, 2018; Compton, 2021). The insulation step was omitted from the practice due to time and lack of access to the material required.

transferred in chalk onto the patterns for 3D printing. This technique can be done on flat and concave patterns. The bust ham discussed earlier for 3D printing was utilised for the cups. The bra cup pattern was placed on top, and the design transferred through prick and pounce, then 3D embellished.

Fig.9.22. Testing 3D Printing pens.
Images left to right: Nuly 3D pen, Giantarm 3D pen, Astrocosmic 3D pen, and TecBoss Intelligent 3D pen.



Introducing 3D-printed design embellishments necessitated experimentation with 3D pens and filaments (**Fig.9.22**.). Initially, Nuly and TecBoss Intelligent 3D pens were used (Section L.1.1.1.), suitable for PLA filaments due to their temperature settings. However, when flexible TPE filaments were required for the designs, new pens from Giantarm and Astrocosmic were purchased, each excelling in specific features. The Giantarm pen facilitated better TPE filament flow, enhancing overall design, while the Astrocosmic pen's smaller extrusion hole allowed for intricate detailing. Both pens were employed in the embellishment of the bras. [108]

Fig.9.23. Integrating technology.

Integrating the technology into the final samples was similar to the white prototypes. Here I wanted to point out some specific examples. Removable straps were employed as channels to move the energy from the battery in the bottom band. **Fig.9.23.** (first image from left) demonstrates the experiment. Zigzag hand stitches using stainless steel fibre conductive thread were placed on the inside of the elastic straps with care, making sure the stitches did not show through on the outside. Then the metal g-hooks and slides were positioned onto the straps. The conductive thread was stitched to encounter the metal g-hooks and slides.

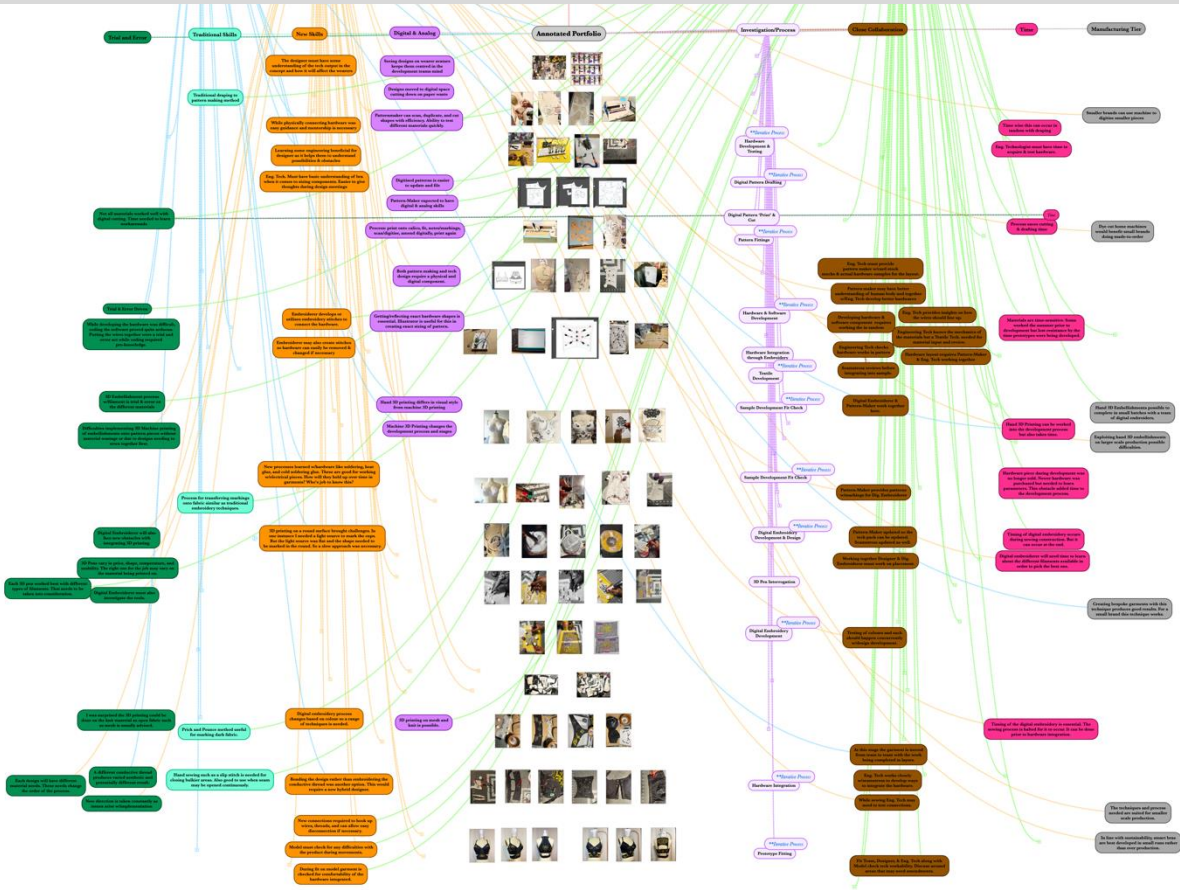
[108] Trial-and-error was necessary for 3D pens as each brand uses different specifications. This is not an issue when using a 3D printing machine, as the nozzles are regulated. Although not discussed, using a 3D printer would change the process, mainly the operation order.

A short test was conducted to ensure the set-up worked using an LED as an output. The same implementation was followed in the final samples and tested using a vibration motor.

In some instances, the conductive thread was machine sewn; however, it was hand-sewn for many pieces due to the order of operation, desire to hide seams or ease. Conductive seams connecting the front bra frame to the back wing required the stitches to be hand sewn into the metal hook and eyes. Similarly, the conductive thread was slipped stitched on the inside of the wing elastics before turning and zigzag stitching. Utilising conductive thread necessitated an interweaving of machine and hand stitching.

9.4.2. Development Reflections

Fig.9.24. BWD&DP Annotated Portfolio Themes
**Images are not meant to be legible.*



Employing an annotated portfolio method (Section 6.1.3.3.), the design-researcher reviewed and retrospectively reflected on the enacted BWD&DP. Gray and Malins (2004, p. 23) argue the advantage of design-researchers practice, positing that '(their) 'insider' knowledge, experience and status usually lend (their) research credibility and trustworthiness'. The annotated portfolio permits leveraging my practice experience of the D&DP as foundational to producing insights. This section focuses on the insights from my first-hand experience. Five themes were generated: 1) blending the digital and analogue, 2) acquiring new skills, 3) returning to traditional skills, 4) close collaboration, and 5) iterations, trial-and-error, and time

(**Fig.9.24.**). **Fig.9.24.** showcases sixteen rows of images grouped by activity from the BW prototypes development; for ease the rows will be referred to as stages.

Blending digital and analogue. The first theme of combining the digital and analogue commenced the DP, extending across several stages. For instance, in the second stage, concepts were physically realised through draping, then digitally amended and patterned – mixing analogue and digital. Despite the potential for a skilled bra patternmaker to initiate the process with a digital pattern in programs like CLO3D, the draping stage facilitated a reflective, action-oriented engagement, fostering material conversations on challenges and opportunities. For example, during manipulating the calico on the form, I worked through potential options by pinning the seams together while recalling other information. The incorporation of new technological machineries such as Silhouette and ScanNCut for scanning, printing, and cutting patterns transformed workflow dynamics, enhancing efficiency through quick digitalisation and printing. The interchangeability of digital and analogue methods in the electrical hardware stages (three and seven), exemplified by coding software digitally and testing analogue hardware output, underscored the flexibility of this integrated approach.

Another area of blending digital and analogue occurred during the 3D embellishments, which can be understood as a merge of craft and technology. It began in stage eight, relying on the patterns being designed and sized in Illustrator, then printed, cut out, and actualised using a digital 3D pen. The computer and several programs became invaluable to this iterative process. As a reflective insight for the BWD&DP, it is recommended that design teams be open to blending digital and analogue to experiment and streamline the process.

Acquiring new skills. As highlighted by previous researchers in smart clothing (McCann and Bryson, 2014; Kaner and Coşkun, 2017; Perry, 2018) the theme of acquiring new skills permeates the annotated portfolio, reflecting the necessity for stakeholders to cultivate expertise from adjacent domains through collaborative engagement. Not many designers develop patterns and sew; however, I was trained to move through all stages due to my background. Nevertheless, the incorporation of software/hardware development and hand 3D printing presented distinct challenges, necessitating a creative and iterative learning process. Balancing the dual responsibilities of coding software and connecting hardware demanded patience and time. The essential interdisciplinary interaction between electrical engineers, patternmakers, sewists, and designers at different stages became evident. The electrical engineer would need to explain to the other stakeholders how the hardware comes together, enabling the patternmaker and sewist to decide on design feasibility. The designer would maintain conceptual integrity. Similarly asserted by Price and Lewis (2015), the patternmaker would have to develop new markings to illustrate position, sizing, and wiring placements, in addition to developing new tolerance rules. Meanwhile, the sewist must adapt to interpret and actualise the designs using new sewing methods, possibly learning to hand 3D print. The 3D print work could also be given to a trained embroiderer who would need to develop new ways of integrating thread and hardware

materials. Moving away from the sewing machine, the sewist or embroiderer would have to become accustomed to tracing or free-styling designs onto materials developing rules as they go. Reflecting on this experience underscores the imperative for all stakeholders to continually acquire new skills within the dynamic and interdisciplinary DP.

Returning to traditional skills. A further theme was returning to traditional skills, such as physically draping the patterns, utilising the prick and pounce transfer method, and employing hand-sewn stitches in the design. With many brands moving towards virtual prototyping and digital production, such as 3D prototyping designs, employing programs like CLO3D, physical activities like draping or physical patternmaking to develop patterns occur less (Atkinson, 2022). However, returning to physically interacting with the dress form and mannequin allows the designer to comprehend the nuanced needs between the body and materials. For instance, in the development of the complex bra design during stage two, draping onto the dress form facilitated the exploration of potential challenges and opportunities. This hands-on experience of designing and making not only granted access to new knowledge (Schön, 1992; Dalsgaard, 2014; Dixon, 2020) but also prompted a deeper inquiry into and comprehension of the body's requirements. Direct engagement with the mannequin proved instrumental in determining appropriate hardware sizing and potential layouts on the body. The revival of traditional skills, such as draping on dress forms and interacting with mannequins, not only introduced a more deliberate and slower design approach but also allowed for thorough contemplation of the development process.

Another traditional skill exploited was the prick and pounce method, which embroiderers often utilise when transferring designs from paper onto fabric, especially when working on materials that are difficult to mark (Corbet, 2011). While initially utilising heat-erasable pens for marking prototypes in white fabric, this method proved inadequate when working with black samples, underscoring the influence of fabric composition and colours on the employed processes. The prick and pounce technique emerged as a crucial tool for transferring designs onto darker materials, particularly facilitating the development of intricate designs on sewn, concave pieces like the bra cup. This traditional technique seamlessly integrated with modern technology, notably 3D printing, to cultivate a novel skill and process.

Lastly, incorporating hardware into soft materials, such as textiles, often necessitated hand-stitches, as observed in this study. Conductive thread was manually applied for embroidery, employing both chain and straight stitches to connect the back design pieces. While an embroidery machine could have executed these stitches if available, certain hand-stitches, like the slip stitch closing the bottom of the bra back, proved more effective when done manually. This manual approach not only ensured neat closures but also facilitated easy access for circuit repairs. Hand-stitches were also strategically employed to reinforce connections between conductive channels, exemplified by the Luisia bra's stretch sensor integration into the elastic under-band (Section L.1.4.2.). Although hand-stitching may impede the D&DP and might not be suitable for larger manufacturing (Islam Molla, 2020), it offers advantages in precision and repair

accessibility. Consequently, this study suggests that BW may be better suited for smaller-batch production rather than mass manufacturing.

Close collaboration. Throughout the D&DP, a heightened awareness of my skills' limitations underscored the benefits of collaborative efforts with various stakeholders. This awareness became particularly pronounced during the incorporation of hardware and software components. While the hardware and software development and testing phase (stage three) demanded less immediate collaboration, a proficient team could optimally manage these technical aspects. However, as the process advanced to stage six, involving the design layout for hardware placement, the imperative for close cooperation became evident. For instance, collaboration between the patternmaker and engineering technologist was crucial for understanding hardware specifications and developing an efficient placement strategy within the bra design. Furthermore, the collaborative exchange between the patternmaker and engineering technologists could yield valuable insights into the female body, facilitating the development of e-textiles. This underscores the essential role of cross-disciplinary collaboration in crafting physically comfortable and functionally effective wearables (McCann, 2015b).

As delineated in the annotated portfolio (Appendix O), multiple stakeholder interactions often overlapped and blurred at various stages, requiring close collaboration to inspire innovation – an action advocated by Toomey and Tan (2018). A significant facet in this area is the need for new communication methods that facilitate the exchange and dissemination of the right amount of information between teams (M.C. Price and Lewis, 2015). Although I could seamlessly progress from one stage to the next, equipped with the requisite information, it remained salient that a lack of or ill-articulated information could potentially impede a development team's progress. For example, at the digital embroidery design and development stage, collaboration among multiple team members—designer, patternmaker, sewist, and digital embroiderer—was imperative, involving the exchange of insights and documentation for optimal execution. Once the designer endorsed the placement of 3D embellishments, the patternmaker devises patterns with markings for the digital embroiderer. Subsequently, the team, inclusive of the sewist and digital embroiderer, must engage in discussions to achieve the final output. As illustrated in the annotated portfolio, this process was iterative, demanding diverse team members to collaborate effectively.

Additionally, the seamless transition of samples from one specific site to another necessitates close collaboration and meticulous documentation. Within an in-house design company, the pattern-making room typically offers a confined space for fittings, while a separate room accommodates sewing activities with multiple sewing machines, ironing stations, and smaller stock fabric areas. The common practice involves transferring samples with comprehensive technical packages, housing all relevant information prominently displayed on the exterior. Given the novelty of the BWD&DP, stakeholders face the challenge of determining the specific information that demands detailed documentation for effective transmission. In my capacity as the sole designer, internal reflections prompted me to identify the essential information

required for subsequent stages. It is imperative to acknowledge that certain nuances of information may not be effectively conveyed through documentation alone, necessitating direct face-to-face communication.

Iterations, trial-and-error, and time. Lastly, this section uncovered and combined themes of iterations, trial-and-error, and time. As illustrated in the annotated portfolio, many stages and elements required iterations and trial-and-error throughout the process. The traditional bra D&DP inherently involves iterations, fostering in-action learning, a characteristic that persists in the BWD&DP, consequently lengthening the time. The integration of new materials and techniques necessitated a series of trial-and-error attempts to effectively combine all the components at various stages.

Eleven of the fifteen stages, in the annotated portfolio, were marked as iterative, beginning with draping the patterns and ending with fitting the prototypes. These iterations manifested during conventional bra activities, such as patternmaking, as well as in the incorporation of new technological hardware, exemplified in the hardware development and testing phases. As posited by Hardaker and Fozzard (1997), the bra D&DP dynamically evolves in response to changes in materials and styles, necessitating novel approaches and perspectives and, consequently, endorsing an iterative methodology. Iterations occurred for a variety of reasons linked with trial-and-error activities, indicating the BWD&DP may require extended time.

9.5. Participants Review

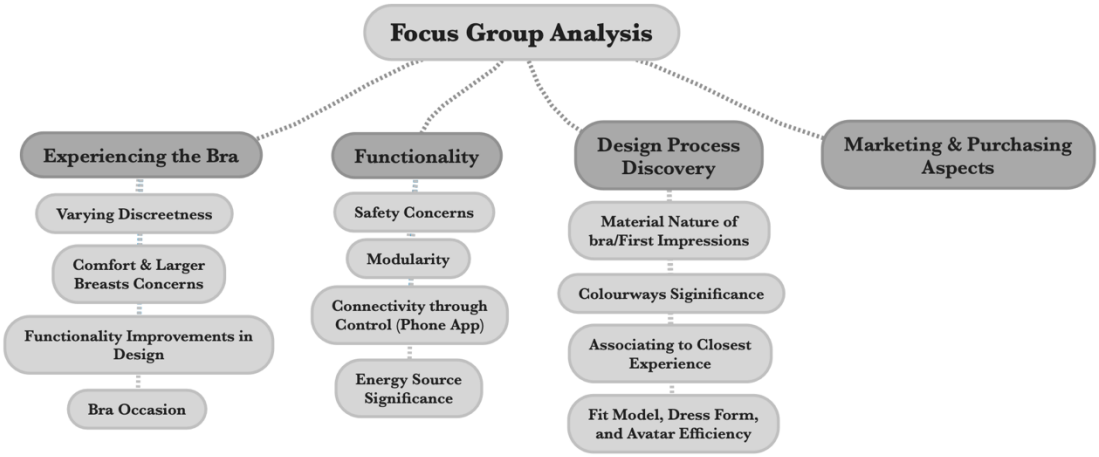
To conclude this stage in the "Pattern & Prototype Development" phase, MW were invited to partake in an expert appraisal-based collaborative review (Section 6.1.3.4.). During this iterative phase, participants evaluate the prototypes with the design-researcher. In industry, additional stakeholders necessary for the design progression would be present. Design teams/stakeholders must then evaluate the results against the BWFSEA criteria (Section 8.4.1.) and Four Pleasures Framework (Section 5.4.2.1.) after each collaborative review until the prototypes are judged successful before moving on to the next phase.

Since this study was affected by the Covid-19 pandemic, the evaluation stage was shortened due to time constraints. Therefore, the design-researcher conducted one round of the collaborative review using the data for the results. Four participants previously partook in prior methods; however, five were new to the research (**Table 6.36.**, p.188). The collaborative review was held over Zoom; therefore, none of the participants could interact physically with the prototypes. A heavily visual presentation was designed to compensate for the lack of interaction. The participants' responses were analysed, and the results are discussed in the following section.

Fig.9.25. Examples of prototypes on the dress form.
Top: Lavinia prototype front, three-quarter, and back views.
Bottom: Luisia prototype front, three-quarter, and back views.

9.5.1. Collaborative Review Results

Fig.9.26. Overarching themes from the Collaborative Review Focus Group.



The results from the collaborative groups appraising the two BW designs are divided into four groups (**Fig.9.26.**): experiencing the bra (9.5.1.1.), functionality (9.5.1.2.), marketing and purchasing (9.5.1.3.), and design process discovery (9.5.1.4.). Below each section is discussed.

9.5.1.1. Experiencing the Bra

Within the theme of experiencing the bra are four areas: comfort and larger breast concerns, functionality improvements, bra discreetness, and bra occasion. Comfort was discussed in terms of donning and wearing the bra. The closures placed at the side seams were a concern for Janet, Nelly, and Clary. Clary expressed potential difficulty hooking the bra on her body due to mobility issues, while Janet and Nelly communicated concerns about the closure during wear[109]. Janet noted, '*You don't want when you have your hands by your side like walking back and forth, it rubs against it and irritate either the arm or the – the sides*'. The participants also had comfort concerns for larger-breasted women, with Crystal querying whether a racer-back design would be comfortable. She shared, '*So, I mean if you're somebody who might have a slight neck problem or a back problem, that might be a little weighty, uhm, depending on your bust line*'. However, McGhee and Steele (2010) highlight the racer-back design as being able to comfortably lift and secure the breast during activity. Informatively, participants tended to speak of experiencing the bra for themselves and other women.

[109] The participants contradicted themselves. Both Clary and Janet agreed to side openings in the fit interviews but brought up new concerns once the prototypes were developed. Contradictory responses is discussed further in Section 9.6. Nevertheless, it is highly recommended having mature fit models experience the garment and provide feedback to the group.

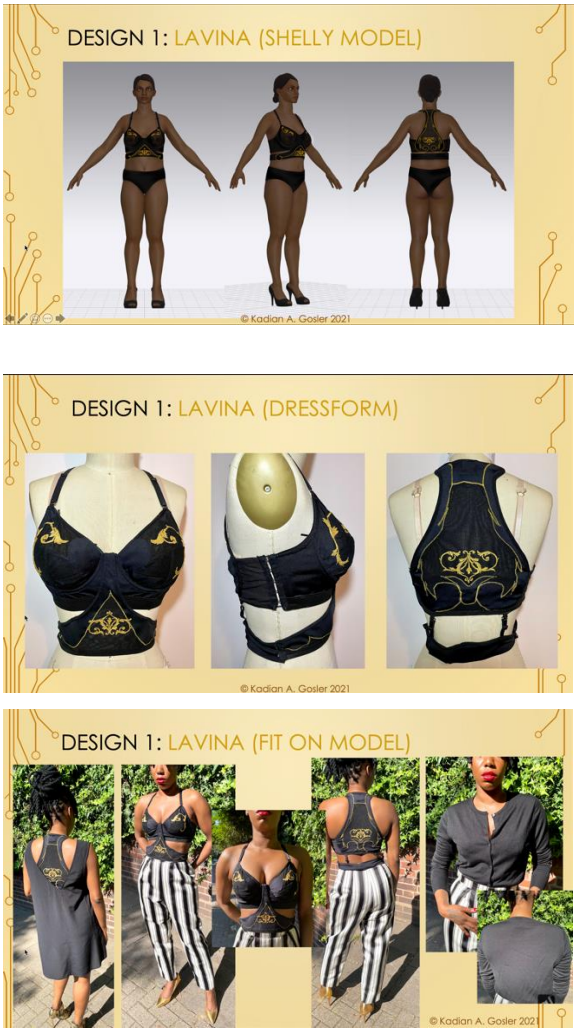


Fig.9.27. Slides from the focus group illustrating the Lavinia design on the digital fit model, dress form, and fit model.

Participants provided functionality improvements to the design, often focusing on added features to shape their bodies. These queries were rooted in the design being open on the sides, which they feared would exacerbate fatty areas. Danah suggested developing the design into a bodysuit, '*…that kind of helps your tummy, and have a smooth underneath. […] you'd be hitting the both areas that women are really kind of conscious about, which is having a smooth line and, you know, and wouldn't shake really*'. Clary agreed, adding that she would like the design to also work on her '*…belly fat at the same time…*'. Both Janet and Nelly had a similar sentiment, with Janet suggesting the design must '*keep the breast nice and firm, and then the stomach is tucked in as much as possible*'. Moreover, larger-breasted participants expressed interest in the bra design aiding under or in-between breast sweating. While the fabric materials were selected to be breathable and moisture-wicking, Nelly questioned whether the design would be adequate for larger breasts sweat. The women's' critiques suggest that the designs can be smart, but they must also include non-smart functions.

The women varied on discreetness in terms of what needed to be inconspicuous. Janet and Nelly wanted the technology, specifically the hardware in the bra, such as the Peltier, to be discreet. While the bra could be discernible, the technology mattered more. Discreetness about the bra varied but everyone agreed the technology should be discreet. The discreetness differed for Clary, who queried, '*If you were wearing a lightweight silk blouse or anything, something like that, would you be able to see any impressions?*' For her, the bra in its entirety must be hidden. Once images of the garment shown on the fit model wearing a thin light sweater were displayed (**Fig. 9.27.** and **9.29**), Clary's perception shifted. She shared, '*I'm just looking at your back view. And your jumper, your top doesn't look very thick, but I can't actually see the shape of the bra there. I'm like surprised, thought you'd be able to see the back panel, but you can't really see through your top, which I think is quite nice*'. Showcasing the garment in different wearing conditions was constructive, as it allowed the participants to judge the bras' discreteness for themselves.

The two BW prototypes generated discussions around bra occasions. Although the bras were designed for everyday usage, the women were unsure of their feasibility. Danah felt the design was luxurious and would

be too expensive for everyday wear. She commented, '*I think it's more socially or you know,* […] *It has to retail for, you know, quite a lot of money. And you probably, if you're going to a very special event, you definitely want to wear that*'. Clary disagreed, noting, '…*if you've got a very stressful job that could help* […]'. While both women focused on the bras' smart function, they differed in thinking about when they would get the most value from it. As the price of BW will be higher than traditional bras (Haffenden and Smith, 2015), women may negotiate its usage to obtain the greatest benefit. Janet concentrated less on the smart function and more on the design, noting that the bra could be worn as a top. When asked would she wear it as a top, she replied, '*maybe to Las Vegas*' or if she had a tummy tuck. Nelly agreed with the sentiment. The occasion becomes pivotal to wearing interest.

9.5.1.2. Functionality

The functionality theme often appeared in modularity, safety concerns, control through connectivity, and energy source significance. The bras' modular capabilities were a passive but positive added feature for the participants. Danah noted it '…*is a good idea personally. So, you have a choice, you can either go basic, or you can add the attachments and have that flexibility*…'. Nelly agreed, adding, '…*I believe that is okay, based on the fact that some people have different needs'*. The modularity feature, designed to assist the bras usage and allow the wearer to control aspects of the style, did not register as a significant selling point.

Some women raised safety concerns, such as the bra overheating or the body's perspiration damaging the product. Nelly shared, '*I'm just, I'm just thinking would it get too hot for me one day, just like a phone per se? […] What if it gets too hot and not – it's not controlled, I can't control the heat. […] But the bra is on you and I'm walking down the street or at work, I'm on the subway, then what do I do then? If it gets too hot? I can't take it off*'. Her concern was twofold in having control over the bra overheating and the incident occurring in a social setting. She likened the experience to having a smartphone that gets hot and can be turned off and put away. Although the wires and components were sandwiched between materials away from direct contact with the skin, Janet wondered if the body's perspiration would trigger a malfunction or electrical shock. She noted that was her only concern in wearing the bra. Thus, clear articulation of safety is necessary for acceptance and should be covered within the DP.

While the bra prototypes were designed to be unconnected and run independently, allowing the women to focus on their daily lives, the participants sought control through connectivity. The women suggested the bras should be connected to a phone app to control and record different facets. Nelly wanted to control the temperature change and timing on the Lavinia cooling bra and the pressure on the Luisia massage bra. Similarly, Danah wanted added control over when the massage bra would run. The desire to control was based on their belief that the technology would not perform to their expectation and their fear of the bra malfunctioning with no control to stop it. For control, Janet suggested a phone application similar to the iPhone health app to monitor her data, specifically her hot flushes. When asked if it was to share with her doctor specifically, she replied no, but it would be in addition.

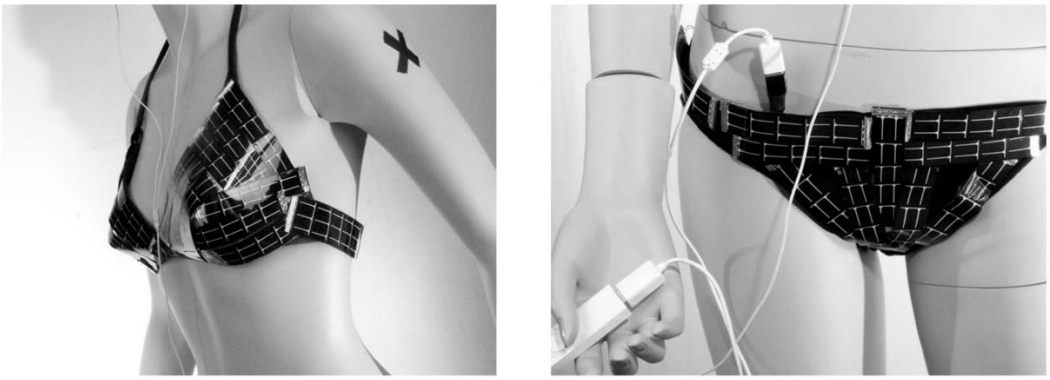


Fig.9.28. The Solar Panel Bikini. (Andrew Schneider, 2011)

The battery was a focal point throughout the collaborative review, with the suggested usage of solar panels[110] (**Fig.9.28.**). The women indicated this theme of energy source significance for various reasons such as working conditions, altering design, and ease of use. The updated bra design with an added mid-design section was not a welcome feature. As noted earlier (Section 9.2.2.2.), the bra form was extended due to the 9V battery's size and the need for it to be placed comfortably on the body. The women proposed new battery substitutes so the band on the bra could be removed. Melly suggested adding a solar panel, '*Is there anything like that, like could be small like that, that could take away from some of the extra layers, and still be able to have it work without the battery?*' Gracie proposed, '*What about that, like a lithium cell. […] because it's so small and round?*' Clary queried, '…*is there any way you can convert the body heat into making these things run to cool you down?*' The women were also apprehensive about the 9V battery applied within the design. Melly wondered how long the 9V battery would work before a new one was needed. While Danah worried about the batteries dying while out, '*I'm just thinking of in terms of the battery running out and things, so you know maybe if you were going somewhere to dinner, and you really wanted to wear this'*. In this sense, the battery needs to be easily rechargeable and alert the wearer when it was time to recharge.

9.5.1.3. Marketing and Purchasing Aspects

Throughout the collaborative review, the women addressed the bras' marketing and purchasing aspects. Price was often discussed in how much the bra would likely cost and be a deterrent. For Danah, the BW concept needed to '… *be solving a huge problem. And be something obviously around health […] Otherwise, you know, I'm not going to – because the investment is, it's going to be a hell of a lot more'*. Shelly agreed, adding that if the bras could help with specific health concerns for '*diabetes or blood pressure*', then '*[those] are the things that I think people would be willing to pay money for'*. Melly shared her perspective, as a nurse, that BW around health concepts could be covered by medical insurance – decreasing the price of the bras. She surmised then more women could be interested due to its affordability. For Clary, adoption would be between the price versus the need. She queried whether having just one of the bras would suffice or would she need to purchase two to three. If so, the price may become too high. She added that because of the possibly high cost, after

[110] At the time of writing this, solar panels were too big and rigid to be used as an energy source in BW. As Fig.9.28. demonstrates multiple panels would be necessary making the design uncomfortable to wear.

purchasing the bra, she would have to '…*pick and choose when you would wear it rather than it being an everyday, although you need it every day'*. Jones (2015) similarly notes that for older consumers, the cost is a concern for smart clothing as they fear it being faulty.

9.5.1.4. Design Process Discovery

Being a part of the collaborative review enabled me to witness how the women encountered and comprehended the BW prototypes. The theme of DP discovery includes sub-groups of material nature and first impressions, colourways significance, association to closest experience, and the roles of the fit model, dress form, and digital avatar.

As the women could not interact with the prototypes physically, they relied on visual appraisal, commenting on the material nature of the bra and first impressions. Crystal shared her first impression, '…*when I look at yours, even though you say the material is, is light, it's a lot of fabric on the body. That's just my perception'*. Gracie agreed, wondering what the mid-section design felt like when worn, as it was a new concept for her. Both Crystal and Clary mentioned that the shape of the Lavinia bra back should be narrower. Crystal likened it to sports bras she owns and how those designs were narrow. Comparably, Clary believed that a narrower back would visually appear to have less fabric.

Moving on from the bra forms, the women critiqued the colourways, highlighting its significance in evaluating the designs. Clary noted, '…*I don't know if it's the colour being black that makes it look very heavy and thick. […] but I think a different colourway will make it look less, less thick. […] And in a way cumbersome'*. After showing the women the toiles in white, Clary liked this colourway sharing; the '*transparency makes it feel lighter*'. Melly disagreed, preferring the black prototype, while Danah suggested more colourway options. Melly advocated seeing the designs in a flesh-tone colour. The responses illustrate that the bra's colourway affects the design perception, which varied among the participants.

To comprehend the prototypes, the women equated different elements to objects they had experienced, comprising this sub-theme of associating to the closest experience. Upon seeing the updated bra form, Danah shared, *'The design is like a corset'*. Clary similarly imparted, *'It's like a long line bra in sections'*. While Janet expressed, '*The bra looks like a top. Something that could be worn out'*. Besides the design, the technology was also associated with other objects. As mentioned previously, Nelly associated the hardware overheating in the bra with when her phone becomes too hot to use. When discussing the vibration functions in the Luisia bra, Shelly equated it to her Fit Bit that could vibrate, recharge, and did not need a large battery. These associations affected how the women appraised the prototypes.

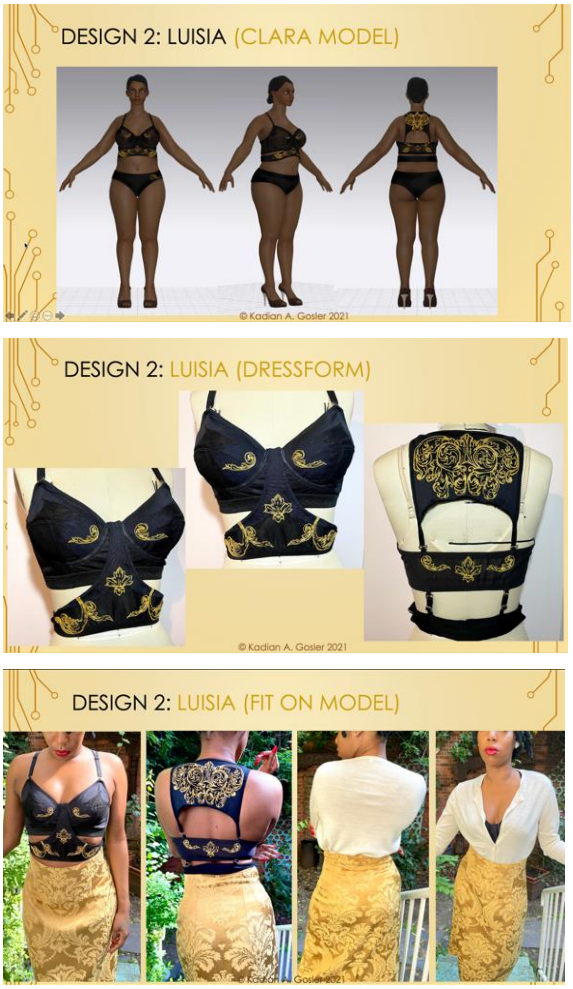


Fig.9.29. Slides from the focus group illustrating the Luisia design on the digital fit model, dress form, and fit model.

The participants were presented with a PowerPoint showcasing the bra prototypes on a digital avatar, dress form, and fit model (**Fig. 9.27.** and **9.29.**). The designs on each subject, presented in the order mentioned, were evaluated differently by the participants. When concepts were viewed on the digital avatar, the participants were often neutral. Although the images reflected the digital fit models from the front, back, and side angles with close-up shots, they lacked materiality. However, it provided the participants with images of the designs reflected on mature women's bodies. Nelly expressed she liked the Luisia style, sharing, '*I kind of like this one for some reason also. I don't know if it's because the model is bigger also. It's kind of seems like my body type*' (**Fig.9.29.** top image). When viewing the designs on the dress form, the perception was less optimistic. The women were unsure what to make of the design, although it allowed them to focus on the bras' materialisation. The designs were then shown on the fit model[111], who was a dress size U.S. 4/6 and U.K. 8. Additionally, the fit models' bra size was 32D. Gracie and Clary mentioned that the designs looked better on the fit model than on the dress form. However, after seeing the designs on the fit model, Clary, Melly, and Danah expressed that the styles were not for them. Danah noted that MW are not shaped like the fit model and have '*some extra lumps and bumps that are not going to show [on fit model]*'. Melly added, '…*even though I love [the designs], I would not feel comfortable with the extra bands. Especially, you know, being that I am a plus-size woman*'. Participants sentiments highlighted the importance of using fit models that reflect the target group.

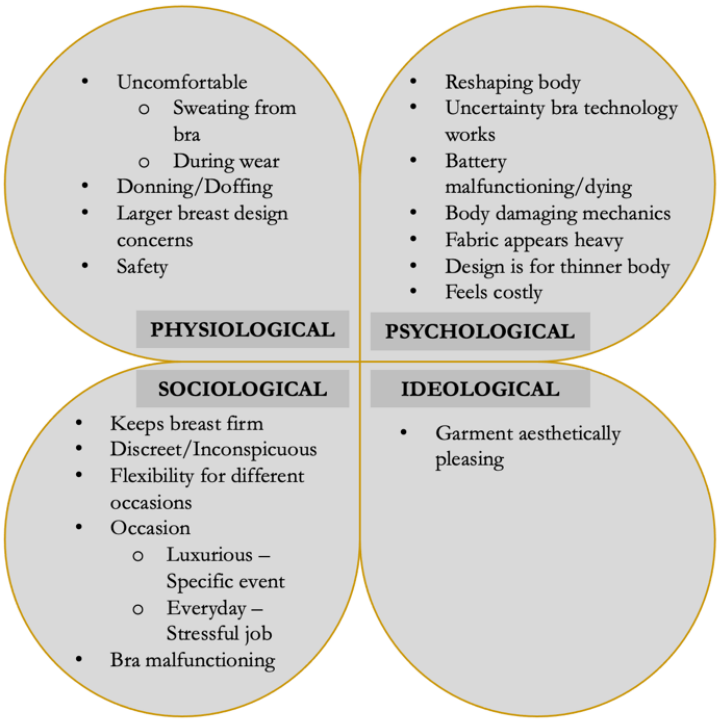
9.5.2. Participants' Evaluations Examined through the Four Pleasures Framework & BWFSEA Model

As noted in Sections 5.4.2. and 5.4.2.1., to design *for* experience assessment of participants potential experience with the product is necessary. This study uses the Four Pleasures framework (9.5.2.1.) and BWFSEA Consumer Needs model (9.5.2.2.) to assess potential experience with BW in the D&DP.

[111] The fit model was outside the average dress size of women in the U.S. 16/18 (Christel and O'Donnell, 2016) and U.K. 16 (Redefining Plus Size - Dressing the 'Average' Woman in Europe, 2020).

9.5.2.1. Four Pleasures Framework

Fig.9.30. Perceived prototype experience through the Four Pleasure Framework



The data from the collaborative review was initially appraised through the Four Pleasures Framework to aid in structuring insights into potential experiences (**Fig.9.30.**). Some of the data fit into more than one of the pleasure categories. However, Jordan (2000, p. 14) asserts that the pleasure category is not the goal; instead, it is the identification of the pleasurable experience and benefit. The women's perceptions and responses were examined through the framework to comprehend their believed experience of the prototypes. With a range of physiological, psychological, and sociological pleasure comments, it is evident that the women were apprehensive about the perceived experience. The comments centred around the product inaccurately functioning and the aesthetic being inappropriate for mature bodies.

Earlier in the BW questionnaire (**Fig.J.24.,** p.464), smart clothing not functioning to the women's standards was identified, with 41% of participants believing the bra would not perform as described and 36% believing it would not function to their standards. Furthermore, they believed BW would be uncomfortable (59%) and heavy (40%). Without having the women experience the products themselves or using a mature fit model to provide insights, their apprehension is heightened. Participants indicated during the questionnaire that they would be interested (45.65%) in BW if a peer recommends it, highlighting the importance of a fit model who is similar in age. Unfortunately, using a fit model who was younger and smaller-framed created an obstacle and potentially increased the belief that the design was not for mature bodies. Nelly mentioned she liked the design on the digital fit model as they shared similar body shapes. This indicates that seeing the garment on a body shape that is not of their group was a detriment. Without

the ability to view the prototype in person or receive insights from a peer, the women's perceived experience may be negative.

9.5.2.2. BWFSEA Consumer Needs Model

The last stage of the "Pattern & Prototype Development" phase in the BWD&DP requires the collaborative review data to be judged against the BWFSEA model. If the women's needs and wants are met, the development process continues into the next stage. However, if not met, the prototype process returns to the beginning of the "Pattern & Prototype Development" phase. In this instance, as discussed prior, the MW's needs were unmet. The following section explains this further through the BWFSEA needs model.

Fig.9.31. BWFSEA consumer needs model

Fig.9.31. illustrates the BWFSEA consumer needs model created in Section 8.4.1. Elements greyed out were not discussed in the collaborative review. Drawing from the women's feedback in the aesthetics section, satisfaction was noted for the discreteness and perceived invisibility of technology in the prototype. While discreet the desire for a smaller battery option was expressed, providing direction for the next iteration. The perception of the designs as fashionable but not mature prompted reconsideration, particularly regarding the added mid-section design deemed unsuitable for fuller mature bodies. This aligns with the notion of the design being perceived as not age-appropriate from the expressive section. Consequently, a modification, such as the creation of a long-line design, is warranted for the mid-section in the next iteration.

In the expressive section, concerns emerged about the perceived age-appropriateness of the designs. While the bra cup design received approval, questions arose regarding the comfort of the bra back design and its efficiency for larger breasts. Addressing these doubts involves conducting trials with larger-breasted mature models to assess the design's compatibility. Additionally, opinions on the occasion theme were divided, with some women deeming the design suitable for daily wear and others restricting it to special occasions. The rationale behind this division centred on technology and potential inadequate cost issues for everyday wear. To delve deeper into the daily wear aspect, an extended wear trial[112] is recommended in subsequent stages.

In the final assessment of the functional and structural aspects, a general inadequacy was identified. Concerns were raised regarding the smart functions, particularly their resilience to body sweat and potential malfunctions. To address these uncertainties, wear trials and rigorous testing are imperative. Furthermore, questions were posed about the comfort of side openings for donning and doffing, thermal comfort related to breast sweat, and the suitability of the design for larger-breasted mature bodies. The upcoming iteration should incorporate fittings on MW's bodies to facilitate participant assessments.

Despite the iterative nature of the women's evaluations of the prototypes, as expected in the DP, the collaborative review reaffirms the efficacy of the evolved BWFSEA model.

9.6. Design-Researcher Reflection – Experiences

McCarthy and Wright (2010, p. 66) highlight that an aspect of experience-centred design is that the design-researcher can make sense of the situation and 'be transformed by it (to achieve new understandings and realise new potentials)'. In this section, I focus my initial reflections on participants' engagement, design-researchers' inexperience of wearables and material limitations.

Participant's feedback. Firstly, it is a significant limitation that the participants were unable to interact with the prototypes. As acknowledged in the generative workshop, it is beneficial for participants to touch and physically engage with the bra, as this allows them to truly evaluate the design (Ferraro and Ugur, 2011). Due to the lack of physical interaction, participants could not interrogate the material or functional aspects to provide richer insights on potential limitations or possibilities. Nevertheless, participants were able to provide feedback resulting in several reflective points:

- Although the BW prototypes checked the areas in the design criteria, the bra's design was not accepted due to its perceptive failure to shape excess fat. The design-researcher erred in not prioritising the design requirements to understand which were more significant than others.

[112] Extended wear trials are placed at the end of the initial BWD&DP before production. Before wear trials begin, a range of sizes fitted on various body types must occur.

Additionally, without trialling on a model to demonstrate the bras effectiveness to shape excess fat, a valuable insight was lost. Thus, fitting with actual MW become imperative with the option to employ digital avatars with bulges for designing for larger bodies during rapid prototyping.

- Throughout the collaborative review participants contradicted prior suggestions. For instance, the digital fit models who judged the designs prior had different responses when faced with the physical garment. Perry (2016) advises that consumers may alter their perceptions once faced with the physical smart garment. Janet still liked it; Shelly was neutral and wanted to try it on first, whereas Clary was sure it was not for her. As the designs were only reviewed with the fit models, it is recommended that they be reviewed with more women in a follow-up design review prior to prototype development. This action would facilitate a means of rapid prototyping necessary for innovation (Hoonhout, 2007), allowing for further participants input.
- Readers must be aware that an empathic approach requires 'creative interactions among […] an interdisciplinary team' (Leonard and Rayport, 1997 in Weber, 2011, p. 87) to engage and listen to participants to access ideas and insight for developing innovative products. A team of stakeholders is necessary to interpret the insights ensuring 'a balanced discussion of design considerations' (McCann, 2015, p. 387). With the bras complexity 'it becomes more difficult to satisfy the different needs' (Bonello and Farrugia, 2023) requiring design-teams to prioritise the most significant design requirements as suggested above. Oygür (2018, p. 25) notes that 'designers rely on their personal experience (e.g., their interaction with the artefact, their experience as user) and their professional experience (e.g., the knowledge coming from designing same or similar artefacts)' to filter user information and drive product direction. Thus, they must utilise their tacit knowledge and expertise to interpret and translate participants feedback into desired designs through an iterative process requiring 'higher level executive design decisions' (McCann, 2015, p. 388).
- For a more effective collaborative review, separately engage new groups of participants from previous participants, as the inclusion of both new and ongoing participants led to a chaotic session with new participants having little understanding of the developed concepts. Researchers differ on when to include participants in an innovative DP (see Section 3.1.2.1.), with some arguing that effective innovation requires strategic participant involvement in crucial stages like specifications, concept development, and prototyping but not in detail design and final product stages (Weber, 2011). Greta et al. (2008 cited in Weber, 2011 p. 245) suggest that those involved in idea generation may struggle to objectively evaluate ideas due to unconscious attachment. Thus, engaging the same participants throughout the innovative DP may have adverse effects. To foster diversity and prevent fixation, Weber (2011) advocates rotating participants across stages through multiple iterations of rapid prototyping and testing for a more dynamic and successful innovation process.

There were several limitations due to this DP occurring within a research format. For example, the participants had diverse bra sizes, each necessitating distinct requirements and styles (Scurr, White and Hedger, 2011; Risius *et al.*, 2014), deviating from conventional industry practices. A more precise targeting

was necessary, for instance, mature Black women of a specific bra size range and income level. Moreover, the design-researcher enacted the DP without a team. Mamykina, Candy and Edmonds (2002, p. 96) acknowledge that 'creative pursuits in industry involve interdisciplinary teams working together to develop a product that cannot be created by a single individual alone'. Nevertheless, by approaching this empirical study the design-researcher gained insights into the necessary knowledge and challenges in the smart clothing DP argued for by researchers (Dunne, 2010; Perry, 2018). Discussed below are the reflective insights on limitations of the fabrication approach, inexperience of the design-researcher and how they impact the DP.

- ***Design-researchers' inexperience.*** Significantly, Perry (2018) found that most smart clothing designers in industry and academia lacked sufficient knowledge when it came to product development, leading to gaps in expertise (Goodman *et al.*, 2018). This has led to difficulties in the most important stage, 'prototyping and technical development'(Goodman *et al.*, 2018, p. 13), related to issues with 'conductive thread and circuits, coding, hard electronics, soft fabric, and curved body; small size; material sourcing' (Perry, 2018). This echoes findings from this study, encountering similar difficulties during prototype development, exacerbated by the involvement of a novice sole stakeholder. As the design-researcher approached each aspect of development from a fashion perspective, she was able to ascertain where each stakeholder would provide direction within the DP. Yet, her lack of comprehension of each stakeholder's domain (i.e., material scientists, engineers, etc.) meant issues with material selection, technology integration, and understanding constraints, which extended iterations in the DP. For instance, the original processor selected for the cooling bra did not work because it was outdated. Unaware, the design-researcher focused on the coding and then the wiring before learning about the processors' obsolescence. As many designers entering smart clothing will be inexperienced, collaboration with experts from other domains become essential.
- ***Fabrication approach.*** Through engaging in a holistic DP and hands-on experimentation, designers are able to learn about the fabrication approach (Ruckdashel, Khadse and Park, 2022). The design-researcher's development of two BW prototypes with distinct material requirements provides a nuanced understanding of challenges, encompassing material selection/sourcing, electronic integration, complex circuitry, necessary machinery, and scalability issues. Material selection/sourcing emerges as a central concern, with some materials posing accessibility challenges, a concern underscored by Goodman et al. (2018) in the smart clothing field. A specific example in our study involves the difficulty in obtaining a smaller Peltier for the cooling bra. Challenges in electronic integration extend to determining optimal placements, illustrated by the need to position the temperature sensor in close proximity to the underarm for accurate readings. Similarly, achieving effective cooling with the Peltier necessitates strategic placement at a cooling point (Section L.1.4.3.). These requirements demand hardware that is compact, durable, and comfortable, introducing various obstacles. Circuitry complexity is exacerbated when working with

small garments like bras, exemplified by the intricacies of the massage bra (**Fig. 9.15.**), which incorporates multiple conductive traces within a confined space. The utilisation of appropriate machinery, such as an embroidery machine, could expedite the circuitry actualisation, minimising the bulkiness and space consumption associated with thick chain-stitched conductive thread (Goveia da Rocha *et al.*, 2020). As discussed in Section 9.4.2., hand sewing was required to allow for ease of repair and connection in some areas. This method poses limitations in scalability if mass production is the goal; however, it is acceptable for small-scale production.

Overall, the experience-centred BWD&DP successfully engaged the participants and provided valuable insights. Based on the design-researchers' reflections and feedback the initial BWD&DP requires several changes which is discussed in Section 10.1.2.4. and shown in **Fig.10.3.,** p.314. Further research and refinement would make this process a useful tool for industry when working with this target market.

9.7. Summary

Chapter 9

- ***Demonstrated*** through an experimental inquiry the development of two experienced-centred BW prototypes which required the design-researcher to approach the design process in innovative ways.

- ***Introduced*** the participants back into the concept stage, engaging them in digital activities to aid the concept creation.

- ***Utilised*** participants as digital fit models, providing a novel way to engage participants in the prototype development phase and gain insights into their emotions and potential experiences with the designs.

- ***Actualised*** prototypes utilising a bricolage approach to navigate development with available tools and materials, employing my past experience and repertoire as a designer to navigate each step.

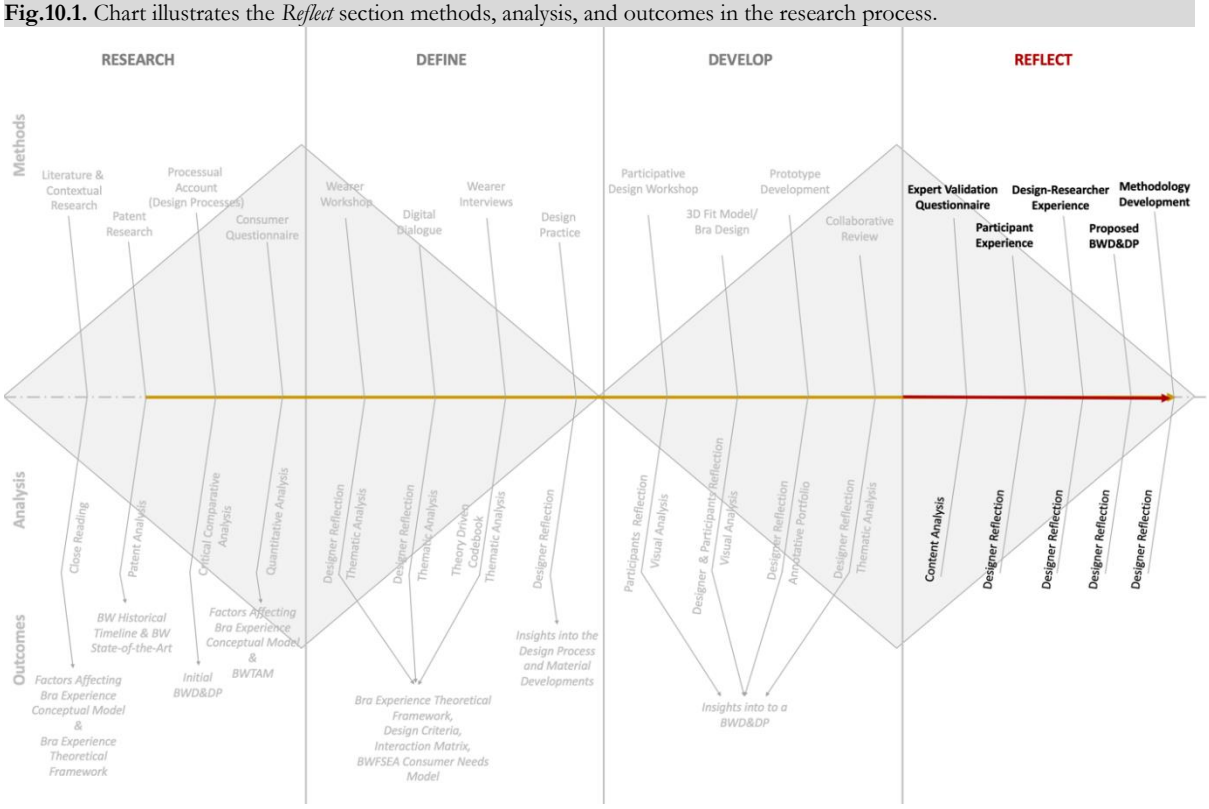
- ***Identified*** potential industry-related obstacles and opportunities through note-taking, photographs and reflections.

- ***Assessed*** participants' potential experiences of the prototypes through the Four Pleasures Framework (**Figure 9.30.**) and the BWFSEA consumer needs model (**Figure 9.31.**), validating both as advantageous in the D&DP.

10

10. REFLECT

Fig.10.1. Chart illustrates the *Reflect* section methods, analysis, and outcomes in the research process.



Chapter 10 presents a reflective review – a form of sense-making– of the research, exploring insights from a woman-centred approach to developing an experience-centred BWD&DP. This theory and practice study required an approach where the developing design process[113] (DP) could be investigated academically, leading to the use of the Four-Stage Research Process (**Fig.10.1.**). The last stage, *Reflect*, allows for reflective insights from the study where *experience* is the common thread. Dalsgaard (2014, p. 150) argues[114] 'experience emerges in the process of making (as artists or designers do) or in the process of encountering the artifact (as […] group of users do.)'. Moreover, Dixon (2020, p. 67) adds that 'research, practice, and knowing are bound together within a continuous process […] open[ing] up the path for design research which involves

[113] The "Research & Concept Development" and "Pattern & Prototype Development" phases of the initial BWD&DP (Fig.7.19., p.224) are housed in the Define and Develop stages of the Four-Stage Research Process.
[114] Underpinned by Dewey's notion of 'Art as Experience' (Dewey, 1934).

design practice'. Therefore, to comprehend the experience in the research, reflection becomes significant for the situation and participants[115]. This chapter addresses Aim #3, objective 3A:

Aim #3. To interrogate the different types of 'experiences' (i.e., the design-researcher and the wearer) that aid in informing BWD&DP.

3a. Demonstrate utilisation of a woman-centred methodology in the design process for understanding & developing BW products *for* and *with* mature wearers.

This research process is based on experiential interaction with the situation, providing an understanding of multiple facets. Kaszynska et al. (2022, p. 27) contend that design practice enables design-researchers to produce 'new designs (concepts) and new knowledge for the situation, for the design practice and for research'. The paper used this study as an example of situated multi-layered practice research to provide insights and guidelines on assessing such work. Consequently, this chapter uses their mapping practice research outcomes model (**Table 10.2.**) to discuss the study's findings. This chapter is divided into three non-chronological parts, producing insights into the situation (10.1.), design-as-practice (10.2.), and design research (10.3.). Effectively, the table illustrates the original contributions to knowledge within this thesis.

Table 10.2. Research Outcomes Mapped
Adapted from: 'Design Practice Research Outcomes analytic framework' Kaszynska, Kimbell, and Bailey (2022)

	For the Situation	For Design-as-Practice	For Design Research
Concepts/Designs	• BW TAM • BWD&DP • Prototypes: Stress Relief Bra & Cooling Bra • Factors Affecting Bra Experience Conceptual Model • Bra Experience Theoretical Framework	• Experiential Map • Involving Participants throughout the design process. Ex: Digital fit models. • Empathy methods: Body Storming, Drawing-as-Seeing	• BWFSEA consumer needs model
Knowledge	• Insights into the psychological, social, and physio-affective bra experience of mature Black women	• Designing *for* clothing experience	• Combining multiple methods to understand clothing experience to design *with* and *for* participants

10.1. Reflection on the Situation

According to Deweyan Pragmatism, inquiry into an indeterminate situation requires comprehending the 'contextual whole' (Dewey, 1998, p. 67). Dalsgaard (2014, p. 150) established that designerly inquiry requires

[115] The chapter is objectively written from a first-person perspective as I reflect on my direct experience and third-person in other instances.

design-researchers to define the situation, which is 'an assemblage of subject, context, socio-cultural constructs and technologies, [utilising] a systematic understanding of the design situation in which all of these components can – and likely will – influence the design process'. Dixon (2020, p. 41) explains that 'the parameters of action are to be seen as being determined within the contingency of a given situation. As such, one cannot anticipate precisely what needs to be done or, indeed, precisely what a particular user's needs will be'. Therefore, to begin developing the D&DP, the design-researcher needed to comprehend the situation by scoping the BW field (Chapter 2), recognising that the traditional bra D&DP varies by bra type and is altered by applied styles and materials (Chapter 3), and identifying the invisibility of mature women (MW) in lingerie and the potential difference in bra experience between Black and white women (Chapter 4). Only through enacting the initial BWD&DP (**Fig.7.19.**, p.224) could the design-researcher apprehend the needs of the wearers and a BWD&DP.

10.1.1. BW State-of-the-Art

As exemplified in Chapter 2, the smart bra field is emerging and ill-defined. Therefore, this study scoped the area to define smart bras and then focused on the BW subfield. Using current media articles, academic repositories, and digital patent databases, a contextual review enabled the development of a modern timeline (**Fig.2.7.**, p.58) and mapping of BW state-of-the-art (Section 2.3.). The BW modern timeline illustrated that within the past thirty-three years, there had been considerable advancement within the field, with the SBW field seeing, albeit short-lived, some commercial success. Additionally, the state-of-the-art revealed eleven distinct categories, with two, SBW (Section 2.3.1.7.) and breast cancer-detecting bras (Section 2.3.1.1.), receiving academic research interest. The review uncovered that the smart bra field was driven from a technology-push standpoint without wearer inclusion. This raised questions about whether the examples designed and patented were fit-for-purpose, meaning they had an actual demand or consumer value, and whether BW could be designed adding a contextual-push to meet consumer needs, and how. Further exploratory and consumer-centred research was essential to provide an insightful body of information that aided comprehension of consumer interest and design opportunities.

10.1.2. Significance of the Design Process

During the scoping, it became apparent that there were no available concrete BWD&DP. Patents reviewed demonstrated an awareness of the need to merge traditional bra-making with electrical hardware, yet a path towards doing so remained elusive. A review of traditional bra D&DP illustrated a complex operation dependent on the design styles and materials (Hardaker and Fozzard, 1997). Evaluation of multiple DP, specifically functional and smart clothing, demonstrated a requirement to include the wearers in the D&DP to access and assess their various needs (Chapter 3). Traditional sports bras and SBW D&DP developed from the functional D&DP and expanded into smart clothing, providing insight into practicability. However, with the inclusion of participants differing between an incremental and innovative DP (Section

3.1.2.1.), empirical insight was necessary to understand when and how to include them in the BWD&DP. This awareness influenced the creation of an initial BWD&DP that includes wearers (Section 7.3.), evolving the traditional bra D&DP. The research endeavoured to determine the validity of the initial BWD&DP, identify obstacles and opportunities for industry, and provide practitioners and researchers with a guide for designing experience-centred BW (Chapters 8 and 9, and Appendix L).

10.1.2.1. BW Technology Acceptance Results

Whilst the sports bra and SBWD&DP advocate for including wearers, customarily, the traditional bra D&DP has not. Therefore, the Technology Acceptance Model (TAM) was employed to address research Aim #1, objective 1D, to 'Utilise the TAM to determine if being a part of the BWD&DP affects mature women's acceptance and purchase intention' (Section 7.2.). Approaching quantitatively, an online questionnaire analysed statistically resulted in the BWTAM (**Fig. 7.11.** and **7.12.**, p.214). Results indicate that a well-developed BWD&DP leads to purchase intention mediated through perceived usefulness. While previous research into smart clothing indicates that perceived usefulness is a contributing factor to attitude and purchase intention (Chae *et al.*, 2007; Chae, 2010; Noh and Park, 2011; Turhan, 2013; Hwang, 2014), no other study factored in the significance of the D&DP. This study's findings suggest that positive purchase intentions are formulated by partaking in the D&DP and understanding the BW product's usefulness. Furthermore, BW interest was a substantial lead towards purchase intention. Notably, the D&DP is where BW interest can be generated. It was concluded that a BWD&DP must undertake measures to include participants throughout the D&DP for acceptance.

10.1.2.2. Significance of Bra Experience

In this section, rather than discuss the specifics of bra experience, the focus is on *why* bra experience matters to the D&DP and *how* the D&DP can affect bra experience. Wilkinson and De Angeli (2014) propose that a product's physical or emotional experience, such as a bra, is similarly crucial to its functionality. Similarly, Hart and Dewsnap (2001, p. 116) assert that the 'bra buyer is motivated by a complex array of interlinked factors – functional, physiological, psychological, psychosocial and economic', indicating the multifariousness of the bra experience. MW wear the bra to 'alter the perception of one's body [and] improve self-confidence' (Risius *et al.*, 2014, p. 373). Niinimäki and Koskinen suggest that if designers can develop products for a 'positive use experience', then wearers would have a more profound 'product satisfaction and […] attachment' (2011, p. 177) and may become more socially confident in how they interact and communicate (Fairburn, Steed and Coulter, 2016). Niinimäki and Koskinen (2011) recommend developing a D&DP where the wearers' memories, associations, past and present experiences can be used to design for future needs and experiences. Therefore, it is surmised, if designers can understand bra wearers experiences within the D&DP then they are better equipped to develop traditional bras and BW for positive experiences.

10.1.2.3. Comprehending Women's Bra Experience to Design for Experience

To design *for* women's BW experience, it was essential first to understand how MW experience the bra and the nuances of the experiences. Therefore, employing a questionnaire, the study addressed Aim #1, 'To comprehend whether the wearers' bra experience is significant in developing a BWD&DP'. Due to the lack of available information, the questionnaire also attempted to gain insight into the current bra experiences of MW, addressing Aim #1, objective 1C. The results were imbalanced, with significantly more white women partaking in the questionnaire. Nevertheless, the data demonstrated that MW were unhappy with the current bra product offerings, undergoing breast changes due to menopause, and believed in unwritten socio-cultural rules about appropriate bra types and colours for them (Section 7.1.). Moreover, larger-breasted MW were more dissatisfied with their bra experience (Spencer *et al.*, 2020), which impacted their sense-of-self and lifestyle (Oon *et al.*, 2022). Comparable to Risius's (2012) study of MW's bra experiences, this study's findings indicate that MW continue to be dissatisfied with their bra experiences. The questionnaire functioned as an instrument of inquiry, providing direction, and understanding of the broader mature bra situation.

The Factors Affecting Bra Experience Conceptual Model. The conceptual model was developed through existing research during the literature review (Section 4.2.4., **Fig.4.4.**) and quantitatively validated with MW. The model assisted in identifying the mature Black and white women's diverse experience and relationship to the bra to contextualise needs and experiences. Hart and Dewsnap's (2001) notion that the bra experience is complex with several interlinked factors was used to frame the Bra Experience Conceptual Model, informing parts of the questionnaire, making this the first study to use statistical analysis to link the sense-of-self factors to bra-wearing. The questionnaire addressed research Aim #1, objective 1A, to 'Identify the factors that affect how mature women experience the bra'. Additionally, Aim #1, objective 1B, to 'Investigate whether Black and white women experience the bra differently'.

The Factors Affecting Bra Experience Conceptual Model was substantiated (**Fig.7.7.,** p.208), indicating that societal bra influences[116] directly affect MW's bra-wearing experiences. Furthermore, the bra-wearing experience directly affects MW's sense-of-self through the feminine-sexuality, identity, and body-image factors. This study defines the media/advertising influence as what products are made available and marketed to MW. Based on that, the study surmises that if BW is not designed for MW, then their experience of it will be negative, potentially causing harm to their sense-of-self. Findings also indicate that mature Black and white women experience the bra differently, with significant differences in factors such as the bra identity relationship, bra feminine-sexuality relationship, and bra-wearing experience. This finding

[116] Societal bra influences include family, romantic partners, peers/friends, media/advertising, and society.

empowered the study to focus solely on mature Black women and enticed more investigation into their explicit bra experiences to develop BW[117].

10.1.2.4. Establishing the BWD&DP

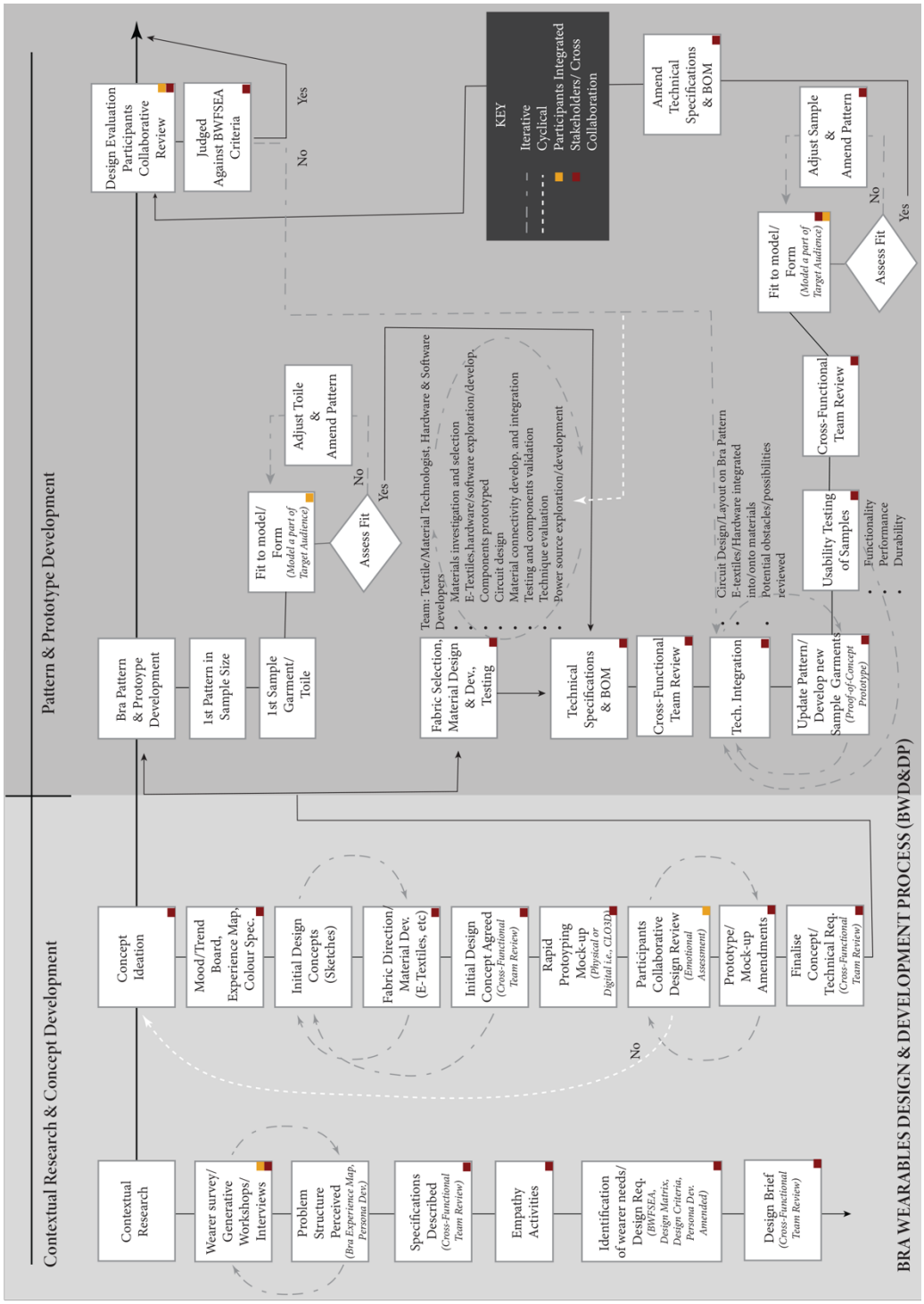


Fig.10.3. Updated BWD&DP

[117] To be clear, this study is not advocating for "race" based lingerie design. Rather it is uncovering that the experience of garments, even those that are inconspicuous, is experienced differently by women, with "race" being a factor. Instead, the study advocates for experience-driven design processes to not generalise findings but understand nuances, so that products can be better designed.

Accomplishing an objective, the developed BWD&DP[118] combined elements from a traditional bra D&DP (Hardaker and Fozzard, 1997; Chan, 2002), functional (DeJonge, 1984; Lamb and Kallal, 1992), and smart clothing D&DP (Haffenden and Smith, 2015; McCann, 2015a; Watkins and Dunne, 2015; Islam Molla, 2020). A RtXD approach (Section 5.5.) was taken to address research Aim # 2, objective 2C, to 'Explore ways of integrating the bra wearer and their experience into the BWD&DP'. The practice focused on the beginning phases of the BWD&DP: the "Research & Concept Development" and "Pattern & Prototype Development". Reflections and feedback from undertaking the initial BWD&DP (**Fig.7.19.** and **7.20.**, p.224) were used to amend the updated DP (**Fig.10.3.**). While the illustration portrays the process as linear, it is imperative to acknowledge the inherent iterative and cyclical nature, particularly evident in stages like prototype development and fitting, characterised by valuable feedback loops. For further discussion on the changes from the initial BWD&DP to the amended BWD&DP see Appendix P. Due to the complex nature of bra design the BWD&DP is more of a framework, 'intended to evolve as research and practice develop', rather than a definitive guideline (*Chapter 14: Standards, Guidelines, and Frameworks*, 2006).

Participant integration vs. Participant information integration: The participatory BWD&DP (**Fig.10.3.**) includes stages where participants are included and excluded. Similarly, Lewis (2023) demonstrates participants moving in and out of stages during the participatory D&DP of a smart jacket (**Fig.C.2.,** p.412). Hoonhout (2007, p. 19) advises keeping participants out of the very early phases of an innovative DP as they may lack the ability to 'articulate future needs, to appreciate the potential limitations of new technologies, or think about possible applications'. Thus, brands must decide when and how much to include participants throughout the fuzzy front-end of the D&DP (**Fig.3.2.**); in addition to having a direct aim as to what information is needed from them or risk receiving too much (Sleeswijk Visser, 2009). Experienced designers and teams are imperative to analyse and interpret the data from participants (McCann, 2015a). **Fig.10.9.** demonstrates the points of participant integration, methods, and insights gained from wearers. During the "Research & Concept Development" phase, it is important to integrate the participants through various methods to understand their experiences and needs and introduce them to the BW field. However, few methods and tools exist to manage wearer needs and experiences in an innovation DP (Agouridas *et al.*, 2006; Tito *et al.*, 2006), requiring the development of the BWFSEA and the Bra Experience Theoretical Framework (discussed below). When developing the design criteria and initial concepts, it is best to integrate participant information with the various design teams/stakeholders involved. Once concept mock-ups are actualised through rapid prototyping, participants are reintegrated to provide input, further direction, and emotional assessment, establishing a wearer feedback loop. As the bra is a complex garment that may not be able to meet consumer desires, like seamless integration of technology, reviewing with wearers during prototype development potentially allows for mitigations. Utilising fit models from the target audience allows for a more accurate representation of the body types and a realistic evaluation of fit, comfort, usability, and functionality from a potential wearer throughout the

[118] A full layout of the updated process is available in Appendix P.

iterative fitting sessions. The fit models may become ambassadors at the participants' reintegration during the collaborative review, providing first-hand experience and knowledge of the BW prototype. In this participatory approach, participants move in and out of the DP, providing insights and direction for the stakeholders.

Research & Concept Development Phase.

Research. The research phase commenced incorporating wearer feedback loops using several methods – questionnaire (6.1.1.1.), generative workshops (6.1.2.1.), digital dialogue (6.1.2.2.) and interviews (6.1.2.3.) – to uncover the wearers' needs, desires, and wants to assess the perceived problem and develop design requirements. Depending on whether the brand has preselected one of the eleven BW categories or not, the category selected will tailor the focus of the research methods. Each method provided a facet of wearer insight due to the nature of the methods. The questionnaire provided general insight as an instrument of inquiry into current product offerings and experiences and introduced BW categories to assess interest from the target group. Generative workshops enabled interaction and more direct insight into needs and preferences. Here, brands can begin to focus on the selected BW category with participants, gaining insights and directly reviewing possibilities through interactive methods. Interviews built upon insights from the workshops and allowed the design-researcher to access personal and sensitive information about the bra-wearing experience. Insights from the interviews should be assessed through the Bra Experience Theoretical Framework (**Fig.8.4.**) discussed in the following section. Empathy activities (discussed in Section 10.2.2.1.) should occur within this stage, with stakeholders from the various design teams partaking to maximise the creative potential of tacit knowledge necessary for innovative designs by fostering an emotional connection and intimate personal engagement (Mascitelli, 2000). Insights from all the methods should be triangulated to frame the situation (Section 8.4.), leading to assessment through the Four Pleasures Framework (**Fig.9.29.**) and the BW Functional, Structural, Expressive, and Aesthetic consumer needs model (BWFSEA) (**Fig.9.30**), culminating with a design brief.

The Bra Experience Theoretical Framework. Dalsgaard (2014, p. 146) establishes that pragmatism acknowledges 'theories are instruments for practice'. Thus, the Bra Experience Theoretical Framework was utilised further to comprehend in-depth mature Black women's bra experience to address research Aim #1, objective 1C, to 'Explore the current bra experiences of mature women'. In Chapter 4, it became evident that bra researchers independently discuss the bra-wearing experience as being affected either socially, psychologically, or physically (Hart and Dewsnap, 2001; Amy-Chinn, Jantzen and Ostergaard, 2006; Jantzen, Østergaard and Vieira, 2006; Tsaousi, 2011; Risius, 2012; R. Wood, 2016). Therefore, to defragment knowledge around bra experience, a Bra Experience Theoretical Framework laddering three disparate theories on experience – embodied practice, enclothed cognition, and affective theory – was developed (Section 4.3.). Product interaction impacts the wearer psychologically, socially, and physically (Fokkinga, Desmet and Hekkert, 2020), influencing 'experience and shap[ing] intentions and decisions'

(Tavares *et al.*, 2021, p. 2). Kafaee et al. (2021) suggest that the D&DP must include methods, approaches, and frameworks to comprehend the physical, psychological, and social experiences of the product to design technology for well-being. Based on this, it was concluded that women's bra experience is essential to designing and developing BW, a garment and product.

Furthermore, the Bra Experience Theoretical Framework enables design-researchers to assess a comprehensive understanding of the participant's experience, both past and present, to aid in designing for future experiences. Through a storytelling interview format, rich data on bra experiences were collected and assessed utilising a theory-driven codebook (6.1.2.3.). The findings indicate that even though it may be perceived as an inconspicuous garment, MW experience the bra in an intricate social, psychological, and physical manner. As illustrated in the Bra-Wearing Experience mapping (**Fig.8.5.,** p.243), the experience of the traditional bra is extensive, interlinked and sometimes contradictory. For example, the theme of aesthetics in this study is experienced psychologically, socially, and physically. Risius et al. (2014, p. 238) study with MW separates aesthetics into 'society's perception', which is social, and 'self-perception', which is more complicated. However, here, aesthetics is cognitive, referring to wearing a style because it can alter their emotions, such as 'feeling younger' or wearing a specific fabric like lace to 'feel sexy'. Aesthetic is also physio-affective, as the participants select a particular bra style because of the materials' properties, such as cotton, for its lightness to feel physical comfort.

Moreover, the Bra Experience Theoretical Framework provides an initial framing to position and explore subjective bra-wearing experiences, wishes, needs, and preferences. As shown in Section 8.4., the framework was used to update the FSEA (**Fig.8.7.,** p.254) and allowed the designer-researcher to develop design criteria (**Table 8.9.,** p.259) and interaction matrix (**Table 8.10.,** p.260) for the target wearer leading to streamlined concept needs. Therefore, the framework aids in transferring the experiences and needs into actionable design outputs. To summarise, the framework works in practice by identifying problems or opportunities, exploring user experience, and aiding in generating design solutions.

Concept Development. In this study, once wearer needs were assessed, or prior to the development of the design criteria, empathy activities were conducted. Empathy activities (Section L.1.2.) enable the design team/stakeholders to understand the wearers' needs more personally (see Section 10.2.2.1.). The second half of the "Research & Concept Development" phase commenced concept development, beginning with concept ideation influenced by the interaction matrix, design criteria, and design brief. In this study, the fabric direction stage occurred concurrently, where initial materials and hardware were explored. Design sketches, mood, and style board (Section L.1.) development overlapped with the participative design workshop (6.1.3.1.). The design-researcher created multiple mood and trend boards and initial style concepts to showcase during the design workshop, including fabric designs, swatches, and ideas to review. Through discussions and brainstorming activities, participants reviewed the information providing direction around the aesthetic, proposing and focusing on the functions of the BW, and contributing more

insight into their desired bra experience (9.2.2.). Following the design review, the design-researcher worked to amend the concepts and gather information for the technical requirements.

The design-researcher suggests several changes to be made for industry during this phase. To not inundate participants with the difficulties of developing innovative concepts (van Kleef, van Trijp and Luning, 2005; Hoonhout, 2007; Gemser and Candi, 2010), they are reintegrated towards the end of this phase. Instead, the various stakeholders must collaborate through concept ideation loops to ideate concepts, develop the necessary creative boards, i.e., the experience map, and work iteratively to design the concepts and fabrication direction. Together, they will agree upon the initial design concept through stakeholder review loops, then move into rapid prototyping, developing mock-ups to be shown to participants during the iterative collaborative review sessions. Here participants provide feedback and direction to help refine the concept (Greengrass, 2015). The outcome may be concept finalisation in preparation for prototype development or returning to concept ideation to begin again.

Pattern & Prototype Development. Numerous stages within the "Pattern & Prototype Development" phase are iterative, while the entire phase is cyclical, requiring multiple rounds with the participants before continuation. Mascitelli (2000, p. 179) argues for the 'face-to-face interaction between innovators [various stakeholders] during the product development, thereby enabling creative improvisation and real-time knowledge sharing'. As discussed in Section 9.4.2., this stage requires several stakeholders to work closely to actualise the prototypes. Pattern technologists, sample makers, engineering and material technologists, designers, fit teams, and participants interact to materialise the product. Lindland (2022, p. 9) warns that with many stakeholders in the D&DP, 'it can be unclear who will have the strongest voice in' the design. Each brings experience to help form and shape the process; therefore, it becomes imperative to centre the wearer. Lewis (2023, p. 413) maintains the designers' voice may be most pivotal as they 'have a key role in the design and development process and [must] be conversant with all those aspects involved throughout'. Thus, the designer must ensure that the various stakeholders collaborate effectively, focusing on how the wearers will experience the garment, evolving their role to a creative director 'capable of managing fashion and technology teams, […] perform[ing] as mediator, interpreter and director' (Kaner and Coşkun, 2017). In this study, new methods such as utilising participants as digital fit models (6.1.3.2.) to assess emotion, design, and potential wearing experiences was advantageous. As digital fit models, participants can remotely be brought back into the D&DP[119] (Section 9.3.). However, in industry digital fit models may be used as a tool for rapid prototyping mock-ups during the concept development stage (**Fig.10.9.**). Participants can view and assess potential concepts on figures representative of their demographic, aiding in this iterative stage towards concept finalisation.

[119] Although this study emphasises the usage of participants as digital fit models, this method is not advised to replace utilising actual mature models. The design-researcher recommends the usage of both.

The design-researcher posits that this phase begins with the "Bra Pattern & Prototype Development" and "Fabric selection, Material Design & Development, Testing" stages occurring concurrently (**Fig.10.3.**). The traditional bra pattern and prototype is developed and fitted with a model from the target audience, allowing for a tried-and-true pattern to be used for the technology integration stage. Meanwhile a team of textile and material technologist and hardware/software developers work collaboratively through this iterative stage to investigate and develop potential e-textiles, hardware, circuits, connections and much more. Both stages provide the necessary information for the following technical specifications and Bill-of-Materials (BOM) stage which consists of a cross-functional team feedback loop. Here the various stakeholders ensure that the design aligns with technical feasibility and materials sourcing opportunities. Next technology integration occurs requiring the different teams 'electronics, textiles and patternmaking team [to] work closely together to ensure the patterns and electronics work seamlessly' (Rosenberg *et al.*, 2023). As noted within this study (Appendix O), the stages of technology integration and updating the pattern and proof-of-concept prototype development is iterative, necessitating the aforementioned stakeholders and designer to work symbiotically. Then the stakeholders must test the samples for usability, functionality, performance, and durability before iteratively fitting with the fit model for comfort, usability and experience. For more variety of opinions more than one fit model from the target audience should be used. Once the sample is approved the technical specifications and BOM is amended before the design evaluation participants collaborative review (6.1.3.4.). At this stage the participants evaluate the sample providing ample feedback from multiple sessions. Their feedback is then assessed using the Four Pleasures Framework (Jordan, 2000) and the BWFSEA framework to understand acceptance (Section 9.5.). If prototypes are reviewed positively and accepted, it moves on to the grading phase. If not, the design teams/stakeholders may return to the technology integration stage and amend the patterns/garment further iterating the design. Or stakeholders may need to return to the "Fabric Selection, Material Design & Dev., Testing" stage to make substantial changes.

For more information on potential stakeholders involved in each stage and what information they might share, see Appendix P, **Fig.P.2**.

Prototypes. In this study, the prototypes served two functions, to provide insight into the designing and development of BW and facilitate research in experience-centred design. Regarding the former, the prototypes reconfirm the challenge of developing BW as a delicate balance is needed to 'match user preference and expectations with design necessity' (Haffenden and Smith, 2015, p. 374). RfXD enables the design-researcher to investigate techniques, methods, and opportunities available to the design of BW (Section 5.5.).

The prototype development had limitations as it concluded before further iterations and moving into the necessities for a factory setting, such as 'developing a pattern marker, stitching patterns using the pattern stitcher, providing for trace crossing and seam crossing, integration of insulation material, technical

documentation for production' and more (Islam Molla, 2020, p. 316). However, if examined by a different standard, say an artisanal approach (10.1.2.6.), the insights gained from the study's situation are pertinent and advantageous. Deweyan Pragmatism attests that an inquiry is substantiated based on the outcomes it achieves from exploring the situation (Dalsgaard, 2014). In this instance, the actualisation of the prototypes through the execution of the BWD&DP establishes its applicability and validity (Section 5.5.1.).

10.1.2.5. BWD&DP Validity

Table 10.4. Validation Questions (*Top*) and Results (*Bottom*).

#	Subject	Question
1	Novelty of Design Process	"What do you think about the Bra Wearables design process shown? Do you think the overall process is novel?"
2	Practise Approach	"What do you think about employing a woman-centred approach where the target wearers' experience and emotions are centred in developing new concepts?"
3	Practise Methods	"What do you think about empathetic practices such as body-storming (*where the designer experiences aspects of what it feels like for their target audience*) and drawing-as-thinking (*where the designer sketches to empathise with the target audience*) as a means to designing meaningful products?"
4	Applications	"Do you think this design process could produce valuable products? Why or why not?"
5	Industrial Applicability	"Do you think the design process can be applied to industry? Why or why not?"

		Classified Codes		
	Comments	Positive (+)	Negative (-)	Neutral (=)
Classified Subjects	Novelty of Design Process	9	0	3
	Practise Approach	14	1	3
	Practise Methods	10	1	6
	Applications	8	0	1
	Industrial Applicability	10	2	9

Kaszynska et al. (2022) argue for practice research to validate[120] the study with stakeholders in the field. Due to the BW field's newness, there are few experts. Unfortunately, those that have direct industry experience were unable to partake. Six fashion technology and bra design experts participated in a short online questionnaire (**Table 10.4.**). The questionnaire (Appendix Q), coding (Appendix S), and full results (Appendix R) can all be found in the appendices. The experts reviewed the proposed BWD&DP and responded to questions on its novelty, woman-centred approach, empathy methods, applications, and industrial applicability. Overall, the experts reacted positively to the subjects, with an almost even split for industry applicability (positive n=10, neutral n=9). While the experts believed the BWD&DP is

[120] The research is validated by internal experts, the participants, and external experts. As discussed in Section 5.2. and 5.5.1., pragmatism argues validation is accessed in the new knowledge gained about a situation and its practical applicability.

advantageous, many highlight the concerns around time, resources, and cost. The consensus was that the industry would need to invest in shifting its production outlook. Alternatively, they suggested the BWD&DP could be easily established for 'niche and designer level' or 'small bespoke brands'. The design experts agreed that the BWD&DP is innovative and has potential for small-to-medium-sized brands. Nevertheless, the BWD&DP is not fully validated, requiring future research to undergo the process in industry with multiple stakeholders.

10.1.2.6. Artisanal BWD&DP

An Artisanal Approach to the BWD&DP. Analysis of the enacted D&DP (Section 9.4.) uncovered five themes: 1) blending the digital and analogue, 2) acquiring new skills, 3) returning to traditional skills, 4) close collaboration, and 5) iterations, trial-and-error, and time. Moreover, reflections on the enacted BWD&DP (Appendix W) provided insights into potential design and product development challenges and opportunities, such as lack of expert knowledge, communication and collaboration, design process length, manufacturing tier and materials. The findings were comparable to Smart X Europe's' (2021), a smart textiles accelerator for SMEs[121], report highlighting the challenges in developing smart textiles for various products. As stakeholders must develop new skills to build their expertise, a longer D&DP is imperative to allow for trial-and-error and iterations. Furthermore, communication and close collaboration without established operational procedures may prove challenging, especially without the time, proper resources, and if working with international stakeholders (Goodman *et al.*, 2018). Although Rosenberg et al. (2023) argue for the necessity of automating the manufacturing process for mass production of smart clothing, the current reality presents a significant challenge as majority of e-textiles are presently developed manually (Ruckdashel, Khadse and Park, 2022). To date the traditional bra also requires manual operations during manufacturing (*Manufacturing a Bra In Lean Setup*, 2012). With the bra, electronics and e-textiles requiring precision during development and the inability for automation, manufacturing BW will require a different approach. These findings have led to the informed conclusion that the BWD&DP must be lengthened, limiting the prospect for certain industrial tiers focused on large-scale manufacturing and shorter production time.

The proposed BWD&DP is best suited for artisanal fashion, where a slower approach linking craftsmanship, technology, wearer experience, and more can eventuate. Aakko (2019, p. 532) reports that artisanal fashion utilises 'craft-based methods, such as hand-stitching, […] and embroidery, as well as manual techniques […] as part of their design and production process'. As mentioned in Section 9.4.2., the BWD&DP requires returning to traditional techniques, such as draping on form and acquiring new skills like hand 3D-printed embroidery. Additionally, this study suggests a need to blend the digital and analogue methods in design, which Aakko (2019) establishes as a facet of the artisanal approach where hand design

[121] SME refers to a small or medium-sized enterprise.

and machine-involved techniques are combined. Lastly, Ott and Cukier (2013, p. 53) uncovered that design emotion is significant in artisanal D&DP, 'whereby emotion transfers from designers to the garment; from garment to wearer; and from wearer to designer, and transforms the relationship among them'. Comparably, the BWD&DP establishes the importance of wearers' emotions to the development of BW (see Sections 5.4.2. and 6.1.3.2.).

Aakko (2019) describes several fundamental characteristics of artisanal fashion: craft, skill, quality, materiality, aesthetic, small-batch production, time, and provenance. As illustrated in **Fig.10.5.**, the BWD&DP has commonalities with the artisanal fashion approach suggesting feasibility. Lewis (2023, p. 409) asserts that following the current mass-manufacture system of 'slimming down and offshoring […] design activities are not compatible with [smart] garments'. Thus, the goal is not to follow into mass-manufacture[122] but to operate similarly to the artisanal approach producing small-scale well-crafted experience-centred BW pieces.

Fig.10.5. Artisanal Fashion approach (*black*) and BW (*gold*) similarities.

[122] Munasinghe et al. (2021) recently investigated the mass-market fashion D&DP, finding that the buyers lead the process where they prioritise profits over creativity and other aesthetic efforts. Focusing on profit over process, design needs, or wearer experience is contrary to the requirements of the BWD&DP.

10.2. Reflection on the Design-as-Practice

'The resolution of a problematic situation may involve transforming the inquirer, the environment, and often both. The emphasis is on the transformation'.
(Dewey, 1938, p. 108)

Design-as-practice allows the design-researcher to employ design, undergoing the primary and secondary experiential nature of research to gather insights and demonstrate its application. By engaging the practice, design-researchers gain situational understanding as 'practice research is a specific mode of knowledge acquisition [requiring] context-based, process-oriented description and explanation' (Andersson et al., 2003, p. 50 in Kaszynska, Kimbell and Bailey, 2022, p. 23). Chapter 9 and Appendix L communicate the details of the practice. Smart clothing requires 'a more considered, respectful, and engaged approach' contends McCann (2015a, p. 414). The developed BWD&DP illustrates a new possibility to combine empathy and experience to achieve this engaged approach. In this section, I will reflect on the knowledge acquired from the design-researchers experience, innovative methods implemented, and participants' experience of the BWD&DP examining the different technologies utilised to design *for* experience.

10.2.1. Designers' Experience Designing BW

As design-researchers investigate situations, they bring their past experience, which influences and informs how they experience the new situation – underpinning Dewey's notion that experience is continuous (Dixon, 2020). Dewey (1998, pp. 66–67) attests that '…we never experience nor form judgements about objects and events in isolation, but only in connection with a contextual whole'. Therefore, as I reflect on my experience in this study, I must also provide awareness of my prior educational and professional experience. As mentioned in Chapter 1, I hold degrees in lingerie design, merchandising and management, centring on entrepreneurship and innovation in intimate apparel. Moreover, over a decade as a head lingerie designer and merchandiser equipped me with the managerial and technical skills to approach this study. Those past experiences provided a tacit knowing that often informed and directed the study.

Dewey advocates that designers must act upon and with the situation to transform it (Dixon, 2020). Here I engage with the practice, reflecting upon my actions to provide insights about designing BW and undergoing the BWD&DP. Schön (1987, p. 41) confirms that 'Designers put things together and bring new things into being, dealing in the process with many variables and constraints, some initially known and some discovered through designing'. Undertaking the BWD&DP produced a wealth of information *for* and *through* designing, which is complex in knowing 'where to look and what to look for' (Watkins and Dunne, 2015, p. 4). Throughout the study, I provided reflections (Sections 8.5. and 9.6.); therefore, I will reflect on the creative aspect and navigating points of resistance in the DP.

One difficulty I encountered in designing was how to proceed creatively. I queried, 'Should I design bras for the present or the future?' Kunieda (2019) advises taking 'a hybrid approach of outside-in approach exploring the existing meaning in an end-user's life and inside-out approach envisioning the possible future life scenario and meaningful experience in the envisioned context'. However, this can be difficult to implement as participants may want designs that are familiar to them, thus, rejecting innovative concepts. Within the concept development phase, during the collaborative design review, the design team engage participants to introduce potential designs. Nevertheless, as within this study, participants may accept the illustrated designs but not be receptive to the prototypes. Innovative technologies like CLO3D and AR/VR have potential benefits as they allow the participants to fully see the digital concepts on a body with movements. Unfortunately, this was not possible within this study. Still, from participant reviews, it would have made a difference to their comprehension of the designs in the concept development phase before prototyping.

Throughout the DP, participants provided critiques and comments that I was unable to address due to the many limitations mentioned throughout the study. However, were some of these points of resistance to occur in industry, there are potential ways to mitigate them. The most obvious is to review the BW prototypes with the participants, allowing them to interact with the product. For example, participants during the survey and workshop noted that they did not believe that BW would perform as described, be comfortable, easy to move in, or fit accurately (**Fig.7.10.**). Their beliefs are partially grounded in their experience with traditional bras. Therefore, enabling them to discuss fit, comfort, ease, and performance with fit models from their target group could alleviate these beliefs. On the other hand, where feedback on specific design details like colour is given, the design team/stakeholders must prioritise design requirements (Burns, 2015), using their intuition and expertise to progress the design (Morris and Ashdown, 2015). Trott, Van Der Duin, and Hartmann (2013) caution that the contribution of participants to innovation should be acknowledged but not overstated, emphasising that participant involvement is not a universal solution to innovation, but rather contingent on effective interaction and response from the design team/stakeholders (Heiskanen *et al.*, 2010). To navigate this, in accordance with Yen et al. (2017, p. 166), the design team/stakeholders should examine participants feedback after the collaborative review, reflecting on the BW aspects and needs, then proceed based on the insights and design expertise. This approach recognises participant inputs value, maintaining a critical perspective on their role in the innovation DP.

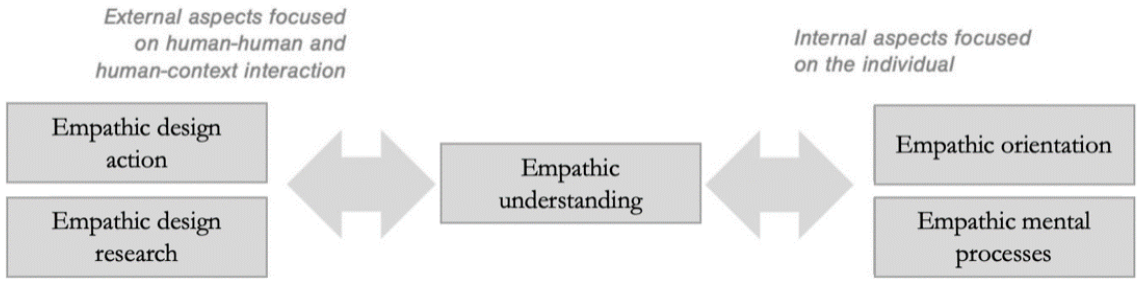
10.2.2. Implementing New Methods for Designing *for* Experience

Designing *for* experience (5.4.2.1.) stems from HCI, specifically the Design Interaction discipline. Copious research exists on designing products *for* experience, but very little is dedicated to fashion. Research into the wearer–clothes relationship impresses the complexity as apparel is tied to memory and functionality (Niinimäki and Armstrong, 2013; DeLong *et al.*, 2017), emotions (Burcikova, 2019; Neto and Ferreira, 2020), materiality, sensory (Chong Kwan, 2016; Burcikova, 2019), and is often interlinked to the multiple

facets mentioned (Ceballos and Min, 2020). Nevertheless, design-researchers should investigate methods that enable designers to reflect and design for those experiences and relationships. Below methods that were useful for understanding experiences in practice are presented: empathy activities (10.2.2.1.), sketching/experience map (10.2.2.2.), digital fit models (10.2.2.3.), and developing prototypes (10.2.2.4.).

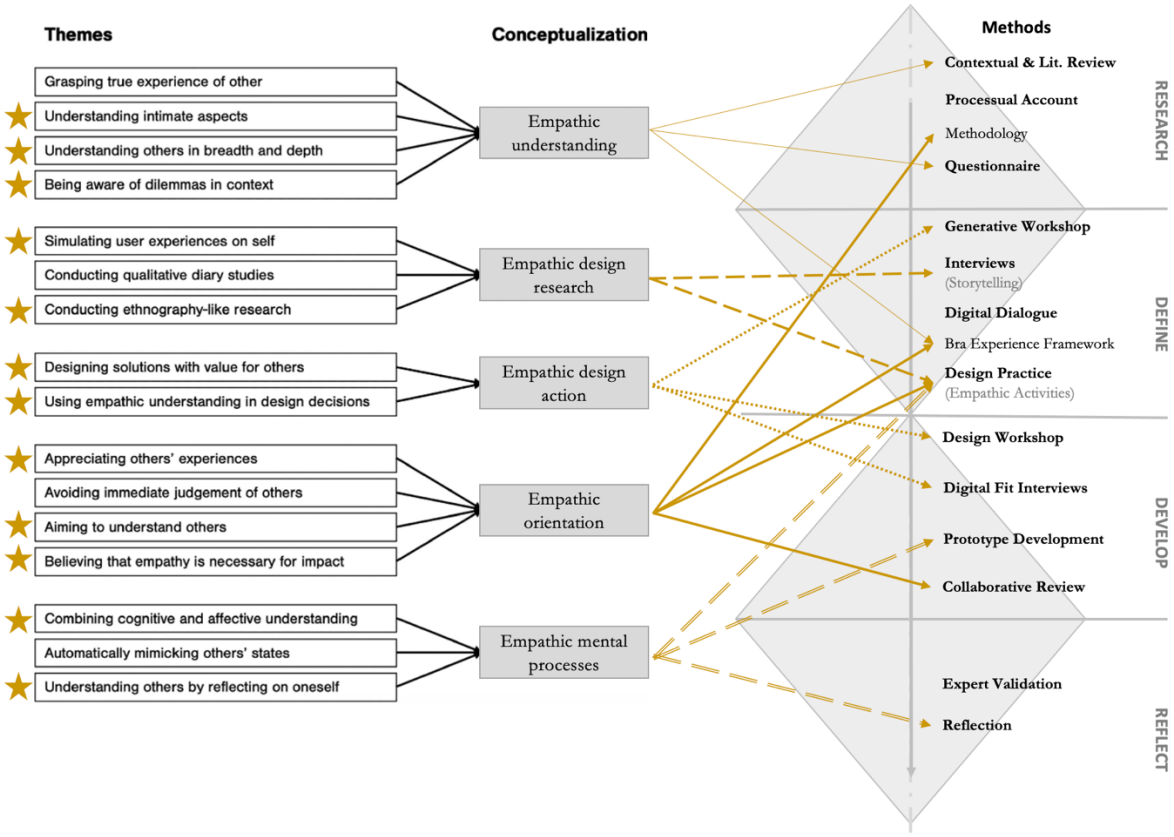
10.2.2.1. Empathy Activities

Fig.10.6. Construction of empathic understanding in design.
Source: 'Conceptualization and operationalization of empathy in design research' (Surma-Aho and Hölttä-Otto, 2022, p. 5)



Empathy is essential for designers to develop meaningful and pleasurable products (Mattelmäki and Battarbee, 2002). In the expert validation, bra experts noted empathy was already a part of the D&DP, but did not specify how. Traditional bra D&DP do not employ explicit methods that allow for the various ways of empathy to be established. Van Rijn et al. (2011) acknowledged that empathy in the D&DP is most effective when the design teams have background information and direct contact with participants. Surma-Aho and Hölttä-Otto (2022) constructed an empathy practice in design research diagram, illustrating that empathic understanding is essential to design action, design research, orientation and mental processes (**Fig.10.6.**). This study employed multiple empathic constructions throughout the research process, which also applied to the BWD&DP. **Fig.10.7.** showcases the themes that underpin each empathic concept and methods utilised to integrate them within this study. Essentially, this study demonstrates that multifaceted empathic conceptualisations can be employed throughout practice research and an apparel D&DP.

Fig.10.7. Empathic conceptualisation through the Four-Stage Research Process.
*Starred themes represent the actions effected throughout the study.
Source: 'Conceptualization and operationalization of empathy in design research' (Surma-Aho and Hölttä-Otto, 2022, p. 3)



Below exemplifies the empathic conceptualisations and how they were employed:

- Empathic Understanding:
    - The contextual and literature review allowed for situational context. It informed the need to understand the participants, using multiple methods that aided access to a breadth and depth of information. Additionally, the study generated a Factors Affecting Bra Experience Conceptual model (**Fig.7.7.,** p.208), to understand the intimate aspects of bra-wearing, such as how the sense-of-self connects to the bra experience (Section 7.1.4.).
- Empathic Design Research:
    - Empathic design research was conducted through interviews and first-person methods. Storytelling interviews were performed, enabling the design-researcher to listen as participants recalled their bra experiences (Section 8.2.). Lindland (2022, p. 8) emphasised, 'It is just as much about using one's experience to hypothesise how to solve a situation, take the attitude of the prospective users and stakeholders for evoking perspective responses to the solutions'. Thus, I reflected on my first-hand experience of trialling and wearing the prototype to empathise with the participant's potential experience of the design.
- Empathic Design Action:

- As the research and design process was women-centred, the participants were at the centre of design decisions. Methods like the generative workshop, collaborative design workshop, and digital fit interviews enabled me to centre the participants in design decisions. For example, probes were used during the generative workshop to elicit empathy for designing experience-centred products. Participants would examine bra samples and discuss their past experiences or highlight desires (6.1.2.1.). The information from these methods allowed for design decisions based on participants' lived-experience.

- Empathic Orientation:
  - The research combined Deweyan Pragmatism, Feminist HCI, and Black Feminist thought to underpin a woman-centred methodology where empathy and understanding of the participants' experiences were grounded (Chapter 5). This belief persisted in the methods selected, and the frameworks created, such as the Bra Experience Theoretical Framework (**Fig.8.4.,** p.240).
- Empathic Mental Processes:
  - Two new methods were applied to incorporate cognitive and affective understanding. During the "Research & Concept development" phase, body-storming (Buchenau and Fulton Suri, 2000) and drawing-as-seeing (Mida and Casey, 2020) were employed for empathising with the wearers (Section L.1.2.). These empathy activities were provided at a specific stage within the D&DP with the aim of 'inform[ing] and inspir[ing] designers' (Kouprie and Sleeswijk Visser, 2009, p. 440). Additionally, throughout the study, I kept a journal reflecting on my understanding and experiences (Section 6.4.).

10.2.2.2. Sketching/Experience Map

Prior to sketching concepts, designers develop a conceptual trend, style, or mood board. These boards help designers to create a feeling and inspire ideas for sketching. However, they are not experienced based and can fall short in designing *for* experience. From my experience, I found obstacles in thinking through the functional and experiential facets to begin sketching concepts (Sections 8.5. and L.1.3.). The traditional mood board I created failed to support ideation. Camere et al. (2015) work on an experience map proved advantageous in conjunction with the traditional mood board. The experience map (**Fig.L.2.,** p.480) aided me in focusing on the experience of the garment and how that could be implemented through tangible and sensorial facets. In addition, the experience map facilitated the centring of the wearer's experience, allowing me to explore how BW could be experienced. Empathy also occurred at this stage, as I 'consider [...] the perspectives of users and designing solutions for them. …by reasoning the existence of a feature with a specific example through the eyes of an end-user' (Surma-Aho, Björklund and Hölttä-Otto, 2018, p. 4). Experiential learning occurred by conversing with the situation through sketching and utilising the experience map. In industry the development of the mood board and experience map 'can act as a catalyst for bringing the [various design teams] together and exploring' the wearers potential experience of the

garment (Mcdonagh and Storer, 2004, p. 22). The methods combined may offer designer's new insights into the potential relationship between BW and its wearers, shifting how they approach designing smart clothing.

10.2.2.3. Digital Fit Models

During the digital fit model method, I experienced many new revelations, namely, designing the concepts on digitised MW figures. Visualising the designs on mature-shaped avatars (**Fig.9.9.**, p.276) firmly established the difference in body sizes and shapes, although the avatars lacked the bulging aspects of a natural body. Nevertheless, designing on mature-figured avatars with an understanding of the wearers allowed for empathising and thinking about their experience of the concept. Surma-Aho, Björklund, and Hölttä-Otto (2018, p. 2) refer to this action of imaging the design and its experience on the wearers as 'perspective taking'. Visualising the concept on mature-figured avatars facilitated a more open-minded manner for perspective-taking. Surma-Aho, Björklund, and Hölttä-Otto (2018, p. 2) recommend that design-researchers employ wearers 'feedback on design concepts, thus depicting a more concept-focused user perspective'. The developed BWD&DP enlisted participants' evaluations throughout the concept and prototype development stages. As digital fit models, participants provided in-depth commentary on the design's aesthetic, emotional assessments, and perceived experience of wearing the garment (6.1.3.2.). The digital fit models also allowed for more objective design evaluations, as I no longer had to rely on my personal bias when making design decisions. Incorporating wearers as digital fit models may provide designers with a more in-depth understanding of the wearers' desires, potential experience, and a broader perspective on their physiques.

10.2.2.4. Designing the Prototypes

During practice research, design-researchers utilise 'practical, experiential, personal, or tacit knowledge' (Niedderer and Roworth-Stokes, 2007, p. 5) as they explore 'designing to test; designing as a demonstration; and designing as creative exploration' (Dixon, 2020, p. 73). Firstly, this study utilised *designing to test* the initial BWD&DP. By undergoing the BWD&DP, I assessed the stages and frameworks. Secondly, *designing as a demonstration* was employed to demonstrate how participants and their experiences can be interrogated and engaged throughout the D&DP. Lastly, this study used *designing as creative exploration* to investigate, record, and inform both the D&DP development and provide insights into prototyping BW – per Aim #2, objective 2C. Objective 2C endeavours to 'Investigate ways of integrating technology into the bra (i.e., new design elements, bra form, and composition)'.

The prototypes were developed through experiential learning. Experiential learning is 'learning from experience through reflection' (Kolb, 1984, p. 41). This type of learning occurs when the design-researcher is actively engaged in an experience, reflecting on that experience, and then applying what was learned to future experiences. As discussed in Section 9.4., the prototypes were developed twice in white samples and then the final in black. During each iteration, I reflected on and evaluated new elements, facilitating a

knowing-in-action (Schön, 1983) and a knowing-through-action (Dalsgaard, 2017) that enabled the development to progress.

10.2.3. Designing *with* Women — Black Women's Design Process Experiences

Designing with the participants required bringing them into the D&DP at specific stages and enabling them to reflect on their experiences. The goal was to understand the women's experience of the stages to develop the BWD&DP better; however, after reflection, the significance of the workshops for the women became evident. Exploiting a Black Feminist Thought Lens, the women's experience of the D&DP was assessed, indicating that the DP became a space for them to connect. During the participative design workshop, the women continued to engage once all the activities were complete. They started sharing recommendations for specific menopausal symptoms and further discussed their experiences. Research indicates that Black women have difficulty speaking to doctors about their health symptoms and changing bodies (Aririguzo, Spencer and Freysteinson, 2022; Kracht *et al.*, 2022). Instead, they wanted to learn and discuss their concerns with other women, forming social support (Kracht *et al.*, 2022) or a sisterhood group (Aririguzo, Spencer and Freysteinson, 2022) as they believed that only other Black women could relate (Im, Lee and Chee, 2010). Moore Clemons (2019, p. 3) acknowledges that 'the act of sharing one's story and drawing a connection to other Black women who have similar experiences is powerful and can aid the understanding of the many challenges people face'. While design-researchers can use the workshops to gain insights into the participants, they can also utilise it as a means for social change. Hill Collins (2000, p. x) asserts that 'when an individual Black woman's consciousness concerning how she understands her everyday life undergoes change, she can become empowered'. In this case, I could sense their need[123] and retract, permitting the women a safe and comfortable space to connect. At the end of the workshop, they exchanged phone numbers and emails, signalling the importance of the connection made. By being in the design methods together, the space provided an opportunity for a mutual becoming together, a togetherness, a type of relationship.

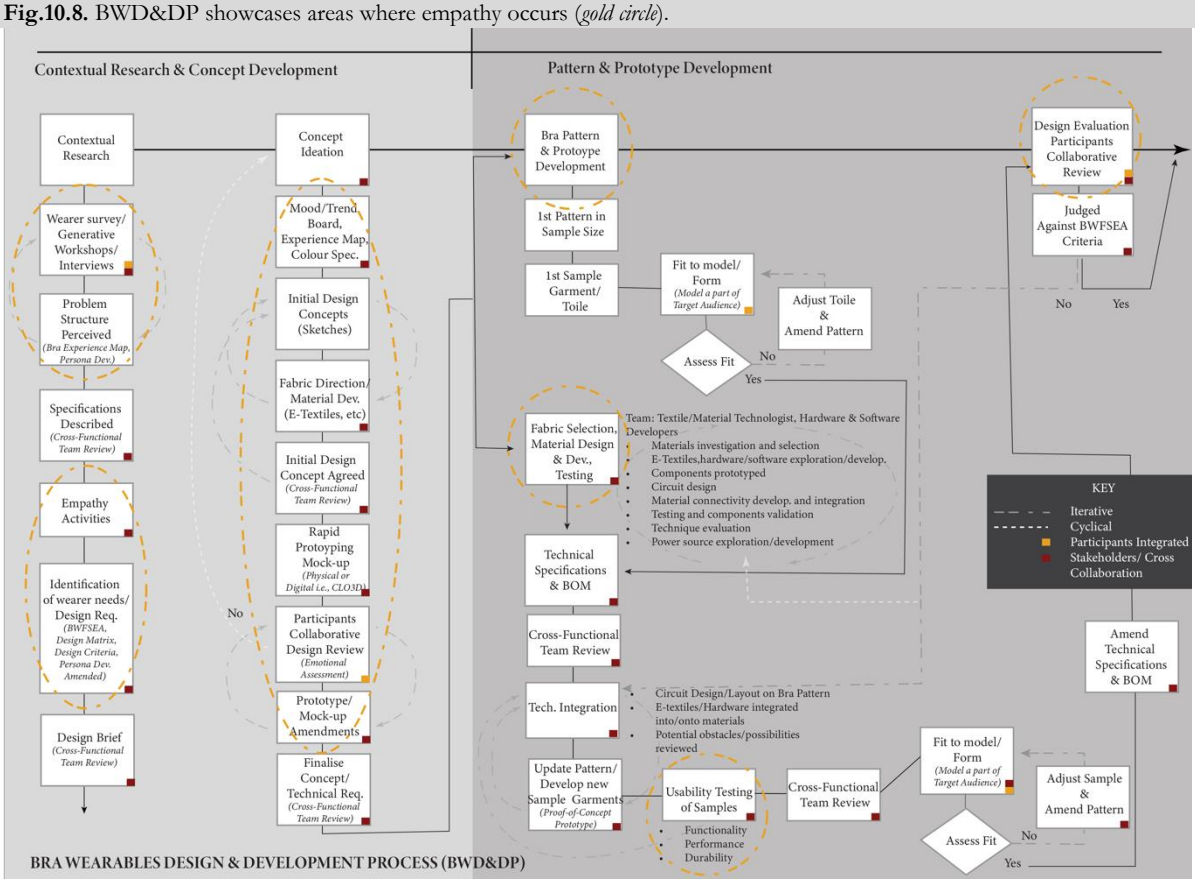
Designing BW for health, sexual and mental wellness is difficult with Black women, due to their silence around sex/sexuality (Melancon, 2015; Nanda, 2019; Harley, 2021), health and symptoms (Aririguzo, Spencer and Freysteinson, 2022), and mental health (Abrams, Hill and Maxwell, 2019; DeCree, 2021). This silence is used to protect themselves (Aririguzo, Spencer and Freysteinson, 2022) against historical and cultural stereotypes and trauma (Harley, 2021). Although the participants were the focus, the women did not always speak referencing themselves, but generalising by noting 'most' or 'other women'. Nonetheless, they were talking about themselves. It was evident from their behaviour that they were uncomfortable centring themselves in this way. In speaking about their experiences and needs, the women had to fight

[123] To sense their need required being empathetic, but also a cultural aspect of knowing when to let elders speak until they are finished.

past the 'ring of silence'[124] (Thomas, 2006). This study advises creating user profiles (i.e., personas) during the generative workshop and in follow-up activities to allow mature Black women to identify with the different profiles and share their experiences through them (Hodson, Svanda and Dadashi, 2023). This enables the participants to distance themselves comfortably, allowing them to co-design a pleasurable future.

10.2.4. Weaving Experience and Empathy into Design-as-Practice

Fig.10.8. BWD&DP showcases areas where empathy occurs (*gold circle*).



Designing *for* experience requires intertwining experience and empathy approaches (Section 5.4.2.). **Fig.10.8.** illustrates the points of empathy and experience within the BWD&DP. The previous sections reflected on stages where both were demonstrated within the D&DP. Most often, empathy and experience approaches were not separated, but driven by one, which included the other. Therefore, an experience-centred D&DP may instinctively possess constructions of empathy. Designing for experience requires empathy to actively centre the wearer. Van Rijn et al. (2011) acknowledge that effective empathic design requires designers to be willing and motivated. Combined, empathy and experience can provide design-

[124] The 'ring of silence' is a term used by Thomas (2006) to highlight the pervasiveness of silencing that occurred throughout their study on Black women's breast experiences.

researchers and designers with an in-depth understanding of the wearers and their potential experience with BW.

10.3. Reflection on the Design Research

This research used a multifaceted approach to explore and comprehend wearer experience in design research, resulting in a new methodology. Cobb et al. (2003) emphasise that the design-researchers' methodological framework is enhanced by enacting the D&DP and gaining new insights. Throughout this chapter, I have reflected on the insights gained. This subsection will highlight a similar approach to designing *with* and *for* wearers, discuss how experience underpinned this methodology, and present an exemplar of a Four-Stage Research Methodology (10.3.1.) and Woman-Centred Methodology (10.3.2.).

A similar methodology researching fashion *with* and *for* MW demonstrates its evolving potential for practice-based research (Townsend, Sissons and Sadkowska, 2017), a small-scale sustainable design business[125] (Townsend, Kent and Sadkowska, 2018), and a participatory approach centring 'participants' experiential knowledge and feedback' (Townsend and Sadkowska, 2020, p. 13). Conversely, their methodology utilises interpretive phenomenological analysis and action research to examine participants' experiences and co-develop designs. The researchers did not discuss their experiences and how it informed or impressed upon the study. Givens and Jeffries (2003, p. xii) posit 'that all research is fundamentally grounded in the experiences of the authors and the research participants'. Nevertheless, their methodology is another example of a woman-centred approach with the end goal of developing products that provide a pleasurable experience and are 'emotionally satisfying' (Niinimäki and Koskinen, 2011).

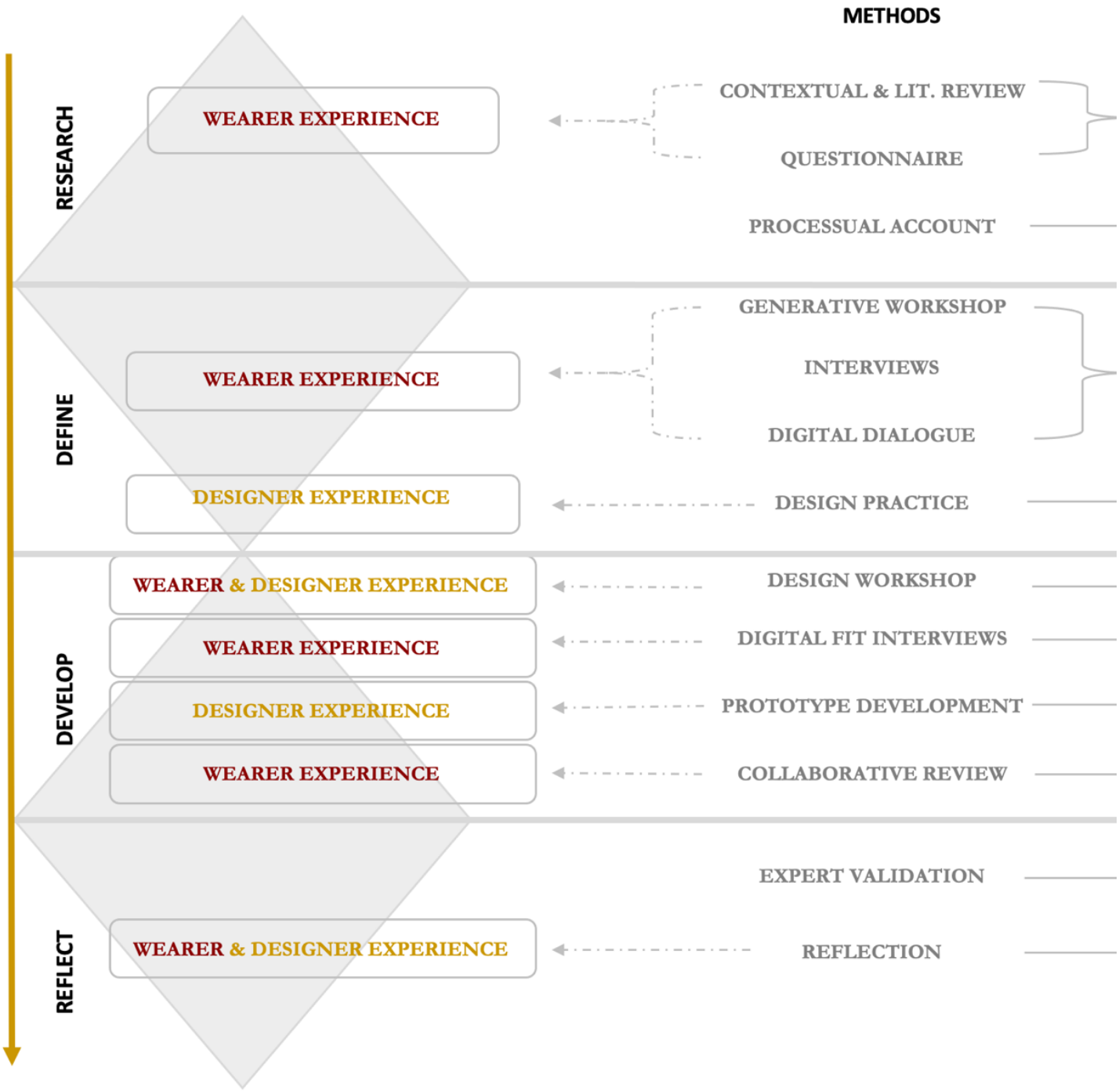
This study's methodology's originality lies in combining multiple experience points to centre the participants, designing *with* and *for* them. Only a few researchers have attempted to combine these methods within a participatory approach to designing *for* experience. This innovative methodology prioritises theoretical and practical methods to comprehend the intricacy of women's bra experience, and the necessities of the experience-driven BWD&DP, through a design approach that also considers the design-researcher. Analysis of the multiple approaches to experience informed the methodology development. Dixon (2020, pp. 37–38) summarises Deweyan Pragmatisms multi-layered fields of experience:

1) 'divides into primary and secondary forms – our direct encounters with real qualities/values (primary experience) and our reflections on those encounters (secondary experience);'
2) 'is social and temporal;'
3) 'emerges through our cultural understanding and drawing in the past and future, as well as the present;'

[125] Essentially an artisanal fashion approach, similarly, discussed within this chapter.

4) 'referencing the experience-is-double-barreled proposal'. This refers to experience being active 'experienc*ing* – what happens to a person, emotionally or otherwise' and passive 'what the person *does*, how they act and interact with others and the things of the world'.

This study utilised a RtXD approach (Section 5.5.) to precipitate action, allowing the design-researcher and participants to engage in primary experience, and reflect on their encounters in the D&DP representing secondary experience. **Fig.10.9.** illustrates the interweaving of the participants' and the design-researchers' experiences throughout the study demonstrating the insights produced from the various encounters and methods (see **Fig.10.3.** for participant's integration in the BWD&DP). The situating of the research, discussed in Section 10.1., indicates the comprehension and grounding of experience as social and temporal.



In the *Define* stage, innovative methods such as story-telling interviews were employed to acquire participants' experiences, which were then analysed through the Bra Experience Theoretical Framework to understand their experiences. Additionally, digital dialogue and generative design workshops were engaged throughout the D&DP to triangulate and comprehend information on past, present, and future experiences. Nixon and Blakley (2012, p. 171) acknowledge the difficulty of developing a design methodology that 'incorporates past, present, and future' experiences. Initially, the study set out to access active experiencing by designing samples for a few participants to physically experience and then having them recount their experiences to their peers in a focus group facilitating passive experiences. However, due to Covid-19, the research pivoted. Rather a few participants functioned as digital fit models allowing active experiencing to occur as they imagined themselves in the garment. As the participants reviewed the designs as a group, passive experiencing occurred during the collaborative review. To this end, the methodology is underpinned by several approaches (see Chapter 5), enabling the objective to 'demonstrate utilisation of a woman-centred methodology in the design process for understanding & development of wearable products *for* and *with* the mature female wearer' to be achieved.

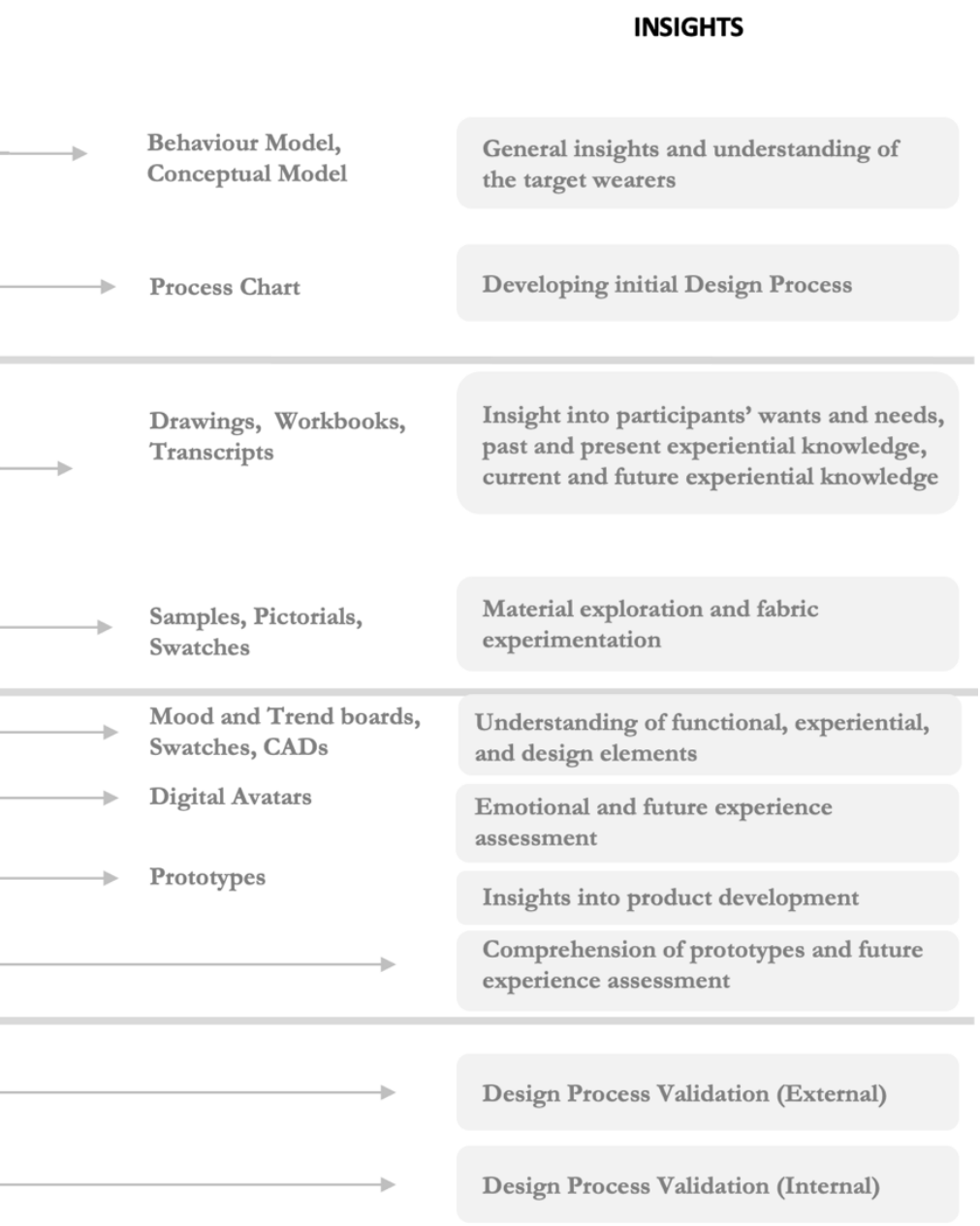


Fig.10.9. Wearer and design-researchers experience throughout.

10.3.1. Four-Stage Research Process Methodology

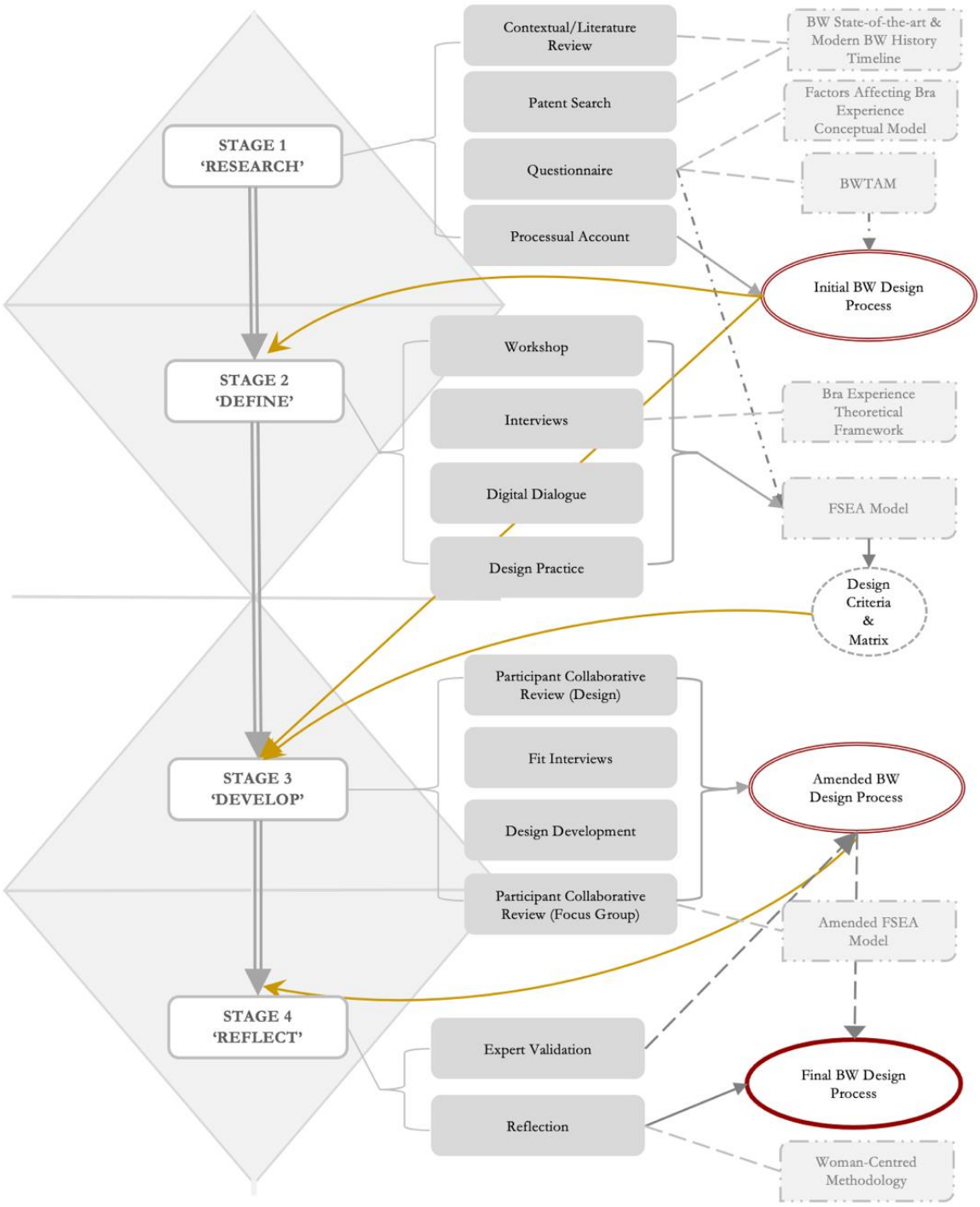


Fig.10.10. Four-Stage Research Model demonstrates paths to original contributions to knowledge.

This methodology used Fairburn et al. (2016) Four-Stage Research Process: Research, Design, Develop, and Reflect. **Fig.10.10.** shows that across the four stages, there are numerous methods. The stages create a framework enabling industry, academic, theoretical, and practice approaches to intertwine. Each stage builds upon the following, connecting insights from previous methods to combine and effectuate new knowledge.

In the first stage, *Research*, literature and contextual review, patent search, questionnaire and processual account are all undertaken, providing insights into the nascent BW field, Factors Affecting Bra Experience conceptual model, Bra Experience Theoretical Framework, BWTAM and an initial BWD&DP. In the *Research* stage, the focus is on designing *for* the participants; therefore, they are passively engaged. The second stage, *Define*, follows the BWD&DP, continuing research to gather details of MW's bra experiences using a generative workshop, interviews, and digital dialogue. Additionally, design practice occurs in this stage, where new design methods for the D&DP are investigated. The *Define* stage results in a developed BWFSEA model, design criteria and interaction matrix – providing the necessary information to proceed to the next stage. The third stage, *Develop*, executes parts of the "Research & Concept Development" and "Pattern & Prototype Development" phases of the BWD&DP. The *Develop* stage uses a range of design methods to actualise prototypes. In the *Define* and *Develop* stage, the participants are being designed *with*; therefore, they are actively engaged. The fourth stage, *Reflect*, uses academic methods such as expert validation and design-researcher reflection to apprehend insights from the study.

10.3.2. Woman-Centred Methodology

A woman-centred methodology was extended into the fashion realm, focused on designing *for* MW's experience with garments. Prior to designing *for* experience, I argue that understanding women's experiences is imperative to the process. Here, the premise that experience will vary based on 'race' is grounded in Black Feminist Thought and Feminist HCI – both stemming from Standpoint Theory (Section 5.3.). By centring Black women who are often marginalised and face numerous stigmatisations – such as racism, sexism, classicism, and ageism – this study moves into an apprehension of non-mainstream intersectional experiences. However, to further understand the situational nature of experience, Deweys' Pragmatist Philosophy was imperative. Dewey stresses the continuousness of experience, asserting its passive nature, meaning the wearer approaches new interactions with the garment based on knowledge gained from previous interactions. Romans (2018) confirms this by asserting that MW's previous clothing experiences influenced their current perceptions. Chapters 7, 8, and 9 demonstrate the methods used to understand past, current, and potential future experiences. Sections 10.2.2.1., 10.2.3., and **Fig.10.9.** illustrates the continuous centring of the women throughout the D&DP to comprehend their multifaceted bra experience. Therefore, understanding past and present experience become essential in developing an experience-centred D&DP.

10.4. Summary

Chapter 10

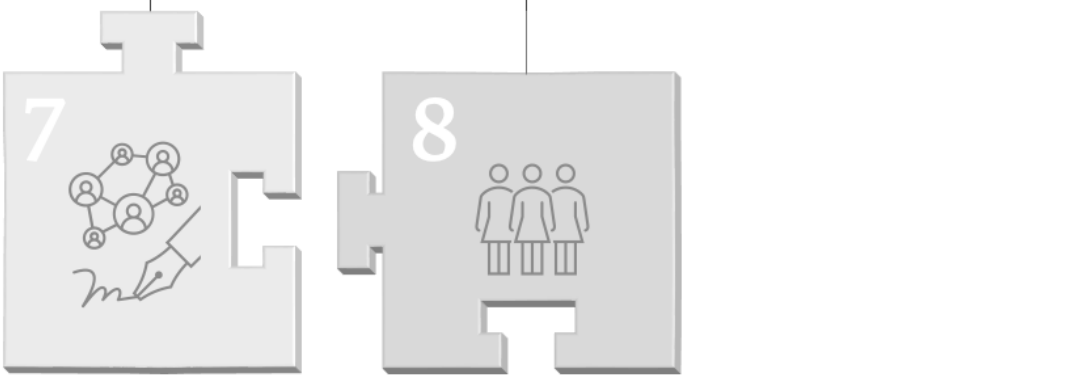
- ***Provided*** a reflection on the study's methods and findings, utilising a design practice research analytic framework (Kaszynska, Kimbell and Bailey, 2022).
- ***Examined*** outcomes for their contribution to knowledge in design and research.
- ***Reflected*** on the amended BWD&DP (Appendix P), illustrating that its actualisation has artisanal underpinnings.
- ***Validated*** the artisanal approach and applicability of the amended BWD&DP with industry experts.
- ***Substantiated*** the BWD&DP as an experience and empathic-driven process, mixing the experience of both participants and designers.
- ***Confirmed*** that a woman-centred approach and Four-Stage Research Process are both advantageous to the development of a woman-centred methodology.

PART C SUMMARY

Part C presented findings across multiple methods from the design process. It highlights both the interweaving of the design-researchers' and participants' experience in developing the BWD&DP.

Chapter 7 "RESEARCH"
Provided insight into mature women's bra experience. Substantiated difference in bra-wearing experience between Black and white women. Validated the Factors Affecting Bra Experience conceptual model and BWTAM. Developed the initial BWD&DP.

Chapter 8 "DEFINE"
Introduced the participants into the research stage of the BWD&DP. Expanded the Bra Experience Theoretical Frameworks providing insights into each category. Combined theory and practice resulting in a BWFSEA consumer needs model, design criteria, and interaction matrix.



Chapter 9 "DEVELOP"
Developed two BW prototypes providing insights into obstacles and opportunities. Introduced digital fit models as a design tool for the D&DP. Confirmed the applicability of the Four-Pleasures Framework and BWFSEA consumer needs model for assessing wearer critique.

Chapter 10 "REFLECT"
Reflected on the transformation of the situation. Established an empathy-driven experience-centred D&DP. Partially-validated the BWD&DP and Woman-Centred Methodology.

11

11. CONCLUSION

11.1. Summary of the Research

'Perhaps it is time to reframe clothing as a product like any other — to deconstruct the qualities that are necessary for older and disabled people […]. Then one could reconstruct the design development process following the more rational, effective, and participatory methods of inclusive design and not the more discursive and spontaneous ones used by fashion designers […]'.
(Cassim, 2015, p. 289)

This thesis set out to explore the development of a Bra Wearables design and development process (BWD&DP) that centred on the wearers and their experiences to assist in producing fit-for-purpose products. There were three motives, first was to delineate the smart bra and BW field, establishing the field as a growing market in need of research. The second was to develop a path forward that genuinely focused on the wearers and a contextual-push, rather than profit or introducing new technology for innovation's sake. Third, to suggest an innovative D&DP that deviated from the current push for mass-produced smart clothing. Combined, these motives increased the focus on designing for marginalised communities who are often left out of the development of future-facing products (J. Bardzell and Bardzell, 2011). The study, therefore, aimed to inform on what could be learned from an experience-centred BWD&DP. Chapter 11 concludes the results informed by the exploration with a: summary of research (11.1.), limitations and suggestions (11.2.), contributions to knowledge (11.3.), and future recommendations (11.4.).

11.1.1. Accomplishing the Aims and Objectives

The introduction (Section 1.6.) presented the three aims and multiple objectives that guided this research and were accomplished and fulfilled through theory and practice. **Table 11.1.** outlines the aims and accomplishments through corresponding objectives.

The research established the possibility of developing a BWD&DP that centres on the wearer's experiences through empathy. It demonstrated a need to approach smart clothing from a more experiential facet that is participatory and inclusive, as Cassim (2015) suggests, to better design and develop meaningful products.

A lesson learned from this study is that empathy should and can be enacted throughout the D&DP. This research has found that one way to develop experiential products is to understand how the product affects the wearer (The Factors Affecting Bra Experience Conceptual model, **Fig.7.6.,** p.207) and the multifaceted nature of the product experience (The Bra Experience Theoretical Framework, **Fig.8.4.,** p.240).

Moreover, the research illustrated the applicability of a woman-centred approach (Section 10.3.2.) to designing that focused on understanding the wearers and the designers.

Table 11.1. Accomplishing the aims and objectives.

AIM 1. To comprehend whether the wearers' bra experience is significant in developing a BWD&DP.

Objectives	Accomplishments
1A. Identify the factors that affect how mature women experience the bra.	**Chapter 7** (Section 7.1.) establishes the Factors Affecting Bra Experience Conceptual Model. The model illustrates that bra-wearing affects the mature woman's feminine-sexuality, identity and body-image. This led to the comprehension that bras must be designed with a focus on the wearers' end experience.
1B. Investigate whether Black and white women experience the bra differently.	**Chapter 4** queried and hypothesised the bra experience of mature Black women differed from white women. **Chapter 7** (Section 7.1.) confirmed that Black and white women experience the bra differently leading the research to focus solely on Black women.
1C. Explore the current bra experiences of mature women.	**Chapter 7** (Section 7.1.) and **Chapter 8** (Section 8.1. – 8.3.) are triangulated through multiple methods, providing breadth and depth of insights into the bra experiences of mature Black women. A Bra Experience Theoretical Framework substantiated the psychological, social and physio-affective experience of the bra (Section 8.2.).
1D. Utilise the TAM to determine if being a part of the BWD&DP affects mature women's acceptance and purchase intention.	**Chapter 7** (Section 7.2.) identifies the significance of the BWD&DP in influencing BW Interests leading to a favourable attitude and purchase intention. This established the BW Technology Acceptance Model (BWTAM), indicating a need for a design process that integrates the wearers.

AIM 2. To investigate approaches that can be utilised to inform the design of BW that improves the bra wearers' experience.

Objectives	Accomplishments
2A. Scope the BW field to map the state-of-the-art.	**Chapter 2** reviews the current BW field providing insights into the eleven sub-fields. This inquiry led to establishing a modern history timeline expanding across 30+ years for the BW field.
2B. Examine various design processes to develop an initial BWD&DP.	**Chapter 3** identifies the need for a specific BWD&DP, and **Chapter 7** (Section 7.3.) establishes an initial BWD&DP framework.
2C. Explore ways of integrating the bra wearer and their experience into the BWD&DP.	**Chapters 8 and 9** enact the initial BWD&DP, including the wearers in the process at several stages (designing *with*) and reflecting on their experience at other stages (designing *for*).
2D. Investigate ways of integrating technology into the bra (i.e., new design elements, bra form, composition).	**Chapter 9** (Section 9.4.)and **Appendix L** describe the approaches taken by the design-researcher to integrate technology into the bra. The exploration uncovered the bra form will have to evolve to marry the current hardware.
2E. Develop BW products that allow for the exploration of designing for meaningful and pleasurable experiences.	**Chapters 8** (Section 8.5.) demonstrate the development of the design criterion, matrix and updated FSEA model that transfers the wearer's experiences into actionable design outputs. **Chapter 9** provides insight into the operational aspect of designing and developing BW.

AIM 3. To interrogate the different types of "experiences" (i.e., the design-researcher and wearer) that aid in informing the BWD&DP.	
Objectives	Accomplishments
3A. Demonstrate utilisation of a woman-centred methodology in the design process for understanding & developing BW products *for* and *with* the mature female wearer.	Chapter 10 reflects on the significance of empathy which is essential to navigating the wearers' experience and the employment of a "field of experiences" that occurred throughout the BWD&DP. The chapter concludes by illustrating two methodologies, that posit both empathy and experience are imperative to designing *for* and *with* wearers.

11.2. Limitations and Suggestions

The study encountered numerous limitations with access to information, technology, advanced techniques/machinery, and certain environments. Below presents the limitations and suggestions for navigating researching BW and with Black women.

11.2.1. Access to Information

Limitations. Collaborating with participants around sensitive subjects often provides obstacles to be mitigated. In this case, working with Black women around their bra experience brought along an interwoven layer of difficulties. First, access to mature Black women as study participants was challenging. This group of women are often busy as caretakers and breadwinners, which leaves little time for volunteering in research (Section 10.2.3.). Additionally, if the women do not see the substance or find the research topic particularly important, they cannot rationalise donating their little free time. Interest and willingness are further made difficult by the research topic being sensitive in nature. Not many women wanted to talk about their underwear experience or showcase their underwear in any capacity. Therefore, fewer women volunteered to be interviewed but were open to partaking in design activities.

Suggestions. Design-researchers need to engage with marginalised participants by being flexible in time requirements and building trust. It is important for members of the research team to have similarities with the participants. Charmaz (2014, p. 61) postulates that 'how your status as a researcher appears to […] prospective research participants affects your effectiveness in finding suitable people' and building the necessary rapport. Moreover, highlighting the incentive to partake in the research upfront might help recruitment.

11.2.2. Access to Technology

Limitations. This thesis encountered barriers in accessing information related to technology and technological materials altering the scope and depth of the research. At numerous points throughout, information was needed on either understanding available technology or receiving insights on relevant usage for the practice portion. With the lack of expertise, many material approaches were grounded in trial-and-error. This situation demonstrates two knowledge strings. In approaching the study, I gained valuable

insights into the skills necessary for developing BW. As a traditional designer, I employed new construction and development techniques and ways of thinking-and-seeing the garment to evolve into a hybrid designer. Additionally, the insights I have documented provide the reader with an in-depth understanding of obstacles and opportunities. Second, brands or other research teams developing within this area are provided with examples of working around the lack of technological information. While I sought answers from various online spaces, they too can do so or budget to hire a freelancer. However, by working with the lack of access to technology, they have the potential to develop new materials, techniques, insights, and skills.

Suggestions. In the current political and economic climate, numerous R&D labs and companies face shortages and supply chain issues. Therefore, they too are learning to work around a lack of technology and materials. As mentioned, this situation can breed innovation, by experimenting and exploring, new opportunities arise. The limitation regarding expertise suggests the importance of enhancing one's skill set in technology-related domains. Strengthening technical proficiency is essential for a more informed and effective integration of technology into the DP. The researcher's evolution into a hybrid designer signifies the adaptability required in interdisciplinary contexts, emphasising the need for continuous learning and skill diversification. To address the limitations, a strategic approach involves collaboration with technology experts, continuous skill development, exploration of diverse information sources, and documentation of insights gained.

11.2.3. Access to Advanced Techniques & Machinery

Limitations. As the bra is a complex and highly engineered garment, evolving it into BW requires advanced methods and techniques. The fusion of fashion and technology should not compromise the fundamental aspects of a bra, such as support, fit, and aesthetics. Therefore, the DP must seamlessly blend cutting-edge technology with the traditional craftsmanship that defines a well-engineered bra. During this study, the absence of advanced machinery posed challenges, compelling the design-researcher to demonstrate resourcefulness through the utilisation of craft techniques, notably hand embroidery, for the attachment of conductive thread. Similarly, crafting techniques were employed in the development of a stress sensor, involving the exploration of silicone and moulding epoxies. This exemplifies the adaptability of traditional methods in the face of technological constraints. Nevertheless, the potential for expedited and automated processes on a small scale becomes apparent when advanced machinery, such as an embroidery machine, is introduced. This machinery not only facilitates the seamless layout of complex circuitry but also holds the promise of enhancing efficiency in small-scale production.

Suggestions. Advanced machinery, such as automated embroidery machines, and techniques like weaving, along with conductive textiles using delicate, flexible, and comfortable materials, are crucial for seamlessly integrating electronic components. Electronic hardware must be miniaturised and made flexible to allow for placement in sensitive areas. Significantly, electronic components and e-textiles must be biocompatible

and skin-friendly due to the prolonged skin contact of the bra. Incorporating advanced materials with moisture-wicking properties could further enhance the comfort and functionality of the bra without compromising its fundamental aspects. More research into techniques that allow for integrating e-textiles into the fibre, such as weaving, and onto the surface of materials using embroidery, encapsulation, and conductive printing (Rosenberg *et al.*, 2023) is necessary for BW.

11.2.4. Environment

Limitations. Dewey (1997) argues the importance of the environment to the inquiry. The environment elicits alternative approaches to the situation. For this research, the environment was chaotic. Although the study was carried out in association with a university, the university's technological environment was inaccessible. Unable to receive consultations or open lab sessions where ideas could foster proved not just an inconvenience but a significant obstacle. Ideas can develop within academic environments as Dewey argues 'human beings influence one another' (Hansen, 2002, p. 267). To mitigate this, I engaged in several Zoom presentations on wearables topics and attending provided some insights and seeds to reflect on. Writing and reflecting on my notes simulated conversations with the ideas and authors. Additionally, the design environment is vital to the process, and knowledge gained. Working from my atelier meant working with non-industrial machinery in a non-industrial setting. Therefore, steps and processes were altered to fit the environment.

Suggestions. The environment should be assessed when discussing the D&DP as it affects the outcomes. As suggested in Chapter 10, the proposed BWD&DP is best suited for an artisanal approach.

11.3. Contribution to Knowledge

Achieving the aim of the research required several outputs that contribute to the claims of new knowledge. The contributions are divided between contextual (11.3.1.), theoretical (11.3.2.) and methodological (11.3.3.).

11.3.1. Contextual Contribution

Contextual contributions refer to insights into the situation applicable to future researchers, designers, and design-researchers. This research provides contextual contributions in three areas: the BW field, insights into mature bra wearers, and a BWD&DP.

This research is the first to provide a state-of-the-art of the BW field, supplying comprehension of the expanding marketplace and illustrating the fields' potential. Chapter 2 introduced a modern historical timeline (**Fig.2.7.,** p.58), illustrating the fields' evolution and contextual literature on eleven different bra subfields. The identification of the subfields, opportunities and challenges can function as the foundation for others interested in exploring the BW field.

The study finds that mature women (MW) are aware of the changes in their ageing breasts, are happy with their breast appearance and purchase bras to navigate societal expectations. Additionally, they conform to unwritten bra rules about what styles and colours are appropriate for MW, even though they may not agree. The study reveals through the substantiated Factors Affecting Bra Experience conceptual model (**Fig.7.7.**, p.208) that societal bra factors such as family, peers/friends, partners, marketing/advertising, and socio-cultural influence MW's bra-wearing (Section 7.1.). Furthermore, bra-wearing experiences and ageing influence MW's sense-of-self through their feminine-sexuality, identity, and body-image. The findings show that Black and white women experience the bra differently. This research is one of the first to centre Black women in the lingerie discipline producing insights into their experiences.

A further contribution is the partially validated experience-driven BWD&DP (Appendix P). The research contributes by identifying essential stages, teams, and skills involved in a BWD&DP (Chapter 9). Additionally, the process illustrates the significance of empathy as it facilitates centring the wearer and enabling designing *with* and *for* them (Chapter 10). Through the execution of the BWD&DP, two prototypes were developed, providing valuable insights into designing such products. The creation of the BW prototypes demonstrates opportunities and obstacles faced during development up to a design readiness level 6, 'sample demonstration in studio environment' (Lewis, 2023, p. 423). Despite partial validation, the BWD&DP demonstrates potential utility in the development of BW and, with appropriate modifications, traditional bras. The adaptability of this framework will be evident in diverse contexts, particularly within industry characterised by multiple stakeholders. It is anticipated that variations and enhancements to the proposed BWD&DP may arise in these contexts, reflecting the dynamic nature of its applicability and accommodating the intricate facets associated with various stakeholders in industry.

While the experience-driven D&DP targeted BW development, its versatility extends to elevating the development of traditional bras by placing the wearers' experience at the forefront. The D&DP may be executed as is, with the focus being on developing specific functions or occasion-based traditional bras. Importantly, the experience-driven approach employing methods like empathy activities (Section L.1.2.), Experience Map (Section L.1.1.), and updated FSEA (see Section 8.4.1. and **Fig.8.7.,** p.254) may prove instrumental in addressing the unique needs and preferences of different body types, ensuring a more inclusive and diverse range of traditional bras. Additionally, by incorporating wearer feedback, the D&DP can continuously improve the comfort, fit, and overall satisfaction of traditional bras.

11.3.2. Theoretical Contribution

Theoretical contributions refer to insights into new or amended theories for the situation. This research provides theoretical contributions in two areas: the bra experience and the BW acceptance.

This research illustrates through the interdisciplinary Bra Experience Theoretical Framework (**Fig.8.4.,** p.240) that women's experience of their bras is interconnected socially, psychologically, and physio-

affectively (Chapter 8). A Bra-Wearing Experience Map (**Fig.8.5.,** p.243) exploding the exemplars within the framework illustrates that the bra-wearing experience is interrelated and complex. Additionally, the theoretical framework and bra-wearing experience map can be applied to develop both BW and enhance comprehension and development of traditional bras.

Moreover, the Technology Acceptance Model (TAM) (Davis, 1989; Davis, Bagozzi and Warshaw, 1989) was extended to BW, highlighting the necessary factors for its acceptance (Section 7.2.). The BWTAM (**Fig.7.12.**, p.214) demonstrates the importance of the design process to BW interest. Additionally, BW interest is a vital factor to attitude and purchase intention. The BWTAM indicates the significance of a participatory BWD&DP to the wearers.

11.3.3. Methodological Contribution

Methodological contributions refer to insights into new methodological tools, techniques, or approaches. This research provides methodological contributions in two areas: the Four-Stage Research Process and a woman-centred approach.

This study contributes to the Four-Stage Design Process (Fairburn, Steed and Coulter, 2016), which includes Research, Define, Develop, and Reflect (Section 10.3.1.). The study changed the name to the Four-Stage Research Process to differentiate between the industry design process and the research. This research extended the framework for practice research that can be combined with industry to effectuate academic and industry insights. The four stages are overlayed over an industry design process (the initial BWD&DP, **Fig.7.19.,** p.224), enabling methods from academia and industry to be combined.

Moreover, this study contributes to a woman-centred methodological approach (Almeida, 2017). Almeida (2017, p. 137) proposes that this approach should leverage 'multiple philosophical perspectives […] to inform […] practice and to position women' throughout. This research extends the approach underpinned by Deweyan Pragmatism, Feminist HCI, Black Feminist Thought lens, and Emotion-centred design (Chapter 5). The multiple perspectives facilitated the centring of the participants' experiences – past, present, and future – enabling designing *with* and *for* them. Additionally, this methodology demonstrates the usage of an empathetic and experience-driven approach to designing with women (Chapter 10).

11.4. Recommendations for Future Research

As this research area and BWD&DP is emergent more research is required, thus recommendations are divided between the situation (11.4.1.), practice (11.4.2.) and methodology (11.4.3.).

11.4.1. Future Research Situation

Further research can:

- Conduct a study with Black women in earlier age groups to compare their bra experiences with mature Black women. The Factors Affecting Bra Experience conceptual model could be utilised to provide insight into whether the bra experience varies across generations.
- Expand the Factors Affecting Bra Experience conceptual model across age groups, ethnicities, and cultures.
- Explore the role of self-esteem and bra experience, expanding the Factors Affecting Bra Experience conceptual model.
- Map The Factors Affecting Bra Experience conceptual model over the Bra Experience Theoretical Framework to further investigate the ways the sense-of-self factors connect with the social, psychological, and physio-affective nature of bra-wearing.
- Interrogate a larger participant group to interview, expanding the Bra Experience Theoretical Framework. The framework can also be used to compare across age groups, ethnicities, and cultures.

11.4.2. Future Work Practice as Design

Design-researchers can extend this research by:

- Developing the BW prototypes in this study further to a design readiness level 9, 'design verified for production' (Lewis, 2023, p. 423), producing more insight into the D&DP.
- Further validating the BWD&DP in an industrial setting and collaborating with stakeholders to expand on areas like the technical packages.
- Exploring 3D avatars with wearable design in movement and 3D avatars shown to fit models via AR/VR within the design process.
- Including various stakeholders in the design process to further explore communication, skill share, and developed technologies using the proposed BWD&DP.
- Exploring the Bra Experience Theoretical Framework and design process with bra-wearers of similar sizes.
- Developing BW prototypes for the participants allowing them to experience wearing the garment. Then examine whether interacting with the prototypes and using the target fit model during the collaborative review affected assessments.
- Investigating the proposed empathy activities with a group of designers.
- Investigating sustainability and designing-for-repair or disassemble in BW design.

11.4.3. Future Work Methodology

To broaden the methodology, design-researchers can:

- Utilise or amend this methodology to conduct practice research developing other experience-driven products or processes with women.
- Explore how the methodology is modified when academia and industry collaborate.

REFERENCE

Aakko, M. (2016) *Fashion in-between : artisanal design and production of fashion*. PhD Thesis. Aalto University. Available at: https://aaltodoc.aalto.fi:443/handle/123456789/24395 (Accessed: 12 December 2022).

Aakko, M. (2019) 'Unfolding Artisanal Fashion', *Fashion Theory*, 23(4–5), pp. 531–552. Available at: https://doi.org/10.1080/1362704X.2017.1421297.

AARP Announces "Hacking Menopause Challenge" Winners (2020) *MediaRoom*. Available at: https://press.aarp.org/2020-6-16-Hacking-Menopause-Challenge-Winners (Accessed: 24 October 2022).

AARP Research (2005) *Sexuality at Midlife and Beyond: 2004 Update of Attitudes and Behaviors*, *AARP*. Available at: http://www.aarp.org/research/topics/life/info-2014/2004_sexuality.html (Accessed: 25 June 2019).

Abrams, J.A., Hill, A. and Maxwell, M. (2019) 'Underneath the Mask of the Strong Black Woman Schema: Disentangling Influences of Strength and Self-Silencing on Depressive Symptoms among U.S. Black Women', *Sex Roles*, 80(9), pp. 517–526. Available at: https://doi.org/10.1007/s11199-018-0956-y.

Acklin, C. (2010) 'Design-Driven Innovation Process Model', *Design Management Journal*, 5(1), pp. 50–60. Available at: https://doi.org/10.1111/j.1948-7177.2010.00013.x.

Adam, H. and Galinsky, A.D. (2012) 'Enclothed cognition', *Journal of Experimental Social Psychology*, 48(4), pp. 918–925. Available at: https://doi.org/10.1016/j.jesp.2012.02.008.

Adam, H. and Galinsky, A.D. (2019) 'Reflections on enclothed cognition: Commentary on Burns et al.', *Journal of Experimental Social Psychology*, 83, pp. 157–159. Available at: https://doi.org/10.1016/j.jesp.2018.12.002.

Agouridas, V. *et al.* (2006) 'Challenges in the application of systems engineering principles to the design of appealing consumer products', in *INCOSE International Symposium. Sixteenth Annual International Symposium of the International Council On Systems Engineering*, pp. 1503–1518. Available at: https://doi.org/10.1002/j.2334-5837.2006.tb02829.x.

Aiello, J. (2016) 'Heated Bra with a GPS Module'. Available at: https://patents.google.com/patent/US9364030B1/en?oq=US9364030B1 (Accessed: 11 September 2021).

Aldrich, W. (2011) *Metric Pattern Cutting for Menswear*. 5th Edition. Chichester, West Sussex: Wiley-Blackwell.

Allan, J.D., Mayo, K. and Michel, Y. (1993) 'Body size values of white and black women', *Research in Nursing & Health*, 16(5), pp. 323–333.

Almeida, T. (2017) *Designing Technologies for Intimate Care in Women*. Ph.D. Thesis. Newcastle University. Available at: https://www.researchgate.net/publication/318284608_Designing_Technologies_for_Intimate_Care_in_Women (Accessed: 16 July 2017).

Altshuller, G. (1996) *And Suddenly the Inventor Appeared: TRIZ, the Theory of Inventive Problem Solving*. Technical Innovation Center, Inc.

Altshuller, G. (1999) *The Innovation Algorithm: TRIZ, Systematic Innovation and Technical Creativity*. Technical Innovation Center, Inc.

Altshuller, G. (2002) *40 Principles: TRIZ Keys to Innovation*. Technical Innovation Center, Inc.

Altshuller, G.S. (1984) *Creativity As an Exact Science*. 1st Edition. New York: CRC Press.

Ambrosi, A. and Pumera, M. (2016) '3D-printing technologies for electrochemical applications', *Chemical Society Reviews*, 45(10), pp. 2740–2755. Available at: https://doi.org/10.1039/C5CS00714C.

American Society of Plastic Surgeons (2017) *2017 Plastic Surgery Statistics Report*. 2017 Plastic Surgery Statistics Report. USA: American Society of Plastic Surgeons, p. 11. Available at: https://www.plasticsurgery.org/documents/News/Statistics/2017/plastic-surgery-statistics-full-report-2017.pdf (Accessed: 25 June 2019).

Amy-Chinn, D., Jantzen, C. and Ostergaard, D. (2006) 'Doing and Meaning: towards an integrated approach to study women's relationship to underwear.', *Journal of Consumer Culture*, 6(3), pp. 379–401.

An, H. and Lee, I. (2015) 'A conceptual framework for Asian women's emotional needs in fashion design', *International Journal of Fashion Design, Technology and Education*, 8(3), pp. 206–213. Available at: https://doi.org/10.1080/17543266.2015.1053421.

Anthony, S. (2013) *Microsoft's new smart bra stops you from emotionally overeating*, *ExtremeTech*. Available at: https://www.extremetech.com/extreme/172308-microsofts-new-smart-bra-stops-you-from-emotionally-overeating (Accessed: 7 November 2022).

Aouf, R.S. (2018) *Reebok's gel-infused PureMove sports bra firms up in response to movement*, *Dezeen*. Available at: https://www.dezeen.com/2018/08/14/reebok-sports-bra-puremove-gel-infused-firm/ (Accessed: 27 June 2019).

Apparently This Bra Only Unhooks Itself For True Love (2014) *HuffPost UK*. Available at: https://www.huffingtonpost.co.uk/2014/01/27/true-love-bra-ravijour_n_4672386.html (Accessed: 7 November 2022).

Appleton, N. (2018) 'The Problem With Telling Women To "Age Gracefully" Is That We Don't Mean It', *Refinery29*, 10 July. Available at: https://www.refinery29.com/en-us/women-aging-double-standard (Accessed: 26 May 2019).

Archer, B. (1995) 'The nature of research.', *Co-Design Journal*, 2(11), pp. 6–13.

Arigo, D. *et al.* (2018) 'Using social media for health research: Methodological and ethical considerations for recruitment and intervention delivery', *DIGITAL HEALTH*, 4, p. 2055207618771757. Available at: https://doi.org/10.1177/2055207618771757.

Aririguzo, C., Spencer, B.S. and Freysteinson, W. (2022) '"You're acting womanish!" A qualitative descriptive study of the experiences of African American women in menopausal transition', *Journal of Women & Aging*, 34(2), pp. 258–275. Available at: https://doi.org/10.1080/08952841.2021.1915095.

Ariyatum, B. (2005) *New conceptual model for design development of smart clothing*. Ph.D. Thesis. Brunel University. Available at: http://bura.brunel.ac.uk/handle/2438/1347 (Accessed: 6 October 2017).

Ariyatum, B. *et al.* (2005) 'The Future Design Directions of Smart Clothing Development.', *Journal of The Textile Institue*, 96(4), pp. 199–210. Available at: https://doi.org/10.1533/joti.2004.0071.

Ariyatum, B., Holland, R. and Harrison, D.K. (2004) 'Benefits & Challenges of Collaboration in Smart Clothing Development', in *DS 32: Proceedings of DESIGN 2004. The 8th International Design Conference*, Dubrovnik, Croatia, pp. 697–704.

Arribas, V. and Alfaro, J.A. (2018) '3D technology in fashion: from concept to consumer', *Journal of Fashion Marketing and Management: An International Journal*, 22(2), pp. 240–251. Available at: https://doi.org/10.1108/JFMM-10-2017-0114.

Ashby, M. (2022) 'The challenges of bringing pro sport tech to the mass market consumer', in *4th International Conference on the Challenges, Oppurtunities, Innovations and Applications in Electronic Textiles. E-Textiles 2022*, Nottingham, U.K.

Ashdown, S.P. and Na, H. (2008) 'Comparison of 3-D Body Scan Data to Quantify Upper-Body Postural Variation in Older and Younger Women', *Clothing and Textiles Research Journal*, 26(4), pp. 292–307. Available at: https://doi.org/10.1177/0887302X07309131.

Ashdown, S.P. and O'Connell, E.K. (2006) 'Comparison of Test Protocols for Judging the Fit of Mature Women's Apparel', *Clothing and Textiles Research Journal*, 24(2), pp. 137–146. Available at: https://doi.org/10.1177/0887302X0602400207.

Ashford, R. (2018) *Responsive and emotive wearable technology : physiological data, devices and communication*. Ph.D. Thesis. Goldsmiths, University of London. Available at: https://doi.org/10.25602/GOLD.00024005.

Ashok Kumar, L. and Vigneswaran, C. (2016) *Electronics in Textiles and Clothing: Design, Products and Applications*. Boca Raton, FL: CRC Press.

Atkinson, D. (2022) *Tailoring Digital Touch: An ethnography of designers' touch practices during garment prototyping and the potential for their digitisation*. PhD Thesis. University College London. Available at: https://discovery.ucl.ac.uk/id/eprint/10153438/ (Accessed: 5 December 2022).

Avalos, L., Tylka, T.L. and Wood-Barcalow, N. (2005) 'The Body Appreciation Scale: Development and psychometric evaluation', *Body Image*, 2(3), pp. 285–297. Available at: https://doi.org/10.1016/j.bodyim.2005.06.002.

Ayalah, D. and Weinstock, I.J. (1979) *Breasts: Women Speak About Their Breasts and Their Lives*. 1st Edition. New York: Simon & Schuster.

BAAPS Audit (2017) *THE BUST BOOM BUSTS | The British Association of Aesthetic Plastic Surgeons*, *British Association of Aesthetic Plastic Surgeons*. Available at: https://baaps.org.uk/media/press_releases/29/the_bust_boom_busts (Accessed: 25 June 2019).

Baharom, M.Z. *et al.* (2018) 'The Design Evolution of the Zipper: A Patent Review', in *Proceedings of the 4th International Conference on Industrial and Business Engineering*. New York, NY, USA: ACM (ICIBE' 18), pp. 288–294. Available at: https://doi.org/10.1145/3288155.3290586.

Bakhshian, S. and Lee, Y.A. (2022) 'Social acceptability and product attributes of smart apparel: their effects on consumers' attitude and use intention', *The Journal of The Textile Institute*, 113(4), pp. 671–680. Available at: https://doi.org/10.1080/00405000.2021.1898138.

Ball, J. (2019) *The Double Diamond: A universally accepted depiction of the design process*, *Design Council*. Available at: https://www.designcouncil.org.uk/our-work/news-opinion/double-diamond-universally-accepted-depiction-design-process/ (Accessed: 7 November 2022).

Barak, B. and Schiffman, L.G. (1981) 'Cognitive Age: a Nonchronological Age Variable', *ACR North American Advances*, NA-08. Available at: http://acrwebsite.org/volumes/5867/volumes/v08/NA-08 (Accessed: 25 June 2019).

Barclay, D.W., Higgins, C.A. and Thompson, R. (1995) 'The partial least squares approach to causal modeling: Personal computer adoption and uses as an illustration', *Technology Studies: Special Issue on Research Methodology*, 2(2), pp. 285–309.

Bardzell, J. and Bardzell, S. (2011) 'Pleasure is your birthright: digitally enabled designer sex toys as a case of third-wave HCI', in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. New York, NY, USA: Association for Computing Machinery (CHI '11), pp. 257–266. Available at: https://doi.org/10.1145/1978942.1978979.

Bardzell, S. (2010) 'Feminist HCI: Taking Stock and Outlining an Agenda for Design', in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. New York, NY, USA: ACM (CHI '10), pp. 1301–1310. Available at: https://doi.org/10.1145/1753326.1753521.

Bardzell, S. and Bardzell, J. (2011) 'Towards a feminist HCI methodology: social science, feminism, and HCI', in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. New York, NY, USA: Association for Computing Machinery (CHI '11), pp. 675–684. Available at: https://doi.org/10.1145/1978942.1979041.

Barker, C. (2012) *Cultural studies: theory and practice*. 4th edition. Los Angeles, Calif. ; London: SAGE.

Barrie, L. (2019) *Millennials and boomers US Bra sales*, *Just-Style*. Available at: https://www-just-style-com.arts.idm.oclc.org/news/millennials-and-boomers-boost-us-bra-sales_id135905.aspx (Accessed: 22 June 2019).

Barry, B. and Martin, D. (2016) 'Gender rebels: Inside the wardrobes of young gay men with subversive style', *Fashion, Style & Popular Culture*, 3(2), pp. 225–250. Available at: https://doi.org/10.1386/fspc.3.2.225_1.

Battarbee, K. and Koskinen, I. (2005) 'Co-experience: user experience as interaction', *CoDesign*, 1(1), pp. 5–18. Available at: https://doi.org/10.1080/15710880412331289917.

Battarra, M. *et al.* (2021) 'Algorithms for the Calzedonia workload allocation problem', *Journal of the Operational Research Society*, 72(9), pp. 2004–2017. Available at: https://doi.org/10.1080/01605682.2020.1755897.

Bay-Cheng, L.Y. *et al.* (2002) 'Linking Femininity, Weight Concern, and Mental Health among Latina, Black, and White Women', *Psychology of Women Quarterly*, 26(1), pp. 36–45. Available at: https://doi.org/10.1111/1471-6402.00041.

Baytar, F. (2017) 'Apparel CAD patternmaking with 3D simulations: impact of recurrent use of virtual prototypes on Students' skill development', *International Journal of Fashion Design, Technology and Education*, 0(0), pp. 1–9. Available at: https://doi.org/10.1080/17543266.2017.1378731.

Benaquisto, L. (2008) 'Codes and Coding', in L.M. Given (ed.) *The SAGE Encyclopedia of Qualitative Research Methods*. SAGE Publications, pp. 85–88.

Benitez, J. *et al.* (2020) 'How to perform and report an impactful analysis using partial least squares: Guidelines for confirmatory and explanatory IS research', *Information & Management*, 57(2), p. 103168. Available at: https://doi.org/10.1016/j.im.2019.05.003.

Benjamin, R. (2022) 'Foreward: Ruja Benjamin', in A.H. Berry et al. (eds) *The Black Experience in Design: Identity, Expression & Reflection*. eBook. New York, N.Y: Allworth Press, pp. 17–23.

Berg, A. *et al.* (2018) *Faster fashion: How to shorten the apparel calendar | McKinsey*, *McKinsey & Company*. Available at: https://www.mckinsey.com/industries/retail/our-insights/faster-fashion-how-to-shorten-the-apparel-calendar (Accessed: 28 November 2022).

Berg, R.I. (1999) 'Scented material container for lingerie and the like'. Available at: https://patents.google.com/patent/US5899790A/en?q=((A41C3%2f00+)+AND+(sCENT))&q=A41C3%2f0042&before=priority:20100101&after=priority:19900101 (Accessed: 8 September 2021).

Bergen, M.E. *et al.* (1996) 'Design and Evaluation of Clothing for the Neonate', *Clothing and Textiles Research Journal*, 14(4), pp. 225–233. Available at: https://doi.org/10.1177/0887302X9601400401.

Bernard, M. *et al.* (eds) (2000) *Women ageing: changing identities, challenging myths*. London: Routledge.

Bernard, M. and Harding Davies, V. (2000) 'Our ageing selves: Reflections on growing older', in M. Bernard et al. (eds) *Women ageing: changing identities, challenging myths*. London: Routledge, pp. 58–73.

Berry, A.H. *et al.* (2022) *The Black Experience in Design: Identity, Expression & Reflection*. Allworth.

Beşer, E., Aydemir, V. and Bozkaya, H. (1994) 'Body Mass Index and Age at Natural Menopause', *Gynecologic and Obstetric Investigation*, 37(1), pp. 40–42. Available at: https://doi.org/10.1159/000292518.

Biagioli, M., Grimaldi, S. and Ali, H. (2018) 'Designer's emotions in the design process', in *DRS 2018. Design Research Society 2018*, University of Limerick, pp. 1–12. Available at: https://doi.org/10.21606/dma.2017.408.

Birtwistle, G. and Tsim, C. (2005) 'Consumer purchasing behaviour: an investigation of the UK mature women's clothing market', *Journal of Consumer Behaviour*, 4(6), pp. 453–464. Available at: https://doi.org/10.1002/cb.31.

Bishop, K., Gruys, K. and Evans, M. (2018) 'Sized Out: Women, Clothing Size, and Inequality', *Gender & Society*, 32(2), pp. 180–203. Available at: https://doi.org/10.1177/0891243218756010.

Biskjaer, M.M. and Dalsgaard, P. (2012) 'Toward a Constrating Oriented Pragmatism Understanding of Design Creativity', *DS 73-1 Proceedings of the 2nd International Conference on Design Creativity Volume 1*, pp. 65–74.

Bødker, S., Nielsen, C. and Petersen, M.G. (2000) 'Creativity, cooperation and interactive design', in *Proceedings of the 3rd conference on Designing interactive systems: processes, practices, methods, and techniques*. New York, NY, USA: Association for Computing Machinery (DIS '00), pp. 252–261. Available at: https://doi.org/10.1145/347642.347757.

Bollen, K.A. (1989) 'A New Incremental Fit Index for General Structural Equation Models', *Sociological Methods & Research*, 17(3), pp. 303–316. Available at: https://doi.org/10.1177/0049124189017003004.

Bonde, P. *et al.* (2020) 'SBDA-Secured Bra for Women Safety: Smart and Secured Bra for Women Safety Based on Deep Learning Algorithm'. Available at: https://patents.google.com/patent/AU2020102636A4/en?q=(((A41C3%2f00)+AND+(safety)))&before=priority:20201230&after=priority:20000101&num=100&oq=(((A41C3%2f00)+AND+(safety)))+before:priority:20201230+after:priority:20000101 (Accessed: 11 September 2021).

Bordegoni, M., Carulli, M. and Kyfinn, S. (2015) 'Designing and virtualizing the multisensory product experience.', in *Design and semantics of form and movement. DeSForM 2015 Aesthetics of interaction: Dynamic, Multisensory, Wise*, Milano, Italy, pp. 111–118. Available at: https://www.drhu.eu/publications/2015-DeSForM.pdf#page=113 (Accessed: 8 November 2022).

Borland, H. and Akram, S. (2007) 'Age is no barrier to wanting to look good: women on body image, age and advertising', *Qualitative Market Research: An International Journal*, 10(3), pp. 310–333. Available at: https://doi.org/10.1108/13522750710754335.

Bower, A.B. and Landreth, S. (2001) 'Is Beauty Best? Highly versus Normally Attractive Models in Advertising', *Journal of Advertising*, 30(1), pp. 1–12. Available at: https://doi.org/10.1080/00913367.2001.10673627.

Bowles, K.-A. (2012) *Sports Bra Design for Active Women*. PhD Thesis. University of Wollongong. Available at: http://ro.uow.edu.au/theses/3762 (Accessed: 16 August 2018).

Bowles, K.-A., Steele, J.R. and Chaunchaiyakul, R. (2005) 'Do current sports brassiere designs impede respiratory function?', *Medicine and Science in Sports and Exercise*, 37(9), pp. 1633–1640.

Bowles, K.-A., Steele, J.R. and Munro, B.J. (2012) 'Features of sports bras that deter their use by Australian women', *Journal of Science and Medicine in Sport*, 15(3), pp. 195–200. Available at: https://doi.org/10.1016/j.jsams.2011.11.248.

Bradford, M. and Florin, J. (2003) 'Examining the role of innovation diffusion factors on the implementation success of enterprise resource planning systems', *International Journal of Accounting Information Systems*, 4(3), pp. 205–225. Available at: https://doi.org/10.1016/S1467-0895(03)00026-5.

Brandon, J. (2016) *Why It Took 1,683 Prototypes to Make This Smart Bra*, *Inc.com*. Available at: https://www.inc.com/john-brandon/why-it-took-1683-prototypes-to-make-this-smart-bra.html (Accessed: 8 June 2019).

Braun, V. and Clarke, V. (2006) 'Using thematic analysis in psychology', *Qualitative Research in Psychology*, 3(2), pp. 77–101. Available at: https://doi.org/10.1191/1478088706qp063oa.

Brinkmann, S. and Kvale, S. (2015) *InterViews: learning the craft of qualitative research interviewing*. 3rd edition. Los Angeles, California: Sage Publications.

Brueckner, S. and Freire, R. (2018) 'Embodisuit: A Wearable Platform for Embodied Knowledge', in *Proceedings of the Twelfth International Conference on Tangible, Embedded, and Embodied Interaction*. New York, NY, USA: Association for Computing Machinery (TEI '18), pp. 542–548. Available at: https://doi.org/10.1145/3173225.3173305.

Bryman, A. (2012) *Social Research Methods*. 4th Edition. Oxford: Oxford University Press.

Buchanan, R. (1992) 'Wicked Problems in Design Thinking', *Design Issues*, 8(2), pp. 5–21. Available at: https://doi.org/10.2307/1511637.

Buchenau, M. and Fulton Suri, J. (2000) 'Experience prototyping', in *Proceedings of the 3rd conference on Designing interactive systems: processes, practices, methods, and techniques*. New York, NY, USA: Association for Computing Machinery (DIS '00), pp. 424–433. Available at: https://doi.org/10.1145/347642.347802.

Burcikova, M. (2019) *Mundane fashion : women, clothes and emotional durability*. Ph.D. Thesis. University of Huddersfield. Available at: https://ualresearchonline.arts.ac.uk/id/eprint/15829/ (Accessed: 24 February 2021).

Burke, S. and Sinclair, R. (2015) 'Computer-Aided Design (CAD) and Computer-Aided Manufacturing (CAM) of Apparel and other Textile Products', in Rose Sinclair (ed.) *Textiles and Fashion*. Woodhead Publishing (Woodhead Publishing Series in Textiles), pp. 671–703. Available at: https://doi.org/10.1016/B978-1-84569-931-4.00027-1.

Burns, W. (2015) 'Experiences in the design, iterative development and evaluation of a technology-enabled garment for active ageing walkers', in *Textile-Led Design for the Active Ageing Population*. Woodhead Publishing (Woodhead Publishing Series in Textiles), pp. 509–533. Available at: https://doi.org/10.1016/B978-0-85709-538-1.00025-0.

Butler, J. (1988) 'Performative Acts and Gender Constitution: An Essay in Phenomenology and Feminist Theory', *Theatre Journal*, 40(4), pp. 519–531. Available at: https://doi.org/10.2307/3207893.

Butler, J. (2011) *Bodies That Matter: On the Discursive Limits of Sex*. Taylor & Francis.

Buur, J. and Matthews, B. (2008) 'Participatory innovation', *International Journal of Innovation Management*, 12(03), pp. 255–273. Available at: https://doi.org/10.1142/S1363919608001996.

Buyukaslan, E., Baytar, F. and Kalaoglu, F. (2020) 'Exploring the factors influencing consumers' virtual garment fit satisfactions', *Research Journal of Textile and Apparel*, 24(4), pp. 375–388. Available at: https://doi.org/10.1108/RJTA-03-2020-0029.

Bye, E. *et al.* (2022) 'Disseminating and Reviewing Design Research', *International Textile and Apparel Association Annual Conference Proceedings*, 78(1). Available at: https://doi.org/10.31274/itaa.13688.

Cai, Y. (2017) *Nonlinear dynamic analysis of bra fitting using finite element models*. Ph.D. Thesis. The Hong Kong Polytechnic University. Available at: http://ira.lib.polyu.edu.hk/handle/10397/69891 (Accessed: 10 July 2018).

Cai, Y., Yu, W. and Chen, L. (2016) 'Finite element modeling of bra fitting', in Winnie Yu (ed.) *Advances in Women's Intimate Apparel Technology*. Cambridge, U.K.: Woodhead Publishing (Woodhead Publishing Series in Textiles), pp. 147–168. Available at: https://doi.org/10.1016/B978-1-78242-369-0.00009-8.

Calasibetta, C.M., Tortora, P.G. and Abling, B. (2002) *The Fairchild Dictionary of Fashion 3rd Edition*. 3rd edition. New York: Fairchild Books.

Camere, S., Schifferstein, H.N. and Bordegoni, M. (2015) 'The experience map. A tool to support experience-driven multisensory design.', in *Proceedings of the 9th International Conference on Design and Semantics of Form and Movement. DeSForM 2015 Aesthetics of Interaction, Dynamic, Multisensory, Wise*, Milano, Italy: Politecnico di Milano.

Camere, S., Schifferstein, H.N.J. and Bordegoni, M. (2018) 'From Abstract to Tangible: Supporting the Materialization of Experiential Visions with the Experience Map', *International Journal of Design*, 12(2), pp. 51–73.

Cameron, E. *et al.* (2019) 'The female aging body: A systematic review of female perspectives on aging, health, and body image', *Journal of Women & Aging*, 31(1), pp. 3–17. Available at: https://doi.org/10.1080/08952841.2018.1449586.

Candy, L. (2019) *The Creative Reflective Practitioner: Research Through Making and Practice*. Routledge.

Carby, H.V. (2000) 'White woman listen! Black feminism and the boundaries of sisterhood', in K. Owusu (ed.) *Black British culture and society: a text reader*. London: Routledge (Comedia), pp. 82–87.

Carrard, I. *et al.* (2021) 'Associations between body dissatisfaction, importance of appearance, and aging anxiety with depression, and appearance-related behaviors in women in mid-life', *Journal of Women & Aging*, 33(1), pp. 70–83. Available at: https://doi.org/10.1080/08952841.2019.1681882.

Carroll, K.E. and Kincade, D.H. (2007) 'Inclusive Design in Apparel Product Development for Working Women With Physical Disabilities', *Family and Consumer Sciences Research Journal*, 35(4), pp. 289–315. Available at: https://doi.org/10.1177/1077727X07299675.

Carter, A. (1992) *Underwear: The Fashion History*. 1st edition. London: Batsford Ltd.

Cash, T.F. (2000) 'Body image', in A.E. Kazdin (ed.) *Encyclopedia of psychology*. Washington, DC, US: Oxford University Press, pp. 436–439. Available at: https://doi.org/10.1037/10516-161.

Cash, T.F. (2012) 'Cognitive-Behavioral Perspectives on Body Image', in T.F. Cash and L. Smolak (eds) *Body Image, Second Edition: A Handbook of Science, Practice, and Prevention*. 2nd edition. New York, NY: The Guilford Press, pp. 39–46.

Cassel, C., Hackl, P. and Westlund, A. (1999) 'Robustness of Partial Least-Squares Method for Estimating Latent Variable Quality Structures', *Journal of Applied Statistics*, 26(4), pp. 435–446. Available at: https://doi.org/10.1080/02664769922322.

Cassel, C.M., Hackl, P. and Westlund, A.H. (2000) 'On measurement of intangible assets: A study of robustness of partial least squares', *Total Quality Management*, 11(7), pp. 897–907. Available at: https://doi.org/10.1080/09544120050135443.

Cassidy, Tracy (2011) 'The Mood Board Process Modeled and Understood as a Qualitative Design Research Tool', *Fashion Practice*, 3(2), pp. 225–251. Available at: https://doi.org/10.2752/175693811X13080607764854.

Cassidy, T. (2011) 'The Moodboard Process Modeled and Understood as a Qualitative Design Research Tool.', *Fashion Practice: The Journal of Design, Creative Process & the Fashion Industry*, 3(2), pp. 225–252.

Cassidy, T.D. (2008) 'Mood boards: Current practice in learning and teaching strategies and students' understanding of the process', *International Journal of Fashion Design, Technology and Education*, 1(1), pp. 43–54. Available at: https://doi.org/10.1080/17543260802015154.

Cassim, J. (2015) 'Issues and techniques in the inclusive design of apparel for the active ageing population', in *Textile-Led Design for the Active Ageing Population*. Woodhead Publishing (Woodhead Publishing Series in Textiles), pp. 283–305. Available at: https://doi.org/10.1016/B978-0-85709-538-1.00017-1.

Ceballos, L.M. and Min, S. (2020) 'Product experiences of clothing attachment in baby boomers in the United States', *Fashion and Textiles*, 7(1), p. 12. Available at: https://doi.org/10.1186/s40691-020-0206-0.

Celio, A.A., Zabinsky, M.F. and Wilfley, D.E. (2004) 'African American Body Images', in T.F. Cash and T. Pruzinsky (eds) *Body image: a handbook of theory, research, and clinical practice*. New York, London: Guilford, pp. 234–242.

Chae, H.-S. *et al.* (2007) 'An Investigation of Usability Evaluation for Smart Clothing', in *Human-Computer Interaction. Interaction Platforms and Techniques. International Conference on Human-Computer Interaction*, Springer, Berlin, Heidelberg (Lecture Notes in Computer Science), pp. 1053–1060. Available at: https://doi.org/10.1007/978-3-540-73107-8_115.

Chae, J.-M. (2010) 'The Extended Technology Acceptance Model According to Smart Clothing Types', *Korean Journal of Human Ecology*, 19(2), pp. 375–387. Available at: https://doi.org/10.5934/KJHE.2010.19.2.375.

Chae, M. and Evenson, S. (2014) 'Prototype development of golf wear for mature women', *International Journal of Fashion Design, Technology and Education*, 7(1), pp. 2–9. Available at: https://doi.org/10.1080/17543266.2013.837966.

Chambers, T.R. (1894) 'Breast-compressor'. East Orange, N.J. Available at: https://patents.google.com/patent/US513086A/en?oq=US513086A (Accessed: 7 November 2022).

Chan, C.Y., Yu, W.W. and Newton, E. (2001) 'Evaluation and Analysis of Bra Design.', *The Design Journal*, 4(3), pp. 33–40. Available at: https://doi.org/10.2752/146069201789389601.

Chan, I. *et al.* (2021) 'Creation of 3D printed fashion prototype with multi-coloured texture: a practice-based approach', *International Journal of Fashion Design, Technology and Education*, 14(1), pp. 78–90. Available at: https://doi.org/10.1080/17543266.2020.1861342.

Chan, Y.C. (2002) *A conceptual model of intimate apparel design : an application to bra design*. M.Phil. Hong Kong Polytechnic University. Available at: https://theses.lib.polyu.edu.hk/handle/200/1199 (Accessed: 17 April 2018).

Chapter 14: Standards, Guidelines, and Frameworks (2006) *Association of College & Research Libraries (ACRL)*. Available at: https://www.ala.org/acrl/resources/policies/chapter14 (Accessed: 17 March 2023).

Charara, S. (2017) *This Supa Powered smart sports bra is a mash up of neon, heart rate and AI*, *Wareable*. Available at: https://www.wareable.com/sport/supa-powered-smart-sports-bra-features-price-release-date-8888 (Accessed: 7 November 2022).

Charmaz, K.C. (2014) *Constructing Grounded Theory*. 2nd edn. London ; Thousand Oaks, Calif: SAGE Publications Ltd.

Childers, T.L. *et al.* (2001) 'Hedonic and utilitarian motivations for online retail shopping behavior', *Journal of Retailing*, 77(4), pp. 511–535. Available at: https://doi.org/10.1016/S0022-4359(01)00056-2.

Chin, W.W. and Todd, P.A. (1995) 'On the Use, Usefulness, and Ease of Use of Structural Equation Modeling in MIS Research: A Note of Caution', *MIS Quarterly*, 19(2), pp. 237–246. Available at: https://doi.org/10.2307/249690.

Cho, G., Lee, S. and Cho, J. (2009) 'Review and Reappraisal of Smart Clothing', *International Journal of Human–Computer Interaction*, 25(6), pp. 582–617. Available at: https://doi.org/10.1080/10447310902997744.

Cho, K. (2006) 'Redesigning Hospital Gowns to Enhance End Users' Satisfaction', *Family and Consumer Sciences Research Journal*, 34(4), pp. 332–349. Available at: https://doi.org/10.1177/1077727X06286570.

Choi, K. *et al.* (2021) 'Digital-Based Healthy Bra Top Design That Promotes the Physical Activity of New Senior Women by Applying an Optimal Pressure', *International Journal of Environmental Research and Public Health*, 18(9), p. 4651. Available at: https://doi.org/10.3390/ijerph18094651.

Chong Kwan, S. (2016) *Making Sense of Everyday Dress: Integrating multisensory experience within our understanding of contemporary dress in the UK*. Ph.D. Thesis. University of the Arts London. Available at: https://ualresearchonline.arts.ac.uk/id/eprint/12007/ (Accessed: 6 December 2021).

Chong Rodriguez, A.C. and Abarca Abarca, M.L.A. (2019) 'Padded, flexible encasing for body monitoring systems in fabrics'. Available at: https://patents.google.com/patent/US10456080B2/en?oq=US10456080B2 (Accessed: 12 September 2021).

Chrisler, J.C. and Ghiz, L. (1993) 'Body Image Issues of Older Women', *Women & Therapy*, 14(1–2), pp. 67–75. Available at: https://doi.org/10.1300/J015v14n01_07.

Christel, D.A. and O'Donnell, N.H. (2016) 'Assessment of Women's Plus-Size Swimwear for Industry Applications', *Fashion Practice*, 8(2), pp. 257–278. Available at: https://doi.org/10.1080/17569370.2016.1215113.

Chromat #TechTalks: 3D Body Scans, Virtual Reality, 3D Printed Clothing & Responsive Garments (2015) *CHROMAT*. Available at: https://chromat.co/blogs/news/63982595-chromat-techtalks-3d-body-scans-virtual-reality-3d-printed-clothing-responsive-garments (Accessed: 26 November 2022).

Chromat #TECHTALKS: 3D Printing (2015) *CHROMAT*. Available at: https://chromat.co/blogs/news/18673635-chromat-techtalks-3d-printing (Accessed: 7 November 2022).

Chun, J. (2017) 'Development of Wearable Fashion Prototypes Using Entry-Level 3D Printers', *Journal of the Korean Society of Clothing and Textiles*, 41(3), pp. 468–486. Available at: https://doi.org/10.5850/JKSCT.2017.41.3.468.

Chunyan, Q. and Yue, H. (2015) 'The Review of Smart Clothing Design Research based on the Concept of 3F+1I', *International Journal of Business and Social Science*, 6(1), pp. 199–208.

Clancy, J. and Barry, B. (2022) 'Undressing masculinity: An exploratory study on men's embodied engagement with underwear', *Critical Studies in Men???s Fashion*, 9(2), pp. 163–186. Available at: https://doi.org/10.1386/csmf_00058_1.

Clarke, S.E.B. and Harris, J. (2012) *Digital Visions for Fashion + Textiles: Made in Code*. 1st edn. London: Thames and Hudson Ltd.

Clemons, K.M. (2019) 'Black Feminist Thought and Qualitative Research in Education', *Oxford Research Encyclopedia of Education* [Preprint]. Available at: https://doi.org/10.1093/acrefore/9780190264093.013.1194.

Cochrane, L. (2015) 'Fashion world fears designer burnout as pressure takes its toll', *The Observer*, 1 November. Available at: https://www.theguardian.com/fashion/2015/nov/01/fashion-world-pressure-top-designers (Accessed: 7 March 2023).

Cohen, J. (1988) *Statistical Power Analysis for the Behavioral Sciences*. 2nd Edition. New York: Routledge. Available at: https://doi.org/10.4324/9780203771587.

Cole, E.R. and Zucker, A.N. (2007) 'Black and white women's perspectives on femininity', *Cultural Diversity and Ethnic Minority Psychology*, 13(1), pp. 1–9. Available at: https://doi.org/10.1037/1099-9809.13.1.1.

Collier, D. (1993) 'The Comparative Method', in, pp. 105–119.

Collis, J. and Hussey, R. (2021) *Business Research: A Practical Guide for Students*. 5th edn. London: Red Globe Press.

Coltman C. E., Steele J. R., and McGhee D. E. (2016) 'Effect of aging on breast skin thickness and elasticity: implications for breast support', *Skin Research and Technology*, 23(3), pp. 303–311. Available at: https://doi.org/10.1111/srt.12335.

Coltman, C.E., McGhee, D.E. and Steele, J.R. (2015) 'Bra strap orientations and designs to minimise bra strap discomfort and pressure during sport and exercise in women with large breasts', *Sports Medicine - Open*, 1(1), p. 21. Available at: https://doi.org/10.1186/s40798-015-0014-z.

Coltman, C.E., Steele, J.R. and McGhee, D.E. (2017) 'Breast volume is affected by body mass index but not age', *Ergonomics*, 60(11), pp. 1576–1585. Available at: https://doi.org/10.1080/00140139.2017.1330968.

Coltman, C.E., Steele, J.R. and McGhee, D.E. (2018) 'Which Bra Components Contribute to Incorrect Bra Fit in Women Across a Range of Breast Sizes?', *Clothing and Textiles Research Journal*, 36(2), pp. 78–90. Available at: https://doi.org/10.1177/0887302X17743814.

Compton, C. (2021) *Wearable Textile-Based Contact Sensing for Functional Fit Assessment*. PhD Thesis. University of Minnesota. Available at: http://conservancy.umn.edu/handle/11299/225038 (Accessed: 19 September 2022).

Cooper, S. and Slobodkin, M. (2019) 'Self-measuring garment'. Available at: https://patents.google.com/patent/EP3148359B1/en?q=((((A41C3%2f00+)+AND+(bluetooth)))+)&b

efore=priority:20210101&after=priority:19900101&oq=((((A41C3%2f00+)+AND+(bluetooth)))+)+before:priority:20210101+after:priority:19900101 (Accessed: 9 September 2021).

Cooper, S. and Slobodkin, M. (2020) 'Automatic measuring bra'. Available at: https://patents.google.com/patent/WO2020031033A1/en?oq=US20150342266A1 (Accessed: 10 September 2021).

Corbet, M. (2011) 'Prick & Pounce Embroidery Design Transfer', *NeedlenThread.com*, 2 May. Available at: https://www.needlenthread.com/2011/05/prick-pounce-embroidery-design-transfer.html (Accessed: 5 December 2022).

Corbin, J.M. and Strauss, A. (1990) 'Grounded theory research: Procedures, canons, and evaluative criteria', *Qualitative Sociology*, 13(1), pp. 3–21. Available at: https://doi.org/10.1007/BF00988593.

Cornwell, C.J. and Schmitt, M.H. (1990) 'Perceived health status, self-esteem and body image in women with rheumatoid arthritis or systemic lupus erythematosus', *Research in Nursing & Health*, 13(2), pp. 99–107.

Costa, M. (2021) 'Britain Is Pioneering the Menopause-Friendly Workplace', *Reasons to be Cheerful*, 21 May. Available at: https://reasonstobecheerful.world/britain-is-pioneering-the-menopause-friendly-workplace/ (Accessed: 10 October 2022).

Cranny-Francis, A. (2013) *Technology and Touch*. 1st edn. Palgrave Macmillan. Available at: https://link.springer.com/book/10.1057/9781137268310 (Accessed: 27 October 2022).

Crenshaw, K. (1989) 'Demarginalizing the Intersection of Race and Sex: A Black Feminist Critique of Antidiscrimination Doctrine, Feminist Theory and Antiracist Politics', *The University of Chicago Legal Forum*, 140, pp. 139–167.

Creswell, J.W. (2014) *Research design: qualitative, quantitative, and mixed method approaches*. Fourth edition. Los Angeles: Sage Publications.

Creswell, J.W. and Creswell, J.D. (2018) *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*. 5th edn. Thousand Oaks, Calif: SAGE Publications, Inc.

Creswell, J.W. and Plano Clark, V.L. (2007) *Designing and Conducting Mixed Methods Research*. London, U.K.: SAGE Publications Ltd.

Cross, N. (2006) *Designerly Ways of Knowing*. Springer Science & Business Media.

Cross, R. and Warwick-Booth, L. (2016) 'Using storyboards in participatory research', *Nurse Researcher*, 23(3). Available at: https://doi.org/10.7748/nr.23.3.8.s3.

Crouch, C. and Pearce, J. (2012) *Doing Research in Design*. London: Berg Publishers.

Cruz, B.C. and Duplass, J.A. (2009) 'Making Sense of "Race" in the History Classroom: A Literary Approach', *The History Teacher*, 42(4), pp. 425–440.

Cunningham, H.B. (1910) 'Nursing attachment'. Arnot, Penn. Available at: https://patents.google.com/patent/US949414A/en?oq=US949414A (Accessed: 7 November 2022).

Cunnington, C.W. and Cunnington, P. (2000) *The History of Underclothes*. New edition edition. New York: Dover Publications Inc.

Dalsgaard, P. (2014) 'Pragmatism and Design Thinking', *International Journal of Design*, 8(1), pp. 143–155.

Dalsgaard, P. (2017) 'Instruments of Inquiry: Understanding the Nature and Role of Tools in Design', *International Journal of Design*, 11(1), pp. 21–33.

Dalsgaard, P. and Dindler, C. (2014) 'Between theory and practice: bridging concepts in HCI research', in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. New York, NY, USA: Association for Computing Machinery (CHI '14), pp. 1635–1644. Available at: https://doi.org/10.1145/2556288.2557342.

Dalsgaard, P., Halskov, K. and Nielsen, R. (2008) 'Maps for Design Reflection', *Artifact*, 2(3–4), pp. 176–189. Available at: https://doi.org/10.1080/17493460802526412.

Daria (2014) 'Ravijour Bra as a True Love Tester', *Genius Beauty*, 10 February. Available at: https://geniusbeauty.com/tech-gadgets-women/ravijour-true-love-tester-bra/ (Accessed: 7 November 2022).

Das, R. (2019) *Menopause Unveils Itself As The Next Big Opportunity In Femtech*, *Forbes*. Available at: https://www.forbes.com/sites/reenitadas/2019/07/24/menopause-unveils-itself-as-the-next-big-opportunity-in-femtech/ (Accessed: 24 October 2022).

Davis, F.D. (1989) 'Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology', *MIS Quarterly*, 13(3), pp. 319–340. Available at: https://doi.org/10.2307/249008.

Davis, F.D., Bagozzi, R.P. and Warshaw, P.R. (1989) 'User Acceptance of Computer Technology: A Comparison of Two Theoretical Models', *Management Science*, 35(8), pp. 982–1003. Available at: https://doi.org/10.1287/mnsc.35.8.982.

Davis, L. (2015) *African American mother's socialization of daughter's dress and consumption of appearance-related products*. PhD Thesis. Iowa State University. Available at: https://lib.dr.iastate.edu/etd/14692 (Accessed: 27 October 2022).

Davis, M.L. (1996) *Visual Design in Dress*. 3rd edition. Upper Saddle River, N.J: Pearson College Div.

Dawson, P. (2014) 'The processual perspective: studying change in organisations', in H. Hasan (ed.) *Being Practical with Theory: A Window into Business Research*. Wollongong, Australia, pp. 64–66. Available at: https://ro.uow.edu.au/buspapers/414.

Dawson, P. (2019) *Reshaping Change: A Processual Perspective*. 2nd Edition. New York: Routledge.

DeBraganza, N. and Hausenblas, H.A. (2010) 'Media Exposure of the Ideal Physique on Women's Body Dissatisfaction and Mood: The Moderating Effects of Ethnicity', *Journal of Black Studies*, 40(4), pp. 700–716. Available at: https://doi.org/10.1177/0021934708317723.

DeCree, S.J. (2021) *Reclaiming our time: an interpretive phenomenological analysis study of the wellness and aging perceptions of older adult Black women endorsing the strong Black woman schema*. PhD Thesis. Ohio University. Available at: http://alice.library.ohio.edu/search~S7?/aDeCree/adecree/1%2C2%2C3%2CB/frameset&FF=adecree+shekyra+j&1%2C1%2C.

DeCuir-Gunby, J.T., Marshall, P.L. and McCulloch, A.W. (2011) 'Developing and Using a Codebook for the Analysis of Interview Data: An Example from a Professional Development Research Project', *Field Methods*, 23(2), pp. 136–155. Available at: https://doi.org/10.1177/1525822X10388468.

Deeks, A. and McCabe, M. p (2001) 'Menopausal stage and age and perceptions of body image', *Psychology & Health*, 16(3), pp. 367–379. Available at: https://doi.org/10.1080/08870440108405513.

Defrancisco, V.L. and Chatham-Carpenter, A. (2000) 'Self in Community: African American Women's Views of Self-Esteem', *Howard Journal of Communications*, 11(2), pp. 73–92. Available at: https://doi.org/10.1080/106461700246634.

DeJonge, J.O. (1984) 'Forward: The Design Process', in S.M. Watkins (ed.) *Clothing: The portable environment*. 1st edition. Ames, Iowa: Iowa State University Press, pp. vii–xi.

DeLong, M. *et al.* (2017) 'Exploring an Up-cycling Design Process for Apparel Design Education', *Fashion Practice*, 9(1), pp. 48–68. Available at: https://doi.org/10.1080/17569370.2016.1148309.

Denscombe, M. (2014) *The good research guide: for small scale research projects*. 5th edition. Maidenhead: Open University Press (Open UP study skills).

Desjardins, A. *et al.* (2021) 'Introduction to the Special Issue on First-Person Methods in HCI', *ACM Transactions on Computer-Human Interaction*, 28(6), p. 37:1-37:12. Available at: https://doi.org/10.1145/3492342.

Desmet, P. and Dijkhuis, E. (2003) 'A wheelchair can be fun: a case of emotion-driven design', in *Proceedings of the 2003 international conference on Designing pleasurable products and interfaces*. New York, NY, USA: Association for Computing Machinery (DPPI '03), pp. 22–27. Available at: https://doi.org/10.1145/782896.782903.

Desmet, P., Overbeeke, K. and Tax, S. (2001) 'Designing Products with Added Emotional Value: Development and Appllcation of an Approach for Research through Design', *The Design Journal*, 4(1), pp. 32–47. Available at: https://doi.org/10.2752/146069201789378496.

Desmet, P. and Schifferstein, H. (2012) 'Emotion Research as Input for Product Design', in J. Beckley, D. Paredes, and K. Lopetcharats (eds) *Product Innovation Toolbox*. 1st edn. Hoboken, NJ: John Wiley & Sons, Ltd, pp. 149–175. Available at: https://doi.org/10.1002/9781118229248.ch6e.

Desmet, P.M.A. (2002a) 'Designing emotions', *The Design Journal*, 6(2), pp. 60–62.

Desmet, P.M.A. (2002b) *Designing Emotions*. PhD Thesis. Delft University of Technology. Available at: https://studiolab.ide.tudelft.nl/studiolab/desmet/dissertation/ (Accessed: 6 November 2022).

Desmet, P.M.A. (2004) 'From disgust to desire: how products elicit emotions', in D.C. McDonagh et al. (eds) *Design and Emotion: The Experience of Everyday Things*. New York: Taylor and Francis, pp. 8–13.

Desmet, P.M.A. and Hekkert, P. (2007) 'Framework of Product Experience', *International Journal of Dsign*, 1(1), pp. 57–66.

Desmet, P.M.A. and Hekkert, P. (2009) 'Special Issue Editorial: Design & Emotion', *International Journal of Design*, 3(2), pp. 1–6.

Dewey, J. (1934) *Art as experience*. New York: Minton, Balch & Company.

Dewey, J. (1997) *Experience And Education*. Reprint. New York; London; Toronto: Free Press.

Dewey, J. (1998) *The Essential Dewey: Ethics, logic, psychology*. Indiana University Press.

Dewey, J. (2007) *Essays in Experimental Logic*. Edited by D. Micah Hester and R.B. Talisse. Southern Illinois University Press.

Dewsnap, B. and Hart, C. (2004) 'Category management: a new approach for fashion marketing?', *European Journal of Marketing*, 38(7), pp. 809–834. Available at: https://doi.org/10.1108/03090560410539267.

Diamantopoulos, A. and Siguaw, J.A. (2000) *Introducing LISREL: A Guide for the Uninitiated*. 1st edn. London: SAGE Publications Ltd.

Dickerson, B.J. and Rousseau, N. (2010) 'Black senior women and sexuality', in J. Battle and S.L. Barnes (eds) *Black sexualities: probing powers, passions, practices, and policies*. New Brunswick, New Jersey: Rutgers University Press, pp. 423–442.

Dixon, B.S. (2020) *Dewey and Design: A Pragmatist Perspective for Design Research*. Springer International Publishing.

van Dongen, P.L. (2019) *A designer's material-aesthetics reflections on fashion and technology*. PhD Thesis. Eindhoven University of Technology. Available at: https://research.tue.nl/nl/publications/8adbdc80-7858-4b6b-a84e-62854a6f4141 (Accessed: 2 November 2022).

Dorst, K. and Cross, N. (2001) 'Creativity in the design process: co-evolution of problem–solution', *Design Studies*, 22(5), pp. 425–437. Available at: https://doi.org/10.1016/S0142-694X(01)00009-6.

Dove, T. (2016) 'Stretch to fit – made to fit', *International Journal of Fashion Design, Technology and Education*, 9(2), pp. 115–129. Available at: https://doi.org/10.1080/17543266.2016.1167252.

Dover, S. (2018) *Underwear (incl. Loungewear/Nightwear) - UK - June 2018: What Women Buy*, *Mintel Academic*. Available at: http://academic.mintel.com.arts.idm.oclc.org/display/903794/?highlight#hit1 (Accessed: 24 June 2019).

Dunbar, C., Rodriguez, D. and Parker, L. (2001) 'Race, Subjectivity, and the Interview Process', in Gubrium, J. and Holstein, J., *Handbook of Interview Research*. Thousand Oaks, California: SAGE Publications, Inc., pp. 279–298. Available at: https://doi.org/10.4135/9781412973588.n18.

Dunne, L. (2010) 'Smart Clothing in Practice: Key Design Barriers to Commercialization', *Fashion Practice*, 2(1), pp. 41–65. Available at: https://doi.org/10.2752/175693810X12640026716393.

Dunne, L., Ashdown, S. and McDonald, E. (2002) 'Smart Systems: Wearable Integration of Intelligent Technology', *International Centre of Excellence for Wearable Electronics and Smart Fashion Products (ICEWES) Conference* [Preprint].

Dunne, L.E. (2004) *The Design of Wearable Technology: Addresing the Human-Device Interface Through Functional Apparel Design*. Master of Arts. Cornell University.

Dunne, L.E., Ashdown, S.P. and Smyth, B. (2005) 'Expanding Garment Functionality through Embedded Electronic Technology', *Journal of Textile and Apparel Technology and Management,* 4(3), pp. 1–11.

Dunne, L.E., Gioberto, G. and Simon, C. (2015) 'E-Textiles in the Apparel Factory: Leveraging Cut-and-Sew Technology Toward the Next Generation of Smart Garments', in *Fundamentals of Wearable Computers and Augmented Reality*.

Dunne, L.E. and Smyth, B. (2007) 'Psychophysical Elements of Wearability', in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. San Jose, C.A.: ACM (CHI '07), pp. 299–302. Available at: https://doi.org/10.1145/1240624.1240674.

Dwyer, S.C. and Buckle, J.L. (2009) 'The Space Between: On Being an Insider-Outsider in Qualitative Research', *International Journal of Qualitative Methods*, 8(1), pp. 54–63. Available at: https://doi.org/10.1177/160940690900800105.

Elder-Vass, D. (2019) 'Actor-network theory', in P.A. Atkinson et al. (eds) *SAGE Encyclopedia of Research Methods, Forthcoming*. Sage. Available at: https://dspace.lboro.ac.uk/dspace-jspui/handle/2134/27615 (Accessed: 15 June 2019).

Electric bra could spot cancer (2002) *BBC News*. Available at: http://news.bbc.co.uk/1/hi/health/2002809.stm (Accessed: 26 June 2019).

Entwistle, J. (2000a) 'Fashion and the Fleshy Body: Dress as Embodied Practice', *Fashion Theory*, 4(3), pp. 323–347. Available at: https://doi.org/10.2752/136270400778995471.

Entwistle, J. (2000b) *The fashioned body: fashion, dress and modern social theory*. Cambridge: Polity Press.

Entwistle, J. (2015) *The Fashioned Body: Fashion, Dress and Social Theory*. 2nd edition. Cambridge: Polity.

Entwistle, J. (2016) 'Bruno Latour: The Field of Fashion', in A. Rocamora and A. Smelik (eds) *Thinking through fashion: a guide to key theorists*. London: I.B. Tauris (Dress cultures), p. 269.

Esterberg, K.G. (2001) *Qualitative Methods in Social Research*. 1st edn. Boston, Mass.: McGraw-Hill.

Etherington, R. (2012) *Flyknit running footwear by Nike*, *Dezeen*. Available at: https://www.dezeen.com/2012/02/22/flyknit-running-footwear-by-nike/ (Accessed: 28 June 2019).

Ewing, E. (2010) *Fashion in Underwear*. Mineola, N.Y: Dover Publications.

Fairburn, S., Steed, J. and Coulter, J. (2016) 'Spheres of Practice for the Co-design of Wearables', *Journal of Textile Design Research and Practice*, 4(1), pp. 85–109. Available at: https://doi.org/10.1080/20511787.2016.1255445.

Fairhurst, E. (1998) '"Growing old gracefully" as opposed to "mutton dressed as lamb": The social construction of recognising older women', in *The Body in Everyday Life*. 1st edn. London: Routledge.

Falsetti, A. (2005) 'Method and apparatus for preoperative estimation of breast implant volume'. Presto, PA. Available at: https://patents.google.com/patent/US20050284215A1/en?oq=US20050284215A1 (Accessed: 11 September 2021).

Farrell-Beck, J. *et al.* (1998) 'Brassieres and Women's Health from 1863 to 1940', *Clothing and Textiles Research Journal*, 16(3), pp. 105–115. Available at: https://doi.org/10.1177/0887302X9801600301.

Farrell-Beck, J. and Gau, C. (2001) *Uplift: The Bra in America*. 1st edition. Philadelphia: University of Pennsylvania Press.

Fernandes, S.A. (2016) *An Exploratory Study of the Meanings and Experiences of having Larger Breasts on Older Women's Body Image*. Master of Arts. West Chester University of Pennsylvania. Available at: http://search.proquest.com/pqdt/docview/1976098453/citation/3604FB47FB1C4B52PQ/135 (Accessed: 2 June 2018).

Ferraro, V. and Ugur, S. (2011) 'Designing Wearable Technologies Through a User Centered Approach', in *Proceedings of the 2011 Conference on Designing Pleasurable Products and Interfaces*. New York, NY, USA: ACM (DPPI '11), p. 5:1-5:8. Available at: https://doi.org/10.1145/2347504.2347510.

Fibrocystic breasts - Symptoms and causes (2021) *Mayo Clinic*. Available at: https://www.mayoclinic.org/diseases-conditions/fibrocystic-breasts/symptoms-causes/syc-20350438 (Accessed: 7 November 2022).

Fields, J. (2006) 'From Black Venus to Blonde Venus: the meaning of black lingerie', *Women's History Review*, 15(4), pp. 611–623. Available at: https://doi.org/10.1080/09612020500530752.

Fields, J. (2007) *An Intimate Affair: Women, Lingerie, and Sexuality*. University of California Press.

Filipe, A.B. *et al.* (2015) 'The Fitting of Plus Size Bra for Middle Aged Women', *Procedia Manufacturing*, 3, pp. 6393–6399. Available at: https://doi.org/10.1016/j.promfg.2015.07.968.

Finn, B.L. (2011) 'Fashion illumination system'. Available at: https://patents.google.com/patent/US7878675B2/en?oq=US7878675B2 (Accessed: 11 September 2021).

Fisher, L. *et al.* (2010) *Sex, Romance, and Relationships: AARP Survey of Midlife and Older Adults*, *AARP*. Available at: https://doi.org/10.26419/res.00063.001.

Fletcher, K. (2010) 'Slow Fashion: An Invitation for Systems Change', *Fashion Practice*, 2(2), pp. 259–265. Available at: https://doi.org/10.2752/175693810X12774625387594.

Flick, U. (2014) *An introduction to qualitative research*. 5th edition. Los Angeles, California ; London, England: Sage.

Flynn, K.J. and Fitzgibbon, M. (1998) 'Body images and obesity risk among Black females: A review of the literature', *Annals of Behavioral Medicine*, 20(1), pp. 13–24. Available at: https://doi.org/10.1007/BF02893804.

Fokkinga, S., Desmet, P. and Hekkert, P. (2020) 'Impact-Centered Design: Introducing an Integrated Framework of the Psychological and Behavioral Effects of Design', *International Journal of Design*, 14(3), pp. 97–116.

Foos, P.W., Clark, M.C. and Terrell, D.F. (2006) 'Adult age, gender, and race group differences in images of aging', *The Journal of Genetic Psychology*, 167(3), pp. 309–325. Available at: https://doi.org/10.3200/GNTP.167.3.309-325.

Forlizzi, J., Disalvo, C. and Hanington, B. (2003) 'On the Relationship between Emotion, Experience and the Design of New Products', *The Design Journal*, 6(2), pp. 29–38. Available at: https://doi.org/10.2752/146069203789355507.

Forlizzi, J. and Ford, S. (2000) 'The building blocks of experience: an early framework for interaction designers', in *Proceedings of the 3rd conference on Designing interactive systems: processes, practices, methods, and techniques*. New York, NY, USA: Association for Computing Machinery (DIS '00), pp. 419–423. Available at: https://doi.org/10.1145/347642.347800.

Fornell, C. (1982) 'A second generation of multivariate analysis : An overview', *Methods*, pp. 1–21.

Fornell, C. and Larcker, D.F. (1981a) 'Evaluating Structural Equation Models with Unobservable Variables and Measurement Error', *Journal of Marketing Research*, 18(1), pp. 39–50. Available at: https://doi.org/10.1177/002224378101800104.

Fornell, C. and Larcker, D.F. (1981b) 'Structural Equation Models with Unobservable Variables and Measurement Error: Algebra and Statistics', *Journal of Marketing Research*, 18(3), pp. 382–388. Available at: https://doi.org/10.1177/002224378101800313.

Foster, E. (2015) *'Miraculous' vibrating bra 'increases the size of a woman's breasts'*, *Mail Online*. Available at: https://www.dailymail.co.uk/femail/article-3221460/Miraculous-vibrating-bra-claims-increase-size-woman-s-breasts-just-seven-days-without-need-surgery-trialed-U-S.html (Accessed: 7 November 2022).

Foucault, M. (1988) *Technologies of the Self: A Seminar with Michel Foucault*. Edited by M.L. Gutman and P. Hutton. University of Massachusetts Press.

Franklin, A. (2003) 'Black Women and Self-Presentation: Appearing in (Dis)Guise', in Alison Guy, M. Banim, and Ali Guy (eds) *Through the Wardrobe: Women's Relationships with Their Clothes*. Oxford ; New York:

Berg Publishers, pp. 137–150. Available at: http://www.bloomsburycollections.com/book/through-the-wardrobe-womens-relationships-with-their-clothes.

Frayling, C. (1993) 'Research in art and design', *Royal College of Art Research Papers*, 1(1), pp. 1–5.

Friedman, K. (2003) 'Theory construction in design research: criteria: approaches, and methods', *Design Studies*, 24(6), pp. 507–522. Available at: https://doi.org/10.1016/S0142-694X(03)00039-5.

Fulton Suri, J. (2003) 'Empathic design: Informed and inspired by other people's experience', in I. Koskinen, K. Battarbee, and T. Mattelmäki (eds) *Empathic design: User experience in product design*, pp. 51–58.

Gallop, C. (2015) *What is sextech and why is everyone ignoring it?*, *Hot Topics*. Available at: https://www.hottopics.ht/14192/what-is-sextech-and-why-is-everyone-ignoring-it/ (Accessed: 23 October 2018).

Gannon, S. and Müller-Rockstroh, B. (2004) 'In Memory: Women's Experiences of Breasts', *Philosophy in the Contemporary World*, 11(1), pp. 55–65. Available at: https://doi.org/pcw20041118.

Garlinska, A. and Röpert, A. (2013) 'Technology management and innovation strategies in the development of smart textiles', in T. Kirstein (ed.) *Multidisciplinary know-how for smart- textiles developers*. Oxford ; Philadelphia: Woodhead Pub (Woodhead publishing series in textiles, no. 139), pp. 369–398.

Garson, G.D. (2016) *Partial least squares: Regression & structural equation models*. 2016 Edition. Statistical Associates Publishing. Available at: https://www.amazon.com/Partial-Squares-Regression-Structural-Equation-ebook/dp/B00IC5DLHE (Accessed: 15 January 2020).

Garstka, T.A. *et al.* (2004) 'How young and older adults differ in their responses to perceived age discrimination', *Psychology and Aging*, 19(2), pp. 326–335. Available at: https://doi.org/10.1037/0882-7974.19.2.326.

Gaurano, L.M. (2017) *Julian Rios Cantu: Full Story & Details Of Lifesaving Bra*, *College Candy*. Available at: https://collegecandy.com/2017/05/05/julian-rios-cantu-breast-cancer-detecting-bra-eva-invention-details/ (Accessed: 7 November 2022).

Gaver, B. and Bowers, J. (2012) 'Annotated portfolios', *Interactions*, 19(4), pp. 40–49. Available at: https://doi.org/10.1145/2212877.2212889.

Gaver, W. *et al.* (2022) 'Emergence as a Feature of Practice-based Design Research', in *Designing Interactive Systems Conference*. New York, NY, USA: Association for Computing Machinery (DIS '22), pp. 517–526. Available at: https://doi.org/10.1145/3532106.3533524.

Gelinas, L. *et al.* (2017) 'Using Social Media as a Research Recruitment Tool: Ethical Issues and Recommendations', *The American journal of bioethics : AJOB*, 17(3), pp. 3–14. Available at: https://doi.org/10.1080/15265161.2016.1276644.

Gemser, G. and Candi, M. (2010) 'Who should be asked? A comparison of manager, customer and designer evaluations of service aesthetic.', in *Proceedings of the 34th Annual Global Conference on Product Innovation Management. PDMA Conference 2010*, Orlando, USA: s.n., pp. 1–17.

Genç, Ç. *et al.* (2018) 'Exploring Computational Materials as Fashion Materials : Recommendations for Designing Fashionable Wearables', *International Journal of Design*, 12(3), pp. 1–19.

Generett, G.G. and Jeffries, R.B. (2003) *Black Women in the Field: Experiences Understanding Ourselves and Others Through Qualitative Research*. Cresskill, NJ: Hampton Press Inc.

Genova, A. and Moriwaki, K. (2016) *Fashion and Technology: A Guide to Materials and Applications*. New York, NY: Fairchild Books.

George, D. and Mallery, P. (2002) *SPSS for Windows Step by Step: A Simple Guide and Reference, 11.0 Update*. 4th edition. Allyn & Bacon.

Ghalachyan, A. and MacGillivray, M.S. (2016) 'Designing headwear for women with chemotherapy-induced hair loss', *International Journal of Fashion Design, Technology and Education*, 9(3), pp. 222–232. Available at: https://doi.org/10.1080/17543266.2016.1160443.

Ghasemi, A. and Zahediasl, S. (2012) 'Normality Tests for Statistical Analysis: A Guide for Non-Statisticians', *International Journal of Endocrinology and Metabolism*, 10(2), pp. 486–489. Available at: https://doi.org/10.5812/ijem.3505.

Gibbs, A. (1997) 'Focus Group', *Social Research Update*, 19(8), pp. 1–8.

Gibson, I., Rosen, D. and Stucker, B. (2015) 'Direct Digital Manufacturing', in I. Gibson, D. Rosen, and B. Stucker (eds) *Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing*. New York, NY: Springer, pp. 375–397. Available at: https://doi.org/10.1007/978-1-4939-2113-3_16.

Gillham, B. (2008) *Developing a Questionnaire*. 2nd Edition. London: A&C Black.

Ginsberg, R.L. *et al.* (2016) 'Prevalence and correlates of body image dissatisfaction in postmenopausal women', *Women & Health*, 56(1), pp. 23–47. Available at: https://doi.org/10.1080/03630242.2015.1074636.

Gioberto, G., Compton, C. and Dunne, L.E. (2016) 'Machine-Stitched E-textile Stretch Sensors', *Sensors & Transducers*, 202(7), pp. 25–37.

Glaser, M. (2008) *Drawing is Thinking*. Harry N. Abrams.

Goczyńska-Han, E. *et al.* (2020) *The State of FemTech: Current state and future of the FemTech industry*. Kraków: Untitled Kingdom, pp. 1–98. Available at: https://www.untitledkingdom.com/hubfs/The%20State%20of%20FemTech%20_%20Untitled%20Kingdom.pdf (Accessed: 5 November 2022).

Goldsberry, E., Shim, S. and Reich, N. (1996) 'Women 55 Years and Older: Part II. Overall Satisfaction and Dissatisfaction with the Fit of Ready-to-Wear', *Clothing and Textiles Research Journal*, 14(2), pp. 121–132. Available at: https://doi.org/10.1177/0887302X9601400203.

Golsteijn, C. *et al.* (2014) 'Reflections on craft research for and through design', in *Proceedings of the 8th Nordic Conference on Human-Computer Interaction: Fun, Fast, Foundational*. New York, NY, USA: Association for Computing Machinery (NordiCHI '14), pp. 421–430. Available at: https://doi.org/10.1145/2639189.2639194.

Goodall, E.V. *et al.* (2020) 'Systems, Devices and Methods for Monitoring Breastfeeding'. Bellevue , WA. Available at: https://patents.google.com/patent/US20200245922A1/en?oq=US20200245922A1 (Accessed: 11 September 2021).

Goode, J. (2018) 'Fashioning the sixties: fashion narratives of older women', *Ageing & Society*, 38(3), pp. 455–475. Available at: https://doi.org/10.1017/S0144686X1600101X.

Goodman, E., Kuniavsky, M. and Moed, A. (2012) *Observing the User Experience: A Practitioner's Guide to User Research*. 2nd edition. Amsterdam ; Boston: Morgan Kaufmann.

Goodman, L. *et al.* (2018) 'WEAR Sustain Network: Ethical and Sustainable Technology Innovation in Wearables and Etextiles', in *2018 IEEE Games, Entertainment, Media Conference (GEM). 2018 IEEE Games, Entertainment, Media Conference (GEM)*, pp. 1–9. Available at: https://doi.org/10.1109/GEM.2018.8516276.

Gorea, A.C. (2017) *Seamless Knitted Sports Bra Design: A Responsive System Design Exploration*. Ph.D. Iowa State University. Available at: http://search.proquest.com/pqdt/docview/2015529222/3604FB47FB1C4B52PQ/2 (Accessed: 2 June 2018).

Gosler, K. (2020) 'New Technology & Materials: Insights from Bra Patents 1859 - 1940', in. *Adventures in Chemistry and Technology: Exploring the Legacy of 19th Century Innovation in Textiles, Jewellery and Materials – Symposium*, Online. Available at: http://adventureandlegacy.our.dmu.ac.uk/presentations/ (Accessed: 6 November 2022).

Goudswaard, M. *et al.* (2020) 'FabriClick: Interweaving Pushbuttons into Fabrics Using 3D Printing and Digital Embroidery', in *Proceedings of the 2020 ACM Designing Interactive Systems Conference*. New York, NY, USA: Association for Computing Machinery (DIS '20), pp. 379–393. Available at: https://doi.org/10.1145/3357236.3395569.

Goveia da Rocha, B. *et al.* (2020) 'Crafting Research Products through Digital Machine Embroidery', in *Proceedings of the 2020 ACM Designing Interactive Systems Conference*. New York, NY, USA: Association for Computing Machinery (DIS '20), pp. 341–350. Available at: https://doi.org/10.1145/3357236.3395443.

Granot, E. and Brashear, T. (2008) 'From Luxury to Populence: Inconspicuous Consumption As Described By Female Consumers', *ACR North American Advances*, NA-35. Available at: http://acrwebsite.org/volumes/13523/volumes/v35/NA-35 (Accessed: 9 August 2018).

Granville, G. (2000) 'Menopause : A time of private change to a mature identity', in M. Bernard et al. (eds) *Women ageing: changing identities, challenging myths*. London: Routledge, pp. 74–92.

Gray, C. and Malins, J. (2004) *Visualizing Research: A Guide to the Research Process in Art and Design*. Aldershot, Hants, England ; Burlington, VT: Routledge.

Greene, R.R. (2008) 'Carl Rogers and the Person-Centered Approach', in *Human Behavior Theory& Social Work Practice*. 3rd edn. New York: Routledge, pp. 113–132.

Greengrass, J. (2015) 'From co-design to design specifications and manufacture of apparel for the active ageing population', in *Textile-Led Design for the Active Ageing Population*. Woodhead Publishing (Woodhead Publishing Series in Textiles), pp. 309–328. Available at: https://doi.org/10.1016/B978-0-85709-538-1.00018-3.

Grewal, D., Gotlieb, J. and Marmorstein, H. (1994) 'The Moderating Effects of Message Framing and Source Credibility on the Price-perceived Risk Relationship', *Journal of Consumer Research*, 21(1), pp. 145–153. Available at: https://doi.org/10.1086/209388.

Grothaus, M. (2013) *ThirdLove iPhone app accurately calculates bra size with just a few pics*, *Engadget*. Available at: https://www.engadget.com/2013-08-16-thirdlove-iphone-app-accurately-calculates-bras-size-with-just-a.html (Accessed: 11 September 2021).

Groves, P. (2003) 'Insider, Outsider, or Exotic Other? Identity, Performance, Reflexivity, and Postcritical Ethnography', in Generett, G. G. and Jeffries, R. B., *Black Women in the Field: Experiences Understanding Ourselves and Others Through Qualitative Research*. Cresskill, NJ: Hampton Press Inc, pp. 103–115.

Guba, E. (ed.) (1990) *The Paradigm Dialog*. 1st edn. Newbury Park, Calif: SAGE Publications, Inc.

Guler, S.D.D., Gannon, M. and Sicchio, K. (2016) *Crafting Wearables: Blending Technology with Fashion*. 1st ed. edition. New York: Apress.

Gupta, D. (2011) 'Design and engineering of functional clothing', *IJFTR Vol.36(4) [December 2011]*, 36, pp. 327–335.

Gwilt, A. (2011) 'Revealing Historic Traditions of Craftsmanship in the Context of Sustainable Fashion', in *13th Annual International Foundation of Fashion Technology Institutes 2011. Conference Proceedings 2011 Fashion & Luxury: Between Heritage & Innovation*, Paris, France: Institut Français de la Mode (IFM), pp. 19–24. Available at: http://iffti.org/downloads/papers-presented/xiii-IFFTI%20ABSTRACTS%20BROCHURE%202011.pdf#page=21 (Accessed: 2 December 2022).

Haffenden, V. and Smith, J. (2015) 'Designing base layers for apparel for the active ageing population: Balancing technology and aesthetics', in *Textile-Led Design for the Active Ageing Population*. Woodhead Publishing (Woodhead Publishing Series in Textiles), pp. 361–384. Available at: https://doi.org/10.1016/B978-0-85709-538-1.00020-1.

Hahn, J. (2021) *Elvie designs manual Curve breast pump to be hidden inside bra*, *Dezeen*. Available at: https://www.dezeen.com/2021/11/23/elvie-curve-wearable-silicone-breast-pump/ (Accessed: 7 November 2022).

Hair, J. *et al.* (2017) 'An updated and expanded assessment of PLS-SEM in information systems research', *Industrial Management & Data Systems*, 117(3), pp. 442–458. Available at: https://doi.org/10.1108/IMDS-04-2016-0130.

Hair, J. *et al.* (2021) *A Primer on Partial Least Squares Structural Equation Modeling*. 3rd edn. Los Angeles: SAGE Publications, Inc.

Hair, J.F. *et al.* (1998) *Multivariate data analysis*. 4th edn. Upper Saddle River, N.J: Prentice Hall.

Hair, J.F. *et al.* (2010) *Multivariate Data Analysis*. 7th edition. Upper Saddle River, NJ: Pearson.

Hair, J.F. *et al.* (2012) 'An assessment of the use of partial least squares structural equation modeling in marketing research', *Journal of the Academy of Marketing Science*, 40(3), pp. 414–433. Available at: https://doi.org/10.1007/s11747-011-0261-6.

Hair, J.F. *et al.* (2014) 'Partial least squares structural equation modeling (PLS-SEM): An emerging tool in business research', *European Business Review*, 26(2), pp. 106–121. Available at: https://doi.org/10.1108/EBR-10-2013-0128.

Hair, J.F. *et al.* (2018) *Multivariate Data Analysis*. 8th edition. Andover, Hampshire: Cengage Learning EMEA.

Hair, J.F. *et al.* (2019) 'When to use and how to report the results of PLS-SEM', *European Business Review*, 31(1), pp. 2–24. Available at: https://doi.org/10.1108/EBR-11-2018-0203.

Hall, C. (2020) 'TAKING NOTE: Annotated Portfolio as a Method to Analyse the Experience of Design Research Practice', *Journal of Textile Design Research and Practice*, 8(2), pp. 209–231. Available at: https://doi.org/10.1080/20511787.2020.1751960.

Hall, C. (2021) *Design for Recycling Knitwear: a framework for sorting, blending and cascading in the mechanical textile recycling industry*. PhD Thesis. University of the Arts London. Available at: https://ualresearchonline.arts.ac.uk/id/eprint/17668/ (Accessed: 5 October 2022).

Halskov, K. and Hansen, N.B. (2015) 'The diversity of participatory design research practice at PDC 2002–2012', *International Journal of Human-Computer Studies*, 74, pp. 81–92. Available at: https://doi.org/10.1016/j.ijhcs.2014.09.003.

Hamdan, N.A., Voelker, S. and Borchers, J. (2018) 'Sketch&Stitch: Interactive Embroidery for E-textiles', in *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*. New York, NY, USA: Association for Computing Machinery (CHI '18), pp. 1–13. Available at: https://doi.org/10.1145/3173574.3173656.

Hamilton Smith, L. (2018) 'Support & Uplift: How technology defined the bra in the twentieth century', *The Journal of Dress History*, 2(3), pp. 73–99.

Hammond, M. and Wellington, J. (2012) *Research Methods: The Key Concepts*. 1st edn. London: Routledge. Available at: https://doi.org/10.4324/9780203097625.

Hammonds, E. (2004) 'Black (w)holes and the geometry of Black female sexuality', in J. Bobo, C. Hudley, and C. Michel (eds) *The Black studies reader*. New York: Routledge, pp. 301–314.

Hansen, D.T. (2002) 'Dewey's Conception of an Environment for Teaching and Learning', *Curriculum Inquiry*, 32(3), pp. 267–280.

Hansen, N.B. (2016) *Materials in participatory design processes*. Ph.D. Thesis. Aarhus University. Available at: https://research.tue.nl/en/publications/materials-in-participatory-design-processes (Accessed: 2 November 2022).

Hardaker, C.H.M. and Fozzard, G.J.W. (1997) 'The bra design process - a study of professional practice', *International Journal of Clothing Science and Technology*, 9(4), pp. 311–325. Available at: https://doi.org/10.1108/09556229710175795.

Harding, S.G. (ed.) (2004) *The Feminist Standpoint Theory Reader: Intellectual and Political Controversies*. Psychology Press.

Harley, D.A. (2021) 'Sexual expression and pleasure among black minority ethnic older women', in T. Hafford-Letchfield, P. Simpson, and P. Reynolds (eds) *Sex and Diversity in Later Life: Critical Perspectives*. Policy Press, pp. 15–37. Available at: https://bristoluniversitypressdigital.com/view/book/9781447355427/ch002.xml (Accessed: 3 July 2022).

Hart, C. and Dewsnap, B. (2001) 'An exploratory study of the consumer decision process for intimate apparel', *Journal of Fashion Marketing and Management*, 5(2), pp. 108–119. Available at: https://doi-org.arts.idm.oclc.org/10.1108/EUM0000000007282.

Hart, C.A. (2016) *Evolving perceptions of assortments, image and customer experiences in retail environments*. Ph.D. Loughborough University. Available at: https://hdl.handle.net/2134/23159 (Accessed: 14 September 2021).

Hartman, K. (2014) *Make: Wearable Electronics: Design, prototype, and wear your own interactive garments*. 1 edition. Sebastopol, CA: Maker Media, Inc.

Hawthorne, R. and Want, M. (1992) *Bras: a private view*. London: Souvenir Press.

Hayfield, N. and Huxley, C. (2015) 'Insider and Outsider Perspectives: Reflections on Researcher Identities in Research with Lesbian and Bisexual Women', *Qualitative Research in Psychology*, 12(2), pp. 91–106. Available at: https://doi.org/10.1080/14780887.2014.918224.

Haynes, K. (2012) 'Reflexivity in Qualitative Research', in G. Symon and C. Cassell (eds) *Qualitative Organizational Research: Core Methods and Current Challenges*. SAGE, pp. 72–89.

Healthwise Staff (2022) *Body Temperature | Michigan Medicine*, *University of Michigan Health*. Available at: https://www.uofmhealth.org/health-library/hw198785 (Accessed: 18 March 2023).

Hegde, S. *et al.* (2012) 'Music close to one's heart: heart rate variability with music, diagnostic with e-bra and smartphone', in *Nanosensors, Biosensors, and Info-Tech Sensors and Systems 2012*. *Nanosensors, Biosensors, and Info-Tech Sensors and Systems 2012*, SPIE, pp. 140–145. Available at: https://doi.org/10.1117/12.916793.

Heinberg, L.J. (2001) 'Theories of body image disturbance: Perceptual, developmental, and sociocultural factors', in J.K. Thompson (ed.) *Body image, eating disorders, and obesity: An integrative guide for assessment and treatment*. Washington, DC, US: American Psychological Association, pp. 27–47. Available at: https://doi.org/10.1037/10502-002.

Heiskanen, E. *et al.* (2010) 'Constructing innovative users and user-inclusive innovation communities', *Technology Analysis & Strategic Management*, 22(4), pp. 495–511. Available at: https://doi.org/10.1080/09537321003714568.

Hekkert, P. and van Dijk, M. (2001) 'Designing from context: foundations and applications of the VIP approach', *Proceedings of design thinking research symposium 5*. Edited by P.A. Lloyd and H.H.C.M. Christiaans, pp. 383–394.

Henseler, J. (2017) 'Bridging Design and Behavioral Research With Variance-Based Structural Equation Modeling', *Journal of Advertising*, 46(1), pp. 178–192. Available at: https://doi.org/10.1080/00913367.2017.1281780.

Henseler, J., Ringle, C.M. and Sarstedt, M. (2015) 'A new criterion for assessing discriminant validity in variance-based structural equation modeling', *Journal of the Academy of Marketing Science*, 43(1), pp. 115–135. Available at: https://doi.org/10.1007/s11747-014-0403-8.

Henseler, J., Ringle, C.M. and Sinkovics, R.R. (2009) 'The use of partial least squares path modeling in international marketing', in R. R. Sinkovics and P. N. Ghauri (eds) *New Challenges to International Marketing*. Bingley: Emerald Group Publishing Limited (Advances in International Marketing), pp. 277–319. Available at: https://doi.org/10.1108/S1474-7979(2009)0000020014.

Hill Collins, P. (2000) *Black Feminist Thought: Knowledge, Consciousness, and the Politics of Empowerment*. 2nd edn. New York: Routledge. Available at: https://doi.org/10.4324/9780203900055.

Hill Collins, P. (2004) 'Learning from the Outsider Within: The Sociological Significance of Black Feminist Thought', in S.G. Harding (ed.) *The Feminist Standpoint Theory Reader: Intellectual and Political Controversies*. Psychology Press, pp. 103–126.

Hill Collins, P. (2005) *Black Sexual Politics: African Americans, Gender, and the New Racism*. 1st edn. New York: Routledge.

Hill Collins, P. (2008) *Black Feminist Thought: Knowledge, Consciousness, and the Politics of Empowerment*. 1 edition. New York: Routledge.

Hill Collins, P.H. (1986) 'Learning from the Outsider Within: The Sociological Significance of Black Feminist Thought*', *Social Problems*, 33(6), pp. s14–s32. Available at: https://doi.org/10.2307/800672.

Hodgekiss, A. (2015) 'Is your BRA making you ill?', *DailyMail Online*, 20 March. Available at: https://www.dailymail.co.uk/health/article-3000486/Is-BRA-making-ill-Poorly-fitting-underwear-causes-problems-pain-heartburn-read-definitive-guide-picking-best-one-you.html (Accessed: 15 September 2021).

Hodson, E., Svanda, A. and Dadashi, N. (2023) 'Whom do we include and when? participatory design with vulnerable groups', *CoDesign*, 0(0), pp. 1–18. Available at: https://doi.org/10.1080/15710882.2022.2160464.

Hofmeier, S.M. *et al.* (2017) 'Body image, aging, and identity in women over 50: The Gender and Body Image (GABI) study', *Journal of Women & Aging*, 29(1), pp. 3–14. Available at: https://doi.org/10.1080/08952841.2015.1065140.

Holland, S. (2012) 'Alternative Women Adjusting to Ageing, or How to Stay Freaky at 50', in A. Bennett and P. Hodkinson (eds) *Ageing and youth culture: music, style and identity*. London: Berg, pp. 119–129.

Holmes, A.G.D. (2020) 'Researcher Positionality - A Consideration of Its Influence and Place in Qualitative Research - A New Researcher Guide', *Shanlax International Journal of Education*, 8(4), pp. 1–10. Available at: https://doi.org/10.34293/education.v8i4.3232.

Holmlund, M., Hagman, A. and Polsa, P. (2011) 'An exploration of how mature women buy clothing: empirical insights and a model', *Journal of Fashion Marketing and Management: An International Journal*, 15(1), pp. 108–122. Available at: https://doi.org/10.1108/13612021111112377.

hooks, bell (1992) *Black Looks: Race and Representation*. 1st edition. Boston, MA: South End Press.

hooks, bell (2014) *Ain't I a Woman: Black Women and Feminism*. 2nd edition. New York: Routledge.

Hoonhout, H.C.M. (2007) 'Setting the stage for developing innovative product concepts: people and climate', *CoDesign*, 3(sup1), pp. 19–34. Available at: https://doi.org/10.1080/15710880701376752.

Hopwood, P. *et al.* (2001) 'A body image scale for use with cancer patients', *European Journal of Cancer*, 37(2), pp. 189–197. Available at: https://doi.org/10.1016/S0959-8049(00)00353-1.

Hosomi, S., Tsukamoto, M. and Nishio, S. (2007) 'A system for controlling LED blink in wearable fashion', in *Proceedings of the 2007 international conference on Wireless communications and mobile computing*. New York, NY, USA: Association for Computing Machinery (IWCMC '07), pp. 665–670. Available at: https://doi.org/10.1145/1280940.1281081.

Hsu, S.-C. (2007) 'Ligheing emitting devices used in knickers and brassiere'. Available at: https://patents.google.com/patent/US20070236916A1/en?q=brassiere;&q=A41C3%2f00&before=priority:20100101&after=priority:19900101&page=4 (Accessed: 26 June 2019).

Hu, L. and Bentler, P.M. (1999) 'Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives', *Structural Equation Modeling: A Multidisciplinary Journal*, 6(1), pp. 1–55. Available at: https://doi.org/10.1080/10705519909540118.

Hudson, K. and Hwang, C. (2020) 'Application of 3D Prototyping to Promote Size-Inclusive Design Practices for Plus-Size Apparel', *Fashion Practice*, 0(0), pp. 1–21. Available at: https://doi.org/10.1080/17569370.2020.1804152.

Hume, M. and Mills, M. (2013) 'Uncovering Victoria's Secret: Exploring women's luxury perceptions of intimate apparel and purchasing behaviour', *Journal of Fashion Marketing and Management: An International Journal*, 17(4), pp. 460–485. Available at: https://doi.org/10.1108/JFMM-03-2013-0020.

Hurd Clarke, L. (2011) *Facing age: women growing older in anti-aging culture*. Lanham, Md. ; Plymouth: Rowman & Littlefield Publishers (Diversity and aging).

Hurd Clarke, L. (2018) 'Older Women and the Embodied Experience of Weight', in H.L. McBride and J.L. Kwee (eds) *Embodiment and Eating Disorders: Theory, Research, Prevention and Treatment*. Routledge.

Hurd Clarke, L. and Griffin, M. (2008) 'Visible and invisible ageing: beauty work as a response to ageism', *Ageing & Society*, 28(5), pp. 653–674. Available at: https://doi.org/10.1017/S0144686X07007003.

Hurd Clarke, L., Griffin, M. and Maliha, K. (2009) 'Bat wings, bunions, and turkey wattles: body transgressions and older women's strategic clothing choices', *Ageing and Society*, 29(5), pp. 709–726. Available at: https://doi.org/10.1017/S0144686X08008283.

Hwang, C. (2014) *Consumers' acceptance of wearable technology: Examining solar-powered clothing*. Masters of Science. Iowa State University. Available at: https://search.proquest.com/openview/ae7dce7c1e610ad2d26e4992dd60d6bd/1?pq-origsite=gscholar&cbl=18750&diss=y (Accessed: 27 November 2017).

Hwang, C. (2017) *Design requirements for female boomer activewear: A sequential exploratory mixed methods study*. PhD Thesis. Iowa State University. Available at: https://dr.lib.iastate.edu/handle/20.500.12876/31109 (Accessed: 2 November 2022).

Hwang, C., Chung, T.-L. and Sanders, E.A. (2016) 'Attitudes and Purchase Intentions for Smart Clothing: Examining U.S. Consumers' Functional, Expressive, and Aesthetic Needs for Solar-Powered Clothing', *Clothing and Textiles Research Journal*, 34(3), pp. 207–222. Available at: https://doi.org/10.1177/0887302X16646447.

Im, E.-O., Lee, S.H. and Chee, W. (2010) 'Black Women in Menopausal Transition', *Journal of Obstetric, Gynecologic & Neonatal Nursing*, 39(4), pp. 435–443. Available at: https://doi.org/10.1111/j.1552-6909.2010.01148.x.

Islam Molla, Md.T. (2020) *Manufacturing Cut-And-Sew Garment-Integrated Technologies: An Investigation Of Surface-Mount Fabrication For Electronic Textiles*. Ph.D. Thesis. University of Minnesota. Available at: http://conservancy.umn.edu/handle/11299/216879 (Accessed: 19 September 2022).

Islam Molla, M.T., Compton, C. and Dunne, L.E. (2020) 'Product Development Process for E-Textile Garments: A Design Guideline for Apparel Manufacturers', *International Textile and Apparel Association Annual Conference Proceedings*, 77(1). Available at: https://doi.org/10.31274/itaa.12246.

Ismar, E. *et al.* (2020) 'Towards Embroidered Circuit Board From Conductive Yarns for E-Textiles', *IEEE Access*, 8, pp. 155329–155336. Available at: https://doi.org/10.1109/ACCESS.2020.3018759.

Jamieson, S. (2004) 'Likert scales: how to (ab)use them?', *Medical Education*, 38(12), pp. 1217–1218. Available at: https://doi.org/10.1111/j.1365-2929.2004.02012.x.

Jantzen, C., Østergaard, P. and Vieira, C.M.S. (2006) 'Becoming a "woman to the backbone": Lingerie consumption and the experience of feminine identity', *Journal of Consumer Culture*, 6(2), pp. 177–202. Available at: https://doi.org/10.1177/1469540506064743.

Jen, S. (2017) 'Older women and sexuality: Narratives of gender, age, and living environment', *Journal of Women & Aging*, 29(1), pp. 87–97. Available at: https://doi.org/10.1080/08952841.2015.1065147.

Jen, S. (2018) 'Sexuality of midlife and older women: A review of theory use', *Journal of Women & Aging*, 30(3), pp. 204–226. Available at: https://doi.org/10.1080/08952841.2017.1295680.

João, A.F. *et al.* (2020) '3D printing pen using conductive filaments to fabricate affordable electrochemical sensors for trace metal monitoring', *Journal of Electroanalytical Chemistry*, 876, p. 114701. Available at: https://doi.org/10.1016/j.jelechem.2020.114701.

Jones, D.C. (2015) 'The role of wearable electronics in meeting the needs of the active ageing population', in J. McCann and D. Bryson (eds) *Textile-Led Design for the Active Ageing Population*. Woodhead Publishing

(Woodhead Publishing Series in Textiles), pp. 173–183. Available at: https://doi.org/10.1016/B978-0-85709-538-1.00011-0.

Jones, S.W. (1973) *Product Design and Process Selection*. London: Butterworth-Heinemann.

Jordan, P.W. (2000) *Designing Pleasurable Products : An Introduction to the New Human Factors*. CRC Press. Available at: https://doi.org/10.1201/9780203305683.

Joseph-Armstrong, H. (2009) *Patternmaking for Fashion Design*. 5th edition. Harlow: PEARSON INDIA.

Ju, N. and Lee, K.-H. (2020) 'Consumer resistance to innovation: smart clothing', *Fashion and Textiles*, 7(1), p. 21. Available at: https://doi.org/10.1186/s40691-020-00210-z.

Jungnickel, K. (2020) *Bikes and Bloomers: Victorian Women Inventors and their Extraordinary Cycle Wear*. Goldsmiths Press.

Jungnickel, K. (2022) 'Speculative sewing: Researching, reconstructing, and re-imagining wearable technoscience', *Social Studies of Science*, p. 03063127221119213. Available at: https://doi.org/10.1177/03063127221119213.

Kafaee, M. *et al.* (2021) 'Design for well-being: The fourth generation of technology development', *Technology in Society*, 67, p. 101775. Available at: https://doi.org/10.1016/j.techsoc.2021.101775.

Kahney, L. (1998) *Techno Bra Calls the Cops*, *Wired*. Available at: https://www.wired.com/1999/07/techno-bra-calls-the-cops/ (Accessed: 7 November 2022).

Kaiser, S.B. (1990) *The social psychology of clothing: symbolic appearances in context*. 2nd ed. New York: Macmillan.

Kalantari, M. (2017) 'Consumers' adoption of wearable technologies: literature review, synthesis, and future research agenda', *International Journal of Technology Marketing*, 12(3), pp. 274–307. Available at: https://doi.org/10.1504/IJTMKT.2017.089665.

Kaner, G. and Coşkun, A. (2017) 'Collaborative Design for Fashionable Wearables: A Fashion System Perspective', *Nordes*, 7(1). Available at: https://archive.nordes.org/index.php/n13/article/view/552 (Accessed: 9 August 2022).

Kapfunde, M. (2017) 'VITALI Smart Bra, Meet Your Intuitive Wellness Coach', *FashNerd*, April. Available at: https://fashnerd.com/2017/04/vitali-smart-bra/ (Accessed: 7 November 2022).

Kara, H. (2015) *Creative Research Methods in the Social Sciences: A Practical Guide*. Great Britian: Policy Press.

Kaszynska, P., Kimbell, L. and Bailey, J. (2022) 'Practice research in design: Towards a novel definition', in *Social Design Institute Working Paper*. London, England. Available at: https://www.arts.ac.uk/__data/assets/pdf_file/0020/347132/Kaszynska_Kimbell_Bailey_Practice-research-in-design_public.pdf.

Keist, C.N. and Marcketti, S.B. (2019) 'Supporting Acts: Patents for Undergarments for Stout Women, 1891–1956', *Clothing and Textiles Research Journal*, 37(3), pp. 200–214. Available at: https://doi.org/10.1177/0887302X19836513.

Kelch-Oliver, K. and Ancis, J.R. (2011) 'Black Women's Body Image: An Analysis of Culture-Specific Influences', *Women & Therapy*, 34(4), pp. 345–358. Available at: https://doi.org/10.1080/02703149.2011.592065.

Kettley, S. *et al.* (2010) 'Fit for purpose? Pattern cutting and seams in wearables development', *Digital Creativity*, 21(4), pp. 247–256. Available at: https://doi.org/10.1080/14626268.2010.548870.

Kettley, S. (2016) *Designing with Smart Textiles*. Bloomsbury Publishing.

Khouri, R.K. (2002) 'Method and apparatus for expanding soft tissue with shape memory alloys'. Available at: https://patents.google.com/patent/US6478656B1/en?q=(A41C3%2f00)&country=US&before=priority:20200101&after=priority:20000101&num=100&sort=old (Accessed: 11 September 2021).

Kidd, L.K. and Farrell-Beck, J. (1997) 'Menstrual Products Patented in the United States, 1854–1921', *The Journal of the Costume Society of America*, 24(1), pp. 27–42. Available at: https://doi.org/10.1179/036121197805298017.

Kilpela, L.S. *et al.* (2015) 'Body Image in Adult Women: Moving Beyond the Younger Years', *Advances in Eating Disorders (Abingdon, England)*, 3(2), pp. 144–164. Available at: https://doi.org/10.1080/21662630.2015.1012728.

Kim, H.S., Kim, J.M. and Ashdown, S.P. (2014) 'A Comparison Study of Brassiere Preferences and Breast Perceptions among the Middle-aged and Older US Women', *International Journal of Human Ecology*, 15(2), pp. 33–41. Available at: http://dx.doi.org/10.6115/ijhe.2014.15.2.33.

Kimbell, L. (2009) 'Beyond design thinking: Design-as-practice and designs-in-practice', in. *CRESC Conference*, Manchester, pp. 1–15. Available at: https://codecamp.com.br/artigos_cientificos/beyond_design_thinking.pdf (Accessed: 8 November 2022).

Kimbell, L. (2011) 'Rethinking Design Thinking: Part I', *Design and Culture*, 3(3), pp. 285–306. Available at: https://doi.org/10.2752/175470811X13071166525216.

Kincade, D.H., Regan, C. and Gibson, F.Y. (2007) 'Concurrent engineering for product development in mass customization for the apparel industry', *International Journal of Operations & Production Management*, 27(6), pp. 627–649. Available at: https://doi.org/10.1108/01443570710750295.

Kirkland, T. (2023) 'Performative Elegance: The Windrush Generation, Fashion and the Politics of Respectability', in R. Mahawatte and J. Willson (eds) *Dangerous Bodies: New Global Perspectives on Fashion and Transgression*. Cham: Springer International Publishing (Palgrave Studies in Fashion and the Body), pp. 147–166. Available at: https://doi.org/10.1007/978-3-031-06208-7_8.

Kirstein, T. (2013) 'The future of smart-textiles development: new enabling technologies, commercialization and market trends', in Tünde Kirstein (ed.) *Multidisciplinary Know-How for Smart-Textiles Developers*. Woodhead Publishing (Woodhead Publishing Series in Textiles), pp. 1–25. Available at: https://doi.org/10.1533/9780857093530.1.

Kitzinger, J. (1994) 'The methodology of Focus Groups: the importance of interaction between research participants', *Sociology of Health & Illness*, 16(1), pp. 103–121. Available at: https://doi.org/10.1111/1467-9566.ep11347023.

van Kleef, E., van Trijp, H.C.M. and Luning, P. (2005) 'Consumer research in the early stages of new product development: a critical review of methods and techniques', *Food Quality and Preference*, 16(3), pp. 181–201. Available at: https://doi.org/10.1016/j.foodqual.2004.05.012.

Klepp, I.G. and Rysst, M. (2017) 'Deviant Bodies and Suitable Clothes', *Fashion Theory*, 21(1), pp. 79–99. Available at: https://doi.org/10.1080/1362704X.2016.1138658.

Klepp, I.G. and Storm-Mathisen, A. (2005) 'Reading Fashion as Age: Teenage Girls' and Grown Women's Accounts of Clothing as Body and Social Status', *Fashion Theory*, 9(3), pp. 323–342. Available at: https://doi.org/10.2752/136270405778051329.

Kline, R.B. (2004) *Principles and Practice of Structural Equation Modeling, Second Edition*. 2nd edn. New York: The Guilford Press.

Ko, E., Sung, H. and Yun, H. (2009) 'Comparative Analysis of Purchase Intentions Toward Smart Clothing Between Korean and U.S. Consumers', *Clothing and Textiles Research Journal*, 27(4), pp. 259–273. Available at: https://doi.org/10.1177/0887302X08327086.

Koberg, D. and Bagnall, J. (1981) *The all new universal traveler: A soft-systems guide to creativity, problem-solving, and the process of reaching goals*. Rev edition. Los Altos, Calif: W. Kaufmann.

Koff, E. and Benavage, A. (1998) 'Breast Size Perception and Satisfaction, Body Image, and Psychological Functioning in Caucasian and Asian American College Women', *Sex Roles*, 38(7–8), pp. 655–673. Available at: https://doi.org/10.1023/A:1018802928210.

Kolb, D.A. (1984) *Experiential Learning: Experience as the Source of Learning and Development*. Englewood Cliffs, NJ: Prentice-Hall.

Kolko, J. (2010) 'Sensemaking and Framing: A Theoretical Reflection on Perspective in Design Synthesis', *DRS Biennial Conference Series* [Preprint]. Available at: https://dl.designresearchsociety.org/drs-conference-papers/drs2010/researchpapers/67.

Kongahage, D. and Foroughi, J. (2019) 'Actuator Materials: Review on Recent Advances and Future Outlook for Smart Textiles', *Fibers*, 7(3), p. 21. Available at: https://doi.org/10.3390/fib7030021.

Koskinen, I., Binder, F.T. and Redström, J. (2008) 'Lab, Field, Gallery, and Beyond', *Artifact*, 2(1), pp. 46–57. Available at: https://doi.org/10.1080/17493460802303333.

Koskinen, I., Mattelmaki, T. and Battarbee, K. (2003) *Empathic Design: User Experience in Product Design*. Edita, Finland: IT Press,Finland.

Kouprie, M. and Sleeswijk Visser, F. (2009) 'A framework for empathy in design: stepping into and out of the user's life', *Journal of Engineering Design*, 20(5), pp. 437–448. Available at: https://doi.org/10.1080/09544820902875033.

Kozar, J.M. (2010) 'Women's responses to fashion media images: a study of female consumers aged 30–59', *International Journal of Consumer Studies*, 34(3), pp. 272–278. Available at: https://doi.org/10.1111/j.1470-6431.2009.00854.x.

Kracht, C.L. *et al.* (2022) '"It just seems like people are talking about menopause, but nobody has a solution": A qualitative exploration of menopause experiences and preferences for weight management among Black women', *Maturitas*, 157, pp. 16–26. Available at: https://doi.org/10.1016/j.maturitas.2021.11.005.

Krenzer, G., Starr, C. and Branson, D. (2005) 'Development of a Sports Bra Prototype: Patternworks International Best Solution to a Patternmaking Problem, 2000', *Clothing and Textiles Research Journal*, 23(2), pp. 131–134. Available at: https://doi.org/10.1177/0887302X0502300206.

Krishnan, M. (2014) *Indian engineers design electric anti-rape bra | DW | 22.07.2014*, *DW.COM*. Available at: https://www.dw.com/en/indian-engineers-design-electric-anti-rape-bra/a-17798277 (Accessed: 22 October 2018).

Kumar, P.S. *et al.* (2012) 'Nanocomposite electrodes for smartphone enabled healthcare garments: e-bra and smart vest', in *Nanosystems in Engineering and Medicine*. *Nanosystems in Engineering and Medicine*, SPIE, pp. 79–86. Available at: https://doi.org/10.1117/12.946029.

Kunieda, M. (2019) 'Designing for Meaningfulness in Life: creating new meaning in products and services to enhance psychological meaningfulness'. Available at: https://aaltodoc.aalto.fi:443/handle/123456789/39044 (Accessed: 2 July 2022).

Kwon, S. *et al.* (2014) 'CardioGuard: A Brassiere-Based Reliable ECG Monitoring Sensor System for Supporting Daily Smartphone Healthcare Applications', *Telemedicine Journal and e-Health*, 20(12), pp. 1093–1102. Available at: https://doi.org/10.1089/tmj.2014.0008.

LaBat, K.L. and Sokolowski, S.L. (1999) 'A Three-Stage Design Process Applied to an Industry-University Textile Product Design Project', *Clothing and Textiles Research Journal*, 17(1), pp. 11–20. Available at: https://doi.org/10.1177/0887302X9901700102.

Lam, C. (2005) 'Seamless technology: trend and market.', *Journal for Asia on Textile and Apparel*, 16(4), pp. 32–34.

Lamb, J.M. and Kallal, M.J. (1992) 'A Conceptual Framework for Apparel Design', *Clothing and Textiles Research Journal*, 10(2), pp. 42–47. Available at: https://doi.org/10.1177/0887302X9201000207.

Lamba, C. (2019) 'Wacoal to introduce 3D high-tech machines in select stores', *Indiaretailing.com*, 30 April. Available at: https://www.indiaretailing.com/2019/04/30/fashion/wacoal-to-introduce-3d-high-tech-machines-in-select-stores/ (Accessed: 12 September 2021).

Lamkin, P. (2014) *Victoria's Secret Incredible bra wants a piece of your heart*, *Wareable*. Available at: https://www.wareable.com/smart-clothing/victorias-secret-sports-bra-heart-rate-monitor (Accessed: 11 September 2021).

Lan, L. *et al.* (2018) 'Local body cooling to improve sleep quality and thermal comfort in a hot environment', *Indoor Air*, 28(1), pp. 135–145. Available at: https://doi.org/10.1111/ina.12428.

Langenhove, L.V. and Hertleer, C. (2004) 'Smart clothing: a new life', *International Journal of Clothing Science and Technology*, 16(1/2), pp. 63–72. Available at: https://doi.org/10.1108/09556220410520360.

Latour, B. (2004) 'On using ANT for studying information systems: A (somewhat) socratic dialogue', in F. Land (ed.) *The Social Study of Information and Communication Technology: Innovation, Actors, and Contexts*. OUP Oxford.

Latour, B. (2005) *Reassembling the Social: An Introduction to Actor-Network-Theory*. Oxford, England: Oxford University Press.

Latteier, C. (1998) *Breasts: The Women's Perspective on an American Obsession*. Routledge.

Lau, F. and Yu, W. (2016) 'Seamless knitting of intimate apparel', in Winnie Yu (ed.) *Advances in Women's Intimate Apparel Technology*. Cambridge, U.K.: Woodhead Publishing (Woodhead Publishing Series in Textiles), pp. 55–68. Available at: https://doi.org/10.1016/B978-1-78242-369-0.00004-9.

Lau, N. *et al.* (2020) 'Yoga bra design for elderly women', in J. Yip (ed.) *Latest Material and Technological Developments for Activewear*. Woodhead Publishing (The Textile Institute Book Series), pp. 173–192. Available at: https://doi.org/10.1016/B978-0-12-819492-8.00009-0.

Laurent, G. and Kapferer, J.-N. (1985) 'Measuring Consumer Involvement Profiles', *Journal of Marketing Research*, 22(1), pp. 41–53. Available at: https://doi.org/10.1177/002224378502200104.

Lavrakas, P. (2008) 'Closed-Ended Question', in P. Lavrakas (ed.) *Encyclopedia of Survey Research Methods*. 2455 Teller Road, Thousand Oaks California 91320 United States of America: Sage Publications, Inc. Available at: https://doi.org/10.4135/9781412963947.n65.

Lawson, B. (2006) *How Designers Think: The Design Process Demystified*. Routledge.

Lawson, B. and Dorst, K. (2009) *Design Expertise*. 1st edn. London: Routledge. Available at: https://doi.org/10.4324/9781315072043.

Lazaro Vasquez, E.S. (2019) 'Auto-adjustable Bra for Women with a Pronounced Alteration in Breast Volume', in *Proceedings of the Thirteenth International Conference on Tangible, Embedded, and Embodied Interaction*. New York, NY, USA: Association for Computing Machinery (TEI '19), pp. 429–435. Available at: https://doi.org/10.1145/3294109.3300982.

Lee, A.L. and Han, H. (2020) 'Analysis of Domestic Patent Trends Related to Functional Clothing Products for Daily Wearable Human Body Protection and Correction', *Journal of the Korean Society of Clothing and Textiles*, 44(4), pp. 764–775. Available at: https://doi.org/10.5850/JKSCT.2020.44.4.764.

Lee, C. *et al.* (2021) 'Analysis of dynamic vertical breast displacement for the design of seamless moulded bras', *The Journal of The Textile Institute*, 0(0), pp. 1–10. Available at: https://doi.org/10.1080/00405000.2021.1896452.

Lee, C.W. (2020) *Ergonomic design of supportive moulded bras*. PhD Thesis. Hong Kong Polytechnic University. Available at: https://theses.lib.polyu.edu.hk/handle/200/10647 (Accessed: 29 September 2021).

Lee, E. and Park, H. (2017) '3D Virtual fit simulation technology: strengths and areas of improvement for increased industry adoption: International Journal of Fashion Design, Technology and Education: Vol 10, No 1', *International Journal of Fashion Design, Technology and Education*, 10(1). Available at: https://doi.org/10.1080/17543266.2016.1194483.

Lee, E.-Y., Choi, H.-S. and Do, W.-H. (2013) 'A Study on Present State of Technical Designers' Work Responsibilities and Training Conditions -Targeting Technical Designers Working for Clothing Vendors and Agents-', *Journal of the Korean Society of Clothing and Textiles*, 37(3), pp. 292–305. Available at: https://doi.org/10.5850/JKSCT.2013.37.3.292.

Lee, N. (2021) *Wacoal's AI-powered myBraFit app scans your body to give you sizing advice*, *Engadget*. Available at: https://www.engadget.com/wacoal-mybrafit-app-120010227.html (Accessed: 11 September 2021).

Lee, S. *et al.* (2021) 'Implementation of an Automated Manufacturing Process for Smart Clothing: The Case Study of a Smart Sports Bra', *Processes*, 9(2), p. 289. Available at: https://doi.org/10.3390/pr9020289.

Lee, Y., Hwang, C. and Baytar, F. (2018) 'Exploring apparel design and fit for older women: a technology intervention', *International Journal of Fashion Design, Technology and Education*, 0(0), pp. 1–10. Available at: https://doi.org/10.1080/17543266.2018.1496482.

Levin, R. and Meston, C. (2006) 'Nipple/Breast stimulation and sexual arousal in young men and women', *The Journal of Sexual Medicine*, 3(3), pp. 450–454. Available at: https://doi.org/10.1111/j.1743-6109.2006.00230.x.

Lewis, C.M. (2023) 'A methodology for the effective specification of garments with integrated wearable technology', in J. McCann and D. Bryson (eds) *Smart Clothes and Wearable Technology*. 2nd edn. Cambridge; Kidlington: Woodhead Publishing (The Textile Institute Book Series), pp. 405–445. Available at: https://doi.org/10.1016/B978-0-12-819526-0.00009-6.

Li, B. *et al.* (2017) 'LightingHair Slice: Situated Personal Wearable Fashion Interaction System', in *Proceedings of the 2017 CHI Conference Extended Abstracts on Human Factors in Computing Systems*. New York, NY, USA: Association for Computing Machinery (CHI EA '17), pp. 1824–1828. Available at: https://doi.org/10.1145/3027063.3053093.

Li, H. *et al.* (2016) 'Examining individuals' adoption of healthcare wearable devices: An empirical study from privacy calculus perspective', *International Journal of Medical Informatics*, 88, pp. 8–17. Available at: https://doi.org/10.1016/j.ijmedinf.2015.12.010.

Li, T. (2018) *Cueme -Vibrating underwear for couples & solo play*, *Indiegogo*. Available at: https://www.indiegogo.com/projects/2266296 (Accessed: 7 November 2022).

Liang, X. (2008) *An investigation into the pressures and sensations caused by wearing a bra and the influence of these on bra fitting*. Ph.D. Thesis. De Montfort University. Available at: https://www.dora.dmu.ac.uk/xmlui/handle/2086/4810 (Accessed: 28 February 2018).

Liao, C.-S. and Lee, C.-W. (2010) 'The application of codesign in new bra product innovations', *International Journal of Clothing Science and Technology*, 22(2/3), pp. 211–227. Available at: https://doi.org/10.1108/09556221011018676.

Liechty, T. (2012) "'Yes, I worry about my weight … but for the most part I'm content with my body": Older Women's Body Dissatisfaction Alongside Contentment', *Journal of Women & Aging*, 24(1), pp. 70–88. Available at: https://doi.org/10.1080/08952841.2012.638873.

Light, A. (2006) 'Adding method to meaning: A technique for exploring peoples' experience with technology', *Behaviour & Information Technology*, 25(2), pp. 175–187. Available at: https://doi.org/10.1080/01449290500331172.

Lillington, L., Johnson, I. and Chlebowski, R. (2000) 'African-American Women's Perspectives on Research Participation', *Medicine of the Americas*, 1(1), pp. 20–20.

Lim, H. and Cho, H. (2013) 'Designs for Development of Bra Tops for the New Senior Generation', *Fashion & Textile Research Journal*, 15(3), pp. 358–363. Available at: https://doi.org/10.5805/SFTI.2013.15.3.358.

Lin, C.-F. (2012) 'Brassiere structure'. Available at: https://patents.google.com/patent/US20120244783A1/en?oq=US20120244783A1 (Accessed: 12 September 2021).

Lin, M. (2020) *Interfashionality: Body-oriented parametric design and parametric thinking 2.0 for 3D-printed textiles and fashion*. Ph.D. Thesis. Royal College of Art. Available at: https://doi.org/10/7.Parametric%20design%20process%20%28p342%29.mp4.

Lincoln, Y.S. and Guba, E.G. (1985) *Naturalistic Inquiry*. SAGE Publications, Inc.

Lindland, K.M. (2022) 'Re-framing design and designers: Studying design processes through a pragmatist lens', in *DRS Biennial Conference Series. DRS2022: Bilbao*, Bilbao, Spain, pp. 1–13. Available at: https://doi.org/10.21606/drs.2022.567.

Linti, C. *et al.* (2022) 'Intelligent Garment based ECG Monitoring with AI support for Elderly: Special Requirements for Seniors in the Home Environment', *Current Directions in Biomedical Engineering*, 8(2), pp. 793–796. Available at: https://doi.org/10.1515/cdbme-2022-1202.

Liu, K. *et al.* (2018) 'Smart Bra and Protective System Comprising Smart Bra'. China. Available at: https://worldwide.espacenet.com/publicationDetails/biblio?FT=D&date=20181023&DB=&locale=en_EP&CC=CN&NR=108697182A&KC=A&ND=4 (Accessed: 18 June 2019).

Liu, K. *et al.* (2019) 'An analysis of influence factors of sports bra comfort evaluation based on different sizes', *The Journal of The Textile Institute*, 110(12), pp. 1792–1799. Available at: https://doi.org/10.1080/00405000.2019.1620513.

Looney, A.C., Kumar, S.S. and Vazquez Ortiz, A.C. (2018) 'Automated Compression Nursing And Pumping System'. Wilmington , DE. Available at: https://patents.google.com/patent/US20180126052A1/en?oq=US20180126052A1 (Accessed: 11 September 2021).

Lopez, G. *et al.* (2018) 'Development and Evaluation of a Low-Energy Consumption Wearable Wrist Warming Device', *International Journal of Automation Technology*, 12(6), pp. 911–920. Available at: https://doi.org/10.20965/ijat.2018.p0911.

Lovejoy, M. (2001) 'Disturbances in the Social Body: Differences in Body Image and Eating Problems among African American and white Women', *Gender & Society*, 15(2), pp. 239–261. Available at: https://doi.org/10.1177/089124301015002005.

Lovel, K. *et al.* (2006) 'The Application of TRIZ to Technology Forecasting - A Case Study: Brassiere Strap Technology', *The Triz Journal* [Preprint]. Available at: https://triz-journal.com/application-triz-technology-forecasting-case-study-brassiere-strap-technology/ (Accessed: 10 June 2019).

Lövgren, K. (2016) 'Comfortable and leisurely: Old women on style and dress', *Journal of Women & Aging*, 28(5), pp. 372–385. Available at: https://doi.org/10.1080/08952841.2015.1018029.

Luenendonk, M. (2015) *18 Best Idea Generation Techniques*, *Cleverism*. Available at: https://www.cleverism.com/18-best-idea-generation-techniques/ (Accessed: 24 February 2022).

Luk, N. and Yu, W. (2016) 'Bra fitting assessment and alteration', in Winnie Yu (ed.) *Advances in Women's Intimate Apparel Technology*. Woodhead Publishing (Woodhead Publishing Series in Textiles), pp. 109–133. Available at: https://doi.org/10.1016/B978-1-78242-369-0.00007-4.

Lynch, A. (2015) 'There's a new vibrating bra that claims to make your boobs grow', *Metro*, 4 September. Available at: https://metro.co.uk/2015/09/04/the-vibrating-e-bra-promises-to-make-your-boobs-grow-in-just-seven-days-5375842/ (Accessed: 10 October 2022).

Mackey, A. *et al.* (2019) 'Satisfying a Conversation with Materials for Dynamic Fabrics', in *Proceedings of the 2019 on Designing Interactive Systems Conference*. New York, NY, USA: Association for Computing Machinery (DIS '19), pp. 1047–1058. Available at: https://doi.org/10.1145/3322276.3322371.

MacMaster, M. (2012) 'Performing Mrs. Whistler: Women, Image and Identity', in J. Dolan and E. Tincknell (eds) *Aging Femininities: Troubling Representations*. New Castle upon Tyne, U.K.: Cambridge Scholars Publishing, pp. 43–52.

MacQueen, K.M. *et al.* (1998) 'Codebook Development for Team-Based Qualitative Analysis', *CAM Journal*, 10(2), pp. 31–36. Available at: https://doi.org/10.1177/1525822X980100020301.

Mahmood, N. and Lee, Y.-A. (2021) 'Factors Influencing Older Adults' Acceptance of Health Monitoring Smart Clothing', *Family and Consumer Sciences Research Journal*, 49(4), pp. 376–392. Available at: https://doi.org/10.1111/fcsr.12404.

Mair, C. (2018) *The Psychology of Fashion*. Milton, UNITED KINGDOM: Taylor & Francis Group. Available at: http://ebookcentral.proquest.com/lib/ual/detail.action?docID=5303445 (Accessed: 5 May 2020).

Mäkelä, A.M. and Nimkulrat, N. (2011) 'Reflection and Documentation in Practice-led Design Research', *Nordes*, (4), pp. 1–9.

Mäkelä, M. (2007) 'Knowing Through Making: The Role of the Artefact in Practice-led Research', *Knowledge, Technology & Policy*, 20(3), pp. 157–163. Available at: https://doi.org/10.1007/s12130-007-9028-2.

Mama, S.K. *et al.* (2011) 'Body image and physical activity among Latina and African American women', *Ethnicity & Disease*, 21(3), pp. 281–287.

Mamykina, L., Candy, L. and Edmonds, E. (2002) 'Collaborative creativity', *Communications of the ACM*, 45(10), pp. 96–99. Available at: https://doi.org/10.1145/570907.570940.

Mangum, A. (2021) 'The $600 Billion Market for Women in Menopause Is Fit for Disruption', *Bloomberg.com*, 28 March. Available at: https://www.bloomberg.com/news/articles/2021-03-28/womaness-menopause-beauty-products-line-to-be-sold-at-target-tgt-stores (Accessed: 24 October 2022).

Manuel, K. (2014) 'Co-founder of innovative bra that stuns would-be rapists feted by President Pranab Mukherjee in New Delhi', *The American Bazaar*, 15 July. Available at: https://www.americanbazaaronline.com/2014/07/15/co-founder-innovative-bra-stuns-rapists-feted-president-pranab-mukherjee-new-delhi/ (Accessed: 11 September 2021).

Manufacturing a Bra In Lean Setup (2012) *Apparel Resources*. Available at: https://apparelresources.com/business-news/manufacturing/manufacturing-bra-lean-setup/ (Accessed: 28 November 2022).

Marchant, D. (2016) 'The design brief: Requirements and compliance.', *J. Inf. Technol. Constr.*, 21, pp. 337–353.

Markson, E.W. (2003) 'The Female Aging Body through Film', in C.A. Faircloth (ed.) *Aging Bodies: Images and Everyday Experience*. Maryland, U.S.: Rowman & Littlefield Publishers, Inc, pp. 77–102.

Markussen, T. (2017) 'Building Theory Through Design', in L. Vaughan (ed.) *Practice-based design research*. London: Bloomsbury Academic.

Marti, P. and Bannon, L.J. (2009) 'Exploring User-Centred Design in Practice: Some Caveats', *Knowledge, Technology & Policy*, 22(1), pp. 7–15. Available at: https://doi.org/10.1007/s12130-009-9062-3.

Mascitelli, R. (2000) 'From Experience: Harnessing Tacit Knowledge to Achieve Breakthrough Innovation', *Journal of Product Innovation Management*, 17(3), pp. 179–193. Available at: https://doi.org/10.1111/1540-5885.1730179.

Masry, Z.A. *et al.* (2021) 'Early detection of breast cancer: study of the socio-technical impact of an "intelligent" bra', *Sante Publique*, 33(4), pp. 473–482.

Mattelmäki, T. (2006) *Design probes*. Ph.D. Thesis. Aalto University. Available at: https://aaltodoc.aalto.fi:443/handle/123456789/11829 (Accessed: 8 November 2022).

Mattelmäki, T. and Battarbee, K. (2002) 'Empathy Probes', in *Proceedings of the Participation Design Conference. CPSR*, Palo Alto CA, pp. 266–271.

Matthews, D. (2020) *The Black woman student experience: Black identity, activism, and fashion on the college campus*. Masters of Science. Iowa State University. Available at: https://dr.lib.iastate.edu/entities/publication/7435dd20-12de-4940-8fc0-8129e6651f6f (Accessed: 27 October 2022).

Maxwell, J.A. (2013) *Qualitative research design: an interactive approach*. 3rd edition. Los Angeles, California: SAGE (Applied social research methods series, 41).

McCann, J. (2014a) 'Design for ageing well', in A. Gwilt (ed.) *Fashion Design for Living*. 1st Edition. London: Routledge. Available at: https://doi.org/10.4324/9781315770758.

McCann, J. (2014b) 'Older consumers: understanding sizing, body shapes and requirements of apparel for this niche', in M.-E. Faust and S. Carrier (eds) *Designing Apparel for Consumers*. Woodhead Publishing (Woodhead Publishing Series in Textiles), pp. 132–152. Available at: https://doi.org/10.1533/9781782422150.2.132.

McCann, J. (2015a) 'Co-design development: Design direction for the clothing layering system as a wearable technology platform', in *Textile-Led Design for the Active Ageing Population*. Woodhead Publishing (Woodhead Publishing Series in Textiles), pp. 385–423. Available at: https://doi.org/10.1016/B978-0-85709-538-1.00021-3.

McCann, J. (2015b) 'Co-design principles and practice: Working with the active ageing', in *Textile-Led Design for the Active Ageing Population*. Woodhead Publishing (Woodhead Publishing Series in Textiles), pp. 215–243. Available at: https://doi.org/10.1016/B978-0-85709-538-1.00013-4.

McCann, J. (2023) '13 - Identification of design requirements for smart clothes and wearable technology', in J. McCann and D. Bryson (eds) *Smart Clothes and Wearable Technology (Second Edition)*. 2nd edition. Woodhead Publishing (The Textile Institute Book Series), pp. 327–369. Available at: https://doi.org/10.1016/B978-0-12-819526-0.00004-7.

McCann, J. and Bryson, D. (eds) (2014) *Textile-led Design for the Active Ageing Population*. Woodhead Publishing. Available at: https://www.elsevier.com/books/textile-led-design-for-the-active-ageing-population/mccann/978-0-85709-538-1.

McCann, J., Hurford, R. and Martin, A. (2005) 'A design process for the development of innovative smart clothing that addresses end-user needs from technical, functional, aesthetic and cultural view points', in *Ninth IEEE International Symposium on Wearable Computers (ISWC'05). Ninth IEEE International Symposium on Wearable Computers (ISWC'05)*, pp. 70–77. Available at: https://doi.org/10.1109/ISWC.2005.3.

McCarthy, J. and Wright, P. (2004) *Technology as Experience*. Cambridge, Mass: The MIT Press.

McDermid, D. (no date) 'Pragmatism', *Internet Encyclopedia of Philosophy*. Available at: https://iep.utm.edu/pragmati/ (Accessed: 3 September 2022).

Mcdonagh, D. and Storer, I. (2004) 'Mood Boards as a Design Catalyst and Resource: Researching an Under-Researched Area', *The Design Journal*, 7(3), pp. 16–31. Available at: https://doi.org/10.2752/146069204789338424.

McDonagh, D.C. *et al.* (eds) (2004) *Design and Emotion: The Experience of Everyday Things*. New York: Taylor and Francis.

McFatter, R. (2005) *Fashion involvement of affluent female consumers*. Master of Science. Louisiana State University and Agricultural and Mechanical College. Available at: https://digitalcommons.lsu.edu/cgi/viewcontent.cgi?article=4774&context=gradschool_theses (Accessed: 30 January 2018).

McGaw, J.A. (2003) 'Why Feminine Technologies Matter', in N.E. Lerman, R. Oldenziel, and A.P. Mohun (eds) *Gender and Technology: A Reader*. The Johns Hopkins University Press, pp. 13–36.

McGhee, D.E. and Steele, J.R. (2010) 'Optimising breast support in female patients through correct bra fit. A cross-sectional study', *Journal of Science and Medicine in Sport*, 13(6), pp. 568–572. Available at: https://doi.org/10.1016/j.jsams.2010.03.003.

McKinney, E. *et al.* (2017) 'Solaris: A unisex solar-powered jacket for the day hiker', *International Textile and Apparel Association Annual Conference Proceedings*, 74(1). Available at: https://www.iastatedigitalpress.com/itaa/article/id/1734/ (Accessed: 4 November 2022).

McLaren, L. and Kuh, D. (2004a) 'Body Dissatisfaction in Midlife Women', *Journal of Women & Aging*, 16(1–2), pp. 35–54. Available at: https://doi.org/10.1300/J074v16n01_04.

McLaren, L. and Kuh, D. (2004b) 'Women's body dissatisfaction, social class, and social mobility', *Social Science & Medicine (1982)*, 58(9), pp. 1575–1584. Available at: https://doi.org/10.1016/S0277-9536(03)00209-0.

McQuillan, H. (2020) 'Digital 3D design as a tool for augmenting zero-waste fashion design practice', *International Journal of Fashion Design, Technology and Education*, 13(1), pp. 89–100. Available at: https://doi.org/10.1080/17543266.2020.1737248.

Melancon, T. (2015) *Black Female Sexualities*. New Brunswick: Rutgers University Press. Available at: https://muse.jhu.edu/book/39211 (Accessed: 3 July 2022).

Melles, G. (2008) 'An Enlarged Pragmatist Inquiry Paradigm for Methodological Pluralism in Academic Design Research', *Artifact*, 2(1), pp. 3–13. Available at: https://doi.org/10.1080/17493460802276786.

Menheere, D. *et al.* (2018) 'Encouraging physical activity and self-enhancement in women with breast cancer through a smart bra', in *DRS: Design Research Society 2018. 2018: Design Research Society*, Limerick, Ireland. Available at: https://doi.org/10.21606/DRS.2018.437.

Mida, I. and Casey, S. (2020) 'Drawing as a Creative Approach to Researching Extant Garments: A Case Study Involving John Ruskin's Clothing', *Costume*, 54(2), pp. 202–221. Available at: https://doi.org/10.3366/cost.2020.0164.

Millar, H.M. (1873) 'Improvement in bosom-pads'. Louisville, Kentucky. Available at: https://patents.google.com/patent/US143921A/en?q=A41C3%2f00&before=priority:19601231&after=priority:18600101&num=100&sort=old (Accessed: 27 October 2022).

Miller, F.G., Davis, L.L. and Rowold, K.L. (1982) 'Public Self-Consciousness, Social Anxiety, and Attitudes Toward the Use of Clothing', *Home Economics Research Journal*, 10(4), pp. 363–368. Available at: https://doi.org/10.1177/1077727X8201000407.

Milligan, L. (2016) 'Insider-outsider-inbetweener? Researcher positioning, participative methods and cross-cultural educational research', *Compare: A Journal of Comparative and International Education*, 46(2), pp. 235–250. Available at: https://doi.org/10.1080/03057925.2014.928510.

Millsted, R. and Frith, H. (2003) 'Being large-breasted: women negotiating embodiment', *Women's Studies International Forum*, 26(5), pp. 455–465. Available at: https://doi.org/10.1016/j.wsif.2003.08.003.

Mohan, M., Sra, M. and Schmandt, C. (2017) 'Technological interventions to detect, communicate and deter sexual assault', in *Proceedings of the 2017 ACM International Symposium on Wearable Computers*. New York, NY, USA: Association for Computing Machinery (ISWC '17), pp. 126–129. Available at: https://doi.org/10.1145/3123021.3123031.

Mohylsky, D.W. (2011) *Invisible Woman Mature Female Consumers 50 to 64*. PhD Thesis. Florida State University. Available at: https://diginole.lib.fsu.edu/islandora/object/fsu%3A180568/ (Accessed: 27 October 2022).

Molla, Md.T.I., Compton, C. and Dunne, L.E. (2018) 'Launderability of surface-insulated cut and sew E-textiles', in *Proceedings of the 2018 ACM International Symposium on Wearable Computers*. New York, NY, USA:

Association for Computing Machinery (ISWC '18), pp. 104–111. Available at: https://doi.org/10.1145/3267242.3267255.

Molloy, B.L. and Herzberger, S.D. (1998) 'Body Image and Self-Esteem: A Comparison of African-American and Caucasian Women', *Sex Roles*, 38(7), pp. 631–643. Available at: https://doi.org/10.1023/A:1018782527302.

Molloy, B.L. and Herzberger, S.D. (2002) *Body image and self-esteem: A comparison of African-American and Caucasian women*. Needham Heights, MA, US: Allyn & Bacon (Readings in the psychology of gender: Exploring our differences and commonalities).

Mondalek, A. (2019) 'Fashion Industry Burnout Is the Trend No One Wants to See Stick Around', *Fashionista*, 30 May. Available at: https://fashionista.com/2019/05/fashion-industry-burnout-trend (Accessed: 7 March 2023).

Montemurro, B. and Gillen, M.M. (2013) 'Wrinkles and sagging flesh: exploring transformations in women's sexual body image', *Journal of Women & Aging*, 25(1), pp. 3–23. Available at: https://doi.org/10.1080/08952841.2012.720179.

Moreno, M.-V. and Herrera, E. (2019) 'Evaluation on Phantoms of the Feasibility of a Smart Bra to Detect Breast Cancer in Young Adults', *Sensors*, 19(24), p. 5491. Available at: https://doi.org/10.3390/s19245491.

Morris, K. and Ashdown, S.P. (2015) 'In Practice: Perceptions of User Involvement in the Activewear Industry', in *International Textile and Apparel Association Annual Conference Proceedings*. Iowa State University Digital Press, pp. 1–2. Available at: https://www.iastatedigitalpress.com/itaa/article/id/2469/ (Accessed: 15 December 2023).

Morris, K.D. (2011) *Collaborative Product Development: Examining the Development of a Nursing Sports Bra*. Master of Science. Colorado State University. Available at: https://dspace.library.colostate.edu/bitstream/handle/10217/47405/Morris_colostate_0053N_10399.pdf?sequence=1 (Accessed: 31 January 2018).

Morris, N. (2021) 'M&S launches inclusive "nude" underwear with darker skin tones', *Metro Lifestyle*, 22 June. Available at: https://metro.co.uk/2021/06/22/ms-launches-inclusive-nude-underwear-with-darker-skin-tones-14809138/ (Accessed: 27 October 2022).

Mou, H.-J. *et al.* (2020) 'Intelligent bra'. Taiwan. Available at: https://patents.google.com/patent/US20200196683A1/en?q=%22intelligent+bra%22&oq=%22intelligent+bra%22 (Accessed: 4 January 2023).

Munasinghe, P.D., Dissanayake, D.G.K. and Druckman, A. (2021) 'An investigation of the mass-market fashion design process', *Research Journal of Textile and Apparel*, ahead-of-print(ahead-of-print). Available at: https://doi.org/10.1108/RJTA-08-2020-0089.

Murray, E. (1899) 'Breast-shield'. Deadwood, South Dakota. Available at: https://patents.google.com/patent/US623413A/en?oq=US623413A (Accessed: 7 November 2022).

Muthén, L.K. and Muthén, B.O. (2002) 'How to Use a Monte Carlo Study to Decide on Sample Size and Determine Power', *Structural Equation Modeling: A Multidisciplinary Journal*, 9(4), pp. 599–620. Available at: https://doi.org/10.1207/S15328007SEM0904_8.

Na, M.-H. (2009) 'A Study on the Development of Brassiere Pattern for Elderly Women', *Korean Journal of Human Ecology*, 18(2), pp. 397–406. Available at: https://doi.org/10.5934/KJHE.2009.18.2.397.

Nanda, S. (2019) 'Re-Framing Hottentot: Liberating Black Female Sexuality from the Mammy/Hottentot Bind', *Humanities*, 8(4), p. 161. Available at: https://doi.org/10.3390/h8040161.

Naugler, D. (2009) 'Credentials: Breast Slang and the Discourse of Femininity', *Atlantis: Critical Studies in Gender, Culture & Social Justice*, 34(1), pp. 100–110.

Navalta, J.W. *et al.* (2020) 'Validity and Reliability of Three Commercially Available Smart Sports Bras during Treadmill Walking and Running', *Scientific Reports*, 10(1), p. 7397. Available at: https://doi.org/10.1038/s41598-020-64185-z.

Nazarpour, S. *et al.* (2021) 'The relationship between postmenopausal women's body image and the severity of menopausal symptoms', *BMC public health*, 21(1), p. 1599. Available at: https://doi.org/10.1186/s12889-021-11643-6.

Netemeyer, R.G., Bearden, W.O. and Sharma, S. (2003) *Scaling Procedures: Issues and Applications*. 1st edn. Thousand Oaks, Calif: SAGE Publications.

Neto, A. and Ferreira, J. (2020) 'From Wearing Off to Wearing On: The Meanders of Wearer–Clothing Relationships', *Sustainability*, 12(18), p. 7264. Available at: https://doi.org/10.3390/su12187264.

Newton, Z. *et al.* (2012) 'Physical activity and perception of body image of African American women.', *LARNet - The Cyber Journal of Applied Leisure and Recreation Research*, 15(1), pp. 1–12.

Niedderer, K. and Roworth-Stokes, S. (2007) 'The role and use of creative practice in research and its contribution to knowledge', in *IASDR07. IASDR International Conference*, Hong Kong, pp. 1–18.

Niinimäki, K. (2011) *From Disposable to Sustainable: the Complex Interplay between Design and Consumption of Textiles and Clothing*. Ph.D. Thesis. Aalto University. Available at: https://aaltodoc.aalto.fi:443/handle/123456789/13770 (Accessed: 1 November 2022).

Niinimäki, K. and Armstrong, C. (2013) 'From pleasure in use to preservation of meaningful memories: a closer look at the sustainability of clothing via longevity and attachment', *International Journal of Fashion Design, Technology and Education*, 6(3), pp. 190–199. Available at: https://doi.org/10.1080/17543266.2013.825737.

Niinimäki, K. and Koskinen, I. (2011) 'I Love this Dress, It Makes Me Feel Beautiful! Empathic Knowledge in Sustainable Design', *The Design Journal*, 14(2), pp. 165–186. Available at: https://doi.org/10.2752/175630611X12984592779962.

Nike News (2019) *Celebrating the Sports Bra*, *Nike News*. Available at: https://news.nike.com/news/nike-flyknit-sports-bra (Accessed: 27 June 2019).

Noh, M.-J. and Park, H.-H. (2011) 'Acceptance of the Smart Clothing According to Trend and Information Innovation', *The Journal of the Korea Contents Association*, 11(11), pp. 350–363. Available at: https://doi.org/10.5392/JKCA.2011.11.11.350.

Norman, D.A. (2005) *Emotional Design: Why We Love (or Hate) Everyday Things*. 1st edition. New York, NY: Basic Books.

Nugroho, J. (2013) *A conceptual framework for designing wearable technology*. Ph.D. Thesis. University of Technology Sydney. Available at: https://opus.lib.uts.edu.au/handle/10453/24208 (Accessed: 13 October 2022).

Oberg, P. (2003) 'Images versus Experience of the Aging Body', in C.A. Faircloth (ed.) *Aging Bodies: Images and Everyday Experience*. Maryland, U.S.: Rowman & Littlefield Publishers, Inc, pp. 103–139.

O'Cass, A. (2000) 'An assessment of consumers product, purchase decision, advertising and consumption involvement in fashion clothing', *Journal of Economic Psychology*, 21(5), pp. 545–576. Available at: https://doi.org/10.1016/S0167-4870(00)00018-0.

Oon, I.H. *et al.* (2022) 'Women with larger breasts are less satisfied with their breasts: Implications for quality of life and physical activity participation', *Women's Health*, 18, p. 17455057221109394. Available at: https://doi.org/10.1177/17455057221109394.

van Oorschot, R. *et al.* (2022) 'Participation in design research', *Design Studies*, 78, p. 101073. Available at: https://doi.org/10.1016/j.destud.2021.101073.

Orlando, J.Y. (1979) 'Objectifying apparel design', in *Association of College Professors of Clothing and Textiles. Western Region Meeting*, Denver, Colorado.

Orzada, B.T. and Kallal, M.J. (2021) 'FEA Consumer Needs Model: 25 Years Later', *Clothing and Textiles Research Journal*, 39(1), pp. 24–38. Available at: https://doi.org/10.1177/0887302X19881211.

Ott, R. and Cukier, W. (2013) 'Artisanal Fashion Design: Entrepreneurs on Thinking, Process, and Decision Making', *International Textile and Apparel Association Annual Conference Proceedings*, 70(1), pp. 52–53.

Overbeeke, K.C.J. and Wensveen, S.S.A.G. (2003) 'From perception to experience, from affordances to irresistibles', in *Proceedings of the 2003 international conference on Designing pleasurable products and interfaces*. New York, NY, USA: Association for Computing Machinery (DPPI '03), pp. 92–97. Available at: https://doi.org/10.1145/782896.782919.

Oygür, I. (2018) 'The machineries of user knowledge production', *Design Studies*, 54, pp. 23–49. Available at: https://doi.org/10.1016/j.destud.2017.10.002.

Page, K.-A. and Steele, J.R. (1999) 'Breast Motion and Sports Brassiere Design', *Sports Medicine*, 27(4), pp. 205–211. Available at: https://doi.org/10.2165/00007256-199927040-00001.

Pahl, G. *et al.* (2007) *Engineering Design: A Systematic Approach*. Springer Science & Business Media.

Pailes-Friedman, R. (2016) *Smart Textiles for Designers: Inventing the Future of Fabrics*. Laurence King Publishing.

Pallant, J. (2016) *SPSS Survival Manual*. 6th edn. Maidenhead New York: Open University Press.

Papahristou, E. and Bilalis, N. (2017) 'Should the fashion industry confront the sustainability challenge with 3D prototyping technology', *International Journal of Sustainable Engineering*, 10(4–5), pp. 207–214. Available at: https://doi.org/10.1080/19397038.2017.1348563.

Park, C.-C. and Kim, H.-J. (2009) 'Development Trends of Korean Textile Industry by Analyzing Domestic Patent', *Fashion & Textile Research Journal*, 11(5), pp. 840–845.

Park, C.-C. and Kim, H.-J. (2010) 'Development Trends of Domestic Apparel Design by Analyzing Patent Applications', *Fashion & Textile Research Journal*, 12(4), pp. 508–512. Available at: https://doi.org/10.5805/KSCI.2010.12.4.508.

Park, J. and DeLong, M. (2009) 'Understanding new technology adoption in the apparel and footwear industry within a social framework: a case of rapid prototyping technology', *International Journal of Fashion Design, Technology and Education*, 2(2–3), pp. 101–112. Available at: https://doi.org/10.1080/17543260903349007.

Park, J., Kim, D.-E. and Sohn, M. (2011) '3D simulation technology as an effective instructional tool for enhancing spatial visualization skills in apparel design', *International Journal of Technology and Design Education*, 21(4), pp. 505–517. Available at: https://doi.org/10.1007/s10798-010-9127-3.

Park, J.Y. and Jang, J.A. (2014) 'The Actual Wearing Conditions and Preferences for New Silver Women`s Brassiere', *Fashion & Textile Research Journal*, 16(4), pp. 635–644. Available at: https://doi.org/10.5805/SFTI.2014.16.4.635.

Park, J.Y. and Jang, J.A. (2015) 'A Study on Brassiere Development for the New Silver Generation Women', *Fashion & Textile Research Journal*, 17(3), pp. 429–439. Available at: https://doi.org/10.5805/SFTI.2015.17.3.429.

Park, S.-Y. and Sohn, H.-S. (2001) 'A Study on Elderly Women's Breast Types and Their Brassiere Sizes', *Journal of Fashion Business*, 5(4), pp. 144–157.

Parkins, I. (2020) 'Becoming in the Eyes of Others: The Relational Gaze in Boudoir Photography', in M. Laing and J. Willson (eds) *Revisiting the Gaze: The Fashioned Body and the Politics of Looking*. 1st edition. Bloomsbury Visual Arts, pp. 101–121.

Parsons, J.L. (2015) 'Historical Patents as Inspiration for Digital Textile and Apparel Design', *Clothing and Textiles Research Journal*, 33(4), pp. 280–296. Available at: https://doi.org/10.1177/0887302X15600793.

Patton, M.Q. (1990) *Qualitative Evaluation and Research Methods*. 2nd edition. Thousand Oaks, Calif: SAGE Publications, Inc.

Paulson, S. and Willig, C. (2008) 'Older Women and Everyday Talk about the Ageing Body', *Journal of Health Psychology*, 13(1), pp. 106–120. Available at: https://doi.org/10.1177/1359105307084316.

Pechter, E.A. (2008) 'An Improved Technique for Determining Bra Size with Applicability to Breast Surgery', *Plastic and Reconstructive Surgery*, 121(5), p. 348e. Available at: https://doi.org/10.1097/PRS.0b013e31816b1286.

Perry, A. (2017) 'An Expanded Model to Investigate Smart Clothing's Purchase', in *International Textile and Apparel Association (ITAA) Annual Conference Proceedings. 2017 ITAA Annual Conference Proceedings*. Available at: https://lib.dr.iastate.edu/itaa_proceedings/2017/posters/39.

Perry, A. *et al.* (2017) 'Explore consumer needs and design purposes of smart clothing from designers' perspectives', *International Journal of Fashion Design, Technology and Education*, 10(3), pp. 372–380. Available at: https://doi.org/10.1080/17543266.2016.1278465.

Perry, A. (2018) 'Exploring from creators' perspectives issues and solutions about knowledge, difficulties, and disposal in making smart clothing designs', *International Journal of Fashion Design, Technology and Education*, 11(1), pp. 129–137. Available at: https://doi.org/10.1080/17543266.2017.1332246.

Peters, C., Shelton, J.A. and Thomas, J.B. (2011) 'Self-concept and the fashion behavior of women over 50', *Journal of Fashion Marketing and Management: An International Journal*, 15(3), pp. 291–305. Available at: https://doi.org/10.1108/13612021111151905.

Peters, L.D. (2014) 'You Are What You Wear: How Plus-Size Fashion Figures in Fat Identity Formation', *Fashion Theory*, 18(1), pp. 45–71. Available at: https://doi.org/10.2752/175174114X13788163471668.

Peteu, M.C. and Helvenston Gray, S. (2009) 'Clothing Invention: Improving the Functionality of Women's Skirts, 1846-1920', *Clothing and Textiles Research Journal*, 27(1), pp. 45–61. Available at: https://doi.org/10.1177/0887302X08322718.

Petri, G. and Greinke, B. (2021) 'Measuring Pleated Knitted Sensors', *Proceedings*, 68(1), p. 10. Available at: https://doi.org/10.3390/proceedings2021068010.

Pettigrew, A.M. (1997) 'What is a processual analysis?', *Scandinavian Journal of Management*, 13(4), pp. 337–348. Available at: https://doi.org/10.1016/S0956-5221(97)00020-1.

Pink, S. (2020) 'A Multisensory Approach to Visual Methods', in Pauwels, L. and Mannay, D., *The SAGE Handbook of Visual Research Methods*. City Road, London: SAGE Publications, Inc., pp. 523–533. Available at: https://doi.org/10.4135/9781526417015.n33.

Postma, C.E. *et al.* (2012) 'Challenges of Doing Empathic Design: Experiences from Industry', *International Journal of Design*, 6(1), pp. 59–70.

Pottenger, M.D. (2001) 'Piezoelectrically controlled active wear'. Available at: https://patents.google.com/patent/US6198204B1/en?oq=US6198204B1 (Accessed: 11 September 2021).

Prahl, A. (2015) *Designing wearable sensors for Preventative Health: An exploration of material, form and function*. Ph.D. University of the Arts London. Available at: http://ualresearchonline.arts.ac.uk/9077/ (Accessed: 2 June 2017).

Price, M. C. and Lewis, C.M. (2015) '22 - Developing a strategy for the effective specification of functional clothing with integrated wearable technology', in *Textile-Led Design for the Active Ageing Population*. Woodhead Publishing (Woodhead Publishing Series in Textiles), pp. 425–467. Available at: https://doi.org/10.1016/B978-0-85709-538-1.00022-5.

Price, M.C. and Lewis, C.M. (2015) 'Developing a strategy for the effective specification of functional clothing with integrated wearable technology', in J. McCann and D. Bryson (eds) *Textile-Led Design for the Active Ageing Population*. Cambridge, U.K.: Woodhead Publishing (Woodhead Publishing Series in Textiles), pp. 425–466. Available at: https://doi.org/10.1016/B978-0-85709-538-1.00021-3.

Prochner, I. and Godin, D. (2022) 'Quality in research through design projects: Recommendations for evaluation and enhancement', *Design Studies*, 78, p. 101061. Available at: https://doi.org/10.1016/j.destud.2021.101061.

Quinn, B. (2012) *Fashion Futures*. London ; New York: Merrell Publishers.

Rahman, I.A., Memon, A.H. and Karim, A.T.A. (2013) 'Examining Factors Affecting Budget Overrun of Construction Projects Undertaken through Management Procurement Method Using PLS-sem Approach', *Procedia - Social and Behavioral Sciences*, 107, pp. 120–128. Available at: https://doi.org/10.1016/j.sbspro.2013.12.407.

Railton, D. and Watson, P. (2012) '"She's so Vein":Madonna and the Drag of Aging', in J. Dolan and E. Tincknell (eds) *Aging Femininities: Troubling Representations*. New Castle upon Tyne, U.K.: Cambridge Scholars Publishing, pp. 195–205.

Raji, R.K. *et al.* (2019) 'Design and Fabrication of Smart Bandeau Bra for Breathing Pattern Measurement', in K. Arai, R. Bhatia, and S. Kapoor (eds) *Proceedings of the Future Technologies Conference (FTC) 2019*. Cham: Springer International Publishing (Advances in Intelligent Systems and Computing), pp. 40–48. Available at: https://doi.org/10.1007/978-3-030-32523-7_3.

Randall, T. *et al.* (2016) 'Bra incorporating shape memory polymers and method of manufacture thereof'. Available at: https://patents.google.com/patent/EP2984953A1/en?q=(A41C3%2f00)&country=US&before=priority:20200101&after=priority:20000101&num=100&sort=old (Accessed: 11 September 2021).

Rashed, S. (2016) 'Idea to Production: Busty Bras', *Maker's Row Blog*, 16 February. Available at: https://makersrow.com/blog/2016/02/idea-to-production-busty-bras/ (Accessed: 29 September 2021).

Reason, P. (2003) 'Pragmatist Philosophy and Action Research: Readings and Conversation with Richard Rorty', *Action Research*, 1(1), pp. 103–123. Available at: https://doi.org/10.1177/14767503030011007.

Redefining Plus Size - Dressing the 'Average' Woman in Europe (2020) *FashionUnited*. Available at: https://fashionunited.uk/news/business/redefining-plus-size-dressing-the-average-woman-in-europe/2020011447030 (Accessed: 11 June 2022).

Regan, C.L., Kincade, D.H. and Sheldon, G. (1998) 'Applicability of the Engineering Design Process Theory in the Apparel Design Process', *Clothing and Textiles Research Journal*, 16(1), pp. 36–46. Available at: https://doi.org/10.1177/0887302X9801600105.

Reid, L.F. *et al.* (2020) 'Three-Dimensional Body Scanning in Sustainable Product Development: An Exploration of the Use of Body Scanning in the Production and Consumption of Female Apparel', in G. Vignali et al. (eds) *Technology-Driven Sustainability: Innovation in the Fashion Supply Chain*. Cham: Springer International Publishing, pp. 173–194. Available at: https://doi.org/10.1007/978-3-030-15483-7_10.

Reijneveld, K. *et al.* (2003) 'Measuring the emotions elicited by office chairs', in *Proceedings of the 2003 international conference on Designing pleasurable products and interfaces*. New York, NY, USA: Association for Computing Machinery (DPPI '03), pp. 6–10. Available at: https://doi.org/10.1145/782896.782899.

Reinharz, S. and Chase, S.E. (2001) 'Interviewing Women', in Gubrium, J. and Holstein, J., *Handbook of Interview Research*. 2455 Teller Road, Thousand Oaks California 91320 United States of America: SAGE Publications, Inc., pp. 220–238. Available at: https://doi.org/10.4135/9781412973588.n15.

Rider, T., Taite, S. and Ron, A. (2018) 'Technologies for monitoring breastfeeding'. Santa Clara , CA. Available at: https://patents.google.com/patent/US9968140B2/en?oq=US9968140B2 (Accessed: 11 September 2021).

Riewe, K. (2022) 'Digital to Physical Garment Development: Evaluation of Custom Avatar & Bra Development Using CLO 3D', *International Textile and Apparel Association Annual Conference Proceedings*, 78(1). Available at: https://doi.org/10.31274/itaa.13588.

van Rijn, H. *et al.* (2011) 'Achieving empathy with users: the effects of different sources of information', *CoDesign*, 7(2), pp. 65–77. Available at: https://doi.org/10.1080/15710882.2011.609889.

Ringa, V. *et al.* (2013) 'Women's sexuality: from aging to social representations', *The Journal of Sexual Medicine*, 10(10), pp. 2399–2408. Available at: https://doi.org/10.1111/jsm.12267.

Ringle, C.M., Wende, S. and Becker, J.-M. (2015) *Model Fit - SmartPLS*, *SmartPLS*. Available at: https://www.smartpls.com/documentation/algorithms-and-techniques/model-fit (Accessed: 17 August 2022).

Ringrose, J., Tolman, D. and Ragonese, M. (2018) 'Hot right now: Diverse girls navigating technologies of racialized sexy femininity', *Feminism & Psychology*, p. 0959353518806324. Available at: https://doi.org/10.1177/0959353518806324.

Risius, D. *et al.* (2014) 'The influence of ageing on bra preferences and self-perception of breasts among mature women', *European Journal of Ageing*, 11(3), pp. 233–240. Available at: https://doi.org/10.1007/s10433-014-0310-3.

Risius, D.J. (2012) *An Investigation of Breast Support for Older Women*. Ph.D. Thesis. University of Portsmouth. Available at:

https://researchportal.port.ac.uk/portal/files/6034923/Deborah_J._Risius_2013_Ph.D_An_investigation_of_breast_support_for_older_women.pdf (Accessed: 29 March 2018).

Rittel, H.W. and Webber, M.M. (1974) 'Wicked problems', *Man-made Futures*, 26(1), pp. 272–280.

Roach-Higgins, M.E. and Eicher, J.B. (1992) 'Dress and Identity', *Clothing and Textiles Research Journal*, 10(4), pp. 1–8. Available at: https://doi.org/10.1177/0887302X9201000401.

Roberts-Islam, B. (2019) *Customized 3D Printed Bras Have Come To Save Underwear*, *Forbes*. Available at: https://www.forbes.com/sites/brookerobertsislam/2019/05/31/customised-3d-printed-bras-have-come-to-save-underwear/ (Accessed: 12 September 2021).

Rodin, J., Silberstein, L. and Striegel-Moore, R. (1984) 'Women and weight: A normative discontent', *Nebraska Symposium on Motivation*, 32, pp. 267–307.

Romans, M. (2018) *Dress Rules and Body Perceptions of Mature Plus Size Women*. Master Thesis. Louisiana State University and Agricultural and Mechanical College. Available at: https://digitalcommons.lsu.edu/gradschool_theses/4715 (Accessed: 27 October 2022).

Rosenburg, Z.B. *et al.* (2023) 'Design Strategies for e-textile manufacturing', in J. McCann and D. Bryson (eds) *Smart Clothes and Wearable Technology*. 2nd edition. Cambridge; Kidlington: Woodhead Publishing, pp. 485–503.

Ross, S., Dixon, J. and Cohen, J. (2017) 'Stress test bra'. Santa Monica, CA. Available at: https://patents.google.com/patent/US9622704B2/en?q=Intelligent&q=Mastectomy&q=Bra&oq=Intelligent+Mastectomy+Bra&page=1 (Accessed: 18 June 2019).

Ruckdashel, R.R., Khadse, N. and Park, J.H. (2022) 'Smart E-Textiles: Overview of Components and Outlook', *Sensors*, 22(16), p. 6055. Available at: https://doi.org/10.3390/s22166055.

Rudd, N.A. and Lennon, S.J. (2001) 'Body Image: Linking Aesthetics and Social Psychology of Appearance', *Clothing and Textiles Research Journal*, 19(3), pp. 120–133. Available at: https://doi.org/10.1177/0887302X0101900303.

Ruggerone, L. (2017) 'The Feeling of Being Dressed: Affect Studies and the Clothed Body', *Fashion Theory*, 21(5), pp. 573–593. Available at: https://doi.org/10.1080/1362704X.2016.1253302.

Ruggerone, L. and Stauss, R. (2022) 'The Deceptive Mirror: The Dressed Body Beyond Reflection', *Fashion Theory*, 26(2), pp. 211–235. Available at: https://doi.org/10.1080/1362704X.2020.1766228.

Ruixin, L. (2020) *Optimization of the comfort of compression sports bras*. PhD Thesis. Hong Kong Polytechnic University. Available at: https://theses.lib.polyu.edu.hk/handle/200/11032 (Accessed: 30 September 2021).

Sabik, N.J. (2015) 'Ageism and Body Esteem: Associations With Psychological Well-Being Among Late Middle-Aged African American and European American Women', *The Journals of Gerontology: Series B*, 70(2), pp. 189–199. Available at: https://doi.org/10.1093/geronb/gbt080.

Sadkowska, A. (2018) 'Arts-Informed Interpretative Phenomenological Analysis: "Making," as a Means of Embodied Fashion Enquiry into Older Men's Lived Experiences', *Fashion Practice*, 10(3), pp. 405–432. Available at: https://doi.org/10.1080/17569370.2018.1507167.

Saffer, D. (2010) *Designing for Interaction: Creating Innovative Applications and Devices*. 2nd edn. Berkeley, Calif.: New Riders.

Saint-Laurent, C. (1968) *History of Ladies Underwear, The*. First Edition edition. Translated by J. Norman. London: M.Joseph.

Salahuddin, M. and Romeo, L. (2020) 'Wearable technology: are product developers meeting consumer's needs?', *International Journal of Fashion Design, Technology and Education*, 13(1), pp. 58–67. Available at: https://doi.org/10.1080/17543266.2020.1723713.

Saldana, J. (2014) *Thinking Qualitatively: Methods of Mind*. 1st edn. Thousand Oaks, California: SAGE Publications, Inc.

Sanders, E.B.-N. (1992) 'Converging Perspectives: Product Development Research for the 1990s', *Design Management Journal (Former Series)*, 3(4), pp. 49–54. Available at: https://doi.org/10.1111/j.1948-7169.1992.tb00604.x.

Sanders, E.B.-N. (2002) 'From user-centered to participatory design approaches', in J. Frascara (ed.) *Design and the Social Sciences: Making Connections*. 1st edn. New York: CRC Press, pp. 1–8.

Sanders, E.B.-N. (2006) 'Design Research in 2006', *Design Research Quarterly*, 1(1), pp. 1–8.

Sanders, E.B.-N. and Dandavate, U. (1999) 'Design for experiencing: new tools', in *First International Conference on Design and Emotion, TU Delft*.

Sanders, E.B.-N. and Stappers, P.J. (2008) 'Co-creation and the new landscapes of design', *CoDesign*, 4(1), pp. 5–18. Available at: https://doi.org/10.1080/15710880701875068.

Sanders, E.B.-N. and Stappers, P.J. (2012) *Convivial Toolbox: Generative Research for the Front End of Design*. Amsterdam: BIS Publishers.

Saner, E. (2020) 'The death of the bra: will the great lingerie liberation of lockdown last?', *the Guardian*, 5 July. Available at: http://www.theguardian.com/lifeandstyle/2020/jul/05/death-of-bra-will-great-lingerie-liberation-lockdown-last (Accessed: 6 July 2021).

Satenstein, L. (2021) 'I Never Knew My Bra Size, Until I Got Virtually Fitted', *Vogue*, 18 May. Available at: https://www.vogue.com/article/virtual-bra-fitting-wrong-size-wacoal (Accessed: 5 November 2022).

Sayem, A.S.M., Kennon, R. and Clarke, N. (2010) '3D CAD systems for the clothing industry', *International Journal of Fashion Design, Technology and Education*, 3(2), pp. 45–53. Available at: https://doi.org/10.1080/17543261003689888.

Schaar, A.K. and Ziefle, M. (2011) 'Smart clothing: Perceived benefits vs. perceived fears', in *2011 5th International Conference on Pervasive Computing Technologies for Healthcare (PervasiveHealth) and Workshops. 2011 5th International Conference on Pervasive Computing Technologies for Healthcare (PervasiveHealth) and Workshops*, pp. 601–608. Available at: https://doi.org/10.4108/icst.pervasivehealth.2011.246031.

Schermelleh-Engel, K., Moosbrugger, H. and Müller, H. (2003) 'Evaluating the Fit of Structural Equation Models: Tests of Significance and Descriptive Goodness-of-Fit Measures', *Methods of Psychological Research*, 8, pp. 23–74.

Schlenz, I. and Kaider, A. (2007) 'The Brava External Tissue Expander: Is Breast Enlargement without Surgery a Reality?', *Plastic and Reconstructive Surgery*, 120(6), p. 1680. Available at: https://doi.org/10.1097/01.prs.0000267637.43207.19.

Schofield, N.A. *et al.* (2006) 'Improving Pant Fit for Women 55 and Older through an Exploration of Two Pant Shapes', *Clothing and Textiles Research Journal*, 24(2), pp. 147–160. Available at: https://doi.org/10.1177/0887302X0602400208.

Schofield, N.A. and LaBat, K.L. (2005) 'Exploring the Relationships of Grading, Sizing, and Anthropometric Data', *Clothing and Textiles Research Journal*, 23(1), pp. 13–27. Available at: https://doi.org/10.1177/0887302X0502300102.

Schön, D.A. (1983) *The reflective practitioner: how professionals think in action*. London: Temple Smith.

Schön, D.A. (1987) *Educating the Reflective Practitioner: Toward a New Design for Teaching and Learning in the Professions*. San Francisco: Jossey-Bass.

Schön, D.A. (1992) 'Designing as reflective conversation with the materials of a design situation', *Research in Engineering Design*, 3(3), pp. 131–147. Available at: https://doi.org/10.1007/BF01580516.

Schön, D.A. (1995) 'Knowing-In-Action: The New Scholarship Requires a New Epistemology', *Change: The Magazine of Higher Learning*, 27(6), pp. 27–34. Available at: https://doi.org/10.1080/00091383.1995.10544673.

Schön, D.A. and Wiggins, G. (1992) 'Kinds of seeing and their functions in designing', *Design Studies*, 13(2), pp. 135–156. Available at: https://doi.org/10.1016/0142-694X(92)90268-F.

Scraton, S. and Watson, B. (1998) 'Gendered cities: women and public leisure space in the "postmodern city"', *Leisure Studies*, 17(2), pp. 123–137. Available at: https://doi.org/10.1080/026143698375196.

Scurr, J.C., White, J.L. and Hedger, W. (2011) 'Supported and unsupported breast displacement in three dimensions across treadmill activity levels', *Journal of Sports Sciences*, 29(1), pp. 55–61. Available at: https://doi.org/10.1080/02640414.2010.521944.

Seale, C. (ed.) (2012) *Researching society and culture*. 3rd edition. London: SAGE.

Seidman, I. (2005) *Interviewing as Qualitative Research: A Guide for Researchers in Education and the Social Sciences, 3rd Edition*. 3rd edn. New York: Teachers College Press.

Sender, T. (2020) *Underwear: Inc Impact of COVID-19 - UK - June 2020 - Market Research Report*, *Mintel Academic*. Available at: https://reports-mintel-com.arts.idm.oclc.org/display/988890/?fromSearch=%3Ffreetext%3Dbra (Accessed: 29 January 2021).

Seyed, T. and Tang, A. (2019) 'Mannequette: Understanding and Enabling Collaboration and Creativity on Avant-Garde Fashion-Tech Runways', in *Proceedings of the 2019 on Designing Interactive Systems Conference*. New York, NY, USA: Association for Computing Machinery (DIS '19), pp. 317–329. Available at: https://doi.org/10.1145/3322276.3322305.

Seymour, S. (2008) *Fashionable Technology: The Intersection of Design, Fashion, Science, and Technology*. 2008 edition. Wien ; New York, NY: Springer.

Shanahan, P.W. (1950) 'Carrier brassiere'. Vicksburg, Miss. Available at: https://patents.google.com/patent/US2503847A/en?oq=US2503847A (Accessed: 7 September 2021).

Shapiro, L. (2015) 'Chromat S/S 2015: Empowered Fashion of the Future', *The Lingerie Addict - Everything To Know About Lingerie*, 26 January. Available at: https://www.thelingerieaddict.com/2015/01/chromat-ss15-empowered-fashion-of-the-future.html (Accessed: 26 November 2022).

Sharland, E.L. (2018) *The development, piloting and evaluation of a bra intervention for women with larger breasts who are experiencing breast pain*. Ph.D. Thesis. University of Portsmouth. Available at: https://researchportal.port.ac.uk/en/studentTheses/the-development-piloting-and-evaluation-of-a-bra-intervention-for (Accessed: 2 November 2022).

Shathi, M.A. *et al.* (2020) 'Graphene coated textile based highly flexible and washable sports bra for human health monitoring', *Materials & Design*, 193, p. 108792. Available at: https://doi.org/10.1016/j.matdes.2020.108792.

Shephard, A.J. (2012) 'Waterproof Dress: Patents as Evidence of Design and Function From 1880 Through 1895', *Clothing and Textiles Research Journal*, 30(3), pp. 183–199. Available at: https://doi.org/10.1177/0887302X12452910.

Shi, Y. *et al.* (2020) 'The impact of age and body mass index on a bra sizing system formed by anthropometric measurements of Sichuan Chinese females', *Ergonomics*, 63(11), pp. 1434–1441. Available at: https://doi.org/10.1080/00140139.2020.1795276.

Shin, K. (2007) 'Patternmaking for the underwired bra: New directions', *The Journal of The Textile Institute*, 98(4), pp. 301–318. Available at: https://doi.org/10.1080/00405000701503006.

Shin, K. (2014) 'Intimate apparel: designing intimate apparel to fit different body shapes', in *Designing Apparel for Consumers*. Woodhead Publishing (Woodhead Publishing Series in Textiles), pp. 273–291. Available at: https://doi.org/10.1533/9781782422150.2.273.

Shin, K., Ng, S.P. and Liang, M. (2010) 'A geometrically based flattening method for three-dimensional to two-dimensional bra pattern conversion', *International Journal of Fashion Design, Technology and Education*, 3(1), pp. 3–14. Available at: https://doi.org/10.1080/17543260903460200.

Shin, W.K. (2009) *The origins and evolution of the bra*. Ph.D. University of Northumbria at Newcastle. Available at: http://nrl.northumbria.ac.uk/3040/ (Accessed: 10 August 2017).

Simpson, H.W. *et al.* (2013) 'The Chronobra identifies prevailing mammary vascularity as a candidate variable in breast cancer post-operative outcome prediction', *SpringerPlus*, 2(1). Available at: https://doi.org/10.1186/2193-1801-2-241.

Simpson, M.A. (2007) *Innovations in Breast Cancer Detection: The Smart Bra*, *Medical Xpress*. Available at: https://medicalxpress.com/news/2007-10-breast-cancer-smart-bra.html (Accessed: 7 November 2022).

Singer, M. (2015) 'The Year in Fashion: In the Wake of Fall's Designer Exits, It's Time to Start Thinking Small', *Vogue*, 2 December. Available at: https://www.vogue.com/article/the-answer-to-designer-burnout-thinking-small (Accessed: 7 March 2023).

Sinha, P. (2002) 'Creativity in fashion', *Journal of Textile and Apparel, Technology and Management*, 2(4).

Sleeswijk Visser, F. *et al.* (2005) 'Contextmapping: experiences from practice', *CoDesign*, 1(2), pp. 119–149. Available at: https://doi.org/10.1080/15710880500135987.

Sleeswijk Visser, F. (2009) *Bringing the everyday life of people into design*. PhD Thesis. TU Delft. Available at: https://repository.tudelft.nl/islandora/object/uuid%3A3360bfaa-dc94-496b-b6f0-6c87b333246c (Accessed: 27 October 2022).

Smeenk, W., Tomico, O. and van Turnout, K.G. (2016) 'A Systematic Analysis of Mixed Perspectives in Empathic Design: Not One Perspective Encompasses All', *International Journal of Design*, 10(2), pp. 31–48.

'SomaInnofit Review: Trying a Smart Bra On for Size' (2019) *Wirecutter: Reviews for the Real World*, 3 June. Available at: https://www.nytimes.com/wirecutter/blog/somainnofit-smart-bra-review/ (Accessed: 12 September 2021).

'SOMAINNOFIT™, New Bra Fit Technology' (2019) *Soma Blog*, 23 January. Available at: https://origin-blog.soma.com/somainnofit-new-bra-fit-technology/ (Accessed: 12 September 2021).

Spadola, M. (1998) *Breasts: Our Most Public Private Parts*. First Edition edition. Berkeley, Calif. : Emeryville, CA: Wildcat Canyon Pr.

Spall, S. (1998) 'Peer Debriefing in Qualitative Research: Emerging Operational Models', *Qualitative Inquiry*, 4(2), pp. 280–292. Available at: https://doi.org/10.1177/107780049800400208.

Spencer, B.M. (2022) 'The race-gendered clothing choices of the "professional and respectable" Black man in the workplace', *Critical Studies in Men???s Fashion*, 9(1), pp. 57–76. Available at: https://doi.org/10.1386/csmf_00051_1.

Spencer, L. *et al.* (2020) 'The relationship between breast size and aspects of health and psychological wellbeing in mature-aged women', *Women's Health*, 16, p. 1745506520918335. Available at: https://doi.org/10.1177/1745506520918335.

Spivak, M. (2015) *Olay discovers unique skin fingerprint among those who look exceptionally younger than their actual age*, *Multivu-PR Newswire*. Available at: http://www.multivu.com/players/English/7538951-olay-mde-skin-fingerprint-study/ (Accessed: 25 June 2019).

Stappers, P.J. (2007) 'Doing Design as a Part of Doing Research', in R. Michel (ed.) *Design Research Now: Essays and Selected Projects*. Basel: Birkhäuser (Board of International Research in Design), pp. 81–91. Available at: https://doi.org/10.1007/978-3-7643-8472-2_6.

Stappers, P.J. *et al.* (2009) 'Designing for other people's strengths and motivations: Three cases using context, visions, and experiential prototypes', *Advanced Engineering Informatics*, 23(2), pp. 174–183. Available at: https://doi.org/10.1016/j.aei.2008.10.008.

Stappers, P.J. and Giaccardi, E. (2017) 'Research through Design', in M. Soegaard and R. Friis-Dam (eds) *The Encyclopedia of Human-Computer Interaction*. 2nd edn. The Interaction Design Foundation, pp. 1–94. Available at: https://www.interaction-design.org/literature/book/the-encyclopedia-of-human-computer-interaction-2nd-ed/research-through-design (Accessed: 28 October 2022).

Stappers, P.J. and Sanders, E.B. (2003) 'Generative tools for context mapping: tuning the tools', in *Design and emotion*. Taylor & Francis London, pp. 77–81.

Stappers, P.J. and Sanders, E.B.-N. (2005) 'Tools for designers, products for users', in. *International Conference on Planning and Design: Creative Interaction and Sustainable Development*, pp. 1–16.

Stasey, B.J., Gummin, M. and Wyatt, M.W. (2020) 'System for minimizing multi-dimensional breast implant'. Available at: https://patents.google.com/patent/US10791772B2/en?oq=US10791772B2 (Accessed: 11 September 2021).

Stead, L.J. (2005) *'The emotional wardrobe': a fashion perspective on the integration of technology and clothing*. PhD Thesis. University of the Arts London. Available at: http://ualresearchonline.arts.ac.uk/5662/ (Accessed: 10 August 2017).

Steele, J.R. *et al.* (2018) 'The Bionic Bra: Using electromaterials to sense and modify breast support to enhance active living', *Journal of Rehabilitation and Assistive Technologies Engineering*, 5, pp. 1–9. Available at: https://doi.org/10.1177/2055668318775905.

Steen, M. (2011) 'Tensions in human-centred design', *CoDesign*, 7(1), pp. 45–60. Available at: https://doi.org/10.1080/15710882.2011.563314.

Steen, M. (2013) 'Co-Design as a Process of Joint Inquiry and Imagination', *Design Issues*, 29(2), pp. 16–28. Available at: https://doi.org/10.1162/DESI_a_00207.

Stephens, D.P. and Phillips, L.D. (2003) 'Freaks, gold diggers, divas, and dykes: The sociohistorical development of adolescent African American women's sexual scripts', *Sexuality and Culture*, 7(1), pp. 3–49. Available at: https://doi.org/10.1007/BF03159848.

Stevenson, K.R. (2022) 'Product fit in the digital commerce environment: A conceptual study on lingerie brand's digital fit tools', *Fashion, Style & Popular Culture*, 9(4), pp. 539–554. Available at: https://doi.org/10.1386/fspc_00151_1.

Stewart, J. and Williams, R. (2005) 'The wrong trousers? Beyond the design fallacy: social learning and the user', in D. Howcroft and E.M. Trauth (eds) *Handbook of Critical Information Systems Research: Theory and Application*. Cheltenham, UK: Edward Elgar Publishing, p. 195.

Stokes, B. and Black, C. (2012) 'Application of the Functional, Expressive and Aesthetic Consumer Needs Model: assessing the clothing needs of adolescent girls with disabilities', *International Journal of Fashion Design, Technology and Education*, 5(3), pp. 179–186. Available at: https://doi.org/10.1080/17543266.2012.700735.

Stoppa, M. and Chiolerio, A. (2014) 'Wearable Electronics and Smart Textiles: A Critical Review', *Sensors*, 14(7), pp. 11957–11992. Available at: https://doi.org/10.3390/s140711957.

Stormer, S.M. and Thompson, J.K. (1996) 'Explanations of body image disturbance: A test of maturational status, negative verbal commentary, social comparison, and sociocultural hypotheses', *International Journal of Eating Disorders*, 19(2), pp. 193–202. Available at: https://doi.org/10.1002/(SICI)1098-108X(199603)19:2<193::AID-EAT10>3.0.CO;2-W.

Storr, M. (2002) 'Classy lingerie', *Feminist Review*, 71(1), pp. 18–36. Available at: https://doi.org/10.1057/palgrave.fr.9400032.

Suh, M., Carroll, K. and Cassill, N. (2010) 'Critical Review on Smart Clothing Product Development', *Journal of Textile and Apparel, Technology and Management*, 6(4).

Sukumar, S. (2007) 'The Bra and the Indian Woman's Notion of Sexuality', *Journal of Creative Communications*, 2(3), pp. 267–278. Available at: https://doi.org/10.1177/097325860700200301.

Sun, Y. *et al.* (2019) '3D bra and human interactive modeling using finite element method for bra design', *Computer-Aided Design*, 114, pp. 13–27. Available at: https://doi.org/10.1016/j.cad.2019.04.006.

Surma-Aho, A., Björklund, T. and Hölttä-Otto, K. (2018) 'An analysis of designer empathy in the early phases of design projects', in *DS 91: Proceedings of NordDesign 2018, Linköping, Sweden, 14th - 17th August 2018*. *NordDesign 2018*. Available at: https://www.designsociety.org/publication/40875/An+analysis+of+designer+empathy+in+the+early+phases+of+design+projects (Accessed: 3 November 2022).

Surma-Aho, A. and Hölttä-Otto, K. (2022) 'Conceptualization and operationalization of empathy in design research', *Design Studies*, 78, p. 101075. Available at: https://doi.org/10.1016/j.destud.2021.101075.

Sussman, N.M., Truong, N. and Lim, J. (2007) 'Who experiences "America the beautiful"?: Ethnicity moderating the effect of acculturation on body image and risks for eating disorders among immigrant women', *International Journal of Intercultural Relations*, 31(1), pp. 29–49. Available at: https://doi.org/10.1016/j.ijintrel.2006.03.003.

Szmigin, I. and Carrigan, M. (2006) 'Consumption and community: choices for women over forty', *Journal of Consumer Behaviour*, 5(4), pp. 292–303. Available at: https://doi.org/10.1002/cb.181.

Tan, Y., Crown, E.M. and Capjack, L. (1998) 'Design and Evaluation of Thermal Protective Flightsuits. Part I: The Design Process and Prototype Development', *Clothing and Textiles Research Journal*, 16(1), pp. 47–55. Available at: https://doi.org/10.1177/0887302X9801600106.

Tangsirinaruenart, O. and Stylios, G. (2019) 'A Novel Textile Stitch-Based Strain Sensor for Wearable End Users', *Materials*, 12(9), p. 1469. Available at: https://doi.org/10.3390/ma12091469.

Tao, X. (ed.) (2001) *Smart Fibres, Fabrics and Clothing: Fundamentals and Applications*. Cambridge: Elsevier.

Tashakkori, A. and Teddlie, C. (1998) *Mixed Methodology: Combining Qualitative and Quantitative Approaches*. Thousand Oaks, Calif. ; London: SAGE.

Tavares, D.R. *et al.* (2021) 'An Ontological Approach of the Cognitive and Affective Product Experience', *Frontiers in Neuroergonomics*, 2. Available at: https://www.frontiersin.org/article/10.3389/fnrgo.2021.602881.

Tharps, L.L. (2014) 'Opinion | The Case for Black With a Capital B', *The New York Times*, 18 November. Available at: https://www.nytimes.com/2014/11/19/opinion/the-case-for-black-with-a-capital-b.html (Accessed: 16 June 2019).

The Guardian (2021) '"Bras are a curse!" How lockdown changed readers' views of their breasts', 28 April. Available at: http://www.theguardian.com/lifeandstyle/2021/apr/28/bras-are-a-curse-how-lockdown-changed-readers-views-of-their-breasts (Accessed: 6 July 2021).

Thomas, E. (2006) 'Ring of Silence: African American Women's Experiences Related to their Breasts and Breast Cancer Screening', *The Qualitative Report*, 11(2), pp. 350–373.

Thomas, J.B. and Peters, C.L.O. (2009) 'Silver seniors: Exploring the self-concept, lifestyles, and apparel consumption of women over age 65', *International Journal of Retail & Distribution Management*, 37(12), pp. 1018–1040. Available at: https://doi.org/10.1108/09590550911005001.

Thomas, V.G. (2004) 'The Psychology of Black Women: Studying Women's Lives in Context', *Journal of Black Psychology*, 30(3), pp. 286–306. Available at: https://doi.org/10.1177/0095798404266044.

Thomas-Grumbach, E. (2018) *Understanding Coping and Managing Experiences of Aging and Ageism among Older African American Women: A Qualitative Study*, *ProQuest Dissertations and Theses*. Ph.D. Northcentral University. Available at: https://www.proquest.com/docview/2171092092/abstract/F62C4A7107924492PQ/1 (Accessed: 15 September 2021).

Thompson, M. (2020) *Plus-size men: Perceptions of available clothing and models used to market the clothing*. PhD Thesis. Iowa State University. Available at: https://dr.lib.iastate.edu/entities/publication/34890bb2-e145-4688-a68d-d441de7f31b2.

Thorpe, R. *et al.* (2015) 'Old and desirable: older women's accounts of ageing bodies in intimate relationships', *Sexual and Relationship Therapy*, 30(1), pp. 156–166. Available at: https://doi.org/10.1080/14681994.2014.959307.

Tiggemann, M. and Lynch, J.E. (2001) 'Body image across the life span in adult women: The role of self-objectification', *Developmental Psychology*, 37, pp. 243–253. Available at: https://doi.org/10.1037/0012-1649.37.2.243.

Timmins, M.W. and McCann, J. (2015) 'Overview of the design requirements of the active ageing', in Jane McCann and D. Bryson (eds) *Textile-Led Design for the Active Ageing Population*. Woodhead Publishing (Woodhead Publishing Series in Textiles), pp. 185–214. Available at: https://doi.org/10.1016/B978-0-85709-538-1.00012-2.

Tito, M. *et al.* (2006) 'Design and emotions have a key role in the next generation of goods and services', in P. Cunningham and M. Cunningham (eds) *Exploiting the Knowledge Economy: Issues, Applications and Case Studies*. Amsterdam: IOS Press, pp. 726–734.

Titz, D. and Luxey, C. (2014) 'The Bra-tenna: A novel body-mounted antenna for off-body communications', in *2014 Loughborough Antennas and Propagation Conference (LAPC). 2014 Loughborough Antennas and Propagation Conference (LAPC)*, pp. 239–243. Available at: https://doi.org/10.1109/LAPC.2014.6996367.

Tomico, O. *et al.* (2013) 'Crafting wearables: interaction design meets fashion design', in *CHI '13 Extended Abstracts on Human Factors in Computing Systems*. New York, NY, USA: Association for Computing Machinery (CHI EA '13), pp. 2875–2876. Available at: https://doi.org/10.1145/2468356.2479556.

Tomico, O. *et al.* (2017) 'Towards a Next Wave of Wearable and Fashionable Interactions', *International Journal of Dsign*, 11(3). Available at: http://www.ijdesign.org/index.php/IJDesign/article/view/3177/794 (Accessed: 22 March 2018).

Toomey, A. and Tan, J. (2018) 'Interrogating D-STEM: A Design Led Approach to STEM innovation', in *ICERI2018 Proceedings. 11th annual International Conference of Education, Research and Innovation*, Seville, Spain: IATED, pp. 2964–2969. Available at: https://doi.org/10.21125/iceri.2018.1665.

Toussaint, L. (2018) *Wearing Technology: When Fashion and Technology Entwine*. Ph.D. Thesis. Radboud University Nijmegen. Available at: https://repository.ubn.ru.nl/bitstream/handle/2066/195422/195422.pdf (Accessed: 27 October 2022).

Toussaint, L. and Toeters, M. (2020) 'Keeping the Data within the Garment: Balancing Sensing and Actuating in Fashion Technology', in *Proceedings of the 2020 ACM Designing Interactive Systems Conference*. Eindhoven, Netherlands: Association for Computing Machinery (DIS '20), pp. 2229–2238. Available at: https://doi.org/10.1145/3357236.3395577.

Townsend, K., Kent, A. and Sadkowska, A. (2018) 'Fashioning clothing with and for mature women: a small-scale sustainable design business model', *Management Decision*, 57(1), pp. 3–20. Available at: https://doi.org/10.1108/MD-12-2016-0942.

Townsend, K. and Sadkowska, A. (2020) 'Re-Making fashion experience: A model for "participatory research through clothing design"', *Journal of Arts & Communities*, 11(1–2), pp. 13–33. Available at: https://doi.org/10.1386/jaac_00012_1.

Townsend, K., Sadkowska, A. and Sissons, J. (2016) 'Emotional fit: developing a new fashion design methodology for mature women', in P. Lloyd and E. Bohemia (eds) *Proceedings of DRS2016: Design + Research + Society - Future-Focused Thinking Conference, Brighton, 27-30 June 2016*. Coventry: Design Research Society, pp. 3521–3537. Available at: http://www.drs2016.org/422/ (Accessed: 23 March 2018).

Townsend, K., Sissons, J. and Sadkowska, A. (2017) 'Emotional Fit: Developing a new fashion methodology with older women', *Clothing Cultures*, 4(3), pp. 235–251. Available at: https://doi.org/10.1386/cc.4.3.235_1.

Townsend, L. and Wallace, C. (2016) 'Social media research: A guide to ethics'. University of Aberdeen. Available at: https://www.bolton.ac.uk/assets/Uploads/Social-media-ethics-study-Aberdeen-2018.pdf (Accessed: 8 November 2022).

Trott, P., Duin, P.V.D. and Hartmann, D. (2013) 'Users as innovators? Exploring the limitations of user-driven innovation', *Prometheus*, 31(2), pp. 125–138. Available at: https://doi.org/10.1080/08109028.2013.818790.

Tsaousi, C. (2011) *Consuming Underwear: Fashioning Female Identity*. Ph.D. University of Leicester. Available at: https://lra.le.ac.uk/handle/2381/9393 (Accessed: 10 August 2017).

Tsaousi, C. (2016) '"What underwear do I like?" Taste and (embodied) cultural capital in the consumption of women's underwear', *Journal of Consumer Culture*, 16(2), pp. 467–492. Available at: https://doi.org/10.1177/1469540514521084.

Tsaousi, C. and Brewis, J. (2013) 'Are you feeling special today? Underwear and the "fashioning" of female identity', *Culture and Organization*, 19(1), pp. 1–21. Available at: https://doi.org/10.1080/14759551.2011.634196.

Tsapovsky, F. (2021) 'The Pandemic didn't kill the bra', *Vox*, 5 April. Available at: https://www.vox.com/the-goods/22352318/pandemic-bra-sales-wireless-instagram (Accessed: 6 July 2021).

Tsarenko, Y. and Lo, C.J. (2017) 'A portrait of intimate apparel female shoppers: A segmentation study', *Australasian Marketing Journal (AMJ)*, 25(1), pp. 67–75. Available at: https://doi.org/10.1016/j.ausmj.2017.01.004.

Tsarenko, Y. and Strizhakova, Y. (2015) '"What does a woman want?" The moderating effect of age in female consumption', *Journal of Retailing and Consumer Services*, 26, pp. 41–46. Available at: https://doi.org/10.1016/j.jretconser.2015.05.007.

Tse, R. *et al.* (2016) *BigoDicky*, *Indiegogo*. Available at: https://www.indiegogo.com/projects/2068927 (Accessed: 11 September 2021).

Tucker, E. (2016) *Wisp wearables are an alternative to intense sex toys*, *Dezeen*. Available at: https://www.dezeen.com/2016/06/27/wisp-collection-wan-ting-tseng-alternative-sex-toy-erotic-device-royal-college-of-art-graduate-2016/ (Accessed: 7 November 2022).

Turhan, G. (2013) 'An assessment towards the acceptance of wearable technology to consumers in Turkey: the application to smart bra and t-shirt products', *The Journal of The Textile Institute*, 104(4), pp. 375–395. Available at: https://doi.org/10.1080/00405000.2012.736191.

Twigg, J. (2007) 'Clothing, age and the body: a critical review', *Ageing & Society*, 27(2), pp. 285–305. Available at: https://doi.org/10.1017/S0144686X06005794.

Twigg, J. (2012) 'Adjusting the cut: fashion, the body and age on the UK high street', *Ageing & Society*, 32(6), pp. 1030–1054. Available at: https://doi.org/10.1017/S0144686X11000754.

Twigg, J. (2013) *Fashion and Age: Dress, the Body and Later Life*. London ; New York: Bloomsbury Academic.

Tylka, T.L. and Wood-Barcalow, N.L. (2015) 'The Body Appreciation Scale-2: Item refinement and psychometric evaluation', *Body Image*, 12, pp. 53–67. Available at: https://doi.org/10.1016/j.bodyim.2014.09.006.

Tzou, R.-C. and Lu, H.-P. (2009) 'Exploring the emotional, aesthetic, and ergonomic facets of innovative product on fashion technology acceptance model', *Behaviour & Information Technology*, 28(4), pp. 311–322. Available at: https://doi.org/10.1080/01449290701763454.

Ullman, D. (2009) *The Mechanical Design Process*. 4th edition. Boston: McGraw-Hill Education.

Ulrich, K.T. and Eppinger, S.D. (2000) *Product design and development*. Second edition. Boston ; London: Irwin/McGraw-Hill.

United Nations, Department of Economic and Social Affairs, Population Division (2017) *World Population Prospects: The 2017 Revision*. Volume II: Demographic Profiles (ST/ESA/SER.A/400). New York, USA: United Nations, p. 883. Available at: https://population.un.org/wpp/Publications/Files/WPP2017_Volume-II-Demographic-Profiles.pdf (Accessed: 3 June 2019).

US Census Bureau (2017) *Personal Income: PINC-05*, *United Census Bureau*. Available at: https://www.census.gov/data/tables/time-series/demo/income-poverty/cps-pinc/pinc-05.html (Accessed: 3 June 2019).

US Census Bureau, D.I.S. (2017) *Current Population Survey (CPS), CPS Table Creator*, *United States Census Bureau*. Available at: https://www.census.gov/cps/data/cpstablecreator.html?# (Accessed: 22 June 2019).

Valle-Noronha, J. (2019) *Becoming with Clothes : Activating wearer-worn engagements through design*. Ph.D. Thesis. Aalto University. Available at: https://aaltodoc.aalto.fi:443/handle/123456789/40624 (Accessed: 27 October 2022).

Van Rijn, H. *et al.* (2011) 'Achieving empathy with users: the effects of different sources of information', *CoDesign*, 7(2), pp. 65–77.

Vanderploeg, A., Lee, S.-E. and Mamp, M. (2017) 'The application of 3D printing technology in the fashion industry', *International Journal of Fashion Design, Technology and Education*, 10(2), pp. 170–179. Available at: https://doi.org/10.1080/17543266.2016.1223355.

Varadan, V.K. *et al.* (2011) 'E-bra with nanosensors, smart electronics and smart phone communication network for heart rate monitoring', in *Nanosensors, Biosensors, and Info-Tech Sensors and Systems 2011. Nanosensors, Biosensors, and Info-Tech Sensors and Systems 2011*, SPIE, pp. 186–192. Available at: https://doi.org/10.1117/12.885649.

Vares, T. (2009) 'Reading the "Sexy Oldie": Gender, Age(ing) and Embodiment', *Sexualities*, 12(4), pp. 503–524. Available at: https://doi.org/10.1177/1363460709105716.

Veja, P. (2014) *An investigation of integrated woven electronic textiles (e-textiles) via design led processes*. Ph.D. Thesis. Brunel University London. Available at: http://bura.brunel.ac.uk/handle/2438/10528 (Accessed: 6 March 2023).

Venkatesh, V. (2000) 'Determinants of Perceived Ease of Use: Integrating Control, Intrinsic Motivation, and Emotion into the Technology Acceptance Model', *Information Systems Research*, 11(4), pp. 342–365. Available at: https://doi.org/10.1287/isre.11.4.342.11872.

Venkatesh, V. *et al.* (2003) 'User Acceptance of Information Technology: Toward a Unified View', *MIS Quarterly*, 27(3), pp. 425–478. Available at: https://doi.org/10.2307/30036540.

Venkatesh, V. and Davis, F.D. (2000) 'A Theoretical Extension of the Technology Acceptance Model: Four Longitudinal Field Studies', *Management Science*, 46(2), pp. 186–204. Available at: https://doi.org/10.1287/mnsc.46.2.186.11926.

Venkatesh, V., Thong, J.Y.L. and Xu, X. (2012) 'Consumer Acceptance and Use of Information Technology: Extending the Unified Theory of Acceptance and Use of Technology', *MIS Quarterly*, 36(1), pp. 157–178. Available at: https://doi.org/10.2307/41410412.

Vigolo, V. and Ugolini, M.M. (2016) 'Does this fit my style? The role of self-congruity in young women's repurchase intention for intimate apparel', *Journal of Fashion Marketing and Management: An International Journal*, 20(4), pp. 417–434. Available at: https://doi.org/10.1108/JFMM-02-2015-0016.

Vincent, J.F.V. (2006) 'The Materials Revolution', *Journal of Bionic Engineering*, 3(4), pp. 217–234. Available at: https://doi.org/10.1016/S1672-6529(07)60005-5.

Voda, A.M., Christy, N.S. and Morgan, J.M. (1991) 'Body Composition Changes in Menopausal Women', *Women & Therapy*, 11(2), pp. 71–96. Available at: https://doi.org/10.1300/J015V11N02_07.

Wai Fong, L. (2014) *Development of seamless knitted bra for optimum fit*. Ph.D. Thesis. Hong Kong Polytechnic University. Available at: https://theses.lib.polyu.edu.hk/handle/200/7411 (Accessed: 29 September 2021).

Wallace, J. and Press, M. (2004) 'All this Useless Beauty: the Case for Craft Practice in Design for a Digital Age', *The Design Journal*, 7(2), pp. 42–53. Available at: https://doi.org/10.2752/146069204789354417.

Wang, W. and McCormick, M. (2005) 'Apparatus and method for detecting abnormalities in bodily matter'. Leicester, United Kingdom. Available at: https://patents.google.com/patent/US6856824B1/en?q=%22Apparatus+and+method+for+detecting+abnormalities+in+bodily+matter%22&oq=%22Apparatus+and+method+for+detecting+abnormalities+in+bodily+matter%22 (Accessed: 7 November 2022).

Wang, W.-D. (2001) 'Brassiere sash'. Available at: https://patents.google.com/patent/US6283821B1/en?q=((A41C3%2f00+)+AND+(sCENT))&q=A41C3%2f0042&before=priority:20100101&after=priority:19900101&page=2 (Accessed: 8 September 2021).

Watkins, S.M. (1988) 'Using the Design Process to Teach Functional Apparel Design', *Clothing and Textiles Research Journal*, 7(1), pp. 10–14. Available at: https://doi.org/10.1177/0887302X8800700103.

Watkins, S.M. and Dunne, L.E. (2015) *Functional clothing design: from sportswear to spacesuits*. New York: Fairchild Books, an imprint of Bloomsbury Publishing Incorporated.

Wearing, S. (2012) 'Exemplary or Exceptional Embodiment? Discourses of Aging in the Case of Helen Mirren and Calendar Girls', in J. Dolan and E. Tincknell (eds) *Aging Femininities: Troubling Representations*. New Castle upon Tyne, U.K.: Cambridge Scholars Publishing, pp. 145–157.

Weber, M.E.A. (2011) *Customer co-creation in innovations : a protocol for innovating with end users*. Phd Thesis 2 (Research NOT TU/e / Graduation TU/e). Technische Universiteit Eindhoven. Available at: https://doi.org/10.6100/IR710973.

Webster, J. and Tiggemann, M. (2003) 'The Relationship Between Women's Body Satisfaction and Self-Image Across the Life Span: The Role of Cognitive Control', *The Journal of Genetic Psychology*, 164(2), pp. 241–252. Available at: https://doi.org/10.1080/00221320309597980.

West, C. (2012) 'Mammy, Jezebel, Sapphire, and Their Homegirls: Developing an "Oppositional Gaze" Toward the Images of Black Women', in J.C. Chrisler, C. Golden, and P.D. Rozee (eds) *Lectures on the Psychology of Women*. 4th edn. Long Grove, IL: Waveland Press, Inc., pp. 286–299. Available at: https://digitalcommons.tacoma.uw.edu/ias_pub/270.

Whipps, J. and Lake, D. (2017) 'Pragmatist Feminism', in E.N. Zalta (ed.) *The Stanford Encyclopedia of Philosophy*. Winter 2017. Metaphysics Research Lab, Stanford University. Available at: https://plato.stanford.edu/archives/win2017/entries/femapproach-pragmatism/ (Accessed: 2 June 2019).

Wilkinson, C.R. and De Angeli, A. (2014) 'Applying user centred and participatory design approaches to commercial product development', *Design Studies*, 35(6), pp. 614–631. Available at: https://doi.org/10.1016/j.destud.2014.06.001.

Wilkinson, S. (1998) 'Focus groups in feminist research: Power, interaction, and the co-construction of meaning', *Women's Studies International Forum*, 21(1), pp. 111–125. Available at: https://doi.org/10.1016/S0277-5395(97)00080-0.

Wilkinson, S. (2004) 'Focus group Research', in D. Silverman (ed.) *Qualitative Research: Theory, Method and Practice*. SAGE, pp. 175–198.

Williams, K.P. and Anderson, A.M. (2021) 'Two Community-Based Strategies to Recruit Black Women in Research', *Journal of Urban Health*, 98(2), pp. 129–132. Available at: https://doi.org/10.1007/s11524-021-00541-2.

Williams, W.E. (1940) 'Lady's health brassiere and health protector'. Available at: https://patents.google.com/patent/US2222523A/en?oq=US2222523A (Accessed: 7 September 2021).

Winterich, J.A. (2007a) 'Aging, Femininity, and the Body: What Appearance Changes Mean to Women with Age', *Gender Issues*, 24(3), pp. 51–69. Available at: https://doi.org/10.1007/s12147-007-9045-1.

Winterich, J.A. (2007b) 'Aging, Femininity, and the Body: What Appearance Changes Mean to Women with Age', *Gender Issues*, 24(3), pp. 51–69. Available at: https://doi.org/10.1007/s12147-007-9045-1.

Wood, E.E. (2016) 'OmSignal enters the women's fitness market with new smart bra | IT Business', *ITBusiness.ca | Business Advantage Through Technology*, 20 September. Available at: https://www.itbusiness.ca/news/omsignal-enters-the-womens-fitness-market-with-new-smart-bra/79764 (Accessed: 2 July 2021).

Wood, K., Cameron, M. and Fitzgerald, K. (2008) 'Breast size, bra fit and thoracic pain in young women: a correlational study', *Chiropractic & Osteopathy*, 16(1). Available at: https://doi.org/10.1186/1746-1340-16-1.

Wood, R. (2015) *Consumer Sexualities: Women and Sex Shopping*. Ph.D. Thesis. University of Sussex. Available at: https://core.ac.uk/download/pdf/30614558.pdf (Accessed: 5 November 2022).

Wood, R. (2016) '"You do act differently when you're in it": lingerie and femininity', *Journal of Gender Studies*, 25(1), pp. 10–23. Available at: https://doi.org/10.1080/09589236.2013.874942.

Woodward, S. (2005) 'Looking good, feeling right: aesthetics of the self', in D. Miller and S. Kuechler (eds) *Clothing as Material Culture*. Oxford: Berg Publishers, pp. 21–40. Available at: https://www.research.manchester.ac.uk/portal/en/publications/looking-good-feeling-right-aesthetics-of-the-self(a00c1642-e94d-439c-b499-047da4ca74ba).html (Accessed: 1 November 2022).

Woodward, S. (2007) *Why Women Wear What They Wear*. Oxford ; New York: Berg.

Wright, P. and McCarthy, J. (2008) 'Empathy and Experience in HCI', in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. New York, NY, USA: ACM (CHI '08), pp. 637–646. Available at: https://doi.org/10.1145/1357054.1357156.

Wright, P., Wallace, J. and McCarthy, J. (2008) 'Aesthetics and Experience-centered Design', *ACM Trans. Comput.-Hum. Interact.*, 15(4), p. 18:1-18:21. Available at: https://doi.org/10.1145/1460355.1460360.

Wright, P.C. and McCarthy, J.C. (2010) *Experience-centered Design: Designers, Users, and Communities in Dialogue*. Morgan & Claypool Publishers.

Wu, L. *et al.* (2011) 'Shape characterization for optimisation of bra cup moulding', *Journal of Fiber Bioengineering and Informatics*, 4(3), pp. 235–243.

Wu, L.-P., Lin, S.-F. and Wu, T.-J. (2000) 'Perfumed brassiere'. Available at: https://patents.google.com/patent/US6102773A/en?q=((A41C3%2f00+)+AND+(sCENT))&q=A41C3%2f0042&before=priority:20100101&after=priority:19900101&page=1 (Accessed: 8 September 2021).

Wu, R. *et al.* (2019) 'Silk Composite Electronic Textile Sensor for High Space Precision 2D Combo Temperature–Pressure Sensing', *Small*, 15(31), p. 1901558. Available at: https://doi.org/10.1002/smll.201901558.

Xue, H. and Desmet, P.M.A. (2019) 'Researcher introspection for experience-driven design research', *Design Studies*, 63, pp. 37–64. Available at: https://doi.org/10.1016/j.destud.2019.03.001.

Yalom, M. (1998) *A history of the breast*. First Ballantine Books edition. New York, N.Y: Ballantine Books.

Yen, Y.-C.G. *et al.* (2017) 'Listen to Others, Listen to Yourself: Combining Feedback Review and Reflection to Improve Iterative Design', in *Proceedings of the 2017 ACM SIGCHI Conference on Creativity and Cognition*. New York, NY, USA: Association for Computing Machinery (C&C '17), pp. 158–170. Available at: https://doi.org/10.1145/3059454.3059468.

Yick, K.L., Wu, L., Ma, T.W., *et al.* (2011) 'An Efficient Approach of Evaluating the Three-dimensional Geometric Shape of Moulded Bra Cups', in. *Fiber Society Spring 2011 Conference*, Hong Kong, pp. 305–306. Available at: https://www.researchgate.net/profile/Muhammad-Mushtaq-Mangat/publication/282927101_Comfort_aspects_of_denim_garments/links/5e1c3130299bf10bc3a92b3f/Comfort-aspects-of-denim-garments.pdf#page=317 (Accessed: 29 September 2021).

Yick, K.L., Wu, L., Yip, J., *et al.* (2011) 'An evaluation of the three-dimensional geometric shape of moulded bra cups', *Fibers and Polymers*, 12(4), pp. 556–563. Available at: https://doi.org/10.1007/s12221-011-0556-8.

Yip, J., Law, D. and Wong, Z. (2007) 'An investigation of intimate apparel buying behaviour among fashion conscious and non-fashion conscious Chinese Hong Kong female consumers', in *Proceedings of The 9th Asian Textile Conference. Institute of Textiles and Clothing*, Taiwan. Available at: http://ira.lib.polyu.edu.hk/handle/10397/36578 (Accessed: 10 August 2017).

Yip, J. and Yu, W. (2006) 'Intimate apparel with special functions', in *Innovation and Technology of Women's Intimate Apparel*. Woodhead Publishing (Woodhead Publishing Series in Textiles), pp. 171–195. Available at: https://doi.org/10.1016/B978-1-84569-046-5.50008-2.

Yotka, S. (2017) *Will Nike's New Flyknit Bra Change Your Life—Or At Least Your Workouts?*, *Vogue*. Available at: https://www.vogue.com/article/nike-fenom-flyknit-bra (Accessed: 27 June 2019).

Young, I.M. (1992) 'Breasted Experience: The Look and the Feeling', in D. Leder (ed.) *The Body in Medical Thought and Practice*. Dordrecht: Springer Netherlands (Philosophy and Medicine), pp. 215–230. Available at: https://doi.org/10.1007/978-94-015-7924-7_13.

Yu, W. *et al.* (2006) 'Process innovations of seamless intimate apparel', in *Innovation and Technology of Women's Intimate Apparel*. Cambridge, UNITED KINGDOM: Elsevier Science & Technology, pp. 223–239. Available at: http://ebookcentral.proquest.com/lib/ual/detail.action?docID=1666710 (Accessed: 29 September 2021).

Yu, W *et al.* (2006) 'Process innovations of seamless intimate apparel', in W. Yu et al. (eds) *Innovation and Technology of Women's Intimate Apparel*. Woodhead Publishing (Woodhead Publishing Series in Textiles), pp. 223–239. Available at: https://doi.org/10.1016/B978-1-84569-046-5.50010-0.

Yu, W. (2011) 'Achieving comfort in intimate apparel', in G. Song (ed.) *Improving Comfort in Clothing*. Woodhead Publishing (Woodhead Publishing Series in Textiles), pp. 427–448. Available at: https://doi.org/10.1533/9780857090645.3.427.

Yu, W. and Zhou, J. (2016) 'Sports bras and breast kinetics', in Winnie Yu (ed.) *Advances in Women's Intimate Apparel Technology*. Woodhead Publishing (Woodhead Publishing Series in Textiles), pp. 135–146. Available at: https://doi.org/10.1016/B978-1-78242-369-0.00008-6.

Yu, Winnie and Ng, S.-P. (2014) 'Innovations of Bras', in W. Yu et al. (eds) *Innovation and Technology of Women's Intimate Apparel*. Cambridge, U.K.: Woodhead Publishing, pp. 59–75.

Yue, S. (2019) *Finite element model for predicting the pressure comfort and shaping effect of wired bras*. Ph.D. Thesis. Hong Kong Polytechnic University. Available at: https://theses.lib.polyu.edu.hk/handle/200/10322 (Accessed: 29 September 2021).

Zeilig, H. and Almila, A.-M. (2018) '"It's play, really, isn't it?": Dress, creativity, old age', in *Creativity in Later Life*. 1st Edition. Routledge, pp. 131–144.

Zhang, A. (2016) 'Wearable Peltier Cooling', *Hi, I'm Anthony*, 29 June. Available at: https://anthony-zhang.me/blog/peltier-cooler/ (Accessed: 23 March 2021).

Zhang, S., Yick, K., Yip, J., *et al.* (2020) 'An understanding of bra design features to improve bra fit and design for older Chinese women', *Textile Research Journal*, p. 0040517520944253. Available at: https://doi.org/10.1177/0040517520944253.

Zhang, S. (2020) *Design and development of age-friendly bras*. Ph.D. Thesis. The Hong Kong Polytechnic University. Available at: https://theses.lib.polyu.edu.hk/handle/200/10405 (Accessed: 16 September 2021).

Zhang, S., Yick, K., Chen, L., *et al.* (2020) 'Finite-element modelling of elastic woven tapes for bra design applications', *The Journal of The Textile Institute*, 111(10), pp. 1470–1480. Available at: https://doi.org/10.1080/00405000.2019.1704962.

Zhang, S. *et al.* (2021) 'An understanding of bra design features to improve bra fit and design for older Chinese women', *Textile Research Journal*, 91(3–4), pp. 406–420. Available at: https://doi.org/10.1177/0040517520944253.

Zhang S. and Yu Y. (2018) 'A kind of adjustable underwear of front open buckle formula'. Available at: https://patents.google.com/patent/CN207639692U/en?oq=CN207639692U (Accessed: 2 November 2022).

Zheng, R. (2007) *Breast sizing and development of 3D seamless bra*. Ph.D. Thesis. Hong Kong Polytechnic University. Available at: https://theses.lib.polyu.edu.hk/handle/200/2199 (Accessed: 28 February 2018).

Zheng, R., Yu, W. and Fan, J. (2008) 'Prediction of seamless knitted bra tension', *Fibers and Polymers*, 9(6), pp. 785–792. Available at: https://doi.org/10.1007/s12221-008-0123-0.

Zheng, R., Yu, W. and Fan, J. (2009) 'Pressure evaluation of 3D seamless knitted bras and conventional wired bras', *Fibers and Polymers*, 10(1), p. 124. Available at: https://doi.org/10.1007/s12221-009-0124-7.

Zhou, L. (2015) *Could a Bra Actually Detect Breast Cancer?*, *Smithsonian Magazine*. Available at: https://www.smithsonianmag.com/innovation/could-a-bra-actually-detect-breast-cancer-180954612/ (Accessed: 27 June 2019).

김선미 (2019) 'Breast-feeding brassiere with massage function'. South Korea. Available at: https://patents.google.com/patent/KR102004979B1/en?oq=KR102004979B1 (Accessed: 11 September 2021).

김신동 (2001) 'The bust massage vibrator'. South Korea. Available at: https://patents.google.com/patent/KR200255911Y1/en?oq=KR200255911Y (Accessed: 7 November 2022).

이광용 *et al.* (2003) 'Brassiere with Long-last Fragrance'. South Korea. Available at: https://patents.google.com/patent/KR200329464Y1/en?q=((A41C3%2f00+)+AND+(sCENT))&q=A41C3%2f0042&before=priority:20100101&after=priority:19900101 (Accessed: 8 September 2021).

정학년 (2003) 'Incense Bra'. South Korea. Available at: https://patents.google.com/patent/KR20030039983A/en?q=((A41C3%2f00+)+AND+(sCENT))&q=A41C3%2f0042&before=priority:20100101&after=priority:19900101&page=1 (Accessed: 8 September 2021).

何珊 (2015) 'The anti-infringement underwear of a kind of women'. China. Available at: https://patents.google.com/patent/CN204466965U/en?oq=CN204466965U (Accessed: 11 September 2021).

余召师 and 刘松春 (2017) 'Medical brassiere'. Available at: https://patents.google.com/patent/CN206167358U/en?oq=CN206167358U (Accessed: 11 September 2021).

刘凯霞 *et al.* (2018) 'Smart bra and protective system comprising smart bra'. China. Available at: https://patents.google.com/patent/WO2018010141A1/en?oq=WO2018010141A1 (Accessed: 11 September 2021).

卢洁虹 (2015) 'Music massage brassiere'. Available at: https://patents.google.com/patent/CN204838025U/en?oq=CN204838025U (Accessed: 9 September 2021).

吴育林 and 梁明 (2017) 'Safe and portable phototherapy bra'. China. Available at: https://patents.google.com/patent/CN106422086A/en?oq=CN106422086A (Accessed: 9 September 2021).

孙金美 and 宋晓霞 (2018) 'A kind of intelligent brassiere with blood vessel monitoring function'. Available at: https://patents.google.com/patent/CN108478200A/en?oq=CN108478200A (Accessed: 11 September 2021).

张植强 (2015) 'Smart bra capable of playing sounds'. China. Available at: https://patents.google.com/patent/CN105077624A/en?q=smart&q=bras&oq=smart+bras (Accessed: 27 June 2019).

徐朔 and 王建萍 (2017) 'Multifunctional smart sports bra'. China. Available at: https://patents.google.com/patent/CN106690446A/en?oq=CN106690446A (Accessed: 11 September 2021).

易拥军 (2014) 'Massage physiotherapy brassiere and manufacture method thereof'. Available at: https://patents.google.com/patent/CN104126884A/en?oq=CN104126884A (Accessed: 12 September 2021).

杨雪梅 (2017) 'Three-dimensional body measuring bra for women'. China. Available at: https://patents.google.com/patent/CN106343625A/en?q=(((Bra))+AND+(A41H1%2f02+))&before=priority:20211230&after=priority:19900101&num=100&oq=(((Bra))+AND+(A41H1%2f02+))+before:priority:20211230+after:priority:19900101 (Accessed: 10 September 2021).

王军 and 彭甲海 (2018) 'Intelligent brassiere and its progress lesion detection approach, computer-readable recording medium'. Available at: https://patents.google.com/patent/CN107833628A/en?oq=CN107833628A (Accessed: 7 November 2022).

王卫东 *et al.* (2016) 'Intelligent sleep state recording bra'. Available at: https://patents.google.com/patent/CN106136346A/en?oq=CN105077624A+ (Accessed: 9 September 2021).

王卫东 *et al.* (2017a) 'Intelligent bra capable of recording sleep states'. Available at: https://patents.google.com/patent/CN106343623A/en?oq=CN106343623A (Accessed: 9 September 2021).

王卫东 *et al.* (2017b) 'Sleeping brassiere with intelligent awakening function'. Available at: https://patents.google.com/patent/CN106307641A/en?q=((((A41C3%2f00+)+AND+(smart)+AND+(sleep)))+)&before=priority:20210101&after=priority:19900101&oq=((((A41C3%2f00+)+AND+(smart)+AND+(sleep)))+)+before:priority:20210101+after:priority:19900101&page=1 (Accessed: 9 September 2021).

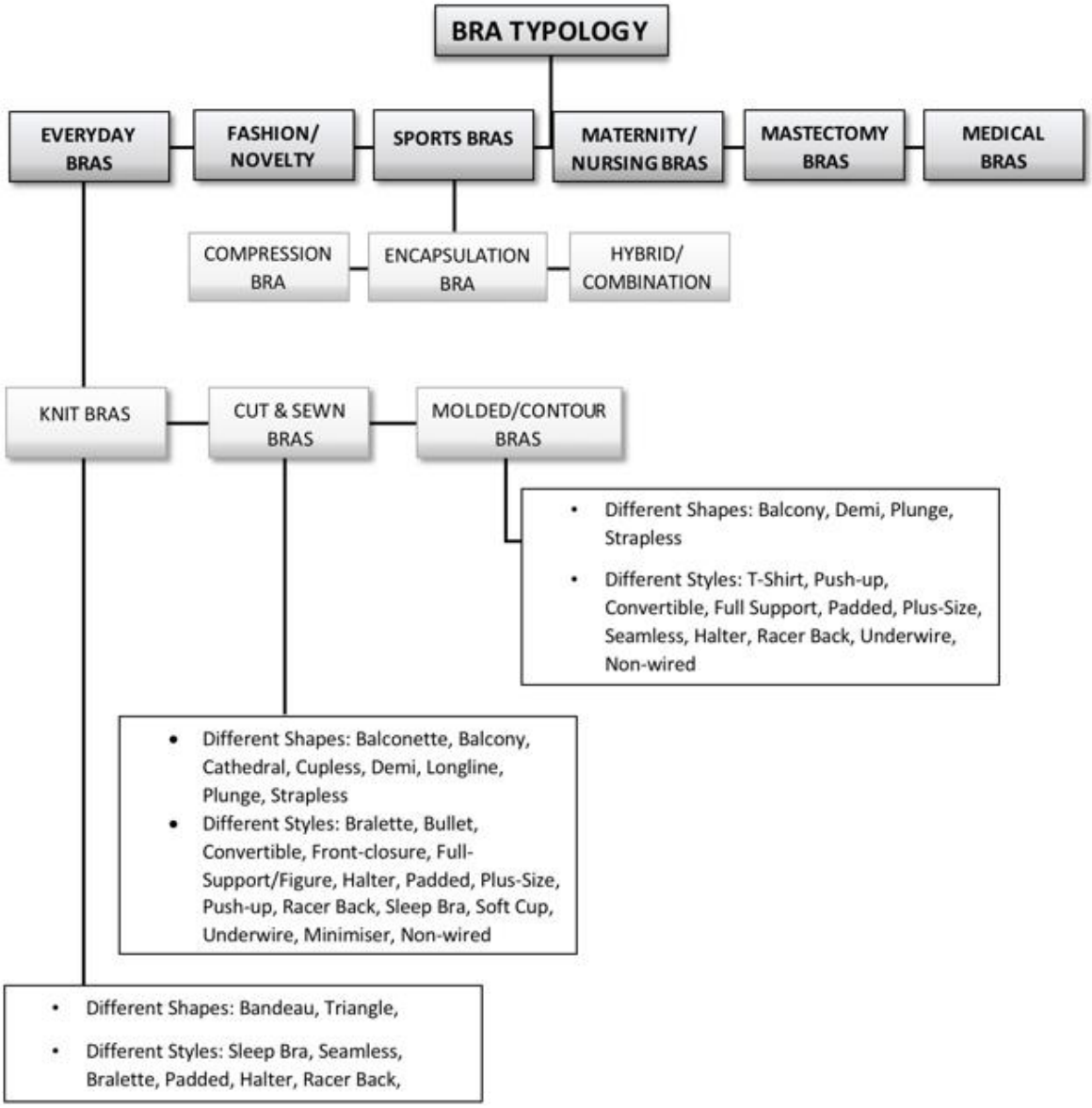
郭晓松 (2013) 'Silicone pulse electronic breast-augmentation bra-type electrode set'. China. Available at: https://patents.google.com/patent/CN202750717U/en?oq=CN202750717U (Accessed: 7 November 2022).

門若布麗奇特 *et al.* (2021) 'Adaptive support apparel systems and methods'. Available at: https://patents.google.com/patent/TW202100042A/en?oq=TW202100042A (Accessed: 11 September 2021).

陆兆丹, 宓现强 and 钟福清 (2012) 'Bra device for treating breast lobular hyperplasia with LED'. Available at: https://patents.google.com/patent/CN202169025U/en?oq=CN202169025U (Accessed: 11 September 2021).

APPENDIX

A. BRA TYPOLOGY

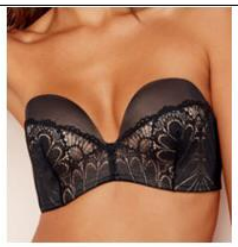
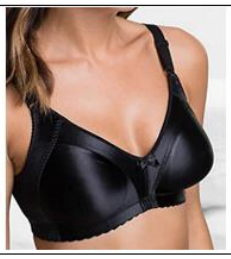


Appendix A.1. Bra Typology. Gosler, 2019

Knit, cut-and-sewn, and moulded bras all have different shapes and styles, which may appear similar. For example, the bandeau bra (see Appendix B) is a shape that is seen in knit, cut-and-sewn, and moulded categories. A cut-and-sewn bra will have different design processes for one similar bra style. For example, the plunge bra in Appendix B shows four distinctive styles. Although similar the design process for each style would vary.

B. BRA IMAGE DATABASE

ADHESIVE BRA (2-PIECE)	ADHESIVE BRA (BACKLESS)	ADHESIVE BRA (CLEAR WINGS)		BALCONETTE BRA
BALCONY BRA (2-PIECE)	BALCONY BRA (4-PIECE)	BALCONY BRA (PADDED)		BULLET BRA
BANDEAU BRA (CUT & SEWN)	BANDEAU BRA (KNIT)	BANDEAU BRA (MOULDED)		
CATHEDRAL BRA	CUPLESS BRA	DEMI BRA (3-PIECE)	DEMI BRA (2-PIECE)	DEMI BRA (1- PIECE)
FRONT CLOSURE PLUNGE BRA	FRONT CLOSURE	FRONT CLOSURE (MOULDED)		

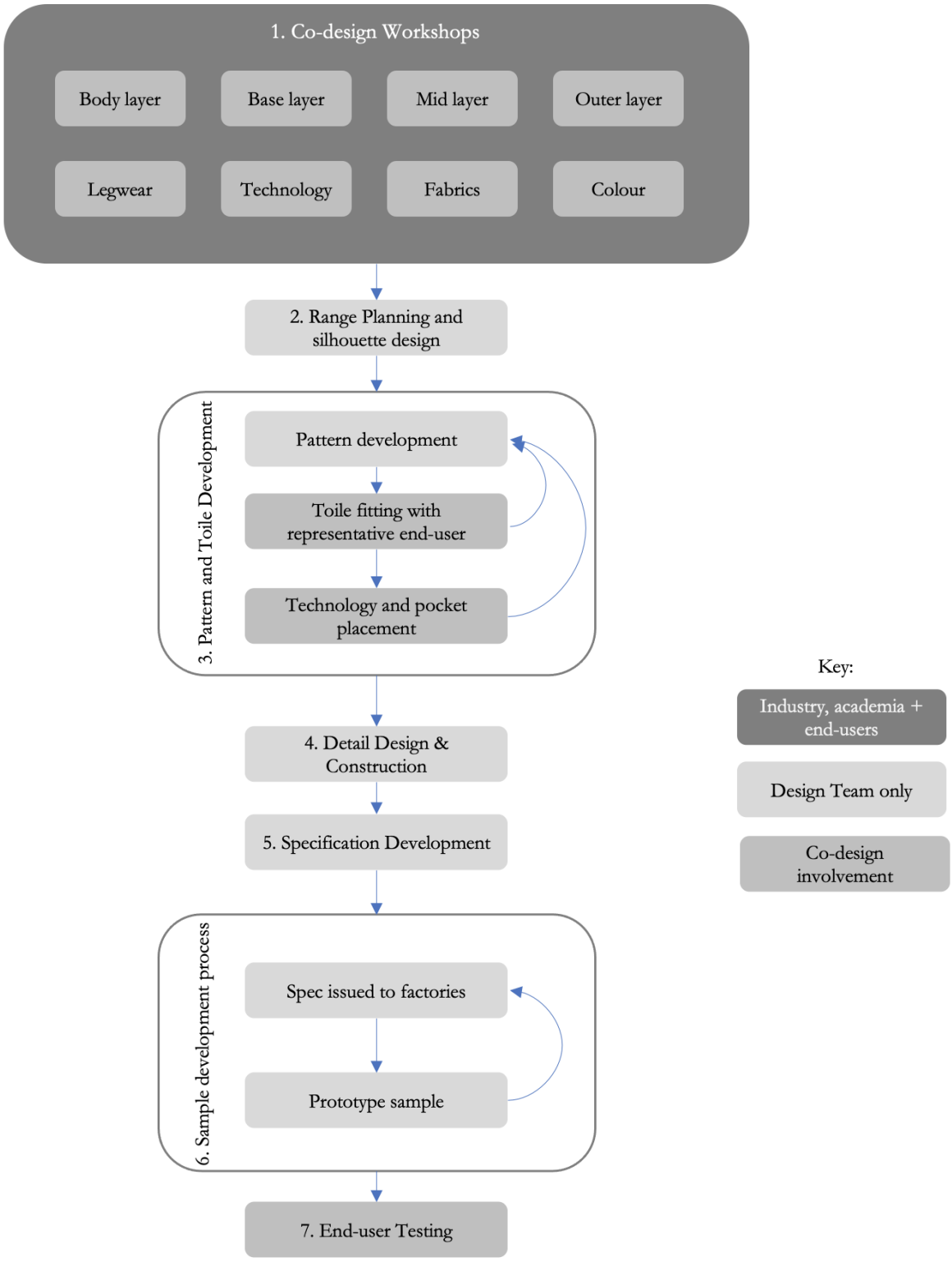
FULL CUP NON-PADDED	FULL CUP WIRE FREE (2-PIECE CUP)	FULL CUP (3-PIECE CUP)		
HALTER BRA (FASHION)	HALTER BRA (CUT & SEWN)		HALTER BRA (MOLDED)	
LONGLINE BRA (CUT & SEWN)	LONGLINE BRA (FASHION)		MASTECTOMY BRA (KNIT)	MASTECTOMY BRA (CUT & SEWN)
				
MOLDED BRA	MOULDED HALTER BRA	MOULDED STRAPLESS BRA		
				
MINIMIZER PADDED BRA	MINIMIZER BRA (CUT & SEWN)	MINIMIZER BRA (MOLDED)		

NURSING/MATERNITY BRA (KNIT)	NURSING/MATERNITY BRA	NURSING/MATERNITY BRA (MOLDED)	NURSING/MATERNITY BRA (CUT & SEWN)	
PLUNGE BRA (NONPADDED)	PLUNGE BRA (CUT & SEWN 4-PIECE)	PLUNGE BRA (CUT & SEWN 4-PIECE)	PLUNGE BRA (PADDED)	
SHELF BRA (CUT & SEWN)		SLEEP BRA (MOLDED NONPADDED)	SLEEP BRA (KNIT)	
COMPRESSION SPORTS BRA	ENCAPSULATION SPORTS BRA	HYBRID/COMBINATION SPORTS BRA		
TRIANGLE BRA (CUT & SEWN)	TRIANGLE BRA (MOLD)	TRIANGLE BRA (KNIT)		

		PROBLEM STATEMENT/IDENTIFICATION		CONCEPTUAL DESIGN			PROTOTYPE DEVELOPMENT	EVALUATION & REFINEMENT			SOLUTION/PRODUCTION PLANNING	
New Product Design	Jones, 1970	Analysis		Synthesis					Evaluation			
	Lewis & Samuel, 1989	Problem Recognition	Problem Definition	Exploration of the Problem	Search for Alternatives			Evaluation & Decision	Specification of Solution		Communication of Solution	
	Crawford & Benedetto, 2003	Opportunity Identification and Selection		Concept Generation	Concept/Project Evaluation		Development				Launch	
	Acklin, 2010 *(Innovation Process Model)*	Evaluate Impulses from Market & Organization	Research Market, Technology, Customer Needs	Idea Selection based on Initial Research	Observational/Experiential Research		Concept Development, Design	Concept Evaluation, User Testing			Implementation, Commercialisation	
Apparel Design	Hank, 1977	Problem Identification	Preliminary Ideas		Design Refinement			Analyse	Decision		Implementation	
	Orlando, 1979	Request	Design Exploration	Problem Identification	Design Criteria & Specification		Prototype	Evaluation				
	Koberg & Bagnall, 1981	Accept Situation	Analyse (Explore & Discover)	Define	Ideate		Select	Implement	Evaluate			
	Davis, 1996	Set Goal	Examine Outside Influences	Establish Criteria	Make Plan		Carry Out Plan	Evaluate				
	Labat & Sokolowski, 1999 (Functional Design)	Problem Definition & Research		Creative Exploration					Implementation			
	Burns & Bryant, 2008	Research & Merchandising (Fashion & Market Research)	Design		Design Development & Style Selection		Marketing the Apparel Line	Pre-Production	Sourcing		Apparel Production	
Functional & Wearable Design	Dejonge, 1984 via McRoberts, 2008	Initial Request	Exploration Design Situation	Problem Structure Perceived	Develop Design Research Specifications		Establish Design Criteria	Prototype Development	Prototype Evaluation			
	Watkins, 1988 *(Adopted from Koberg & Bagnall, 1981)*	Acceptance	Analysis	Define	Ideate		Select	Implement	Evaluation			
	Lamb & Kallal, 1992	Problem Identification		Preliminary Ideas	Design Refinement		Prototype Development		Evaluate		Implement	
	Caroll & Kincade, 2007	Need and Preference	Idea Sketch	Spec Sheet	Prototype		Wear-Test	Industry Evaluation			Implementation	
	Gupta, 2011*	User Survey	User Requirements	Garment Design			Garment Assembly	Testing & Analysis			Production	
	McCann, 2005*	Identification of User Needs	Textile/Fabric Development	Body Measurement/ Size & Fitting	Garment Design	Pattern Development & Grading	Modelling, Simulation & Initial Prototyping	Integration of Smart & Wearable Tech.	Fitting	'Manufacture' (Cutting & Bonding'		Production
Intimate Apparel Design	Hardaker & Fozzard, 1997	Concept Development		Pattern Development			Grading				Production	
	Cherie, 2001	Design Goal	Design Orientation	Design Concept Development	Design Criteria Establishment		Design Specification	Prototype Preparation	Design Evaluation			
	Haffenden & Smith, 2015*	Identification of User Needs	Research	Design Brief	Development of Bra Size Matrix		Bra Design	Prototype Development / with Technical Integration /Specs	Fit & Evaluation		Manufacturing Considerations	
	Nahari, 2016 *(Speciality Bra Design)*	Research & Discovery	Design Sketches from Customer Feedback	Pattern & Prototype Development		Fitting	Grading & Digitizing Patterns	Produce Sample Run & Evaluate	Pre-Production Approval		Production	
	Confidential, 2018 *(High-Street Bra Process)*	Brief set from Supplier	Designers Sketch/Design	Technical Design 1st Pattern	Factory 1st Sample		1st Sample 34B Fit Model	Fit with Supplier's Model	Grading		Production	
	Gosler, 2018 *(Fast Fashion Bra Process)*	Research & Design Brief		Design & Promote to Buyers		Technical Specs & Grading		Fit & Evaluate Samples		Production		

Fig.C.1. Assorted design processes.

Fig.C.2. Process for a smart waterproof jacket.
Source: Design for Aging Well (Lewis, 2023, p. 417)



D. ASSESSING DESIGN RESEARCH

Wood (2000, p. 44) proposes to 'make writing more like designing' within design research. To do so, Wood recommends design-researchers utilise a 'thinking-into' approach to what the readers may require. As such, this section provides the readers with scholarship that presents the intricacies of conducting, writing, and assessing design research. In the end, the reader is made aware of how this study utilised categories of assessments as markers in drafting this thesis.

Bye et al., (2021) highlight the lack of design research, specifically in apparel and textiles, which informs on scholars' methodology, theoretical frameworks, and how these connect to the design research and outcomes. Effective design research should 'add to our knowledge base and help build theory in the field' (Bye, 2010, p. 205). However, conducting design research may be difficult as it incorporates 'designing activities, in which designers, their creative processes, and resulting artifacts' (Nimkulrat, 2012, p. 1) produce rich results which can be challenging to convey (Kaszynska, Kimbell, and Bailey, 2022). Due to its approach to solving 'wicked' problems (Rittel, 1973), vast contributions can be made from design research such as building on prior knowledge, advancing theory, exemplifying research through practice, problem-solving and providing rich documentation (Parsons and Morris, 2021). However, Parsons and Morris (2021, p. 18) assert attributable to design research richness, it may be difficult for scholars to communicate the complexity 'of the knowledge or new insights gained'. Nevertheless, with the pluralistic nature of design research, scholars must be transparent about the design activities to evidence rigour (Bye, 2010) and provide others with enough information to trace, replicate or build upon. Traceability becomes a crucial factor in design research as it 'relies heavily on transparent reasoning and a recoverable research process' (Prochner and Godin, 2022, p. 17).

Prochner and Godin (2022, p. 2) concluded that there was 'no consensus […] found about how to evaluate the *quality* of [design research] projects and their outcomes'. Thus, they devised an assessment indicator to assist researchers and reviewers in evaluating design research, and specifically provide examples in assessing design research employing pragmatism – which this thesis employed. As such, this author utilised their indicators as markers in writing up this interdisciplinary thesis, providing a richness of description in methods, processes, reflections and outcomes. **Fig.D.1.** illustrates some assessment indicators and identifies examples within this thesis.

Fig.D.1. Exemplars of Assessment Indicators
Source: Author, adapted from Prochner and Godin, 2022

Indicator Category	Explanation	Thesis Exemplars
Recoverable and Transparent	• 'a clear explanation of the process that justifies the stated research conclusions is an aspect of pragmatist writing' (p. 9) • 'enough transparency enabling 'the reader […] to trust the author's internal and tacit design process' (p. 10)	• Chapters 8,9, and Appendix L provide rich descriptions for transparency • Chapter 10 situates and justifies the research findings
Interconnectivity	• 'indicators that emphasise links between various elements of a project. This could mean linking concepts, variables, stakeholder viewpoints, and other things in the research context or the environment that is affected by the research.' (p. 10)	• Chapters 5 and 6 link the methodology with the research design and ties in conceptual models and theoretical frameworks • Chapters 8 and 9 provide interconnectivity to the conceptual model and theoretical frameworks
Contextualised	• 'researchers should base their work on strong and contextual evidence.' • 'Real-life contextualisation and "interconnectivity"…' (p. 11)	• Chapters 2, 3, and 4 contextualise the research • Throughout Chapters 5, 6, 9 and Appendix L contextualisation is made to real-life with the consequences of Covid-19 and its effects on the participants, design-researcher, and study
Applicability and Transferable	• 'evaluate the extent that research outcomes can be applied beyond the original research context' (p. 12) • 'transferability evaluates "applicability" of outcomes, recognizing that some results might not be indiscriminately generalizable' (p. 12)	• Chapters 10 and 11 highlight the applicability and transferability of the findings and research approach to other areas • Appendix T applies the design findings to the industry
Reasonableness, Reliability and Dependability	• '…"reasonable" and justifiable decisions throughout the research process, including in the choice and application of measurement techniques.' (p. 15) • 'can be demonstrated through the external audit of the research findings (Lincoln & Guba, 1985) which show the research process to be "reasonable."' (p. 15)	• Chapters 5 and 6 provide in-depth justification linking methodology and research design to showcase reliability and reasonableness • Chapter 10 and Appendix R demonstrates dependability from external experts
Positioned in research and theory	• 'researchers are positioning themselves within a larger school of thought, even if the theoretical context itself is partial or critical' (p. 14)	• Chapters 5 and 10 demonstrate how the research is positioned within human-computer interaction (HCI)

E. CALL FOR PARTICIPANTS

SEEKING BLACK WOMEN (45-64yrs) FOR DOCTORAL RESEARCH

INTERVIEWS:
Looking for mature Black women (**45-64 years**) to participate in interviews on their lived bra wearing experiences. This research aims to understand mature women's bra wearing experience to develop a design process that centres their experiences. Phase two of this research will involve workshops to further develop and test the design process. Further participation in the workshops is optional.

Please note interviews are anonymous and confidential.

INTERVIEW QUESTIONS:
The interview will utilise a story telling format. This means initial questions will ask you to recall in detail, for example, an event or day of wearing your favourite and least favourite bra.

DURATION: 1 Hour
PLACE: Phone or via Video App (Skype, Facetime, WhatsApp, Zoom)
PERIOD: **November 2019- August 2020**

If you are interested in participating or in need of more information, please do contact me at the email below.

Interviewer: Kadian A. Gosler, PhD Candidate | Gosler.Kadian@gmail.com
DOS: Professor Sandy Black | S.Black@Fashion.arts.ac.uk
Co-Sup: Dr Aurore Bardey | A.Bardey@Fashion.arts.ac.uk

This study has been approved by UAL's Research Committee (URC) and Research Ethics Sub-Committee. Contact Researchethics@arts.ac.uk with any queries.

ual: london college of fashion

Kadian A. Gosler

F. SAMPLE WORKBOOK (GENERATIVE WORKSHOP)

PhD Researcher: Kadian A. Gosler
Director of Study: Professor Sandy Black
Co-Supervisor: Dr. Aurore Bardey
London College of Fashion
20 John Prince's St,
Marylebone, London W1G 0BJ

ual: university of the arts london

INTRODUCTORY WORKBOOK

Title of Project: "Futuristic Bras: Developing a Design Process for Bra Wearables"

Introductory

Thank you for opting to participate in this research. The exercises within are meant to be answered one a day. You may choose to do them all in one go; however, it would be most beneficial if done as an exercise a day. The reason is so that you have enough time to really think about your answers. You do not have to answer the exercises in the given order. If you have any questions during the process, please email me and I can help where possible.

Please feel free to contact me or my supervisory team if you have any questions!
Kadian A. Gosler K.Gosler0720171@arts.ac.uk
Professor Sandy Black S.Black@fashion.arts.ac.uk
Dr. Aurore Bardey A.Bardey@fashion.arts.ac.uk

PhD Researcher: Kadian A. Gosler
Director of Study: Professor Sandy Black
Co-Supervisor: Dr. Aurore Bardey
London College of Fashion
20 John Prince's St,
Marylebone, London W1G 0BJ

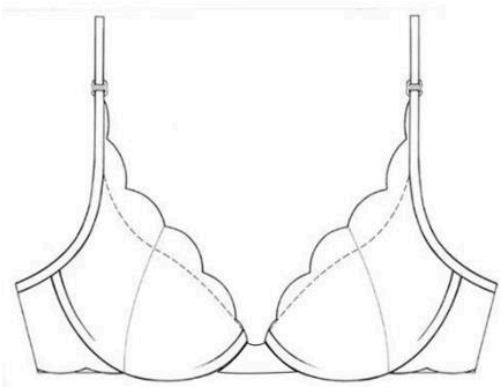
ual: university of the arts london

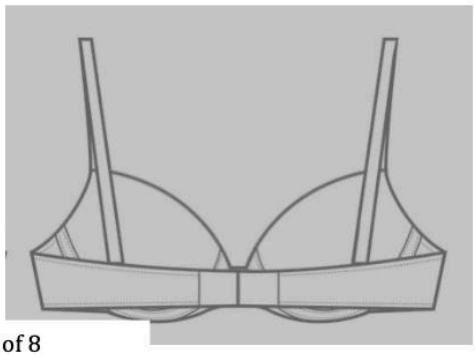
INTRODUCTORY WORKBOOK

Exercise 1: What is your favourite bra?

- List and describe all the things about it you loved. Think about the back as well. Nothing is too insignificant. If you have it, please attach a picture or draw it on top of the image.

Ex: Straps were sturdy with decorative lace in a pop colour. Cups were cut low and soft with unlined with dotted mesh.





Please feel free to contact me or my supervisory team if you have any questions!
Kadian A. Gosler K.Gosler0720171@arts.ac.uk
Professor Sandy Black S.Black@fashion.arts.ac.uk
Dr. Aurore Bardey A.Bardey@fashion.arts.ac.uk

PhD Researcher: Kadian A. Gosler
Director of Study: Professor Sandy Black
Co-Supervisor: Dr. Aurore Bardey
London College of Fashion
20 John Prince's St,
Marylebone, London W1G 0BJ

ual: university of the arts london

INTRODUCTORY WORKBOOK

Exercise 1. **(Continued)** Describe how wearing your favourite bra made you feel. Did you act different while wearing it? If so, how?

Please feel free to contact me or my supervisory team if you have any questions!
Kadian A. Gosler K.Gosler0720171@arts.ac.uk
Professor Sandy Black S.Black@fashion.arts.ac.uk
Dr. Aurore Bardey A.Bardey@fashion.arts.ac.uk

PhD Researcher: Kadian A. Gosler
Director of Study: Professor Sandy Black
Co-Supervisor: Dr. Aurore Bardey
London College of Fashion
20 John Prince's St,
Marylebone, London W1G 0BJ

ual: university of the arts london

INTRODUCTORY WORKBOOK

Exercise 2: What is something you love about your breasts? As you age has your feelings about your breasts changed? Have you found something new to love about your breasts? What is one thing you do not like about your breasts? Do you purchase bras to enhance what you love about your breasts or to hide what you do not like about them?

Please feel free to contact me or my supervisory team if you have any questions!
Kadian A. Gosler K.Gosler0720171@arts.ac.uk
Professor Sandy Black S.Black@fashion.arts.ac.uk
Dr. Aurore Bardey A.Bardey@fashion.arts.ac.uk

PhD Researcher: Kadian A. Gosler
Director of Study: Professor Sandy Black
Co-Supervisor: Dr. Aurore Bardey
London College of Fashion
20 John Prince's St,
Marylebone, London W1G 0BJ

ual: university of the arts london

INTRODUCTORY WORKBOOK

Exercise 3: If a bra could address anything about your health (mental, emotional, physical, sexual) what would you want it to address and why? If nothing, please write why not.

For example: A bra that would disperse lavender scents whenever I'm stressed. Or a bra that would help with anxiety.

Please feel free to contact me or my supervisory team if you have any questions!
Kadian A. Gosler K.Gosler0720171@arts.ac.uk
Professor Sandy Black S.Black@fashion.arts.ac.uk
Dr. Aurore Bardey A.Bardey@fashion.arts.ac.uk

PhD Researcher: Kadian A. Gosler
Director of Study: Professor Sandy Black
Co-Supervisor: Dr. Aurore Bardey
London College of Fashion
20 John Prince's St,
Marylebone, London W1G 0BJ

ual: university of the arts london

INTRODUCTORY WORKBOOK

Exercise 4: When you think about being a mature woman what are the first few words and emotions that come to mind? Can you elaborate using words, stickers (attached to page) and colours on what about experiencing maturity makes you feel that way?

Please feel free to contact me or my supervisory team if you have any questions!
Kadian A. Gosler K.Gosler0720171@arts.ac.uk
Professor Sandy Black S.Black@fashion.arts.ac.uk
Dr. Aurore Bardey A.Bardey@fashion.arts.ac.uk

PhD Researcher: Kadian A. Gosler
Director of Study: Professor Sandy Black
Co-Supervisor: Dr. Aurore Bardey
London College of Fashion
20 John Prince's St,
Marylebone, London W1G 0BJ

ual: university of the arts london

INTRODUCTORY WORKBOOK

Exercise 5: How often do you think about and gauge your health & wellbeing (mental, emotional, physical & sexual)?

Please fill in the boxes below.

	Overall Health	Mental Health	Emotional Health	Physical Health	Sexual Health
Once a Year					
Every 6 Months					
Every 3 Months					
Monthly					
Bi-Weekly					
Weekly					
Daily					
Never					

Example: If you think about your overall health daily you shade up to the box with daily.

	Overall Health	Mental Health
Weekly		
Daily	■	
Never	■	

Please feel free to contact me or my supervisory team if you have any questions!
Kadian A. Gosler K.Gosler0720171@arts.ac.uk
Professor Sandy Black S.Black@fashion.arts.ac.uk
Dr. Aurore Bardey A.Bardey@fashion.arts.ac.uk

PhD Researcher: Kadian A. Gosler
Director of Study: Professor Sandy Black
Co-Supervisor: Dr. Aurore Bardey
London College of Fashion
20 John Prince's St,
Marylebone, London W1G 0BJ

ual: university of the arts london

Thank you for your participation. I look forward to seeing you at the workshop!

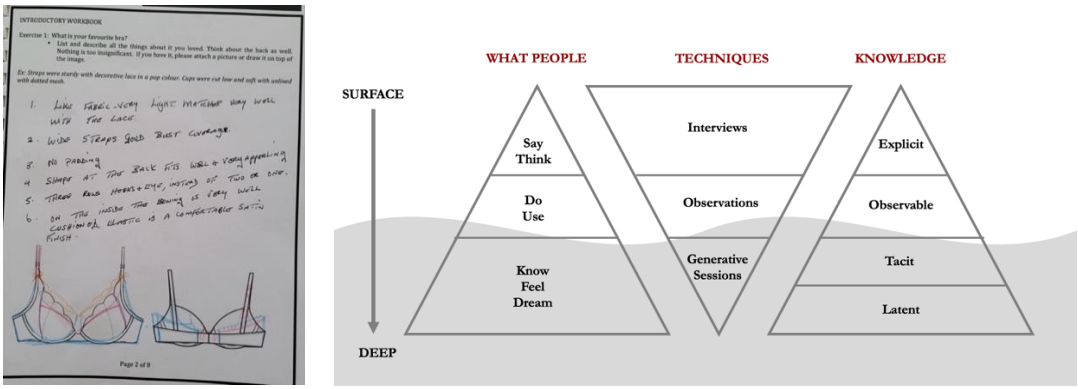
Please feel free to contact me or my supervisory team if you have any questions!
Kadian A. Gosler K.Gosler0720171@arts.ac.uk
Professor Sandy Black S.Black@fashion.arts.ac.uk
Dr. Aurore Bardey A.Bardey@fashion.arts.ac.uk

G. GENERATIVE WORKSHOP PHASE 2 & 3 EXPLAINED

Phase 2: Sensitising Phase

The sensitising phase is developed per Sleeswijk Visser et al.'s (2005) recommendations. This stage initiates contact with the participants and introduces them to the research. It is meant to encourage the women to reflect on their current and previous bra experience, ageing body, health, and menopausal experience. Through pre-workshop self-reflection, the women can readily access more profound insights into their previous bra and bodily experiences, preparing them to share information during the workshop sessions (*ibid*). With this goal, the workbook is used as an information-gathering probe to access the women's experiences and thoughts necessary for the pre-design fuzzy front-end of the design stage (Mattelmäki, 2005; Sanders and Stappers, 2014). The women were given a sensitising workbook to complete for a week before the workshop, allowing them time to comprehend the goals and topic of the research and feel at ease.

Fig.G.1. *Left:* Page from a participants' workbook. *Right*: Latent Needs Model*.
**Source:* 'Contextmapping: experiences from practice' (Sleeswijk Visser *et al.*, 2005)



The workbook contains five days' worth of activities, also referred to as probe tasks (Mattelmäki, 2006), for the women to complete in the comfort of their own homes (workbook in Appendix F). A great deal of attention went into developing the workbook, with the design-researcher cautiously considering which tasks to include. While many probe kits often incorporate disposable cameras, it was decided best not to include them due to the sensitive and personal nature of bras. Instead, one of the exercises was to draw a bra, which is a non-intimidating way to get information on positive or negative attributes and a good self-expression task (Mattelmäki, 2006). A blank bra outline and coloured pencils were provided (**Fig.G.1**.). They were asked to list all the best things about it, and how wearing it makes them feel. Whilst the workbooks can provide data to be analysed, this study used them solely as a sensitising probe, instead focusing on the rich data gathered at the workshop.

Phase 3: Workshop

Sanders (2000) that various generative techniques are best used during the workshop. Therefore, the workshop was designed with three exercises in varying 'make, say, do' techniques to access the women's tacit and latent needs – 'know, feel, dream' (**Fig.G.1.**). The first exercise, 'Tools for Visioning', aimed to understand women's emotions towards various bras and was designed to last thirty minutes. A collection of bra images (*n* =124) taken from assorted brands of various colours, shapes, and sizes was collated on A4 size paper. A separate page was developed with descriptive words (e.g., outdated, fun, posh) and blank options to provide their own. The women were tasked with selecting ten images, ordering them from favourite to least favourite. They were then asked to select or provide words they attributed to each selection. Following the 10-minute make activity, they were asked to present their selections within another 10-minute interval. Lastly, questions were developed around why they chose words and designs for the 10-minute group discussion portion. This activity was selected to begin the session as it quickly and easily immersed the women into thinking about their experiences (Sleeswijk Visser *et al.*, 2005).

The second exercise, 'Tools for Feelings', aimed to engage the women regarding BW through a 35-minute mind-mapping activity. Before the women were asked to begin this task, they were presented with a state-of-the-art of the BW field through a PowerPoint presentation, including the BW Historical Chart and images from scoping the sub-fields. Provided with various colouring and designing tools, the women were tasked with selecting BW ideas with various useful capabilities. They were then prompted to map their expected experience with it. After a 15-minute presentation period, the women were asked to discuss as a group their ideas. The facilitator was provided with questions to prompt the 10-minute group discussion.

The third exercise, 'Tools for Dreaming', slated to last 40 minutes, was developed to allow the women to design their own BW ideas. During this exercise, the women were given a design packet with fifty-three bra CADs in black and white to aid bra shape inspirations. Moreover, aiming for the women to not focus too much on their designing abilities by providing CADs of bra shapes, it allowed them to focus on designing rather than creating perfect drawings. Further, designing tools such as lingerie fabric and lace swatches, colour chips, and decorative bra straps were provided. Participants were asked to use the tools provided to design their own BW, including the functionality aspect. Following a 15-minute presentation, they were asked to present their design ideas in an 'As Seen on T.V.' format. Last, they were prompted to discuss their ideas in a group for 10 minutes.

In between each exercise, there was a planned 15-minute break. During the three breaks, there were three quick exercises to access the 'path of expression' (Sanders and Stappers, 2012) to gain information on 'present experiences, good and bad memories from the past and hopes and dreams for the future' (Sanders and Stappers, 2014). Each quick exercise was 5 minutes with the participants tasked with writing down one to three words based on the prompts, and then a quick 5-minute discussion followed. The first prompt tasked the women with describing their bra experiences, thinking about their feelings when wearing, purchasing, and laundering the bra over the years. The second prompt asked the women to describe how

they wanted to feel when wearing their bras. The last prompt introduced the idea of sensuality and sexual wellness. The women were then asked to write down words on scents, colours, and feelings that would define sensuality.

A final presentation slide was presented at the end, thanking the women for participating and inviting them to follow the research further.

H. GENERATIVE WORKSHOP OUTLINE

Bra Wearables Workshop 1
Date: Saturday April 13th 2019 (9am-7pm)
Location: 272 High Holborn, Rm 214

Introduction 5-8 mins

- Introduce yourself (facilitator), you may talk about your research.
- I'll quickly introduce myself and the research.
- **Facilitator**: Please note that we ask for confidentiality in this workshop. Please do not repeat any information discussed by your fellow participants with anyone outside the workshop. We will not be taking photos of anyone's faces and ask that you don't as well. You may elect to use a nickname, go by a first letter or an alias. We will not be video recording just audio recording for this session. We ask that everyone is respectful and not speak over each other. This workshop is meant to be fun and creative, so we'd like you to feel relaxed. If you have any requests do ask us. Please sign the consent sheet and we'll begin.
- Begin warm up with quick 5 min exercise

[redacted] the quick sticky exercises will be kept to a strict time. I don't want them to go over into the other exercises. But if there is something in-depth being said we'll continue it at the table during the next exercise.

Once they make then they present. If people are presenting and discussing at the same time and its flowing, we can format it to that. We'll just make sure not to go over time for the exercise session.

I will also participate and urge conversation/participation. I'll also discuss with them while doing the exercises certain topics/ areas that may come up. But I will defer to you as the facilitator to lead and guide the workshop. I can also set a timer if you want.

As there is no video just audio taping, I will be trying to take as much notes as possible on expressions and movements, etc. Please ask that they don't speak over one another which will help a lot when transcribing.

<table>
<tr><th>EXERCISE</th><th>ACTIVITY</th><th>DISCUSSION</th></tr>
<tr><td>Intro Exercise (5 Mins)
'Warm up'
<table><tr><td>Make</td><td>5 mins</td></tr><tr><td>Discussion</td><td>5 mins</td></tr></table></td><td>Write 1-3 words on each sticky describing your bra experiences. Think about your feelings when wearing, purchasing, and laundering the bra over the years.</td><td>• [We'll place the stickies up on a wall and begin to group like experiences.]
Note: Everyone will have different experiences, but some may share similarities.</td></tr>
<tr><td>Exercise 1: (30 Mins)
'Tools for Visioning'
<table><tr><td>Make</td><td>10 mins</td></tr><tr><td>Present</td><td>10 mins</td></tr><tr><td>Discussion</td><td>10 mins</td></tr></table></td><td>Images of different bra shapes/designs with a selection of words will be given to each participant. Participants will select 10 images place them in order from favourite to least. Select a word or write your own to describe each bra they've selected. After they will present their selections and we will discuss as a group.</td><td>• Would anyone like to talk about one of their selections?
• Why did you pick that word?
• What design details stood out about the bra? (e.g. colour, straps, bra cup shape, etc.)
• What did you like? What didn't you like?
• Would you change anything about it?
• Would you wear it? Why? Why not?</td></tr>
<tr><td>5 Minute Break</td><td></td><td></td></tr>
<tr><td>Quick Exercise
<table><tr><td>Make</td><td>5 mins</td></tr><tr><td>Discussion</td><td>5 mins</td></tr></table></td><td>Write 1-3 words on stickies describing how you want to feel wearing your bra. Think about how you want to feel when shopping for one, when trying one on, when wearing it all day, or wearing it for an occasion.</td><td>• [We'll place the stickies up on a wall and begin to group like experiences]
• Note: The bra for everyone will mean something different therefore they will want a different experience. Its important to understand the varying experiences in order to design for it.</td></tr>
<tr><td>Exercise 2: (35 Mins)
'Tools for Feelings'
<table><tr><td>Make</td><td>10 mins</td></tr><tr><td>Present</td><td>15 mins</td></tr><tr><td>Discussion</td><td>10 mins</td></tr></table></td><td>Kadian will present the different areas for bra wearables then activity will be introduced.

Create a mind-map using the various coloured papers and tools of ideas for bras with wearable technology. Ideas can be for bras with any capabilities you may find worthwhile or might be helpful for other women. After you will present your</td><td>• What are your bra wearables ideas?
• Describe the women who would wear it?
• Why would she want it?
• How does it make her feel when she wears it?
• Where would she wear it? (What occasions? What events?)
• Does she talk about it with anyone?
• Where did she purchase it? (Online? In stores? Catalogue?)</td></tr>
</table>

	ideas and we will discuss as a group.	• Discussion: • Does anyone like an idea you've heard? • Does anyone want to add to it?
5 Minute Break		
Quick Exercise Make 5 mins Discussion 5 mins	Bras are functional but may be worn for many different reasons and experienced in a variety of ways. One key area of this research project is women's sexual wellness and health which is tied to the bra because of its relationship with sexuality. Sexual health is defined by the World Health Organisation as '…a state of physical, emotional, mental and social well-being in relation to sexuality.' They go on to describe sexuality as 'a central aspect of being human…[encompassing] gender identities and roles, sexual orientation, eroticism, pleasure, intimacy…' and sensuality. In thinking about sensuality in a general sense or within the bra write down 1-3 words per sticky on scents/smells, colours, words, foods, feelings that you consider sensual.	• [We'll place the stickies up on a wall and begin to group like experiences] • Note: The bra is not considered sensual to everyone due to their culture or experiences. However, if we can start to define sensuality for mature women, we may begin to create bras that help women to experiencing better sexual health. • Kadian [*I will note the next step in my research is designing a bra for sexual wellness.*]
Exercise 3: (40 Mins) 'Tools for Dreaming' Make 15 mins Present 15 mins Discussion 10 mins	Paper with a variety of bras will be given, along with lingerie fabric swatches, and colour chips. Participants using the tools given will design their own bra wearable, adding the selected fabrics & colour swatches. They will then create a function that the bra will adhere to and	• Tell me about your bra. • Describe your samples. • How would you put this bra on? • How do you care for this bra? Charging? Cleaning? Laundering? • How are you interacting with the bra? When are you checking the data- where? How?

	present it to the group in an 'As Seen On T.V.' fashion. Part of this activity is to think about how women would experience your product. After we will discuss as a group.	• Does it need to give you feedback/data?
Wrap up- Thanks for coming	Thank you all for coming and participating in this workshop. It was a pleasurable experience and I hope you all had fun and felt engaged. If you did not do the workbook ahead then please take one and do it after. The information will help provide a holistic view of mature women's experiences.	Kadian *[Presents last slide on the next stage of research]*.

I. CONSUMER QUESTIONNAIRE

Questionnaire was reformatted for the SurveyMonkey online survey platform.

Bio-Data

1. Location

U.S.A	Canada	U.K.	Europe	Other

2. Age Range

45-49	50-54	55-59	60-64	65+

3. What is your relationship status?

Single	Partnered/Married	Widowed	Divorced	Other

4. What ethnic group(s) do you consider yourself to be a member of? Please check all that apply.

Black/ African American/ African/ Caribbean	Hispanic / Latina/ South American (Non-White)	White/European	South Asian
American Indian/ Alaskan Native	East Asian and other Pacific Islander	Mixed (please specify)	Other (please specify)

5. Highest Education Level

Some High School/GCSE	High School Diploma/ A-Levels	Some College	Certificate Degree
Associates Degree	Bachelor's Degree	Master's Degree	Doctoral degree

6. Combined Family Income ($ / £ / €)

Less 10,000	10,000 -29,000	30,000 - 49,000	50,000 - 69,000
70,000 - 89,000	90,000- 109,000	More than 100,000	Choose not to answer

Menopausal questions

7. What is your menopausal status?

Pre-menopausal	Menopausal	Post-Menopausal

8. What is one word you would use to describe menopause? Please write it in below.

9. If you are or have experienced menopausal symptoms, which ones impacted you the most? (Select your top 3)

Hot Flushes/Flashes	Night Sweats	Insomnia	Fatigue

Anxiety	Mood Swings	Depression	Aches/Pains
Dry Skin/Itching	Weight Gain	Low Libido	Other (Please add)
No Symptoms			

10. Which menopausal symptoms would you want addressed by your clothing if you had an option? (Select your top 3)

Hot Flushes/Flashes	Night Sweats	Insomnia	Fatigue
Anxiety	Mood Swings	Depression	Aches/Pains
Dry Skin/Itching	Weight Gain	Low Libido	Other (Please add)
No Symptoms			

11. Do you currently or previously own any menopausal relieving tool(s)? (Ex: Menopause: Bracelet, Camisoles, Necklaces, etc.)

Yes, please list.	No.

12. Since experiencing menopause has your perceptions of your *femininity* changed?

I feel more feminine.	I feel slightly more feminine.	I feel less feminine.	I feel extremely unfeminine.	No. I feel the same.
Please explain if possible.				

13. Since experiencing menopause has your perceptions of your *sexuality* changed?

I feel more sexual.	I feel slightly more sexual.	I feel less sexual.	I feel extremely asexual.	I feel the same.
Please explain if possible.				

14. Since experiencing menopause have you felt more or less like a woman?

I feel more like a woman.	I feel less like a woman.	No. I feel the same.
Please explain if possible.		

15. Since **turning 45** has your perceptions of your *femininity* changed?

I feel more feminine.	I feel slightly more feminine.	I feel less feminine.	I feel extremely unfeminine.	No. I feel the same.
Please explain if possible.				

16. Since **turning 45** has your perceptions of your *sexuality* changed?

I feel more sexual.	I feel slightly more sexual.	I feel less sexual.	I feel extremely asexual.	I feel the same.
Please explain if possible.				

17. Since **turning 45** have you felt more or less like a woman?

I feel more like a woman.	I feel less like a woman.	No. I feel the same.
Please explain if possible.		

Body Image

18. Please rate the statements below about your body image experiences.

	Select the closest number that you agree with for each statement.					
I have high self-esteem.	1	2	3	4	5	I have low self-esteem.
I am very aware of how people view my clothing.	1	2	3	4	5	I am not aware of how people view my clothing.
My body has changed for the worst with age.	1	2	3	4	5	My body is getting better with age.
Because I am older my body is less attractive.	1	2	3	4	5	Because I am older my body is more attractive.
I dress to enhance and show my body.	1	2	3	4	5	I dress to minimize and hide my body.
I dress my age.	1	2	3	4	5	I don't dress my age.
Lingerie doesn't change how I feel about my body.	1	2	3	4	5	Wearing lingerie, I like makes me feel better about my body.
I dress to look younger.	1	2	3	4	5	I dress to look mature.

19. My body image is influenced by…

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Family	1	2	3	4	5
Romantic Partner	1	2	3	4	5
Peers/Friends	1	2	3	4	5
Colleagues/Coworkers	1	2	3	4	5
Media/Advertising	1	2	3	4	5
Society	1	2	3	4	5

20. Please rate the statements below on your appearance.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I dress similar to the women of my ethnicity.	1	2	3	4	5
The women in my social circle are all similar body size and shape.	1	2	3	4	5
I look to older women as inspiration on how I should dress.	1	2	3	4	5
The appearance of my clothing is extremely important to my identity.	1	2	3	4	5

21. Please rate the statements below on your opinions of mature women's presentation.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
A confident woman is beautiful no matter what she is wearing.	1	2	3	4	5
I think positively of other women if they dress to stand out from the crowd.	1	2	3	4	5
I think other women think positively of me when I dress similar to them.	1	2	3	4	5
Other women would think negatively of me if I dress to stand out.	1	2	3	4	5
Pretty lingerie could make a mature woman more beautiful.	1	2	3	4	5

Breasts related questions

22. Since turning 45 have your breasts changed and how?

No Change	Size Increase	Size Decrease	Shape Change	Skin Change

23. How do you feel about the appearance of your breasts?

They're perfect. I'm happy with how they look.	They've changed but slightly happy with it.	I don't care / Have not thought of it.	They've changed and slightly unhappy about it.	I'm really unhappy with how they look.

24. Please note your level of agreement to the identity-based statements below.

	Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
My breasts are a part of my identity.	1	2	3	4	5
I purchase bras that reflect my identity.	1	2	3	4	5
The bras I wear affects what outer clothing I purchase or wear.	1	2	3	4	5
I consider my bra collection to be more fun than boring.	1	2	3	4	5

25. Please note your level of agreement to the sexuality-based statements below.

	Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
My breasts are a part of my sexuality.	1	2	3	4	5
I do not wear or purchase bras to feel sexy.	1	2	3	4	5
The kind of bra I wear does not affects my sexuality.	1	2	3	4	5
When trying to impress a romantic partner I think about the type of bra I wear.	1	2	3	4	5

26. Please note your level of agreement to the femininity-based statements below.

	Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
Having breasts makes me feel feminine.	1	2	3	4	5
The appearance of my breasts makes me feel less feminine.	1	2	3	4	5
Purchasing bras makes me feel more feminine.	1	2	3	4	5
My bras are not feminine just functional.	1	2	3	4	5

Bra Purchasing Questions related to Influence

27. Do you think your identity as a mature woman affects how you purchase bras?

My style has evolved but still fashionable.	I feel like I must wear mature bras now.	I purchase for function and comfort.	No. I still shop for styles I liked in my 30's.	No. It does not affect my purchasing decisions.

28. I find bras marketed to mature women to be…

Just my style.	Fashionable.	Plain/Functional.	Too matronly.	Unflattering and not stylish.

29. My bra choices are influenced by…

	Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
Family	1	2	3	4	5
Romantic Partner	1	2	3	4	5
Peers/Friends	1	2	3	4	5
Media/Advertising	1	2	3	4	5
Society	1	2	3	4	5

30. How important is it for your bra to be discreet?

Very Important	Somewhat Important	Not Important	Depends on the social setting

31. If your bra was to be seen in a social setting, what do you think others would think about it?

	Select the closest number that you agree with for each statement.					
Outdated	1	2	3	4	5	Fashionable
Bland	1	2	3	4	5	Very Sexy
Matronly	1	2	3	4	5	Youthful
Age Appropriate	1	2	3	4	5	Inappropriate
Fits my style	1	2	3	4	5	Not my style

Bra Purchasing/Wearing

32. Please select from the options below reasons you wear a bra.

Because society says so.	I feel comfortable wearing one.	I wear it as a fashion statement.	It makes my clothing fit better.	Large Breasts size.	I don't know.

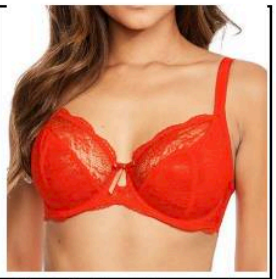
33. What kind of bras do you find sexy/sensual for your body?

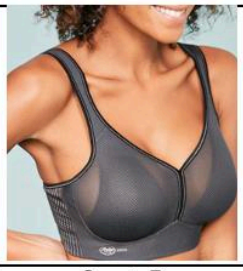
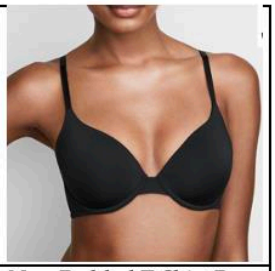
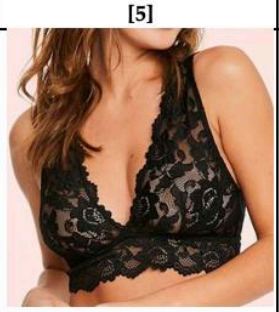
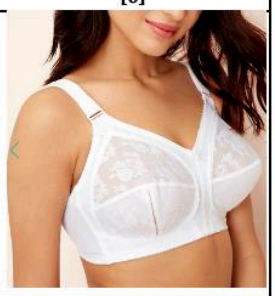
Floral Prints	Lacy/Sheer Designs	Wearing Red Styles	Wearing Black Styles	Low cut bras	Push-up bras	I wear bras for function only.

34. Please select your level of agreement to the statements below on how wearing certain bras makes you feel.

	Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
Wearing floral printed bras makes me feel more feminine.	1	2	3	4	5
Wearing overly lacy bras or sheer designs makes me feel sexy.	1	2	3	4	5
When I wear printed or 'girlish' bras I act more feminine.	1	2	3	4	5
When I wear sexy/sensual bras I act more confident.	1	2	3	4	5
The bra I wear affects how I act.	1	2	3	4	5
If I am wearing a plain bra I don't feel as confident.	1	2	3	4	5
When I wear a red bra, I feel and act more powerful.	1	2	3	4	5

35. The next few questions will be based on the bra pictures shown of various types of bras.

		
Padded Bras **[1]**	Padded Push-Up Bras **[2]**	Non-Padded Plunge Bras **[3]**

		
Unlined/Unpadded Bras **[4]**	Sports Bras **[5]**	Non-Padded T-Shirt Bras **[6]**
		
Balconette Bras **[7]**	Triangle Bras **[8]**	Non-wired Bra **[9]**

a. Which types of bras do you wear the most? Please focus on the shape and style of the bra. Please select 2.
b. Is there a style you would like to wear but don't? Please note the style here. Give a quick reason below.
c. Please select from the bras above which would be ***most*** appropriate for a social event. Please select 1.
d. Please select from the bras above which would be ***least*** appropriate for a social event. Please select 1.
e. Please select from the bras above which would be ***most*** appropriate for a professional event. Please select 1.
f. Please select from the bras above which would be ***least*** appropriate for a professional event. Please select 1.
g. Do you believe certain types of bras should not be worn by mature women? If so, are any styles present above? Select up to 3 if so. If not, can you quickly describe it here.

36. Please see the pantone colours below to select from in answering the following questions.
    a. Which of the bra colours shown would you not wear during daily social engagements? Please select.
    b. Which of the bra colours shown would you not wear during professional engagements? Please select.

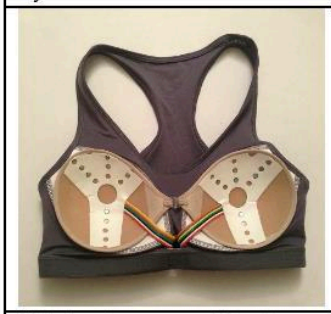
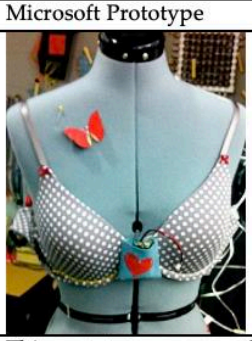
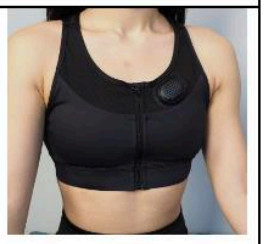
c. Are there any colours shown you do <u>not</u> find appropriate for mature women? Please select.

d. Please rate the bra colours below based on your opinion.

	Very Attractive	Attractive	Neutral	Unattractive	Very Unattractive
	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5

Opinions about Bra Wearables

The chart below shows a few examples of Bra Wearables with a description of the product. Please note these are all prototypes and examples of what technology can offer.

Cyrcadia Bra	Microsoft Prototype	Vitali Bra
		
This bra is a cancer detecting bra that monitors cancer cells in the breasts. It would then alert the wearer through an app if they should see a doctor.	This prototype assesses the wearers stress levels then alerts the wearer through an app when their emotional eating pattern is triggered.	This bra product assesses the wearers stress levels then assists the wearer through an app in breathing exercises to calm down.

37. Please indicate your degree of interests with the statements shown below.

Bra Wearable Ideas	**Strongly Dislike**	**Dislike**	**Neutral**	**Like**	**Strongly Like**
Bra that detects and monitors heart disease.	1	2	3	4	5
Preventative Breasts Cancer bra.	1	2	3	4	5
Stress detection and relief bra.	1	2	3	4	5
A bra designed for sexual stimulation.	1	2	3	4	5
Bra that monitors health vitals.	1	2	3	4	5

38. Please indicate your degree of agreement or disagreement with the statements shown below.

	Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
I believe there is a need for Bra Wearables.	1	2	3	4	5
Wearing Bra Wearables would improve the quality of my overall health.	1	2	3	4	5
Wearing Bra Wearables would increase my sense of self.	1	2	3	4	5

Bra Wearables would not be useful to me.	1	2	3	4	5

39. Please indicate your degree of agreement or disagreement with the statements shown below.

	Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
Understanding how to use Bra Wearables would not require a lot of mental effort.	1	2	3	4	5
It would be easy to use Bra Wearables.	1	2	3	4	5
Wearing Bra Wearables would be more difficult than wearing a regular bra.	1	2	3	4	5

40. Please answer the questions below indicating your degree of agreement or disagreement.

	Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
How confident are you that Bra Wearables will perform as described?	1	2	3	4	5
How certain are you that Bra Wearables will work satisfactorily?	1	2	3	4	5
Do you feel Bra Wearables will perform the functions that they are set to do well?	1	2	3	4	5

41. I believe wearing Bra Wearables would be…

	Select the closest number that you agree with for each statement.					
Uncomfortable	1	2	3	4	5	Comfortable
Rigid	1	2	3	4	5	Flexible
Difficult to move in	1	2	3	4	5	Easy to move in
Heavy weight	1	2	3	4	5	Lightweight
Ill Fitting	1	2	3	4	5	Fitting

42. Please indicate your degree of agreement or disagreement with the statements shown below.

	Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**

Health & Wellness Bra Wearables may suit my needs.	1	2	3	4	5
Bra Wearables would be compatible if its discreet underclothing.	1	2	3	4	5
Bra Wearables would be not be appropriate for my lifestyle.	1	2	3	4	5
I would only wear Bra Wearables in private situations.	1	2	3	4	5
Bra Wearables should be made to be worn at any time.	1	2	3	4	5

43. Please indicate your degree of agreement or disagreement with the statements shown below.

	Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
The aesthetics of Bra Wearables is important for my acceptance.	1	2	3	4	5
Bra Wearables should look like regular bras.	1	2	3	4	5
The longevity of Bra Wearables is not as important to me.	1	2	3	4	5
Caring for Bra Wearables is a deterrent for my interest.	1	2	3	4	5
I do not want to be aware of the bra I am wearing.	1	2	3	4	5
The technological elements should be hidden in the bra.	1	2	3	4	5

44. I believe a Bra Wearables purchase would be…

	Select the closest number that you agree with for each statement.					
Inexpensive	1	2	3	4	5	Expensive
Unfavourable	1	2	3	4	5	Favourable
Foolish	1	2	3	4	5	Wise
Fad Product	1	2	3	4	5	The Future
Not beneficial	1	2	3	4	5	Beneficial

45. Please indicate your degree of agreement or disagreement with the statements shown below.

	Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
I intend to try this type of product when made available.	1	2	3	4	5

I am interested in Bra Wearables but not sure I would try it.	1	2	3	4	5
I would like more examples of Bra Wearables.	1	2	3	4	5
If recommended by my peers, I would be interested.	1	2	3	4	5

46. Please indicate your degree of agreement or disagreement with the statements shown below.

	Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
Mature women should participate in the design process of Bra Wearables.	1	2	3	4	5
I believe as a bra wearer I have insight on what's best for mature female bodies.	1	2	3	4	5
I would be more interested in Bra Wearables if I were a part of the design process.	1	2	3	4	5
I would be interested in Bra Wearables if I knew my peers were involved in the design process.	1	2	3	4	5

J. QUESTIONNAIRE ANALYSIS

This section provides statistical analysis for the questionnaire and compliments results in Chapter 7, Section 7.1. and 7.2.

J.1. Factors Affecting Bra Experience

J.1.1. Demographics of Sample

Fig.J.1. Words to describe Menopause (*n* = 206)

Considering the bulk of participants were on the lower end of the age spectrum, it is reasonable that 50% of the women were pre-menopausal, 24% were menopausal, and 25% were postmenopausal. To describe menopause, they used words such as "exhausting", "change", "hot", "annoying", and "freedom" (**Fig.J.1.**). The words' sentiment ranged from negative to neutral. Those who have experienced menopausal symptoms were most impacted by "hot flush/flash" (42%), "night sweats" (39%), "weight gain" (29%), and "insomnia" (28%). The top three menopausal symptoms they wanted most addressed by their clothing were "hot flush/flash" (56%), "night sweats" (43%), and "weight gain" (25%). Only 3% owned a menopausal relieving product.

Table J.2. Age and Menopause Experience on Femininity, Sexuality, and Feeling Womanly

	N	Mean	SD
Since experiencing menopause has your perceptions of your femininity changed?	156	2.69	0.71
Since experiencing menopause has your perceptions of your sexuality changed?	157	2.64	0.94
Since experiencing menopause have you felt more or less like a woman?	157	2.89	0.85
Since turning 45 has your perceptions of your femininity changed?	139	2.94	0.73
Since turning 45 has your perceptions of your sexuality changed?	139	2.96	1.13
Since turning 45 have you felt more or less like a woman?	139	2.97	0.90

Chapter 4 postulates the effect ageing, and menopause has on mature women (MW); however, it lacks depth. So, six questions were designated to identify whether ageing or menopause had the most considerable effect on the MW's sense-of-self (**Table J.2.**). Questions were scaled similarly to a 5-point Likert scale with feeling "extremely or less" feminine, sexual, or like a woman, respectively scaling 1 or 2, feeling "the same" scale at 3, and feeling "slightly or more" feminine, sexual, or like a woman, respectively at 4 or 5. The means were used to evaluate the results. Menopause affects MW's sense-of-self more than ageing. Sexuality (M=2.64, SD=0.94) is most affected by menopause, with femininity (M =2.69, SD =0.71) following closely. Ageing appeared to have less effect on sexuality (M =2.96, SD =1.13) and feeling like a woman (M =2.97, SD =0.90). Although it did have, albeit slightly more effect on femininity (M =2.94, SD =0.73).

Table J.3. Mature Women's Breast and Bra Experience

	Frequency (n)	Percentage (%)
Do you currently or previously own any menopausal relieving tool(s)? (n=178)		
Yes	6	3.3
No	172	94.5
Since turning 45 have your breasts changed and how? (n= 181)		
No Change	50	27.5
Size Increase	47	25.8
Size Decrease	12	6.6
Shape Change	57	31.3
Skin Change	15	8.2
How do you feel about the appearance of your breasts? (n=181)		
They're perfect. I'm happy with how they look.	36	19.8
They've changed but slightly happy with it.	36	19.8
I don't care / Have not thought of it.	42	23.1
They've changed and slightly unhappy about it.	54	29.7
I'm really unhappy with how they look.	13	7.1
Do you think your identity as a mature woman affects how you purchase bras? (n=173)		
I purchase for function and comfort.	72	39.6
I feel like I must wear mature bras now.	4	2.2
No. It does not affect my purchasing decisions.	43	23.6
No. I still shop for styles I liked in my 30's.	26	14.3
My style has evolved but still fashionable.	28	15.4
I find bras marketed to mature women to be... (n=172)		
Other (please specify)	43	23.6
Unflattering and not stylish.	30	16.5
Too matronly.	48	26.4
Plain/Functional.	39	21.4
Just my style.	4	2.2
Fashionable.	8	4.4
Reasons you wear a bra. (n=170)		
Because society says so.	23	13.53
I feel comfortable wearing one.	80	47.06
I wear it as a fashion statement.	9	5.29
It makes my clothing fit better.	77	45.29
Large breasts size.	87	51.18
I don't know.	6	3.53
How important is it for your bra to be discreet? (n=173)		
Extremely important	20	11
Very important	25	13.7
Somewhat important	54	29.7
Not so important	29	15.9
Not at all important	19	10.4
Depends on the social setting	26	14.3

The questionnaire also aimed to comprehend ageing on MW's breasts and bra experience (**Table J.3.**).

Given the option to select more than one answer, participants were asked the reason they wore a bra, with 51% selecting due to their "large breast size", 47% because they felt either physically or mentally "comfortable wearing one", and 45% because "it makes their clothes fit better". Only 14% selected "because society says so", and an even smaller amount at 5% wear it as "a fashion statement". The importance of the bra to be discreet ranged from a combined 25% "extremely" to "very important", 30% "somewhat important", a combined 26% "not so important" to "not at all important", and 14% dependent on the social setting.

Table J.4. Bras Appropriateness

Q.35	Padded	Padded Push-Ups	Non-Padded Plunge	Unlined/ Unpadded	Sports Bras	Non-Padded T-shirt	Balconette	Triangle	Non-wired
Which types of bras do you wear the most? Please focus on the shape and style of the bra. (n=143)									
Percentage (%)	13.99%	9.79%	31.47%	27.97%	28.67%	37.06%	18.88%	2.10%	16.78%
Frequency (n)	20	14	45	40	41	53	27	3	24
Is there a style you would like to wear but don't? (n=110)									
Percentage (%)	2.73%	3.64%	12.73%	12.73%	6.36%	11.82%	24.55%	42.73%	0.00%
Frequency (n)	3	4	14	14	7	13	27	47	0
Please select from the bras above which would be most appropriate for a social event? (n=127)									
Percentage (%)	11.81%	11.02%	25.98%	14.96%	1.57%	19.69%	17.32%	0.79%	3.94%
Frequency (n)	15	14	33	19	2	25	22	1	5
Please select from the bras above which would be least appropriate for a social event? (n=126)									
Percentage (%)	2.38%	5.56%	3.97%	2.38%	39.68%	3.17%	7.14%	18.25%	21.43%
Frequency (n)	3	7	5	3	50	4	9	23	27
Please select from the bras above which would be most appropriate for a professional event? (n=128)									
Percentage (%)	16.41%	3.13%	17.97%	21.09%	3.91%	33.59%	6.25%	0.78%	8.59%
Frequency (n)	21	4	23	27	5	43	8	1	11
Please select from the bras above which would be least appropriate for a professional event? (n=126)									
Percentage (%)	3.17%	18.25%	7.14%	2.38%	30.16%	3.97%	5.56%	26.19%	8.73%
Frequency (n)	4	23	9	3	38	5	7	33	11
Do you believe certain types of bras should not be worn by mature women? If so are any styles present above? (n=38)									
Percentage (%)	13.16%	13.16%	10.53%	7.89%	18.42%	13.16%	15.79%	26.32%	34.21%
Frequency (n)	5	5	4	3	7	5	6	10	13

Bras for certain settings were also investigated. **Table J.4.**, Bras Appropriateness, and **Table J.5.,** Colour Appropriateness, focus on bra styles and colours to comprehend whether there was a Western belief of appropriateness for MW. Fifteen Pantone colours were displayed on which the participants based their answers (**Table J.5.** and colours samples in Appendix I). With Black women participants underrepresented, the colour options are skewed towards the dominantly represented white women.

Q.36	Black	White	Beige	Brown	Dark Purple	Red	Mauve	Deep Pink	Yellow	Blue	Light Grey	Light Pink	Light Purple	Light Blue	Light Yellow
Which of the bra colours shown would you not wear during daily social engagements? (n=105)															
Percentage (%)	7.62%	17.14%	10.48%	22.86%	18.10%	32.38%	21.90%	21.90%	54.29%	20.95%	11.43%	18.10%	17.14%	16.19%	51.43%
Frequency (n)	8	18	11	24	19	34	23	23	57	22	12	19	18	17	54
not wear during professional engagements? (n=103)															
Percentage (%)	9.71%	14.56%	10.68%	24.27%	21.36%	43.69%	29.13%	30.10%	62.14%	25.24%	14.56%	21.36%	22.33%	23.30%	55.34%
Frequency (n)	10	15	11	25	22	45	30	31	64	26	15	22	23	24	57
Are there any colours shown you do not find appropriate for mature women? (n=38)															
Percentage (%)	10.53%	10.53%	15.79%	7.89%	15.79%	26.32%	13.16%	23.68%	44.74%	13.16%	21.05%	15.79%	10.53%	10.53%	34.21%
Frequency (n)	4	4	6	3	6	10	5	9	17	5	8	6	4	4	13
Please select the colours you would most like to wear. (n=132)															
Percentage (%)	69.70%	39.39%	46.97%	15.15%	31.06%	34.85%	35.61%	26.52%	9.85%	31.06%	37.12%	28.79%	25.00%	21.97%	9.85%
Frequency (n)	92	52	62	20	41	46	47	35	13	41	49	38	33	29	13

Table J.5. Colour Appropriateness

J.1.2. Exploratory Factor Analysis

Table J.6. Constructs for Bra Experience.
The asterisk (*) constructs were amended to new constructs.
Image a copy of Table 7.3. in Chapter 7.

Construct	Short Hand	Definition	Sources
Age Experience	AgeExp	Construct to comprehend how ageing has affected sense of self.	Hopwood et al., 2001
Menopause Experience	MenoExp	Construct to understand how menopause has affected femininity, sexuality, and feeling womanly.	Hopwood et al., 2001
Body Image*	BodImag	Construct to understand how bra-wearing affects body image.	Kelch-Oliver and Ancis, 2011; Risuis, 2012
Body Image 1	BODImag1	A new construct combining other construct items that focuses on body image.	Newly developed construct.
Bra Femininity*	BraFem	Construct to understand how bra-wearing affects femininity.	Tsaousi, 2011
Bra Sexuality*	BraSex	Construct to understand how bra-wearing affects sexuality.	Tsaousi, 2011
Bra Femininity-Sexuality	BRAFemSex1	A new construct combining other construct items that focuses on femininity and sexuality.	Newly developed construct.
Bra Identity*	BraIden	Construct to understand how bra-wearing affects identity.	Tsaousi, 2011
Bra Identity 2	BRAIden2	A new construct combining other construct items that focuses on bra identity.	Newly developed construct.
Bra-Wearing	BRAWear1	Construct focused on understanding bra-wearing experience.	Risuis, 2012
Bra Influence	BraInflu1	Construct combining societal factors items to gauge influence on bra-wearing.	Tsaousi, 2011; Tiggemann, 2006; Grabe, Ward, Hyde, 2008

To determine whether the questionnaire items were accurately grouped and measuring similar concepts, an Exploratory Factor Analysis (EFA) was performed. Items were first adjusted from their negative formatting and turned into positive outputs. Once all the measurements were adjusted, an EFA using the principal components method with a varimax rotation was passed on all constructs to determine whether the items measured the designed themes. An EFA was conducted on previously and newly developed constructs. All constructs were examined for appropriateness through factor analysis and passed the Kaiser/Meyer/Olkin (KMO) and Bartlett's Test of sphericity (> .50) and were significant (p <0.01). Factor loadings of .45 and over were accepted as part of the new factors (Hair *et al.*, 1998). Items that did not load on their corresponding factors, nor loaded well with other constructs on the rotated component matrix were removed. **Table J.6.** showcases the constructs. Several questions were withdrawn from two previous constructs, "body-image" (BodImag) and "appearance", (App1), with the creation of a new factor, referred to as "Body-image 1" (BODImag1). The constructs measuring "femininity" (BraFem) and "sexuality" (BraSex) had some cross-loadings, which led to the development of a new construct, "Feminine-Sexuality" (BRAFemSex1). Similarly, the concept of "identity" (BraIden) had loadings from "femininity" and "sexuality", which were added, leading to the rename of the construct to "Bra Identity 2" (BRAIden2). The construct validity of all the items was checked for reliability using Cronbach's *alpha (*Cronbach α) (Garson, 2016; Hair *et al.*, 2019). Cronbach α for all the constructs must be equal to or above a >.70, unless they are

newly developed exploratory constructs, then >.60 (Hair *et al.*, 2019). The Cronbach α ranged from .68 to .89, displaying acceptable results. Lastly, the factors were combined for their mean scores for further usage in the next section.

J.1.3. Assumptions of Normality

Table J.7. Shapiro-Wilk Test Results

	Shapiro-Wilk		
	Statistic	df	Sig.
BODImag1	0.983	169	0.038
BRAIden2	0.972	169	0.002
BRAFemSex1	0.984	169	0.043

Assumptions of normality must first be met before conducting statistical analysis such as t-tests or regressions. The assumptions of normality are the basis of parametric statistics and tests that the sample distribution is normally distributed. Ghasemi and Zahediasl (2012) note that large sample sizes (n >40) tend to have normal sampling distribution. However, as the study uses a 5-point Likert scale[126], nonparametric tests are employed instead (Jamieson, 2004). First, the data were checked for outliers using the z-descriptives with their subsequent removal. Then a Shapiro-Wilk test was conducted to test for normality amongst the dependent variables. A test for normality was done on the dependent bra-wearing (BRAWear1) construct. The Shapiro-Wilk normality test was significant, meaning the bra-wearing construct is not normally distributed, W (146) = 0.98, p= 0.02. Further tests were performed on the bra-wearing dependent constructs (BODImag1, BRAIden2, and BRAFemSex1), which resulted in all being significant, thus deviating from normality (**Table J.7.**). With the constructs deviating from normality, they were treated as non-parametric, ruling out the usage of parametric statistics.

Table J.8. Spearman's Rho Correlation Matrix
** Correlation is significant at .01 level (2-tailed)
* Correlation is significant at .05 level (2-tailed)

	Spearman's rho Correlations							
	AgeExp	MenoExp	BODInflu1	BRAInflu1	BRAWear1	BRAIden2	BRAFemSex1	BODImag1
AgeExp	1							
MenoExp	.551**	1						
BODInflu1	-.071	-.211**	1					
BRAInflu1	-.078	-.186*	.340**	1				
BRAWear1	.030	-.078	.347**	.643**	1			
BraIden2	.239**	.066	.303**	.326**	.400**	1		
BraFemSex1	.226*	.036	.218**	.428**	.624**	.550**	1	
BODImag1	.181*	-.001	.299**	.325**	.567**	.507**	.616**	1

A Spearman's correlation was performed on the non-parametric data to measure the strength of the relationship between constructs. **Table J.8.** illustrates the results from the Spearman matrix, where most of the constructs display the statistical significance of either one-tail (*) or two-tail (**). Cohen (1988, pp.

[126] This study treats the 5-point Likert scale as ordinal, meaning that each point is arranged in ranking order.

79–81) provides guidelines for examining the relationship strengths between the two variables (small r = .10 – .29, medium r = .30 – .49, large r = .50 – 1.0). Additionally, the coefficient of determination is calculated to determine the shared variance between the two variables.

The ageing experience (AgeExp) had a significant relationship, albeit small strengths, to bra identity (BRAIden2) ϱ (121), r_s = .24, p <.008, bra feminine-sexuality (BRAFemSex1) ϱ (123), r_s = .23, p <.011, and body-image (BODImag1) ϱ (132), r_s = .18, p <.036. Ageing itself does not directly impact how MW experience the bra. The menopause experience (MenoExp) does not have a significant relationship to the dependent variables that affect the MW's sense-of-self. However, the menopause experience (MenoExp) is negatively affected by societal body influences (BODInflu1) ϱ (153), r_s =-.21, p <.008, and societal bra influences (BRAInflu1) ϱ (144), r_s =-.19, p <.025. Neither the ageing nor the menopause experience has a significant relationship to the bra-wearing experience.

Societal body influences (BODInflu1) ϱ (144), r_s = .35, p <.000 and bra influences (BRAInflu1) ϱ (144), r_s = .64, p <.000 have a significant relationship to the bra-wearing experience (BRAWear1), with societal bra influences having a stronger impact on the bra-wearing experience. BraInflu1 and BraWear1 contribute 40.96% shared variance, with a large correlation between them (r = .64), suggesting a strong relationship (Cohen, 1988). Bra influence explains 41% of the variance in participants' scores on bra-wearing experiences. Therefore, the bra-wearing experience is social and affected by societal norms.

Lastly, the bra-wearing experience (BRAWear1) had a large significant relationship to bra identity (BRAIden2) ϱ (141), r_s = .40, p <.000 with 80% shared variance; bra feminine-sexuality (BRAFemSex1) ϱ (143), r_s = .62, p <.000 with 124% shared variance; and body-image (BODImag1) ϱ (144), r_s = .57, p <.000 with 114% shared variance. Bra-wearing experience helps to explain large percentages of variance in MW's responses to the sense-of-self concepts (identity, feminine-sexuality, and body-image). Therefore, the bra-wearing experience affects the wearer's sense-of-self. On the other hand, the ageing experience does not affect the bra-wearing experience but affects the wearers' sense-of-self in smaller amounts.

J.1.4. Difference Between Factors Affecting Black & White Women

One of the research's aims was to establish whether there were differences between Black and white women regarding their bra relationship and experience. As previously noted, there was a disproportionate amount of white (81%) to Black (10%) participants. One way to determine any significant difference is to utilise the Mann-Whitney U Test. Mann-Whitney U Test is suitable when testing smaller, and in this case, unequal sample sizes. It compares the medians and ranks between the two variables, evaluating any significant difference (Pallant, 2016). Due to the small participant size for Black women, which can skew a non-significant result, the alpha level, usually p =.05, is adjusted to a cut-off of p =.10 (Steven, 1996 in Pallant,

2016, p. 301). The null hypothesis is that the two populations, Black and white women, are equal. **Table J.9.** and **Table J.10.** illustrate the test results.

Table J.9. Mann-Whitney U Test between Black and white women's Demographics

		N	Mean Rank	Sum of Ranks
Age Range	White/European	148	85.11	12596.50
	Black/ African American/	19	75.34	1431.50
	Total	167		
Relationship	White/European	148	85.89	12711.00
	African/ Caribbean	19	69.32	1317.00
	Total	167		
Education	White/European	148	83.56	12367.50
	Black/ African American/ African/ Caribbean	19	87.39	1660.50
	Total	167		
Income ($ / £ / €)	White/European	147	83.16	12224.00
	Black/ African American/ African/ Caribbean	19	86.16	1637.00
	Total	166		

	Age Range	Relationship	Education	Income ($ / £ / €)
Mann-Whitney U	1241.500	1127.000	1341.500	1346.000
Wilcoxon W	1431.500	1317.000	12367.500	12224.000
Z	-0.899	-1.770	-0.334	-0.260
Asymp. Sig. (2-tailed)	0.368	0.077	0.738	0.795

Table J.10. Mean Rank Results

		Age Range	What is your relationship status?	Highest Education Level	Combined Family Income ($ / £ / €)
White/European	N	148	148	148	147
	Median	2.0000	2.0000	6.0000	4.0000
Black/ African American/ African/ Caribbean	N	19	19	19	19
	Median	1.0000	2.0000	6.0000	4.0000
Total	N	167	167	167	166
	Median	1.0000	2.0000	6.0000	4.0000

The Mann-Whitney U Test revealed no significant difference in the age range of Black (Md = 1, n = 19) and white women (Md = 2, n = 148), U = 1241, z = -.899, p =.37. The Mann-Whitney U Test revealed no significant difference in the relationship status of Black (Md = 2, n = 19) and white women (Md = 2, n = 148), U = 1127, z = -1.770, p =.08. The Mann-Whitney U Test revealed no significant difference in the education levels of Black (Md = 6, n = 19) and white women (Md = 6, n = 148), U = 1341, z = -.334, p =.74. The Mann-Whitney U Test revealed no significant difference in the income levels of Black (Md = 4, n = 19) and white women (Md = 4, n = 147), U = 1346, z = -.260, p =.80.

Statistical 2-tailed significance is accepted if results are less than <.05. With no response revealing significance, this group of women are not statistically demographically different. Therefore, the null hypothesis is accepted that the two populations in the study are equal.

Table J.11. Age and menopausal effect on Black and white women

		N	Mean Rank	Sum of Ranks
What is your menopausal status?	White/European	147	83.19	12228.50
	Black/ African American/ African/ Caribbean	18	81.47	1466.50
Since experiencing menopause has your perceptions of your femininity changed?	White/European	125	71.14	8893.00
	Black/ African American/ African/ Caribbean	16	69.88	1118.00
Since experiencing menopause has your perceptions of your sexuality changed?	White/European	126	72.96	9192.50
	Black/ African American/ African/ Caribbean	16	60.03	960.50
Since experiencing menopause have you felt more or less like a woman?	White/European	127	71.50	9080.00
	Black/ African American/ African/ Caribbean	15	71.53	1073.00
Since turning 45 has your perceptions of your femininity changed?	White/European	112	65.62	7349.50
	Black/ African American/ African/ Caribbean	16	56.66	906.50
Since turning 45 has your perceptions of your sexuality changed?	White/European	113	65.30	7379.00
	Black/ African American/ African/ Caribbean	15	58.47	877.00
Since turning 45 have you felt more or less like a woman?	White/European	112	64.44	7217.00
	Black/ African American/ African/ Caribbean	16	64.94	1039.00

Table J.12. Mann-Whitney U significance on age and menopausal effect on Black and white women

Test Statistics							
	What is your menopausal status?	Since experiencing menopause has your perceptions of your femininity changed?	Since experiencing menopause has your perceptions of your sexuality changed?	Since experiencing menopause have you felt more or less like a woman?	Since turning 45 has your perceptions of your femininity changed?	Since turning 45 has your perceptions of your sexuality changed?	Since turning 45 have you felt more or less like a woman?
Mann-Whitney U	1295.500	982.000	824.500	952.000	770.500	757.000	889.000
Z	-0.156	-0.141	-1.272	-0.005	-1.192	-0.709	-0.073
Asymp. Sig. (2-tailed)	0.876	0.888	0.203	0.996	0.233	0.478	0.942

The Mann-Whitney U Test revealed no significant differences between the sample of Black and white women across age and menopausal effects (**Table J.11.** and **Table J.12.**). There were no significant differences in the samples' menopausal status, Black (*Md* =1.5, *n* = 18) and white women (*Md* = 2.0, *n* =147), *U* = 1295.5, *z* = -.156, *p* =.88. There were no significant differences in the effects of menopause on femininity within the sample, Black (*Md* =3.0, *n* = 16) and white women (*Md* = 3.0, *n* =125), *U* = 982, *z* =

-.141, p =.89. There were no significant differences in the effects of menopause on sexuality within the sample, Black (*Md* =3.0, n = 16) and white women (*Md* = 3.0, n =126), U = 824.5, z = -1.272, p =.20. There were no significant differences in the effects of menopause on feeling like a woman within the sample, Black (*Md* =3.0, n = 15) and white women (*Md* = 3.0, n =122), U = 952, z = -.005, p =.99.

There were no significant differences in the effects of ageing on femininity within the sample, Black (*Md* =3.0, n = 16) and white women (*Md* = 3.0, n =112), U = 770.5, z = -1.192, p =.23. There were no significant differences in the effects of ageing on sexuality within the sample, Black (*Md* =3.0, n = 15) and white women (*Md* = 3.0, n =113), U = 757, z = -.709, p =.48. There were no significant differences in the effects of ageing on feeling like a woman within the sample, Black (*Md* =3.0, n = 16) and white women (*Md* = 3.0, n =112), U = 889, z = -.073, p =.94. Therefore, the null hypothesis is accepted that the two populations in the study are equal.

Table J.13. Mann-Whitney U Mean Rank Results

		N	Mean Rank
BRAInflu1	White/European	138	77.34
	Black/ African American/ African/ Caribbean	18	87.39
BODInflu1	White/European	148	84.93
	Black/ African American/ African/ Caribbean	19	76.76
AgeExp	White/European	107	62.72
	Black/ African American/ African/ Caribbean	16	57.19
MenoExp	White/European	124	71.32
	Black/ African American/ African/ Caribbean	16	64.13
BRAWear1	White/European	117	64.45
	Black/ African American/ African/ Caribbean	16	85.66
BODImag1	White/European	148	82.83
	Black/ African American/ African/ Caribbean	19	93.08
BRAIden2	White/European	136	74.14
	Black/ African American/ African/ Caribbean	18	102.92
BRAFemSex1	White/European	139	76.62
	Black/ African American/ African/ Caribbean	18	97.36

Table J.14. Mann-Whitney U Results

Test Statistics								
	BRAInflu1	BODInflu1	AgeExp	MenoExp	BRAWear1	BODImag1	BraIden2	BraFemSex1
Mann-Whitney U	1082.0	1268.5	779.0	890.0	637.5	1233.5	766.5	920.5
Z	-0.893	-0.695	-0.605	-0.700	-2.068	-0.872	-2.591	-1.825
Asymp. Sig. (2-tailed)	0.372	0.487	0.545	0.484	0.039	0.383	0.010	0.068

The constructs that measured body influence, bra influence, bra feminine-sexuality, bra identity, body-image and bra-wearing experience were examined next for differences between Black and white women. As these constructs were previously noted as ordinal, the Mann-Whitney U Test was utilised. Mann-Whitney U Test is the non-parametric version of the Independent *T*-test used to interrogate the difference between two groups (Pallant, 2016). Since the distribution has different shapes, only the mean ranks are compared. The aim is to use Mann-Whitney U to uncover whether mature Black and white women differ in the factors that affect their bra experience (**Table J.13.**). Data illustrates the factors that influence Black women more. Black women scored higher in mean ranks for BRAFemSex1 (M =97.36), BRAIden2 (M =102.92), BODImag1 (M =93.08), BRAWear1 (M =85.66), and BRAInflu1 (M =87.39). White women were more influenced by BODInflu1 (M =84.93), the AgeExp (M =62.72), and MenoExp (M =71.32).

The Mann-Whitney U test found significant results of difference in three constructs between Black and white women (**Table J.14.**). The alpha level, usually p =.05, is adjusted to a cut-off of p =.10 (Steven, 1996, in Pallant, 2016, p. 301). When inspecting the BRAIden2 relationship, there was a significant difference in the scores for Black (M =102.92, n =18) and white women (M =74.14, n =136), U = 767, z = -2.59, p =.01, r =.21. These results suggest that the bras relationship to the identity concept is stronger for Black women than white. Examining BRAWear1 recorded a significant difference in the scores for Black (M =85.66, n =16) and white women (M =64.45, n =117), U = 638, z = -2.07, p =.04, r =.18. Similarly, the results indicate that Black women's bra-wearing experience is different from white women. Lastly, the BRAFemSex1 relationship indicates there is a significant difference in scores for Black (M = 97.36, n = 18) and white women (M = 76.62, n = 139), U = 921, z = -1.83, p =.07, r =.15. This result connote Black women have a stronger relationship the bra feminine-sexuality concept.

J.1.5. Bra Experience Structural Model

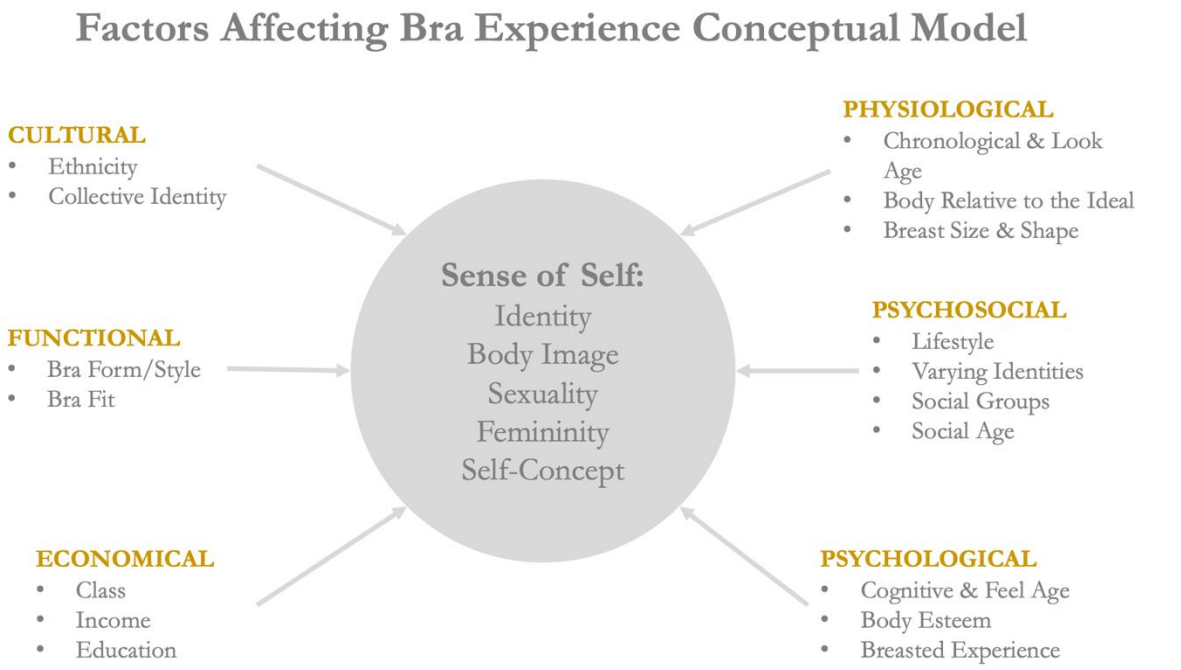


Fig.J.15. Generic Factors Affecting Bra Experience Conceptual Model

Through the literature in Chapter 4, Section 4.2.4., the generic Factors Affecting Bra Experience Conceptual model (**Fig.J.15.**) was developed; therefore, SmartPLS was utilised to explore whether the sense-of-self constructs was, in fact, statistically connected to the bra-wearing experience, and how. Hair et al. (2017) argues that PLS-SEM is superior for exploring the relationships between constructs. SmartPLS is a variance-based software that uses partial least squares (PLS) analysis to 'estimate complex models … [and] emphasizes prediction in estimating statistical models…' (Hair *et al.*, 2019, p. 2). The program is better suited for this exploration task as it easily allows for multivariate analysis, meaning multiple constructs can be connected and interrogated simultaneously (Hair *et al.*, 2018). Furthermore, the program is known for handling complex models (Henseler, Ringle and Sinkovics, 2009). This developing Bra Experience Conceptual model utilises a mixture of formative and reflective constructs, which makes it complex. Formative constructs are composed of indicators/items that combine to cause a construct (Henseler, 2017). In this study, the formative construct of societal bra influences (BRAInflu1) comprises social indicators, i.e., family, peers/friends, media/advertising, society, and romantic partner. The rest of the factors in this study are reflective, where 'the construct causes its indicators' and is frequently used when working with psychological factors (Henseler, 2017, p. 180).

Using SmartPLS v.3.3.2, factor analysis was conducted by selecting the Partial Least Squares Algorithm (PLS Algorithm), noting factor as the weighting scheme with a maximum of 1,000 iterations and using mean replacement to handle the missing values (Ringle, Wende and Becker, 2015). Bootstrapping allows for non-parametric data to be statistically evaluated for significance. Consequently, a complete bootstrapping was performed using a Bias-Corrected and Accelerated (BCa) bootstrap with parallel

processing of 5,000 samples. This provided the factor loadings utilised in the chart below. For the formative construct based on BRAInflu1, the outer weights were used instead of loading scores.

The PLS Algorithm output model appraisal indicates that the BODInflu1 and MenoExp paths were not significant. Therefore, these constructs were removed from the model before re-calculation.

		Mean	SD	Factor Loadings	Chronbach's *alpha*	Composite Reliability	Collinearity Statistics (VIF)
AgeExp					**0.71**	**0.80**	
A45Femin	Since turning 45 has your perceptions of your femininity changed?	2.94	0.73	0.73			1.53
A45Sexu	Since turning 45 has your perceptions of your sexuality changed?	2.96	1.12	0.76			1.36
A45Wom	Since turning 45 have you felt more or less like a woman?	2.97	0.90	0.65			1.44
BIBodAttr	Because I am older my body is more attractive.	2.37	0.86	0.68			1.45
BIBodChanPOS	My body has changed for the better with age.	2.60	1.12	0.52			1.41
MenoExp					**0.68**	**0.78**	
MenoFemin	Since experiencing menopause has your perceptions of your femininity changed?	2.69	0.71	0.53			1.40
MenoSexu	Since experiencing menopause has your perceptions of your sexuality changed?	2.64	0.94	0.86			1.25
MenoWom	Since experiencing menopause have you felt more or less like a woman?	2.89	0.85	0.80			1.38
BODImag1					**0.70**	**0.82**	
Appear2e	Pretty lingerie could make a mature woman more beautiful.	3.38	1.08	0.66			1.33
BIFB	I dress to enhance and show my body.	2.93	1.13	0.85			1.41
BILing	Wearing lingerie, I like, makes me feel better about my body.	3.45	1.15	0.81			1.50
BRAFemSex1					**0.82**	**0.87**	
BBFem1c	Purchasing bras makes me feel more feminine.	2.98	1.10	0.76			1.84
BBFem1dPOS	My bras are feminine.	3.02	1.25	0.71			1.85
BBIden1d	I consider my bra collection to be more fun than boring.	2.70	1.24	0.65			1.60
BBSex1cNEG	The kind of bra I wear does not affects my sexuality.	2.66	1.19	0.81			1.54
BBSex1d	When trying to impress a romantic partner I think about the type of bra I wear.	3.41	1.15	0.81			1.76
BRAIden2					**0.74**	**0.82**	
BBFem1a	Having breasts makes me feel feminine.	3.90	0.80	0.78			1.64
BBIden1a	My breasts are a part of my identity.	3.68	1.04	0.67			1.66
BBIden1c	The bras I wear affects what outer clothing I purchase or wear.	3.11	1.18	0.53			1.20
BBSex1a	My breasts are a part of my sexuality.	3.97	0.88	0.90			1.57

BRAWear1					**0.89**	**0.88**	
WearBra3a	Wearing floral printed bras makes me feel more feminine.	2.83	1.17	0.69			1.78
WearBra3b	Wearing overly lacy bras or sheer designs makes me feel sexy.	3.16	1.21	0.90			2.22
WearBra3c	When I wear printed or 'girlish' bras I act more feminine.	2.14	0.98	0.62			2.37
WearBra3d	When I wear sexy/sensual bras I act more confident.	2.73	1.21	0.90			3.58
WearBra3e	The bra I wear affects how I act.	2.61	1.16	0.61			1.77
WearBra3f	If I am wearing a plain bra I don't feel as confident.	1.96	0.87	0.65			2.17
WearBra3g	When I wear a red bra, I feel and act more powerful.	2.18	1.01	0.64			1.88
				Outer Weights	**T Statistics**	**P Values**	
BRAInflu1							
BRAInflu1a	Family	1.63	0.81	*0.13*	3.30	0.00	1.43
BRAInflu1b	Romantic Partner	2.66	1.26	*0.44*	7.17	0.00	1.28
BRAInflu1c	Peer/Friends	2.09	1.05	*0.23*	5.93	0.00	1.66
BRAInflu1d	Media/Advertising	2.24	1.13	*0.31*	8.56	0.00	1.85
BRAInflu1e	Society	2.01	0.99	*0.23*	6.30	0.00	1.78

Fig.J.16. Descriptive Statistics
Image a copy of Table 7.4. in Chapter 7.

J.1.6. Assessing the Measurement Model

The measurement model represents the outer model focused on the relationships between the constructs and their items, also referred to as indicator variables (Hair *et al.*, 2019). To assess the inner measurement model for convergent and discriminant validity, the item loadings, Cronbach's *alpha* (Cronbach α), Composite Reliability (CR), Fornell-Larcker criterion and Heterotrait-Monotrait Ratio were examined. The indicator reliability investigates item loadings for the acceptable (α >.70) indicator variance explanation. Item loadings ranged between .50 and .90, with the lower scoring being acceptable for newly developed exploratory factors and a significant sample size of over 120 (Hair *et al.*, 1998, 2014).

The convergent validity tests whether the constructs are measuring the concept reported and is assessed by examining the average variance extracted (AVE), Cronbach α and CR. The Average Variance Extracted (AVE) is the minimum variance allowed for a construct before it no longer measures the construct. **Table J.17.** demonstrates that all constructs passed the recommended value of >.50 except AgeExp (Hair *et al.*, 2014). While this may be worrisome, it may be accepted if the construct has a high Cronbach α and CR. Cronbach α also measures the latent variable for validity with a scale of >.60 for exploratory research; > .70 is acceptable, and >.80 signifies a good scale (Garson, 2016, p. 64). The Cronbach α for this study ranged from .68 to .89 signalling an acceptable to good scale for this exploratory research. Researchers have criticised Cronbach α for being too inconsistent in its predictability, often over or underestimating reliability (Garson, 2016, p. 63). Instead, CR is suggested, producing outputs closer to truer reliability. CR was examined to ensure that Cronbach α was not providing false reliability. CR is scaled >.60 for exploratory research, >.70 is adequate for confirmatory purposes, and >.80 for confirmatory research (Garson, 2016,

p. 63). As shown in **Table J.16.**, all measurements are over .80 except one, which is .78, making the model well above the score necessary for exploratory research. Convergent validity has been met.

The discriminant validity was assessed for collinearity which indicates each item is correctly situated within the correct construct with low correlation. First, multicollinearity was tested using the Variance Inflation Factor (VIF), which indicates high collinearity for item scores over 4.0 (Garson, 2016, p. 71). The highest factor was 3.58, meaning multicollinearity was not an issue. Next, the Fornell-Larcker (1981a, 1981b) criterion was utilised to determine whether there were any highly correlated constructs (**Table J.17.**). With all correlation values under the square root of the AVE (bolded diagonal lines) being smaller than the bolded, adequate discriminant validity is achieved. However, PLS-SEM advocates argue that the Fornell-Larcker criterion does not always prove discriminant validity reliably and instead suggests the Heterotrait-Monotrait (HTMT) ratio (Henseler, Ringle and Sarstedt, 2015). HTMT is more stringent with two cut-offs, $HTMT_{.85}$ and $HTMT_{.90}$, which note values greater than 0.85 and more conservative 0.90, indicate problematic discriminate validity. The HTMT, **Table J.18.**, demonstrates no constructs over the .85 or .90 limit. Therefore, discriminant validity is achieved.

Table J.17. Average Variance Extracted (AVE) and Fornell-Larcker Criterion

	AVE	Fornell-Larcker Criterion					
		AgeExp	BODImag1	BRAFemSex1	BRAIden2	BRAInflu1	BRAWear1
AgeExp	0.45	**0.672**					
BODImag1	0.62	0.340	**0.787**				
BRAFemSex1	0.58	0.294	0.625	**0.759**			
BRAIden2	0.57	0.202	0.525	0.559	**0.755**		
BRAInflu1		-0.045	0.298	0.463	0.382		
BRAWear1	0.59	0.032	0.452	0.603	0.376	0.604	**0.771**

Table J.18. Heterotrait-Monotrait Ratio (HTMT)

	Heterotrait-Monotrait Ratio (HTMT)				
	AgeExp	BODImag1	BRAFemSex1	BRAIden2	BRAWear1
AgeExp					
BODImag1	0.444				
BRAFemSex1	0.372	0.829			
BRAIden2	0.283	0.729	0.720		
BRAWear1	0.120	0.565	0.686	0.451	

As this model is mixed with reflective and formative constructs; there is an assortment of assessment criteria. Formative constructs are examined by their significance and outer weights, producing smaller numbers than the factor loadings. To assess a formative measurement, the indicators should be checked for collinearity, examining the VIF results (<5), and the outer weights' T-statistics must have significant values (Hair *et al.*, 2019). As shown in **Table J.16.**, there is no multicollinearity for the formative construct BRAInflu1. The T-statistics are all over (>1.96), ranging from 3.30 to 8.56, along with significant *p*-values indicating the criteria have been met.

J.1.7. Assessing the Structural Model

Fig.J.19. Bra-Wearing Experience Structural (Conceptual) Model

Bold numbers represent Path Coefficients (β) with significance in parenthesis and effect size (f^2) beneath in italics. The coefficient of determination (r^2) is inside the grey circle.

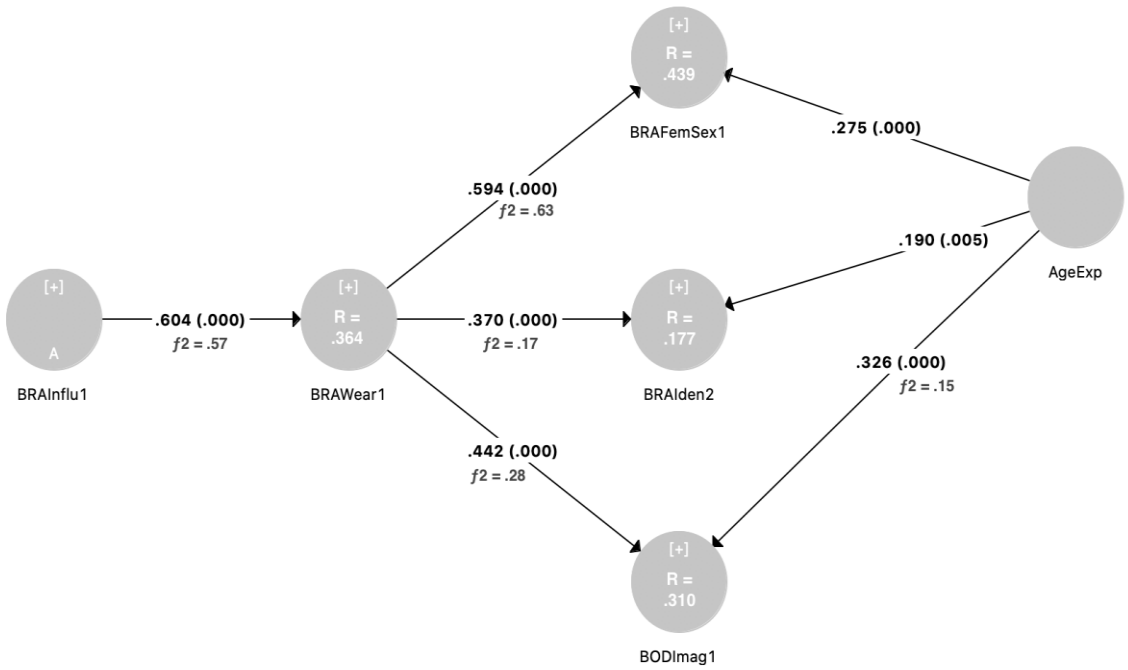


Table J.20. Path Coefficients

Beta (ß)	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
AgeExp -> BODImag1	0.33	0.33	0.07	4.68	0.00
AgeExp -> BRAFemSex1	0.28	0.28	0.07	4.02	0.00
AgeExp -> BRAIden2	0.19	0.20	0.07	2.83	0.01
BRAInflu1 -> BRAWear1	0.60	0.61	0.04	14.17	0.00
BRAWear1 -> BODImag1	0.44	0.44	0.07	6.48	0.00
BRAWear1 -> BRAFemSex1	0.59	0.60	0.06	10.43	0.00
BRAWear1 -> BRAIden2	0.37	0.37	0.06	5.73	0.00

The structural model represents the inner model and focuses on the relationships between the constructs (**Fig.J.19.** and **Table J.20.**) (Hair *et al.*, 2017). Path coefficients (β) measure the size of the relationship between constructs, (r^2) quantifies predictable variance, and effect size (f^2) are all examined to discuss the relevant findings (Benitez *et al.*, 2020). In investigating the relationships among the constructs, it is apparent BRAInflu1 positively and significantly affects BRAWear1 (β=.604, p<0.01), explaining 36% of the variance with a substantial effect size (f^2 = .57). Thus, societal bra influences affect the wearers' bra experience.

BRAWear1 positively and significantly affect BRAFemSex1 (β =.594, p<0.01), BRAIden2 (β =.370; p<0.01), and BODImag1 (β =.442; p<0.01). Moreover, BRAWear1 explains 44% of variance in BRAFemSex1 (r^2 adjusted= 0.43), 17% in BRAIden2 (r^2 adjusted= 0.17), and 31% in BODImag1 (r^2 adjusted= 0.30). The effect size of BRAWear1 ranges from medium on BRAIden2 (f^2 = .17) and BODImag1 (f^2 = .28) to sizeable on BRAFemSex1 (f^2 = .63). Therefore, the bra-wearing experience strongly relates to the bra feminine-sexuality and moderately to the body-image and identity constructs.

Since this research examines mature women's bra relationships, it was wise to explore whether ageing (AgeExp) or menopause (MenoExp) affected the experience. Results for the BRAWear1 relationship on AgeExp and MenoExp proved not significant. However, significant results were found by exploring AgeExp and MenoExp on the self-concept constructs. While the menopause experience did not prove significant, the ageing experience did. AgeExp positively and significantly affected BRAFemSex1 (β=.275, p<0.01), BRAIden2 (β=.190, p<0.01), and BODImag1 (β=.326, p<0.01). Noticeably, the only significant effect size was on BODImag1, body-image, with a medium effect size (f^2 = .15).

Table J.21. Specific Indirect Effects

Specific Indirect Effects Beta (ß)	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
BRAInflu1 -> BRAWear1 -> BODImag1	0.27	0.27	0.05	5.75	0.00
BRAInflu1 -> BRAWear1 -> BRAFemSex1	0.36	0.36	0.05	8.04	0.00
BRAInflu1 -> BRAWear1 -> BRAIden2	0.22	0.23	0.05	4.88	0.00

SmartPLS also indicates mediation among constructs and provides the results in the form of a Specific Indirect Effects table (**Table J.21.**). Societal bra influences mediated through bra-wearing experience affect body-image (BRAInflu1 -> BRAWear1 -> BODImag1, ß=.27), feminine-sexuality (BRAInflu1 -> BRAWear1 -> BRAFemSex1, ß=.36), and identity (BRAInflu1 -> BRAWear1 -> BRAIden2, ß=.22). These findings indicate socio-cultural messages about bras are received by mature women and through bra-wearing affect their sense-of-self.

J.1.8. Model Fit

Some researchers attempt to use PLS-SEM results to develop a model fit equation, but it is advised against (Hair *et al.*, 2017). Moreover, while some parameters may allow for a goodness-of-fit measure to be developed, those are not adequate for this model. This model is a mixed model which has no model fit criteria. SmartPLS guidelines posited for this model type; there has not been much work on verifying model fit, nor a definitive acknowledgement of a need to. Therefore, novices are cautioned to tread carefully (Ringle, Wende and Becker, 2015). For this reason, no model fit measurements are given for this exploratory mixed model.

J.2. Factors Affecting BW Acceptance

J.2.1. Factor Analysis, Instrument Reliability, and Validity

The constructs within the BWTAM model are explained in **Table J.22.** Construct abbreviations may be used moving forward.

Table J.22. Constructs for BWTAM.

Construct	Abbrev.	Definition	Sources
Bra Wearables Interest	BWInt	Construct to comprehend BW interest using multiple BW scoping items.	Newly developed construct for present study.
Perceived Usefulness	PUse	Construct to measure the perceived usefulness of BW.	Davis, 1989; Childers et al, 2001; Hwang, 2014
Perceived Ease of Use	PEoU	Construct to measure BW ease of use.	Davis, 1989; Childers et al, 2001; Hwang, 2014
Perceived Performance Risk	PPerR	Construct to measure the perceived performance risk of BW.	Grewal, Gotlieb and Marmorstein, 1994; Hwang, 2014
Perceived Comfort	PComf	Construct to comprehend perceived physical comfort of BW.	Hwang, 2014
Perceived Compatibility	PComp	Construct to understand perceived compatibility with BW.	Bradford and Florin, 2003; Ko et al., 2009; Hwang, 2014
Perceived Aesthetic Attributes	PAAtt	Construct to measure perceived intrinsic aesthetic attributes of BW.	Hwang, 2014
Attitude	Attit	Construct to understand attitude towards purchasing BW.	Hwang, 2014
Purchase Intention	PurIn	Construct to measure purchase intentions of BW.	Bower and Landreth, 2001; Hwang, 2014
Design Process	DProc	Construct measuring design process beliefs.	Newly developed construct for present study.

J.2.1.1. Partial Confirmatory Factor Analysis

Table J.23. KMO and Bartlett's Test of Sphericity

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.904
Bartlett's Test of Sphericity	Approx. Chi-Square	4202.225
	df	780
	Sig.	0.00

A Partial Confirmatory Factors Analysis was used to establish whether the variables were suitable for exploratory factor analysis. The Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy allows for clarity in the difference of variables indicating factors that are incompatible with the data (**Table J.23.**). KMO values closer to 1.0 and above .60 connotes data is acceptable (Pallant, 2016). The KMO recorded was .904, signalling that the variables are suitable for further exploration. Bartlett's Test of Sphericity indicates whether the data is significant enough for factor analysis. Significance is evidenced if it is .05 and

below (Pallant, 2016). Bartlett's test expressed significance at .00, signposting it was safe to proceed with exploratory factor analysis.

An Exploratory Factor Analysis (EFA) was conducted using varimax rotation to review and ascertain factor loadings. Questions that did not load over .45 in new constructs or loaded onto different constructs were removed. The factor loadings for each item must be greater than the .5 acceptance to indicate item reliability (Hair *et al.*, 1998; Rahman, Memon and Karim, 2013). However, for newly developed and exploratory constructs, .45 is the lowest loading acceptable (Hair *et al.*, 1998). The lowest factor loading recorded for this study was .57, with all other factors performing greater than .60.

J.2.1.2. Reliability Analysis

Cronbach's *alpha (*Cronbach α) was utilised to measure the internal consistency and reliability of the instrument. Acceptable measurements begin at .70, with those above ranging from good (.80) to excellent (.90) (Hair *et al.*, 1998; George and Mallery, 2002). The Cronbach α for this instrument varied from .73 to .95, meeting the baseline and indicating internal reliability. The adequate numbers of the Cronbach α and factor loadings signify that the instrument has passed in terms of reliability.

Composite reliability (CR), construct reliability, evaluates the reliability of the scale items' internal consistency (Hair *et al.*, 2018). Researchers disagree on the threshold for CR, with .60 being one point (Fornell, 1982; Tzou and Lu, 2009) and .70 being another (Netemeyer, Bearden and Sharma, 2003; Hair *et al.*, 2014). The constructs within this research ranged from .74 to .95, thus producing acceptable results to continue.

J.2.1.3. Convergent Validity

Convergent validity is used to measure whether constructs that are meant to be related theoretically display high correlations indicating relations (Netemeyer, Bearden and Sharma, 2003). Two tools used to appraise convergent validity are Average Variance Extracted (AVE) and composite reliability (CR) (Fornell and Larcker, 1981a). AVE can determine convergent and divergent validity (Garson, 2016, p. 65). The AVE threshold is commonly cited at > .50 (Diamantopoulos and Siguaw, 2000; Hair *et al.*, 2010); however, .40 is also acceptable if the constructs' CR surpasses .60 (Fornell and Larcker, 1981a). The AVE results ranged from .49 to .87; therefore, the instrument can be validated as having adequate convergent validity for continuation.

Using SPSS v26, the skewness and kurtosis were analysed for normality. A review of the skewness statistics ranged from -1.305 to .857, and the kurtosis statistics from -.692 to .101. None of the skewness values exceeded 2.0, nor did any of the kurtosis values exceed 3.0, meaning the data did not violate normality (Kline, 2004). Therefore, PLS was considered suitable for the rest of the data analysis as it did not violate the assumptions of normality (Hair *et al.*, 2012).

Fig.J.24. Summary of Measurement Scale

		Mean	SD	Factor Loadings	Chronbach's alpha	Composite Reliability	Average Variance Extracted
Bra Wearables Interest		**3.21**	**1.03**		**0.86**	**0.91**	**0.67**
BWInt1	Bra that detects and monitors heart disease.	3.30	1.25	0.900			
BWInt2	Preventative Breasts Cancer bra.	3.33	1.34	0.849			
BWInt3	Stress detection and relief bra.	3.31	1.29	0.873			
BWInt4	A bra designed for sexual stimulation.	2.83	1.31	0.477			
BWInt5	Bra that monitors health vitals.	3.33	1.21	0.912			
Perceived Usefulness		**2.74**	**1.05**		**0.92**	**0.95**	**0.81**
PUse1	I believe there is a need for Bra Wearables.	2.99	1.12	0.900			
PUse2	Wearing Bra Wearables would improve the quality of my overall health.	2.83	1.21	0.952			
PUse3	Wearing Bra Wearables would increase my sense of self.	2.35	1.10	0.868			
PUse4POS	Bra Wearables would be useful to me.	2.76	1.27	0.881			
Perceived Ease of Use		**3.19**	**0.81**		**0.76**	**0.86**	**0.67**
PEoU1	Understanding how to use Bra Wearables would not require a lot of mental effort.	3.53	0.90	0.791			
PEoU2	It would be easy to use Bra Wearables.	3.41	0.96	0.878			
PEoU3POS	Wearing Bra Wearables would be easier than wearing a regular bra.	2.71	1.09	0.789			
Perceived Performance Risk		**2.71**	**0.91**		**0.94**	**0.96**	**0.90**
PPer1	I am confident that Bra Wearables will perform as described.	2.65	0.95	0.966			
PPer2	I am certain that Bra Wearables will work to my standards.	2.73	0.96	0.921			
PPer3	I believe Bra Wearables will perform the functions that they are set to do well.	2.78	0.95	0.959			
Perceived Comfort		**2.61**	**0.68**		**0.88**	**0.91**	**0.67**
PComf1POS	Comfortable	2.50	0.93	0.839			
PComf2POS	Flexible	2.79	0.84	0.862			
PComf3POS	Easy to move in	2.68	0.86	0.830			
PComf4POS	Light Weight	2.74	0.83	0.738			
PComf5POS	Fitting	2.47	0.91	0.814			
Perceived Compatiblility		**3.34**	**0.94**		**0.89**	**0.92**	**0.75**
PComp1	Health & Wellness Bra Wearables may suit my needs.	3.05	1.25	0.902			
PComp2	Bra Wearables would be compatible if its discreet underclothing.	3.46	1.09	0.911			
PComp3POS	Bra Wearables would be appropriate for my lifestyle.	2.99	1.11	0.885			
PComp5	Bra Wearables should be made to be worn at any time.	3.86	0.86	0.752			
Perceived Aesthetic Attributes		**3.89**	**0.61**		**0.69**	**0.81**	**0.52**
PAAtt1	The aesthetics of Bra Wearables is important for my acceptance.	3.76	1.02	0.850			
PAAtt2	Bra Wearables should look like regular bras.	3.98	0.84	0.788			
PAAtt3POS	The longevity of Bra Wearables is important to me.	3.83	0.84	0.513			
PAAtt6	The technological elements should be hidden in the bra.	3.95	0.83	0.682			

Attitude		**3.00**	**0.83**		**0.91**	**0.94**	**0.75**
Attit2POS	Favourable	2.92	0.92	0.801			
Attit3	Wise	3.08	0.95	0.895			
Attit4	The Future	3.33	0.97	0.861			
Attit5POS	Beneficial	3.18	0.92	0.920			
Attit6POS	Staple Product	2.48	1.06	0.836			
Purchase Intention		**1.95**	**0.69**		**0.87**	**0.92**	**0.79**
PurIn1	I intend to try this type of product when made available.	1.77	0.68	0.890			
PurIn3	I would like more examples of Bra Wearables.	2.09	0.87	0.901			
PurIn4	If recommended by my peers I would be interested.	1.98	0.78	0.874			
Design Process		**3.69**	**0.71**		**0.82**	**0.87**	**0.63**
DProc1	Mature women should participate in the design process of Bra Wearables.	4.13	0.80	0.743			
DProc2	I believe as a bra wearer I have insight on what's best for mature female bodies.	3.92	0.87	0.678			
DProc3	I would be more interested in Bra Wearables if I were a part of the design process.	3.22	1.06	0.861			
DProc4	I would be interested in Bra Wearables if I knew my peers were involved in the design process.	3.30	1.11	0.878			

J.2.2. Instrument Descriptive Statistics Results

The summary of the measurement scale, **Fig.J.24.**, showcases the results discussed in this section. The construct BW Interests reveals that participants are neutral to positive in their interests (BWInt, *M* =3.21, *SD* =1.03). MW are neutral in their beliefs that there is a need for BW (PUse1, *M* =2.99, *SD* =1.12). Overall, they did not find BW would be useful according to the construct perceived usefulness (PUse, *M* =2.74, *SD* =1.05). The construct perceived ease of use (PEoU, *M* =3.19, *SD* =.81) demonstrates that most women felt learning how to use BW would be easy. Thus, perceived performance risk is adverse (PPerR, *M* =2.71, *SD* =.91), with women believing it will not perform to their standards or as described.

MW believe BW would be uncomfortable with a low perceived comfort (PComf, *M* =2.61, *SD* =.68). Their beliefs may be due to the addition of clunky hardware shown in photos of prototypes at the beginning of the questionnaire. Alternatively, their lived experience with traditional bras also being uncomfortable may be another reason.

The women are neutral to slightly positive regarding perceived compatibility (PComp, *M* =3.34, *SD* =.94). In general, women are favourable to health & wellness BW (PComp1, *M* =3.05, *SD* =1.25). If BW is made to fit discretely beneath clothing (PComp2, *M* =3.46, *SD* =1.09) and could be worn at any time (PComp5, *M* =3.86, *SD* =.86), women would find it more compatible. Altogether they are neutral on whether BW would be appropriate for their lifestyle (PComp3POS, *M* =2.99, *SD* =1.11). Therefore, more information is needed in the design process to make BW appropriate for MW's lifestyles.

Perceived aesthetic attributes received the most substantial ratings (PAAtt, *M* =3.89, *SD* =0.61), indicating women are highly in agreement that the aesthetics of BW are imperative for its acceptance. It needs to look like regular bras (PAAtt2, *M* =3.98, *SD* =.84), with technological components hidden (PAAtt6, *M* =3.95, *SD* =.83), and have a longevity of wear (PAAtt3POS, *M* =3.83, *SD* =.84).

The construct attitude (Attit, *M* =3.00, *SD* =.83) reveals that women are neutral to BW. This demonstrates that MW are neither for nor against BW. They believe it is going to be the future for bras (Attit4, *M* =3.33, *SD* =.97), even beneficial (Attit5POS, *M* =3.18, *SD* =.92), and potentially a wise purchase (Attit3, *M* =3.08, *SD* =.95). Nevertheless, they do not believe it will become favourable (Attit2POS, *M* =2.92, *SD* =.92) or a staple product (Attit6POS, *M* =2.48, *SD* =1.06). MW did not intend to purchase BW (PurIn, *M* =1.95, *SD* =.69). The construct purchase intention reveals that women do not intend to try the product if made available (PurIn1, *M* =1.77, *SD* =.68) or if recommended by their peers (PurIn4, *M* =1.98, *SD* =.78).

Surprisingly, when asked about the design process, women responded more favourable. The construct design process interests (DProc, *M* =3.69, *SD* =.71) reveal the importance of the BW design process to MW. They believe that they offer valuable insights (DProc2, *M* =3.92, *SD* =.87) that are pivotal to the design process of BW. Furthermore, if they (DProc3, *M* =3.22, *SD* =1.06) or their peers (DProc4, *M* =3.30, *SD* =1.11) were a part of the design process, they would be more interested in the product. It is critical for these women to be a part of the design process (DProc1, *M* =4.13, *SD* =.80).

To conclude, women are not interested in BW due to low perceived comfort and adverse performance risk indicating it would not work up to par, thus lowering perceived usefulness. However, women believe BW is beneficial and the future of bras. Potentially the belief is that BW is not for them but for other women. Therefore, based on the positive scores of aesthetics, compatibility, and BW interest, the design process may become critical for acceptance and purchase intention. Especially as women indicate favourably that if they or their peers are a part of the design process, they would be more interested.

J.2.3. Data Analysis

The following section employs SmartPLS for exploratory purposes to discern the relationships between the design process (DProc) and BW interest (BWInt) with the other constructs and understand their relationships to attitude (Attit) and purchase intention (PurIn). The results will be a new BWTAM, illustrating variables significant to the acceptance and purchase intention of BW.

SmartPLS is a structural equation modelling (SEM) analysis method similar to SPSS, but component-based using partial least squares (PLS) (Hair *et al.*, 2019). SmartPLS allows for both a factor or path modelling analysis to be conducted where the connection of multiple constructs is possible, permitting simultaneous analysis of a mixture of independent and dependent variables (Hair *et al.*, 2019). While similar to multiple regression analysis, this method proves advantageous when exploring numerous relationships (Hair *et al.*,

2018). Therefore, this program allows for attention to be provided to how each construct influences the other and to multi-step influence referred to as construct mediations. SmartPLS can thus discover new predictive and theoretical relationships (Chin and Todd, 1995).

> 'PLS can handle multicollinearity, many independent variables, and because its focus is prediction, not explanation, lack of well-understood relationships of independents to the dependent is not critical' (Garson, 2016, p. 241).

The usage of SmartPLS provides many advantages, as expressed in the quote above and specifically, in this case, its ability to handle small sample sizes (n<20) (Garson, 2016). For the SPSS Amos program, this study's sample size (n=140) is considered small, which may distort the data (Bollen, 1989; Muthén and Muthén, 2002; Schermelleh-Engel, Moosbrugger and Müller, 2003). Schermeller-Engel et al. (2003) conclude, from much research in this area, that a sample size of n=200 is the baseline for SPSS Amos. While the small sample size is possible for SmartPLS, there is a 'rule of 10', which states there must be a minimum of ten responses per question for statistical significance (Barclay, Higgins and Thompson, 1995). This study has a minimum of 134 replies per question, deeming it adequate for PLS analysis.

SmartPLS is robust enough to handle multicollinearity, heteroskedasticity, missing values, and the violation of statistical assumptions (Cassel, Hackl and Westlund, 1999, 2000; Hair *et al.*, 2014) . Outliers and normality were checked with SPSS and revised.

First, a PLS Algorithm was conducted to run a confirmatory factor analysis (CFA) using a factor weighting scheme with mean replacement to handle missing data and a maximum of 3000 iterations. The summary of measurement scales, **Table J.24.** in the previous section, illustrates the results displaying the construct means, standard deviations and factor loadings. Perceived compatibility (PComp) loaded high on the constructs attitude (Attit) and purchase intention (PurIn); therefore, it was removed. All other factor loadings passed the adequate requirements, with the lowest at .51 and the highest at .97.

Next, a PLS Algorithm was conducted using a path weighting scheme with a stop criterion of 7 and a maximum of 3000 iterations. The algorithm was set to use mean replacement for missing data. This provided a SmartPLS report where the final results, later reviewed and discussed, are inclusive of the path coefficients and indirect effects. In addition, the quality criteria report containing the r square, f square, construct reliability (CR) and validity, discriminant validity, collinearity statistics (VIF), and model fit are reviewed. Then, a complete bootstrapping was performed to test the significance of all findings. Specifically employed was a Bias-Corrected and Accelerated (BCa) Bootstrap with parallel processing of 5000 subsamples utilising a two-tailed test significant level at .05.

J.2.3.1. Assessing the Measurement Model

Table J.25. Cronbach Alpha (α), Composite Reliability (CR), Average Variance Extracted (AVE) and Fornell-Larcker Criterion

	Cronbach's Alpha	Composite Reliability	Average Variance Extracted (AVE)	Attit	BWInt	DProc	PAAtt	PComf	PEoU	PPerR	PUse	PurInt
Attit	0.92	0.94	0.75	0.87								
BWInt	0.86	0.91	0.67	0.73	0.82							
DProc	0.82	0.87	0.63	0.50	0.51	0.80						
PAAtt	0.69	0.81	0.52	0.24	0.27	0.43	0.72					
PComf	0.87	0.91	0.66	0.60	0.44	0.22	0.21	0.81				
PEoU	0.75	0.86	0.66	0.39	0.36	0.16	0.18	0.49	0.82			
PPerR	0.95	0.97	0.90	0.64	0.51	0.32	0.21	0.59	0.45	0.95		
PUse	0.92	0.95	0.81	0.81	0.78	0.48	0.20	0.55	0.43	0.63	0.90	
PurInt	0.87	0.92	0.79	0.75	0.70	0.45	0.19	0.41	0.35	0.55	0.76	0.89

Table J.26. Heterotrait-Monotrait Ratio (HTMT)

	Attit	BWInt	DProc	PAAtt	PComf	PEoU	PPerR	PUse	PurInt
Attit									
BWInt	0.81								
DProc	0.52	0.54							
PAAtt	0.29	0.35	0.54						
PComf	0.66	0.49	0.24	0.25					
PEoU	0.47	0.46	0.24	0.26	0.59				
PPerR	0.69	0.57	0.32	0.27	0.64	0.54			
PUse	0.88	0.86	0.49	0.23	0.60	0.51	0.67		
PurInt	0.84	0.79	0.49	0.23	0.46	0.43	0.60	0.85	

The measurement model was assessed for reliability and discriminant validity (**Table J.25.** and **Table J.26.**). Cronbach's *alpha* (Cronbach α) should produce acceptable values over $a > .70$, with this model values ranging from .69 to .95. While the lowest construct had slightly lower ratings, viewing its composite reliability (CR) score will indicate whether it is reliable or not. CR is said to produce better reliability measurements than Cronbach α (Hair *et al.*, 2018). This model had ratings from .81 to .97, denoting those constructs are internally consistent and acceptable. The average variance extracted (AVE) must be more than .50 for good convergent validity, with the measurements for this model ranging from .52 to .90.

Divergent validity is assessed by the Fornell-Larcker criterion shown in **Table J.25.** The AVE squared produced numbers all lower than those on the diagonal, thus demonstrating validity. Conversely, the Heterotrait-Monotrait Ratio (HTMT) indicates a better discriminant validity result with values below the $HTMT_{90}$ criteria (Henseler, Ringle and Sarstedt, 2015). With the highest value being .88, discriminant validity is confirmed (**Table J.26.**).

Table J.27. Collinearity Values Inner Statistics (VIF)

	Attit	BWInt	DProc	PAAtt	PComf	PEoU	PPerR	PUse	PurInt
Attit									3.86
BWInt	2.75			1.34	1.34	1.34	1.34	1.34	2.91
DProc	1.61	1.00		1.34	1.34	1.34	1.34	1.34	1.67
PAAtt	1.28								1.29
PComf	1.80								1.95
PEoU	1.44								1.44
PPerR	1.97								2.05
PUse	3.40								4.09
PurInt									

Lastly, the variance inflation factor (VIF), measuring collinearity among the constructs, is assessed (**Table J.27.**). Acceptable levels are below <10 (Hair *et al.*, 2018), with some arguing for the stricter cut-off of <5 (Hair *et al.*, 2010). The measurements for this model illustrate low correlated factors, with the highest at 4. Based on this, the conclusion is that collinearity is not an issue.

J.2.3.2. Assessing the Structural Model

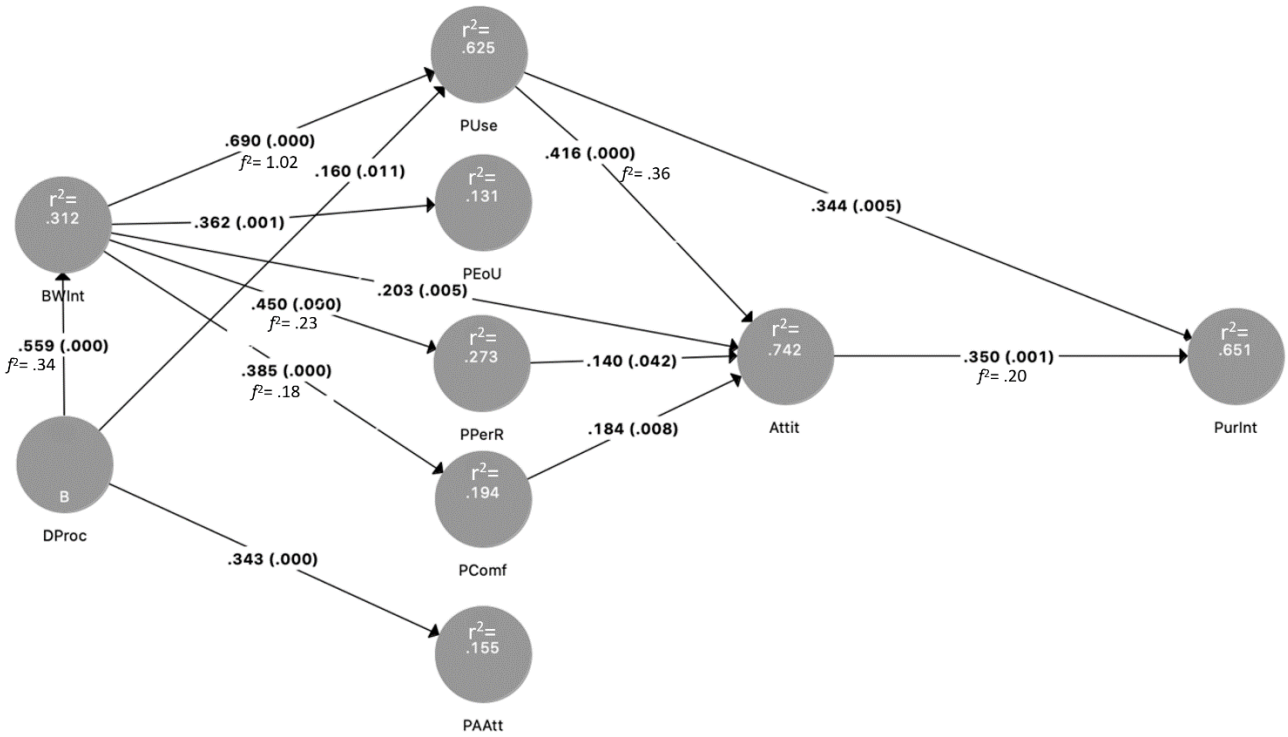


Fig.J.28. Bra Wearables Structural Model
(BWInt = Bra Wearables Interest, DProc = Design Process, PUse = Perceived Usefulness, PEoU = Perceived Ease of Use, PPerR = Perceived Performance Risk, PComf = Perceived Comfort, PAAtt = Perceived Aesthetic Attributes, Attit = Attitude, PurInt = Purchase Intention) Bold numbers represent Path Coefficients (β) with significance in parenthesis and effect size (f^2) beneath in italics. The coefficient of determination (r^2) is inside the grey circle.

Table J.29. Bra Wearables Structural Model in Chart Form

Beta (ß)	Original Sample (O)	Standard Deviati	T Statistics (|O/STDEV|)	P Values
BWInt -> PUse	0.72	0.05	15.20	0.00
DProc -> BWInt	0.51	0.06	9.22	0.00
BWInt -> PPerR	0.47	0.08	6.02	0.00
PUse -> Attit	0.42	0.07	5.93	0.00
BWInt -> PComf	0.44	0.08	5.23	0.00
DProc -> PAAtt	0.39	0.08	4.90	0.00
BWInt -> PEoU	0.38	0.10	3.73	0.00
Attit -> PurInt	0.35	0.11	3.26	0.00
PUse -> PurInt	0.34	0.12	2.80	0.01
BWInt -> Attit	0.21	0.07	2.78	0.01
PComf -> Attit	0.19	0.07	2.77	0.01
PPerR -> Attit	0.14	0.07	2.00	0.05

The grey circles in the BW structural model (**Fig.J.28.**) depict the r^2 values with lines illustrating the path coefficients (ß) and their significant *p* values. Similarly, **Table J.29.** shows the numerous path coefficients, *t*-statistics, and *p*-values. The path coefficient (ß) measures one construct's direct effect on another and is appraised by their weights. Weights closer to 1 indicate a strong path, while those closer to 0 indicate a weak path (Hair et al., 2018).

The two most robust paths are BW interest to perceived usefulness (BWInt -> PUse, ß=.72) and design process to BW interest (DProc -> BWInt, ß=.51). Several paths are medium strengths ranging from .34 to .47. Of interest are those that lead to attitude and purchase intention. Significant effects on attitude (Attit) are perceived usefulness (PUse -> Attit, ß=.42), BW interest (BWInt -> Attit, ß=.20), perceived comfort (PComf -> Attit, ß=.18), and perceived performance risk (PPer -> Attit, ß=.14). Therefore, if women perceive BW to be of interest, useful, comfortable, and working to their standards, then their attitude may be favourable. Attitude has the most significant path to purchase intention (Attit -> PurInt, ß=.35), with perceived usefulness being quite close (PUse -> PurInt, ß=.34). Hence, a positive attitude or belief of usefulness will influence the intention to purchase BW.

Table J.30. BW Structural Model F-Square Results

	Original Sample (O)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
BWInt -> PUse	1.02	0.26	3.89	0.00
DProc -> BWInt	0.34	0.11	3.22	0.00
PUse -> Attit	0.36	0.12	2.99	0.00
BWInt -> PPerR	0.23	0.10	2.38	0.02
BWInt -> PComf	0.18	0.08	2.19	0.03
Attit -> PurInt	0.20	0.09	2.11	0.04

The path coefficients' effect size is also measured using *f*-square (**Table J.30.** and **Fig.J.28.**), with those not significant $p<.05$ removed. Effect size reads as .02 to .15 is a small f^2, .15 to .35 is a medium f^2, and those above .35 is a high f^2 (Cohen, 1988 in Garson, 2016, p. 85). Therefore, as illustrated, most of the effect sizes were medium, with perceived usefulness to attitude having a high effect (PUse -> Attit, f^2=.36) and BW interest to perceived usefulness providing a substantial effect (BWInt -> PUse, f^2=1.02).

Table J.31. R^2 and R^2 Adjusted Values

	R Square			R Square Adjusted		
	Original Sample (O)	T Statistics (|O/STDEV|)	P Values	Original Sample (O)	T Statistics (|O/STDEV|)	P Values
Attit	0.74	20.74	0.00	0.73	19.34	0.00
BWInt	0.26	4.59	0.00	0.25	4.47	0.00
PAAtt	0.19	2.98	0.00	0.18	2.76	0.01
PComf	0.19	3.34	0.00	0.18	3.09	0.00
PEoU	0.13	2.16	0.03	0.12	1.92	-
PPerR	0.27	4.19	0.00	0.26	3.97	0.00
PUse	0.62	12.00	0.00	0.61	11.72	0.00
PurInt	0.65	15.29	0.00	0.63	13.95	0.00

To further understand the effect sizes (f^2), we can review the coefficient of determination, r^2 or r^2 adjusted values (**Table J.31.**). The r^2 measures the variances explained by the dependent construct, while the adjusted r^2 accounts for the addition or subtraction of independent constructs (Garson, 2016). Here we will focus solely on the r^2 results noting those over Cohen's (1988) .26 value which suggests a consequential model. The design process (DProc) explains 26% of the variance in BW interest (BWInt). Exemplifying one of the most indicative constructs, BWInt explains 27% of the variance in perceived performance risk (PPerR) and 62% in perceived usefulness (PUse). Furthermore, BWInt combined with perceived usefulness (PUse), performance risk (PPerR), and comfort (PComf) explain 74% of the variance in attitude (Attit). Lastly, attitude (Attit) and perceived usefulness (PUse) explain 65% of the variance in purchase intention (PurIn). The importance of perceived usefulness to the construct attitude is evident; thus, the value of BW interest becomes significant.

J.2.3.3. Specific Indirect Effects

Table J.32. Specific Indirect Effects

Specific Indirect Effects Beta (ß)	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
BWInt -> PUse -> Attit	0.29	0.29	0.06	5.00	0.00
DProc -> BWInt -> PUse -> Attit	0.16	0.16	0.04	4.65	0.00
DProc -> BWInt -> Attit	0.11	0.11	0.04	2.69	0.01
BWInt -> PComf -> Attit	0.07	0.07	0.03	2.28	0.02
DProc -> PUse -> Attit	0.07	0.07	0.03	2.24	0.03
DProc -> BWInt -> PComf -> Attit	0.04	0.04	0.02	2.06	0.04
BWInt -> PUse -> PurInt	0.24	0.24	0.09	2.66	0.01
PUse -> Attit -> PurInt	0.15	0.15	0.06	2.63	0.01
BWInt -> PUse -> Attit -> PurInt	0.10	0.10	0.04	2.57	0.01
DProc -> BWInt -> PUse -> Attit -> PurInt	0.06	0.06	0.02	2.56	0.01
DProc -> BWInt -> PUse -> PurInt	0.13	0.14	0.05	2.50	0.01
BWInt -> Attit -> PurInt	0.07	0.07	0.03	2.15	0.03
DProc -> BWInt -> Attit -> PurInt	0.04	0.04	0.02	2.14	0.03
DProc -> BWInt -> PUse	0.39	0.39	0.05	7.97	0.00
DProc -> BWInt -> PPerR	0.25	0.25	0.06	4.18	0.00
DProc -> BWInt -> PComf	0.22	0.22	0.06	3.53	0.00
DProc -> BWInt -> PEoU	0.20	0.21	0.07	2.94	0.00

Viewing the specific indirect effects provides additional insights into the mediation of relationships for casual models (Hair *et al.*, 2021). Construct mediations show how independent constructs, through casual relationships, affect dependent constructs through intervening variables. This model produced complementary partial mediations, which demonstrate one-directional flow. Only specific indirect effects

with significant *p*-values are illustrated in **Table J.32**. The focus is on constructs that provide mediated relationships to attitude (Attit) and purchase intention (PurInt). The relationship between BW interests and attitude is mediated by perceived usefulness (BWInt -> PUse -> Attit, ß=.29), together producing the strongest correlation to attitude. Adding the design process construct to the previous relationship, illustrates a smaller correlation to attitude mediated through BW interest and perceived usefulness (DProc -> BWInt -> PUse -> Attit, ß=.16). The design process is also correlated at a smaller ß to attitude through the mediation of BW interest (DProc -> BWInt -> Attit, ß=.11).

Moving on to purchase intention, the table displays that one of the strongest correlations is through the mediated relationship of perceived usefulness from BW interest (BWInt -> PUse -> PurInt, ß=.24). When design process is added to the previous chain, the correlation value is lowered (DProc -> BWInt -> PUse -> PurInt, ß=.13). The relationship between BW interest and purchase intention is also mediated through perceived usefulness and attitude (BWInt -> PUse -> Attit -> PurInt, ß=.10). When the design process is added the correlation, value decreases (DProc -> BWInt -> PUse -> Attit -> PurInt, ß=.06). Removal of the constructs design process and BW interest provide a much higher coefficient with perceived usefulness correlated to purchase intention through attitude (PUse -> Attit -> PurInt, ß=.15). At smaller coefficients BW interest is mediated by attitude to purchase intention (BWInt -> Attit -> PurInt, ß=.07) and the addition of design process lowers the correlation (DProc -> BWInt -> PUse -> Attit -> PurInt, ß=.04).

The model fit was evaluated using the standardised root mean residual (SRMR), which measures values observed and expected for the difference in strength. Values should be less than .08 or more lenient .10 to be considered a good fit (Hu and Bentler, 1999; Henseler, Ringle and Sarstedt, 2015). This model proved to have a good fit with an SRMR of .07.

K. INTERVIEW QUESTIONS

Hi [insert name], I'd like to thank you for agreeing to participate in this research. As you would have read in the participant information sheet, the overall goal of my study is to develop a design process that integrates the experiences of mature women for the development of bra wearables. The purpose of this interview is to understand the bra wearing experiences of mature women. I will be using a storytelling format that allows for your own voice to speak about your experience. I will interject with probing questions to help you recall more details about your experience. There will be two lines of questioning, one on your favorite bra experience and one on your worst. Please remember you can stop the interview at any time for any reason as this is entirely voluntary. If you accept, please let me know again and we can continue.

Interview Questions 2

Bra Wearing experience

- What is your favorite bra? Or is there a bra you like wearing often? What kind of silhouette is it? Can you describe it?
- Can you recall one of your favorite times wearing the bra?
    - When did this memory happen? (Time)
    - Where were you going? (Place)
    - Who would be there? (Acquaintances?)
- When selecting the bra for the event what were you thinking?
    - Did you select it because of the event, the outfit, a feeling?
- Did you select the bra or the outfit first?
- Once selected the bra did you think about how you wanted to feel while wearing it with the outfit at the event?
    - What were your expectations on how you would or should feel?
- Did you think about how wearing it in past occasions made you feel?
    - How did wearing it for previous occasions make you feel?
- What was your mood while putting the bra on for X event? How did you feel putting it on? (Physically/emotionally)
    - How does the bra feel, smell, look?
    - Do you remember what you looked like with it on? Can you describe what you felt looking at yourself in just the bra set?
- What is it like to wear the bra? Does it evoke a specific kind of feeling to wear this design?
    - Does it match your expectation on how it should feel?

- How did it physically feel wearing the bra on your body? Is it tight? Do you feel your body standing straighter? Are your shoulders hunched?
- How would you describe that feeling emotionally?
- What did you expect the bra to feel like while wearing it? Physically (Based on touch, the look of it, the style)
- Can you recall the outfit you were wearing over it? How would you describe the style or character of the outfit?
    - Did that style or characteristic match the bra?
- Once dressed did you check to make sure you looked the way you wanted?
    - What was the look you wanted?
    - How did you feel you looked?
    - Was the bra visible under the outfit?
    - How did the outfit fit with the bra?
- You are now at the event how do you feel? What is your mood?
- How did it physically feel wearing the bra at the event? How would you describe the feeling emotionally?
- Based on how you felt did you do, act, or say anything differently?
- In relation to everyone else at the event how do you think you measure? Were you in accordance with the social rule? What do you think the social rule dictated? Did you stand out?
- What do you mean by comfortable? By how your body feels? How your body looks? How you like to feel emotionally?
- What is happening?
    - What does your body feel like standing? Sitting, etc. in the bra?
- Now thinking back on it - Can you mention any specific sensations that the garment evokes? Is that a positive, neutral, or negative aspect of your experience? Can you elaborate? Based on how you felt did you do, act, or say anything differently?
- These questions are outside of that experience:
    - Have you ever thought about how your bra would affect the way people viewed you?
        - Would you say that's tied to your race as a Black woman? Why?
    - How is it that you usually want to present your breasts in social settings? Professional settings?

- How do you want to present yourself and what does that mean to how you present your breasts?
- How do you register what bra is appropriate for an event?

Thank you for discussing the positive bra experience. We will now discuss your negative bra experience with similar questions.

L. DESIGN PRACTICE

L.1. Initiating Design Practice

'Design knowledge is knowing in action, revealed in and by actual designing.'
(Schön, 1992, p. 3)

This section provides the readers with the design-researchers experimental actions as I attempt to engage with the design situation by applying a Deweyan pragmatist perspective. Dalsgaard (2014) established that a pragmatist perspective guides the design-researcher to engage and participate in the design situation to gain knowledge. Moreover, Lewis (2023, p. 423) argues that 'the designer should have a key role in the design development process and be conversant with all [the] aspects involved throughout all technical stages'. Therefore, I began exploring the initial design practice by using an inquiry approach (Dewey, 2007) and conversing with the materials (Schön, 1983, 1992; Mackey *et al.*, 2019). Being in conversation with the materials allows the design-researcher to acquire new knowledge enabling the movement from an 'unknown situation to one of known' (Dewey, 2007). Dalsgaard, Halskov, and Nielson (2008, p. 178) highlight that design materials are utilised 'as a means for inquiry' and can include 'written memos, […] sketches on paper, […] 3D renderings, [and] physical models'. Hence this section aims to gain knowledge to inform the development of the BWD&DP by exploring design materials for two BW concepts selected by participants – a massage and a cooling bra (Section 9.2.2.).

Moreover, this section details the practice development stage, which is absent from the initial BWD&DP and is imperative for the rest of this study's progression, especially as the design-researcher is developing electronics and design knowledge (Schön, 1992). Undertaking this study serves three functions:

- to introduce the design-researcher with first-hand experience – by actual designing – in learning about and developing smart clothing
- document areas of tensions and flow in developing the BWD&DP
- experiment with various methods that facilitate technology integration into the bra, allowing for the evolution of BW.

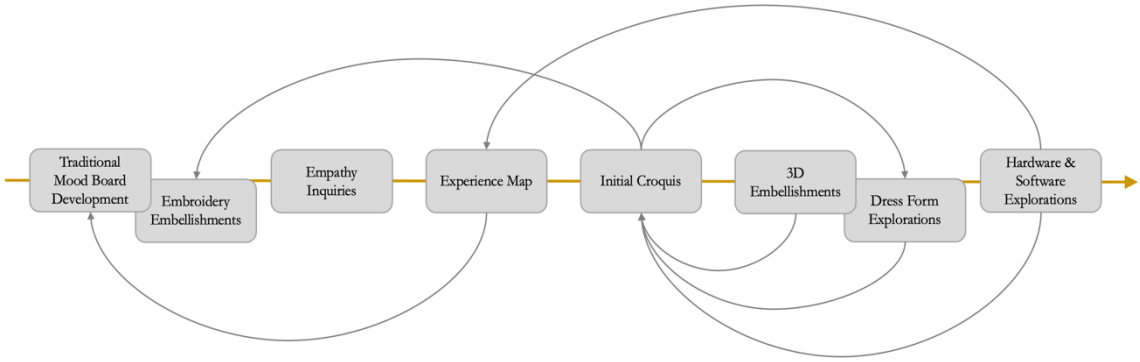
Throughout this practice, I explore from a 'fashion perspective' (Stead, 2005), documenting my experience moving from a traditional lingerie designer to a hybrid designer, engaging with electronic functionality in clothing, while centring the wearer.

Although this section is not a part of the initial BWD&DP, it follows a similar path, making it vital to note the methods approached and provide valuable experiential information. The samples developed are for

exploration to learn from the *doing* rather than evaluation. Initially, I proceeded with a linear set of activities based on my prior experience as a lingerie designer. This starting point is what Dewey would refer to as the beginning of an experience where the design-researcher approaches the problem using past experiences to inform them (Dewey, 1997). However, through reflection-for-action[127], it immediately registered that I would have to acquire novel approaches and skills to progress. This led to a complex phase of being in a 'reflective conversation with the situation' as I attempted to 'respond to the demands of the design situation' (Schön, 1992), with many of the activities happening simultaneously, asynchronously, and sometimes sporadically.

Unwittingly this process required me to reflect-in-action and reflect-on-actions, gaining design knowledge to determine the subsequent activities which Dalsgaard (2017) refers to as knowing-through-action. For example, in sketching ideas, I realised I had minimal conception of how and where the technology would go in the designs. This proved an obstacle requiring me to examine electrical hardware and its sizes on a dress form. While it clarified the layout and positions, I needed to understand the wiring placements. This action facilitated a nonlinear process moving from activity to understanding next possibilities. Thus, I moved to test the hardware on breadboards (**Fig.L.10.**) to comprehend the necessary hook-ups and then return to ideating on placements and designs. My actions were in-line with what Schön (1992) describes as 'seeing-moving-seeing', where through these activities, I gained new information and understanding of the situation, allowing me to better place it within the D&DP. Additionally, by approaching designing in stages (Kettley *et al.*, 2010), I was constantly cognisant of the nexus and slippage between the various disciplines. Moreover, this was a year-and-a-half endeavour between taking courses, seeking assistance, and experimenting. Activities were iterative and cyclical, often feeding back into earlier methods that would inspire movement forward and new directions. As this inquiry is a part of the fuzzy front-end of the D&DP, which is often described as "messy", I struggled to recount my actions in a precise sequence instead of reporting them in an iterative sectioned format (**Fig.L.1.**).

Fig.L.1. Progression chart illustrating the cyclical sequence



[127] Reflection-for-action is defined as the 'planning/thinking through before engaging in practice' (Thompson and Thompson, 2018, p.28) employed by designers.

L.1.1. Mood Boards, Visual, Tactile and Olfactory Explorations

The bra design process (DP) can begin with fabric design and selection or inspiration gleaned from mood boards (Hardaker and Fozzard, 1997). Many different types of mood boards are amalgamated with visuals, objects, and materials that impart 'tactile, visual, and olfactory sensations' (Mcdonagh and Storer, 2004, p. 18) to help designers creatively and innovatively approach designing (Cassidy, 2008; Tracy Cassidy, 2011). As a trained lingerie designer, I often begin the process by creating a conceptual mood board derived from current inspiration focused on a particular theme. It is not imperative to begin a mood board 'prior to the design brief' (Mcdonagh and Storer, 2004, p. 18); however, this exploration began after reviewing the interaction matrix and design criteria for this practice (Section 8.4.3.).

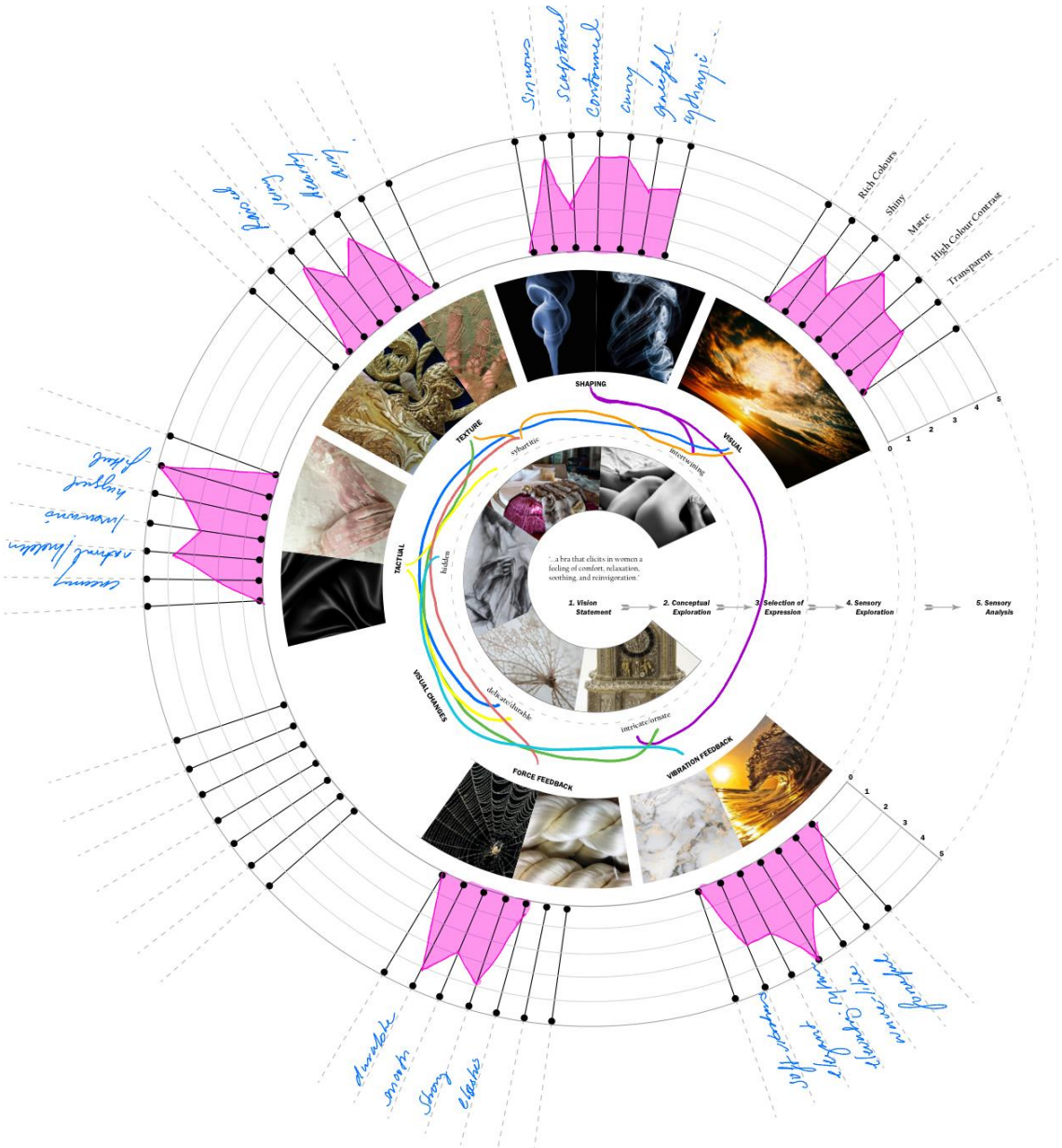
The designed conceptual mood board was named "Mastering Baroque". It was inspired by Baroque period painter Caravaggio, architect and sculptor Bernini, and ironwork motifs of the same epoch (**Fig.L.2.**). The mood board inspired new style lines that reflect similar Baroque ideals, such as theatrics and movement. The movement is evocative of the changes happening when BW functions are enacted on the body. Furthermore, Caravaggio and Bernini's work, which captures intense scenes, was utilised to inspire centring the wearers' experience when the body transitions to pleasure or relaxation. Numerous elements were pulled from the board to inspire new bra design ideas conceptually. However, I found myself stuck while designing the croquis, questioning whether the design style positions would interfere with the hardware placements. Reflecting on the quick sketches, I conducted, it became clear they were missing the functional and modality aspects of BW[128]. This led me to look outside of the visual aesthetics of the bra to define the other sensory qualities.

Interaction design-researchers Camere, Schifferstein, and Bordegoni (2015) developed an 'Experience Map' tool to assist designers in utilising an experience-driven multi-sensory approach to creating products that can interact with the wearers, eliciting a desirable and 'meaningful' experience. During the D&DP, designers can engage with the five levels, moving from abstract to tangible sensory properties in the product (Bordegoni, Carulli and Kyfinn, 2015). Realising the sensory experience for BW ideas may differ, I began by focusing on a concept for a massaging bra[129] (explained in Section L.1.4.2.). Beginning at the centre, I applied a vision statement for '…a bra that elicits in women a feeling of comfort, relaxation, soothing, and reinvigoration' (**Fig.L.2.**). The next layer, the conceptual exploration resembles a mood board; however, it emphasises how 'that specific experience can be rendered in a product' (Camere, Schifferstein and Bordegoni, 2015, p. 151). I placed rich imagery in this section analogous to the already completed traditional

[128] Sketches are later discussed and shown in Section L.1.3, 'Design Sketches'.
[129] Please note as this is not linear, that the empathy activities in Section L.1.2. was enacted during the initial mood board development.

mood board. However, in the third step, the selection of expression, where words were selected to reflect 'the product's expression' (*ibid*), I began to engage with the sensory aspect.

Fig.L.2. Traditional mood board 'Mastering Baroque' (Top) and Massage Bra Experience Map (Bottom).



Words such as *sybaritic*, *delicate yet durable*, and *ornate* were selected to describe the massage bra, allowing me to capture sensations not only of the product but the desired wearers' aesthetic experience. The sensory exploration, the fourth step, enabled the selection of more images but specifically focused on the tangible and sensory aspects of the product divided into ten sections: visual, product shaping, texture, tactual facet, olfactory attributes, auditory, visual adaptations, force feedback, vibration feedback, and olfactory feedback (Camere, Schifferstein and Bordegoni, 2015). In the case of the massage bra, with a vibration functionality, I initially applied only six sensory properties focusing intently on the visual, shaping, texture, tactual, force, and vibration feedback. However, once I started working with the electrical components, I added the auditory section, as it was important for the bra to be silent when functioning. During the fifth and last stage, the sensory analysis section, I began to unfold creatively, grasping the necessary multi-sensory aspects. I considered the tactile nature of the design due to the introduction of hardware and factor in the designs' needs. For example, the texture being raised and hearty meant that the vibration motor could be hidden or disguised within the embroidered designs[130]. Examining the vibration feedback led to exploring the felt experience on the wearers' body as being wave-like, forceful, yet rhythmically soft. The force feedback would be strong and smooth. This activity inspired the material embellishments (Section L.1.1.1.) and vibration motor hardware exploration (Section L.1.4.).

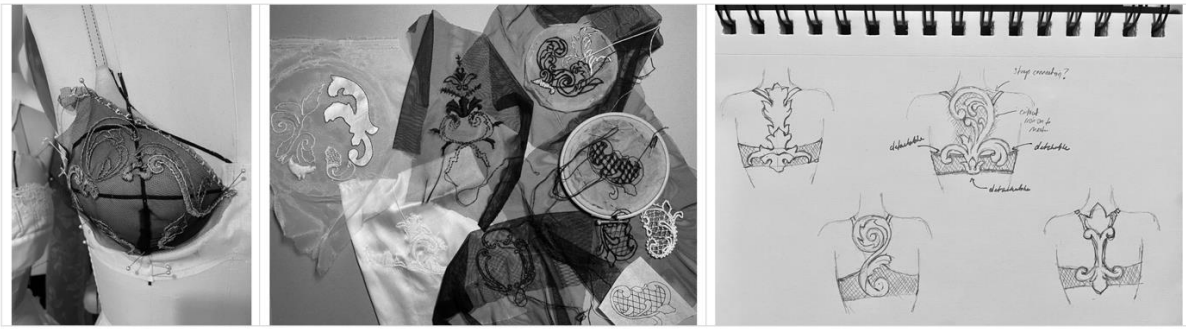
The experience map (**Fig.L.2.)** was useful for delving into the design ideas' sensorial facets and works in conjunction with the traditional conceptual mood board – providing a sensory-centric approach. However, the experience map – I believe – should not be used to replace the traditional mood board. I often reverted to the traditional mood board when generating ideas, especially style lines and shapes. It captures the conceptual exploration from the experience map on a larger scale allowing design ideation in reference to details. However, while sketching, I appraised the designs against the massage bra experience map and explored the fabrication and vibration function needs. Separately, the experience map helped me focus the wearer into the mood and style board stage in a contemplative manner, allowing me to consider the experience I am designing *for*, and *their* potential experience with the garment. The wearers' experience of various design aspects was continuously examined in the subsequent stages.

L.1.1.1. Material Embellishment

> *'...materials forms part of a problematic situation, and might also serve as the means of transforming the situation.' (Hansen, 2016, p. 41)*

[130] Style concepts were further inspired by the developed style board (Fig.9.5.) in Section 9.2.2.2.

Fig.L.3. Embroidery exploration.



In some design processes, fabric exploration, testing, and selection can occur pre-mood and style board and design. When innovating new materials, it can occur in stages, evolving through testing and multiple iterations. As highlighted in the initial BWD&DP (**Fig. 7.19.** and **7.20.,** p.224), fabric direction can occur before the design brief or in tandem. Following is the fabric selection, design and testing phase, which can occur simultaneously with the design sketch. Traditionally, a separate fibre and textile team leads the investigation; however, with the introduction of technology, specialised members called textile and engineering technologists now oversee the development. Textile technologists attempt to combine soft materials with electrical hardware through e-textiles, also referred to as soft actuators, which can be 'integrated *into* or *onto* fabric substrates' (Veja, 2014, p. 1), making it an ideal method to trial in BW design. Much research can be found on the utilisation of machine embroidery in the development of e-textile and wearables (Ashok Kumar and Vigneswaran, 2016; Hamdan, Voelker and Borchers, 2018; Goudswaard *et al.*, 2020; Goveia da Rocha *et al.*, 2020; Ismar *et al.*, 2020). However, with a lack of access to an embroidery machine and as a designer trained to approach creative projects manually, I investigated this facet using hand embroidery. I began exploring embroidery, a traditional component in lingerie, to extend the concept of movement in the design and incorporate wiring and e-textiles in the form of conductive thread. Previously, to refresh and further develop my skills, I took two short courses at UAL: Embroidery, Embellishment and Appliqué (July 2018) and Embroidery Level 2 (July 2019). From the samples developed (**Fig.L.3.**), a few methods progressed as design possibilities, such as using couching to apply the wiring or conductive threads decoratively and employing the satin stitch to hide the designs' hardware. The use of appliqué techniques, especially when coupled with embroidery, also inspired the possibility of concealing or revealing certain hardware integration acting as small pockets when necessary. During these endeavours, while journaling and reflecting on potential design ideas, it crystallised that it was not compulsory to hide the electrical components as their employment is part of the bra evolving into BW.

Nevertheless, the ideas proved incongruous with the mature participants wants from the survey (Chapter 7 and Appendix K) and generative workshop (Chapter 8). They desired invisibility of the technology and their bras while being worn, which the usage of raised embroidery designs may possibly impact. Embroidery on the bra cups would draw viewers' attention to the wearer's breasts. Therefore, the placement of the embroidery was imperative for the wearer's acceptance and emotional experience. Further constrictions were therefore placed on the design ideas limiting the placement of technology and

embellishments on an already compact garment. Hence, it became apparent that the bra's shape must evolve in a symbiotic relationship with the introduction of technology. As a designer, this realisation was inspiring, freeing up ideas for sketches, and enabling innovative style ideation in the bra's straps and back patterns.

Fig.L.4. 3D Printing pen motifs and design exploration.

Working comprehensively, I attempted to interrogate further Baroque shapes influenced by the conceptual mood and style board (**Fig.L.2.,** p.480 and **Fig.9.5.**). Some of these shapes were previously examined using traditional embroidery. The goal was to capture movement and to help inspire new lines in designing BW utilising novel materials. Employing two 3D printing pens compatible with multiple filaments, I manually recreated and designed intricate motif swatches (**Fig.L.4.**). They were then applied to different areas on a dress form and mannequin, inspiring fresh ways of seeing bra shapes to possibly evolve the bra form. Experimenting with various filaments such as a rigid PLA and a flexible TPU allowed for the visualisation of new materials outside of the traditional lace. The process – understood through trial-and-error – involved designing the scroll shapes, copying the designs onto wax paper, tracing over the design using the 3D pen, and building onto the design to secure the lines. Once complete, the samples were removed from the paper and shaped onto the mannequin using a heat source to allow for malleability. The heat source is required more so when using PLA filament as TPU is flexible; thus, it is unnecessary.

Working with the filaments caused experiential tension as I grappled with the embodied tacit knowledge of traditional bra fabrics' tactile malleability and softness. Schön (1992, p. 5) argue that design practitioners possess implicit knowledge that is not only thought-based but also 'involves sensory, bodily knowing'. The 3D materials, while inspirational and undoubtedly futuristic, led to self-inflicted barriers, referred to as *conflict* by (Dalsgaard, 2014), stemming from my experience as a commercial designer. My concerns were about the wearability and the wearers' physiological comfort of the material. Pivoting to participants' comments on their wanting for the bra to remain close to its familiar form (**Fig.J.24.,** p.464), I again struggled to balance the creative possibilities and their conservative views. This tension hindered creative conversation with the materials (Schön, 1983, p. 135). Acknowledging that commercially innovative ideas can fail if they are ahead of their time, I shelved the more prominent usage of 3D elements. Instead, I contemplated smaller alternatives with 3D-printed accessories such as rings and slides or closure options, and decorative 3D embroidery designs.

L.1.2. Empathy Activities

Empathy should be at the centre of designing futuristic garments that are desirable and pleasurable (Fairburn, Steed and Coulter, 2016). Sleeswijk Visser (2009, p. 58) separates empathy into two components: the affective component, the 'identifying with, feeling, and emotional response' and the cognitive component, the 'understanding, perspective taking, and imagining the other'. Both components are required for the designer to effectively empathise with the participants. Additionally, Smeenk, Tomico, and van Turnhout (2016) argue for developing empathy by utilising a mixture of perspectives such as third-person, examining data findings from research, and first-person, using the designers' own experiences. Approaching empathy using a first-person perspective introduces the design-researcher along with their past and present experience into the design process. Unfortunately, as an "average" sized bra wearer (32D), I have had limited difficulty in my own bra experience with very little trouble purchasing or wearing bras off the rack. I categorise my own bra experience as one of exploration and enjoyment. Therefore, to further establish empathy with mature women, I focused on their changing bodies and menopausal experience. Applying a body storming technique (Buchenau and Fulton Suri, 2000) and a drawing-as-seeing (Mida and Casey, 2020) method, I attempted to empathise by utilising the affective component in identifying with their menopausal experience and the cognitive component to understanding the physical body changes due to maturing.

Fig.L.5. The design-researchers' first-person experimental experience of hot flushes.

Menopausal hot flush is the ailment most selected by the women in the survey and the ailment they most wanted to be addressed by a smart bra (Section J.1.1.); therefore, it was selected for this activity. On June 9th, 2020, I began the menopausal hot flush experiential experiment (**Fig.L.5.**). This day was selected as I had Zoom events to attend, such as a short course and a birthday party with a five-hour time difference. I needed to be working and also interacting with people for this experience to be meaningful, similar to the working women in this study. First, I set random alarms throughout a work evening to imitate erratic hot flushes. Once the alarms buzzed, I promptly stopped whatever work I was conducting and headed to the bathroom, where it would be highly steamed. The heat and steam raised my body temperature, mimicking

a hot flush. After spending five to eight minutes in the bathroom, I would then head back to my tasks. This was done several times. Afterwards, I journaled about the experience and reflected on the emotional and physical aspects.

While undergoing this experiment, I was hyper-aware, taking stock of my physical and emotional state. Mostly, I felt annoyance from the stray interruptions while working, which grew into frustration as I would forget my position once I returned. I also felt embarrassed and self-conscious returning to my course and the party as I was much dewier and sweatier, using my hair to cover underarm sweat marks on camera and in the photos. The experience caused an image disruption as the way I wanted to present myself was impeded by the results of the simulated effects. Though I could undergo some aspects of a hot flush, I realised that if this were simulated in a space where people physically surrounded me, I would have been more embarrassed, self-conscious, and frustrated. Of this, I wrote in my notes, '*I'm not sure if it's due to my vanity, but I wouldn't feel comfortable doing this in front of people*'.

The experience heightened my willingness and ability to empathise with mature women (MW) encountering hot flushes. The simulated hot flush experiment emotionally connected me to the participants, enabling me to step into their shoes (Kouprie and Sleeswijk Visser, 2009; van Rijn *et al.*, 2011). I imagined the changes the women had to make to their wardrobes to feel cooler, hide sweat marks, or help regain the image they were used to. At one point I recalled imagining what the future would have 20 years later for my menopausal experience – hoping that there would be tools or medicine to hasten or prevent it. Nevertheless, during the reflection and subsequent rereading of my notes, I was able to produce creative ideas inspiring me to deliberate on what may actually be beneficial for MW.

Experience-driven design calls for observation to empathise with participants and gain knowledge on their product interaction, yet this can be difficult with sensitive topics. As an insider, I was aware that many mature Black women would not want their privacy invaded by viewing their lingerie selections directly or through still images. Woodward (2007, p. 52) affirmed this notion indicating when it came to researching clothing; women were 'more reticent' to showing or discussing their underwear with researchers. Therefore, rather than observing their bra selections or wearing habits, I observed the changes in their bodies that affect their bra experiences such as sloping shoulders, skin and breast ptosis, and weightier upper torso (Park and Sohn, 2001; Na, 2009; Kim, Kim and Ashdown, 2014). The aim was to apprehend the variety of changes in MW's body and empathise with the multiplicity of different breasts and torso shapes. As my practice and professional experience were always geared towards designing on mannequins based on youthful bodies, I did not spend time understanding MW's bodies. While research has provided a textual understanding of the body changes faced by MW (Ayalah and Weinstock, 1979; Ashdown and Na, 2008; Zhang, 2020), as a visual-centric designer, perceiving those changes was more significant to exploiting empathy.

Furthermore, as a hobbyist and student artist, I spent many years – throughout the bachelor's and master's programs – partaking in life-drawing, live fashion drawing courses, and practising personally. During my PhD, I joined the university's life drawing society as a creative and relaxing activity. Thus, my willingness, comfort, and familiarity with drawing underpinned my selection of this approach.

Fig.L.6. A selection of empathy explorations through sketching the MW's body.

Centring women as 'subjects', I applied fashion research, and dress history method referred to as 'a slow approach to seeing', usually employed in object-based research (Mida and Casey, 2020, p. 204). Mida and Casey (*ibid*) argue for researchers to exploit drawing to help 'the mind to slow down' as a way of 'deeper understanding' and, in my case, explicitly empathising with the subject. Drawing as a method of thinking, 'drawing is thinking' (Glaser, 2008), has been explored in-depth, concluding that during drawing, the practitioner can become entranced in a meditative state allowing disparate information to connect. This state is one of awareness and reflection that 'enable(s) identification and recall of relevant knowledge' (Cross, 2006, p. 37). Therefore, through drawing MW's bodies, it is practicable to empathise cognitively as I reflect on data from the research methods, literature review, and contextual experiences acquired from social media.

In drawing the upper torso of MW (**Fig.L.6.**), I worked towards visual comprehension of the bodily changes, slowly seeing and reflecting. I could see past the textual descriptions in prior research that described those changes, for instance, the sloping of the rounding shoulders and widening of the back. This type of 'seeing' is similar to Schön (1983) notion of being in conversation with the situation through seeing-doing-seeing, which can foster empathy. From a design perspective, this enabled contemplation of the types of fabrics necessary to pull in and smooth fatty areas. While drawing the varying breasts and torsos, I recalled conversations about breast size changing and breast presentation with participants from the workshop, digital dialogue session, and interviews (Chapter 8). The long glances and tight pencil marks

triggered past imagery of youthful breasts, random remarks disparaging ageing breasts, and snippets of anecdotes from a book on breasted experiences (Ayalah and Weinstock, 1979). I found the nude models being all white women created a psychological distance that enabled me to be simultaneously connected and disconnected. It is possible that this space provided the ability to be receptive and shift perspective. Sketching facilitated a streamlined form of thinking, where I seemingly accessed fleeting memories from various sources tied to this study. The materialistic tools, a pen and sketchbook, were not vital; it was the act of sketching that allowed for deeper reflection, inducing empathy.

L.1.3. Design Sketches

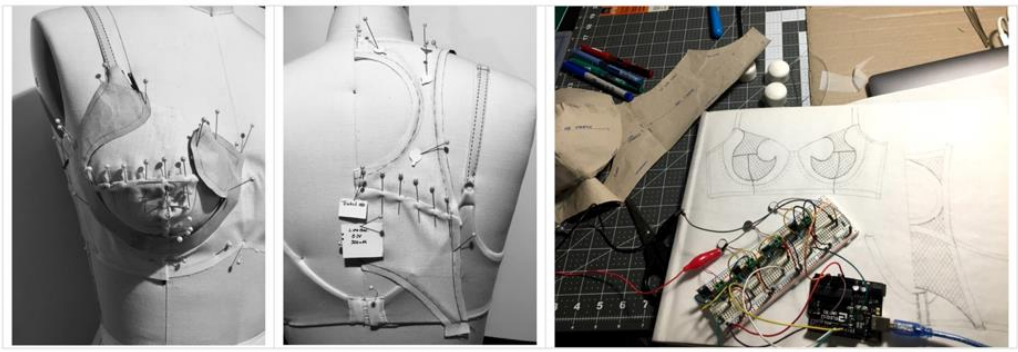
Traditionally, after mood boards, fashion sketching occurs to assist designers in exploring and documenting ideas (Hardaker and Fozzard, 1997). Before I discuss the sketching process, I must explain the modular concept's significance, which underscores the design direction (see Section 1.1.1.). Before undertaking this thesis, I developed a modular bra (**Fig.1.1.**) during my master's research between 2010 and 2013. The modular bra was designed to provide the tween-teen market with an innovative product to assist in individuality and self-exploration. The bras' straps, wings, and cups were all removable and interchangeable, creating a patentable concept. As I became widely read, I realised the sustainable possibilities of my modular bra concept (Fletcher, 2010). The bras' modularity provides an extension of its life and usage, integrating into sustainable strategies such as designing for repair and longevity. After taking the short course Design for Sustainability at UAL (June 2020), I learnt that sustainable efforts are most effective within the early stages of the design process allowing for the design for repairability (Seyed and Tang, 2019). Therefore, through revisiting and analysing the initial BWD&DP, it was updated to include areas for sustainable[131] exploitation. However, due to the expansiveness of this thesis, that aspect was removed and noted as an area for future research. Within the design sketch stage, I focused on ideating the bras' modularity to assist with ease of repair, promote longevity, and design for a pleasurable experience.

Fig.L.7. Earliest croquis study

[131] Sustainability in BW requires more research. BW development teams will have to balance the ease of disassembly with technology integration levels. The more integrated the technology the more difficult it will be to disassemble an already complicated garment such as the bra.

The initial croquis (**Fig.L.7.**) consisted of thirty sketches inspired by the 'Mastering Baroque' mood board and embellishments exploration. As mentioned in the mood board section, I found it challenging to design ideas without understanding a proposed function and experience of the concepts. After developing the experience maps, which were tied to two bra concepts stemming from the design workshop (Sections 6.1.3.1. and 9.2.1.), ten designs were selected from twenty additional croquis sketches. Selected designs were re-sketched into a larger flat format with back and front views, allowing for transparent overlays guiding hardware, wiring positions, and design styles. Although progressing, I still found ideating complicated as I struggled with the lack of knowledge of necessary hardware, sizes and shapes, and positional requirements. Understanding those aspects were essential as bras are smaller garments with less available space to house hardware. Moreover, as it is worn snug against the body, covering shapely delicate and bulbous areas, the materials require specific properties that hardware needed to align with. At points of conflict, design practitioners utilise a *repertoire* gathered from past experiences, teachings, and readings to assess and approach problem-solving (Schön, 1983). Consequently, I explored other methods from my own repertoire, moving on from just the pen and paper materials to experimenting on a dress form along with other methods to inform new opportunities for design ideas.

Fig.L.8. Integration of multiple stages in early prototyping



Traditionally, I approach new designs with a fusion of draping and patternmaking. I found myself working across designing, sampling on the dress form, coding, and wiring hardware examples. Ideas that seemed fruitful were either developed through patternmaking or draped onto the dress form by applying oak tag mock-ups of the hardware elements to test for size accuracy (**Fig.L.8.**). This manner of working between methods integrating the different materialistic elements advanced my creative comprehension of new bra design possibilities married together with technology integration. During working on the form, I began exploring the notion of utilising the garment's seams as channels to conceal technology, or to become decorative elements allowing the technology to become part of the design structure (Kettley *et al.*, 2010). While laying out the possible placements for hardware, I realised another lining layer stationed away from the wearer's body would be necessary to keep the hardware safely away from direct skin contact. This provoked new inquiry into multiple layering and routes around the need to layer with removable facets. Through the act of designing and reflecting the complexity and opportunities of the BW design process crystallised.

This process was unlike those approached from a technological push as the garment and wearer were centred. Wearable Technologist Rain Ashford (2018, p. 95) explained their approach,

> 'The idea for the overarching project came first, next came the prototyping of the electronics and code, the cut and style of the skirt came later when the approximate size and weight of the electronics were known and could be factored into the choices of fabric, length, and tailoring of the skirt.'

As demonstrated, Ashford placed more importance on the electrical elements which dictated the form and style of the garment. While a skirt's shape can be designed in multiple styles cut away from the body to combine and conceal technological hardware, as mentioned, the bras' proximity to the body makes it significantly more complicated. Attempting to balance the needs of the bras' form with the introduction of technology and the wearers' desires and needs proved difficult.

To continue, I momentarily removed the wearers' aesthetic wants, instead placing in my aesthetic assessments. Once I could visualise through toiles, including prototyped hardware samples aiding concrete design possibilities, I moved to redesign the concepts through CADs. CADs are computer-aided designs that visually display ideas to other teams, buyers, and factories. Oscillating between analogue and digital designing provided a different perspective, especially as I mainly employed CADs professionally. The CADs illustrated the two BW prototype styles (**Fig.9.6.**) along with hardware and wiring placements. They were clear enough to demonstrate the look but were missing vital information for the next stage – placement into technical packages. Technical packages, also referred to as tech packs, are informational packets comprising garment measurements, clear images of design details, sewing instructions, grading specifications, and bills of materials. This introduced a new space that needed to be explored; however, due to time constraints, this was omitted from this study and noted as an area for future research.

L.1.4. Material Exploration

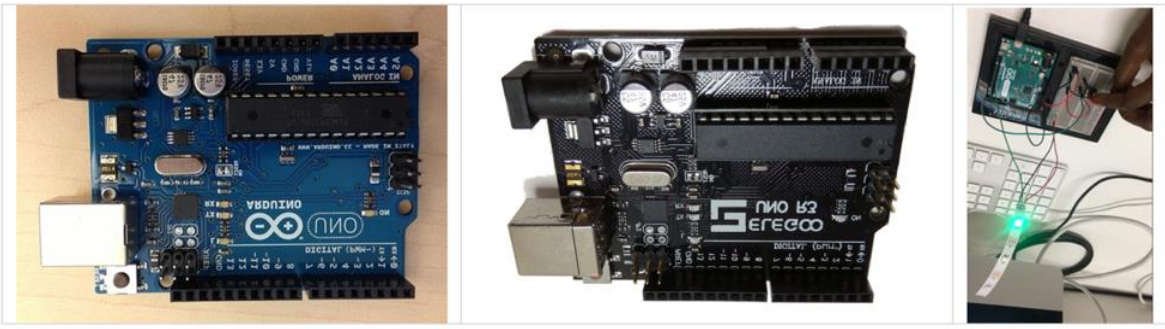
Part of the design practice involved material exploration, which includes investigating technical hardware and electrical materials. Material exploration enables design-researchers to plan and evaluate potential design ideas (Dalsgaard, Halskov and Nielsen, 2008). While the sections in this stage are separated by design focus, it is important to note that they occurred simultaneously, enabling each exploration to inspire the design-researcher. Furthermore, they were enacted while also designing on paper and exploring on the dress form. This was my first time exploring wearable hardware; thus, many of my endeavours were steeped in trial-and-error.

Based on the wearers' feedback and their apprehension of the technology (Sections 7.2.2. and **Fig.J.24.**, p.464). I sought to develop design prototypes that would operate without the need for an app to house data or provide further means of communication – an approach called 'inward-oriented fashion technology'

(Toussaint and Toeters, 2020, p. 2). Moreover, with the lack of time and technical assistance, designing without an app was more applicable.

L.1.4.1. Arduino Programming

Fig.L.9. Arduino boards, an affordable duplicate board called UNO, and LED strip sample.



To begin learning about the e-textiles and hardware development process, I turned to a transdisciplinary 'Textile Academy' called Fabricademy[132], a lab-based textile, digital fabrication and biology course facilitating open-source learning. Most of their lecture slides and videos are available for free, granting me the opportunity to acquire basic skills to begin prototyping. Needing more assistance and unable to attend Fabricademy in-person, I took a UAL based short course (Physical Computing: Electronics and Code with Arduino July 2019), an online Udemy 'Arduino Programming and Hardware Fundamentals' course and watched several Learning Arduino videos on Lynda.com[133]. Through these courses, I was introduced to a vital aspect of the development of wearable technology called Arduino. Arduino is an 'open-source electronic prototyping platform' (www.arduino.cc) and one of the leading programming software necessary to write codes that are then loaded to a readable microcontroller board. **Fig.L.9.** showcases the original Arduino board, an image of the duplicate and less expensive board[134] I used, and a sample LED light strip project from the short course.

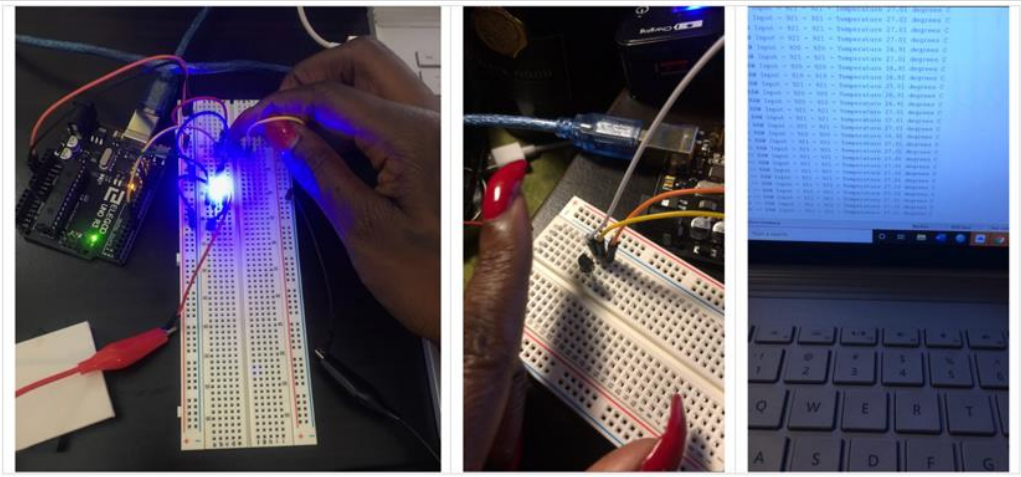
The combined in-person and online courses provided a better skill set to work with Arduino, including writing code, experimenting with wiring, and various sensors. Learning the coding language, sensors, voltage exchanges, and experimenting brought numerous challenges, including its iterative trial-and-error nature. Unfortunately, as I had to approach this learning sans tutelage, my frustrations were incredibly heightened, which undoubtedly affected the creative process. While exploring, I frequently checked in with myself to reframe the problems as an overall lack of tuition and frustration with acquiring the knowledge independently rather than with the materials themselves. This frequent reminder grounded me as a

---

[132] https://textile-academy.org/ 'Fabricademy is a transdisciplinary course that focuses on the development of new technologies applied in the textile industry, in its broad range of applications, from the fashion industry and the upcoming wearable market'.
[133] Lynda.com, now known as LinkedIn Learning, is a paid service site that hosts courses in various disciplines to assist in acquiring new skills and certifications.
[134] Usage of this board was suggested by the instructor from UAL's Physical Computing course, who has over fifteen years in this field as a systems integration engineer and technical service manager.

practitioner, refocusing my consciousness on the experiential exploration. During my explorations in learning the basics, I produced some examples of LEDs with buttons, temperature sensors, and an LCD display (**Fig.L.10.**). However, these were just the hardware elements. I was keen to begin implementing textiles, so I began exploring the concepts selected by participants (Section 9.2.2.), a massaging bra and a cooling bra.

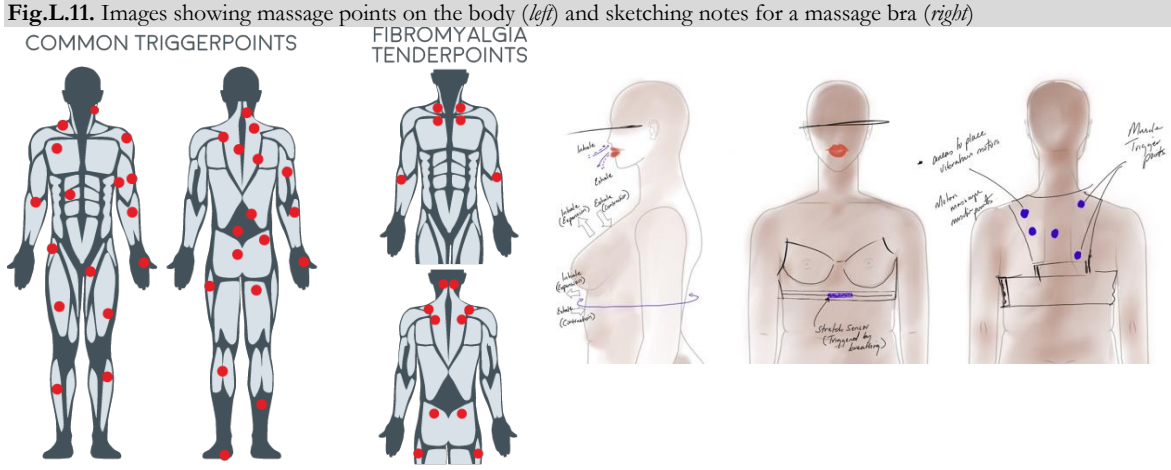
Fig.L.10. Coding and wiring images for LEDs with push button and a temperature sensor with readings



L.1.4.2. Motors and Breathing Sensor

One prototype idea was a massage bra that would detect the wearer's stress, triggering a gentle massaging sensation. The concept was selected by women in the design workshop (Sections 6.1.3.1. and 9.2.1.). Additionally, after attending an online Twitter chat with women who spoke about their frustrations working in the corporate world and how they were essentially forced out because they were undergoing menopause reinforced the need for such a bra. Reflecting on my own hot flush experience of frustration and difficulty resuming work, I empathised deeply with their experience. Thus, I began exploring the design elements for a massage bra to relieve stress, assisting the wearer in relaxing to regain focus. A similar concept was explored in a biosensing sports bra that utilises 'heart rate, acceleration and respiration sensors' to sense and monitor the wearers 'health, stress level and sports performance' (Toussaint and Toeters, 2020, p. 2). However, they employed a separate fitness app to collect data and allow the wearer to interact with the data. Data privacy is a growing area of concern in wearables research, so I opted to explore samples that were self-contained. Toussaint and Toeters (2020) also developed a stress-reducing shirt that monitors the wearer's 'heartbeat, movements and breathing' providing a vibration reaction on the back to calm the wearer. These examples proved the viability of the massage bra investigation.

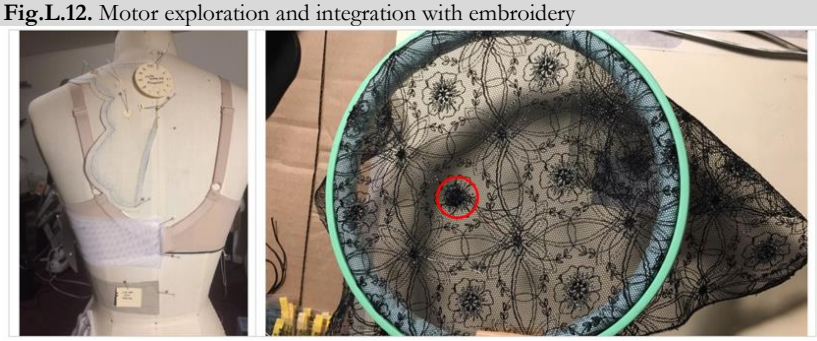
Fig.L.11. Images showing massage points on the body (*left*) and sketching notes for a massage bra (*right*)



Research into available massage bra patents (Section 2.3.1.) detailed many were designed to massage the breasts and needed to be turned on by a switch. Viewing the patents solidified the concept as viable, as well as provided the idea of having the bra turn on and off independent of the wearer. The massage bra would include hidden motors at the wearer's back placed along the trapezius muscles to relieve tension (**Fig.L.11.**). Research into the optimal placement required reviewing tension areas on the female body and mapping possibilities where the bra could cover. The trapezius muscle covers the upper back, shoulders, and neck, placing it in a pivotal position for a back bra strap design. Situating the bra straps higher up on the shoulder would significantly ease shoulder groove pain faced by many women (Coltman, McGhee and Steele, 2015) and address strap slippage. Therefore, one goal was to move the straps up in a comfortable position and design it to cover the trapezius muscle.

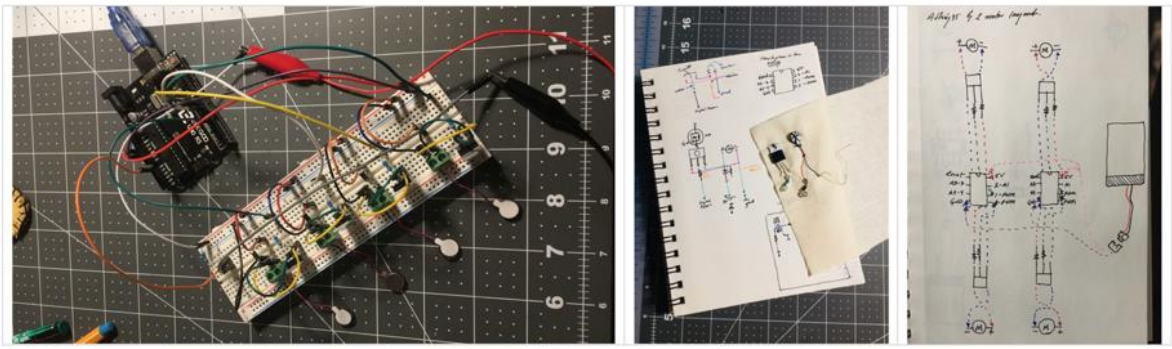
After designing croquis and selecting the most suitable style ideas, I then manually drew large schematics to begin thinking through placements. **Fig.L.12.** illustrates moving between designing, draping, and laying out materials to physically understand components, sizing, and placement possibilities. Simultaneously, I was also exploring the feasibility of the coin vibration motors hidden as part of lace designs through a satin embroidery stitch. Doing and reflecting-in-action inspired new bra shapes and hardware integration ideas leading to an iterative process of designing, mocking up, and laying out. This is a similar iterative process wearable technologists Ashford (2018) and smart fashion designer van Dongen (2019) report in their PhD theses.

Fig.L.12. Motor exploration and integration with embroidery



Besides investigating visual elements, I had to test the hardware abilities. Ashford (2018) informs that foremost in developing wearables is constructing and testing the electronic circuitry before moving on to the textile facets. However, Ashford (2018, p. 95) warns during the generation of electronic prototypes that, the 'complexity start to become an issue, with the use of code and algorithms, components, and power, and hard and soft materials'. Ideally, this aspect of the design would be undertaken conjointly with the design engineer and textile technologist teams in the industry context. The purpose was to explore the number of motors possible for the function, investigate different vibration patterns and intensities, and comprehend the number of total hardware elements necessary. For assistance, I turned to the previously mentioned online courses, websites like Instructables[135] and Github[136], and technologists' personal blogs.

Fig.L.13. Vibration coin motor exploration, schematics, and calico layout



Furthering the exploration, I probed placement for vibration motors, power, and other components on the form. The hardware needs to be placed in areas that are comfortable to wear and could be easily concealed beneath garments. Nevertheless, first, I needed to assemble the coin vibration motors and test them. In testing the coin vibration motors, the vast amount of wiring became another impediment that had to be examined regarding the bra's aesthetic, function, and wearability. **Fig.L.13.** demonstrates the process of wiring motors with Arduino and breadboard, drawing out the schematics and attaching the hardware to calico to test, then scaling the schematics to include multiple motors and a smaller processor, called an ATTiny85. Moving from investigating on a breadboard to textiles integration proved onerous – even more so – due to the self-taught nature. The sheer number of wires reignited my belief in substituting with conductive thread in a decorative embroidery format for the final prototype. At this point, I focused on creating the switch that would signal the motors to turn on.

The goal was to construct the massage bra to function without needing the wearer to turn it on physically. As highlighted in the generative and design workshops, the wearer should feel like they are not wearing anything (discussed in Section 8.1.). At this point, the bra would become one with their bodies operating without interference or needing their attention. Research into the different ways bodies reacts to stress resulted in acquiring information on physiological reactions such as upper abdomen shallow breathing and

[135] Instructables is an online tutorial site that provides 'how to' for craft, technology, and art skills.
[136] Github is an online community mixed with designers of various skills who share their downloadable codes for projects.

increased heart rate. I deduced that a heart rate sensor placed within the bra's cups, or the gore could be successful.

The wearers' increased heart rate would initially trigger the bra's massage features. Purchasing available heart rate hardware called the Pulse Sensor Amped; I began coding and testing. Unfortunately, the heart rate module slightly registered the heartbeats when pressed against my fingertips and did not register when placed on the chest. Subsequent discussions with other technologists uncovered that this specific module was unreliable. Their alternative suggested heart rate module was costly and only available from the States. Therefore, I had to select a different route to capturing shallow breaths. Perry (2017, p. 4) noted researchers would need to learn how to pivot in designing smart fashion due to the numerous difficulties 'related to technical issues, conductive thread and circuits, coding, hard electronics, soft fabric, and curved body, and material sourcing'.

Further exploration uncovered that when a person is stressed, they take quick, shallow breaths[137] rather than calming, deep diaphragmatic breaths. The wearers' stressed upper chest quick breathing would signal the bra to begin its massage functions for a set period. Once the wearer's breathing fell back into a calm range, the repetitive massage function would cease. After reviewing available hardware to sense pressure and strain, I decided a seamless integration into the elastic of the underband was a better choice for the bra. The underband elastic is fixed, thus making it secure to pick up the wearers breathing. Moreover, it would allow for easier laundering if the components were a part of the elastic since it is an element imperative to the fit and bra wearability.

Fig.L.14. Samples of resistive substrates used in detecting slight breathing.

The stretch sensor design was inspired by silicone on elastics often found in strapless bras (first image on the left in **Fig.L.14.**). Review of material sensor research presented a range of research on stretch sensors from knit stretch sensors (Trovato, Tobin, and Thørväld, 2017; Metcalf *et al.*, 2009; Atalay *et al.*, 2015; Kobakant), fabric sensors[138] (Kobakant), and various printed conductive mixtures (Lorussi *et al.*, 2005; Ejupi and Menon, 2018; Tolvanen, Hannu and Jantunen, 2018; Gong *et al.*, 2015). However, the papers utilising resistive mixtures often tested substrates from companies working with university research labs and studies

[137] https://www.betterhealth.vic.gov.au/health/healthyliving/breathing-to-reduce-stress
[138] https://www.kobakant.at/DIY/?p=1762
https://www.kobakant.at/DIY/?p=210

by teams with chemical engineering backgrounds. Ejupi and Menon (2018) developed a resistive stretch sensor to monitor breathing composed of a mixture of polymer and conductive materials. Their resistive mixture appeared feasible to develop at home. YouTube presentations and Instructables projects demonstrated previous exploratory research into making resistive substrates at home. I began experimenting by purchasing latex and silicone DIY kits, nickel and carbon-based paints, graphite powder, chopped carbon fibre, Bare Conductive electric paint, and the necessary equipment (process in **Fig.L.14.**).

The concocted substrates were placed onto 10mm wide ribbed elastics cut to 10-inch with conductive threads[139] as electrical leads, resulting in twenty samples. Using a digital multimeter, I manually assessed each sample's conductive paths resistance in a relaxed and stretched state at one-quarter of an inch and half an inch. Originally the substrates were placed at 6-inch long; however, the readings were too high or did not register. Gioberto, Compton, and Dunne (2016) noted that 1-inch stitched sensors worked best as longer sensors gave higher resistance which could not be read on digital multimeters. Once shortened to 1-inch, I was able to get resistive readings for nine of the substrates (**Table L.15.**). After reading Tangsirinaruenart and Stylios's (2019) paper on conductive threads' ability to register as a stretch sensor with different stitches, a sample was created using a zigzag stitch to test as they noted this stitch was best to measure strain sensing.

Table L.15. Substrates stretched and relaxed.

	Substrates	Relaxed	Stretched 1/4"	Stretched 1/2"
1	Polystyrene, Toluene, Acetone, Graphite (Kremer)	0.L	0.L	0.L
2	Graphite (Kremer) and Acrylic Paint	0.L	0.L	0.L
3	Nickel Coating	0.L	0.L	0.L
4	Carbon Coating	432.6 KΩ	0.L	0.L
5	Graphite (Kasp), Modge Podge	0.L	0.L	0.L
6	Carbon Fibre, Acrylic Paint, Latex	3.48 KΩ	40.16 KΩ	3.254 KΩ
7	Carbon Coating and Latex	2.330 MΩ	0.L	11.31 MΩ
8	Nickel Coating and Latex	3.382 MΩ	0.L	0.L
9	Graphite (Kreme & Kasp) and Latex	0.L	0.L	0.L
10	Graphite (Kremer) and Silicone	0.L	0.L	0.L
11	Bare Conductive and Silicone	0.812 MΩ	0.L	0.L
12	Nickel Coating and Silicone	0.L	0.L	0.L
13	Carbon Coating and Silicone	65.1 KΩ	564.5 KΩ	0.L
14	Carbon Fibre and Silicone	0.608 KΩ	447.3 Ω	322.6 Ω
15	Carbon Fibre, Flex Lite, Conductive Thread	186.3 Ω	305.3 Ω	1.625 KΩ
16	Zig-Zag Kitronik Conductive Thread	32.0 Ω	41.3 Ω	36.3 Ω

Next, the values of the elastic were sensed using an Eegloo Uno controller and Arduino software (version 1.8.10). Using Liz Starks' tutorial[140], a heart-shaped circuit tester was created and used in combination with

[139] Two types of conductive threads were utilised. Kitronik's Electro-Fashion conductive thread and Stainless-steel conductive thread from Sparkfun. While both worked efficiently, samples that needed to be cured in an oven using Kitronik's thread changed shape and loosened. Thus, Stainless-steel worked best on the nickel and carbon-based samples.
[140] Tutorial link and code: http://thesoftcircuiteer.net/soft-sensors/

a voltage divider circuit and code to gauge the resistance changes of the elastic samples (Petri and Greinke, 2021). Once the elastic sensors were ready, they were wired up along with the vibration motors and tested with various codes. Sensor substrates performed well with the zigzag stitch, carbon fibre mixtures, and carbon coating with silicone.

At this juncture, I moved on to CADs as a way to lay out the design, think through component placement, and assess the modularity concept (see Section 9.4.). Exploiting CAD, instead of continuing to work on the mannequin, provides a distance that allows for macro viewing. In laying out the bra design, I could easily make multiple copies of the design and shift or incorporate new style lines. This also allowed me to explore various examples of the component's placement making deliberation easier. As I laid out the components, I deliberated on locations that would mediate the modularity aspect. For example, the stretch sensor placed in the front bra frame needs to connect to the wings on the bra back where the motors and battery power are located. This meant ideating ways to continue the electrical connection through the closures with new materials such as metal and 3D-printed copper filaments.

L.1.4.3. Peltier

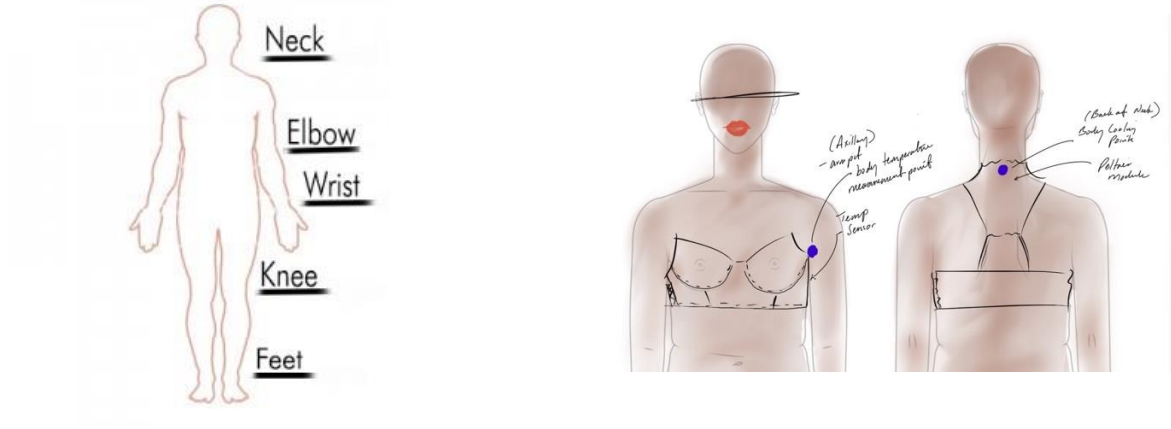
The participants also selected the idea for a bra that would keep them cool (see Section 9.2.2.). Hot flushes impacted the women the most in the earlier survey and was the most selected symptom they wanted addressed by their clothing (Section J.1.1.) This inspired the investigation into a cooling bra. The concept explored a bra that would sense when the wearers' body temperature rose, signalling the Peltier module to begin a cooling process. A Peltier[141] is a hardware module, found often in refrigerators, using thermoelectric cooling properties to cool one side of the device. Once the wearer's temperature dropped to its baseline, the device would turn off. Before formulating the design, a separate experience map was developed with the following vision statement of '…a bra that elicits in women a feeling of control, freshness, cooling, and balance'. The cooling bra was designed simultaneously with the massaging bra, following a similar process. As discussed earlier, during the ideation process, both bras would have modular features as part of a repairability and longevity aim. While the visual conception was viable with a limited skill set, the actualisation proved difficult. However, designing both bras in tandem permitted the investigation into interchangeable components and – thus – a better understanding of the feasibility.

The cooling bra design came with its own demands, as the hardware needed to be placed at specific points on the body. The Peltier module, the cooling hardware, must be placed at an area on the body that would easily facilitate the entire body cool down. **Fig.L.16.** illustrates locations on the body capable of this at pulse points like behind the knees, inner elbows, wrists, temples, chest, and neck (Lan *et al.*, 2018; Lopez *et al.*, 2018). Behind the neck was selected for investigation as it is suitable for bra design. Similarly, temperature sensors operate best when placed near areas on the body such as 'the mouth, the ear, the

[141] https://www.britannica.comm/science/Peltier-effect

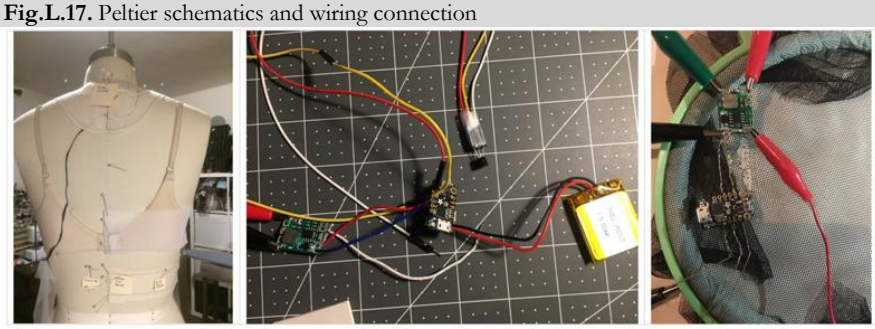
armpit, and the rectum' (Healthwise Staff, 2022). The temperature sensor placed near the armpit would continuously measure the wearer, and when their temperature rose above a threshold, a signal would initiate the Peltier to begin cooling. Both the Peltier and temperature sensor hardware have particular parameters that must work with the bras' silhouette.

Fig.L.16. Cooling points on the body (*left*) and sketching notes for a cooling bra (*right*)



Laying out the placements on the dress form assisted in developing design ideas further (**Fig.L.17.**). While smaller Peltier modules exist, the product was difficult to acquire in the U.K.; therefore, the design had to work with the larger instrument. Once a few design ideas were selected, I moved on to coding, wiring, and testing the components.

Fig.L.17. Peltier schematics and wiring connection



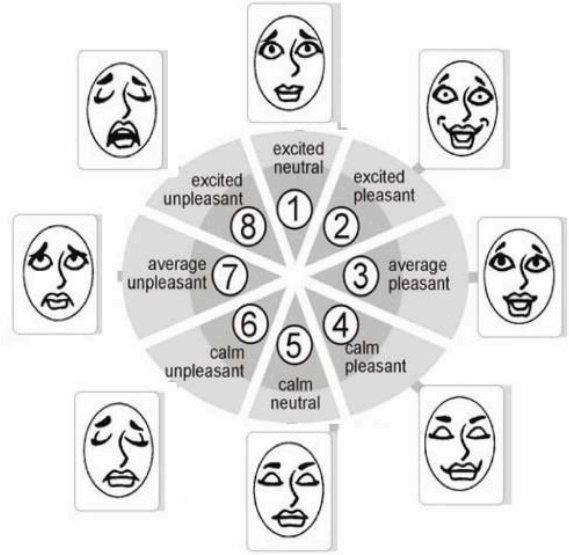
Developing the cooling bra concept proved much more complex than the massage bra. Less information was available online for working with the Peltier module in a wearable project. I found one blog post by a programmer on his journey to creating a wearable cooling device (Zhang, 2016). I acquired similar hardware and wiring according to his post's instructions. Unfortunately, I struggled immensely with the update of many hardware elements and my limited knowledge of voltage changes and energy transformation. After several attempts in a trial-and-error format, I was able to then move on to testing the layout with textiles (**Fig.L.17.**). While connecting the alligator clips to the hardware to test, the wires touched, and the conductive thread overheated, sparking, and burning the mesh material. This event highlighted the importance of safety in a wearable garment for the developer and wearer. Safety testing is another step that must be added throughout the D&DP.

The explorations ceased due to a lack of available assistance in troubleshooting the codes and restrictions from the Covid-19 lockdown. Nevertheless, this exploration proved insightful as I gained a deeper understanding of developing BW. The traditional bra design process is already iterative (discussed in Chapter 3); therefore, introducing the electrical elements extends its length. As a bra designer already accustomed to its trial-and-error nature, I did not find this a deterrent. I found the need for precision and care when working with electrical components more challenging. A simple error in circuit wiring could cause significant problems down the line, so it was essential to take time and double-check the work at every step.

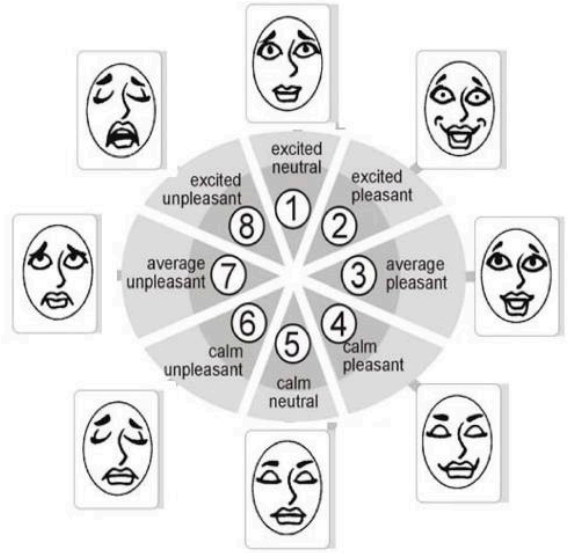
Following this process, the design practice ceased and began a year later at the digital fit interview stage (Section 9.3.). For the activity timeline see **Fig.6.4.**, p.149).

M. FIT MODEL QUESTIONNAIRE

1. How do you consider the overall design?



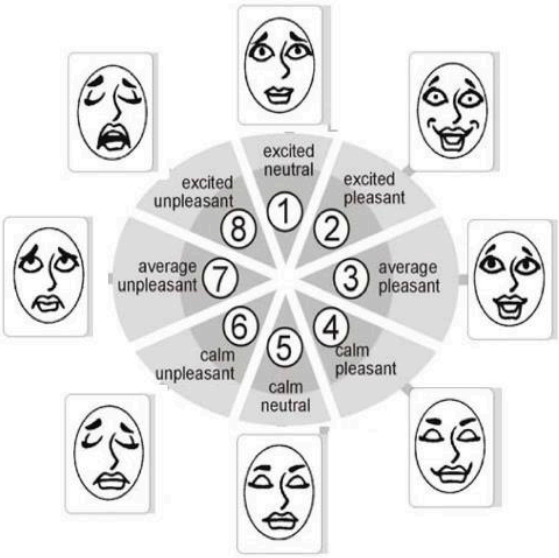
2. How do you consider the colours/colour combo?



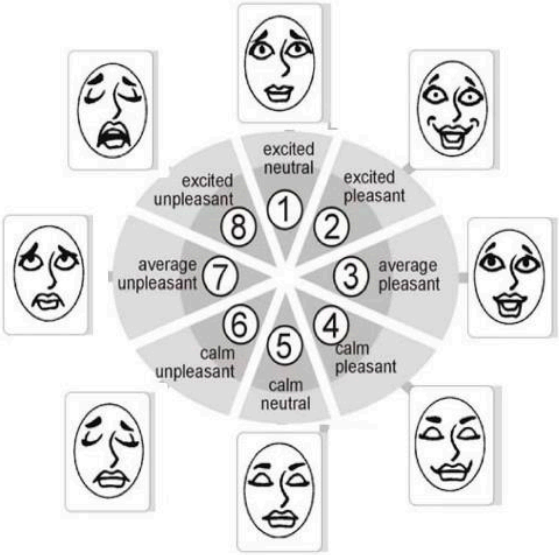
Design Look 1

Soft - Hard
Feminine - Masculine
Womanly - Girly
Light - Heavy
Traditional - Futuristic
Warm - Cool
Delicate - Rough
Fluid - Stiff
Funny - Serious
Appropriate - Inappropriate
Sexy - Neutral
Complex - Simple
Unique - Ordinary
Dynamic - Static
Edgy - Safe
Everyday- Specialty
Discreet - Visible
Modest - Ostentatious

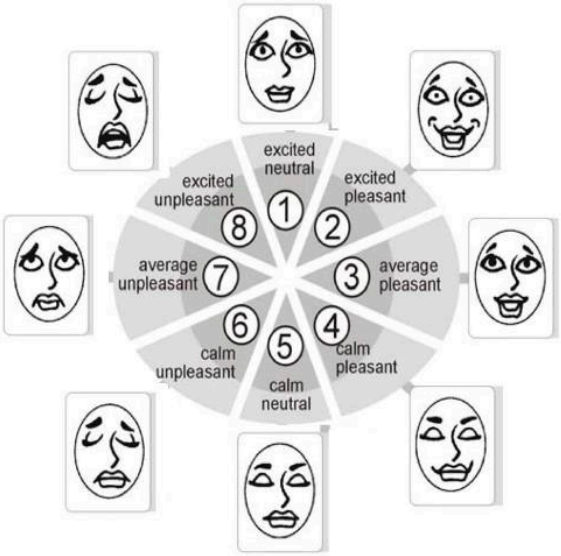
3. How do you consider the fit?



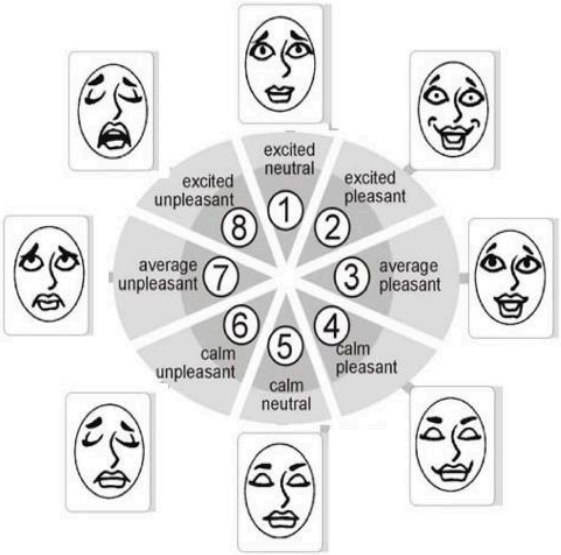
4. How do you consider the materials?



5. How do you consider the design on the model's figure?



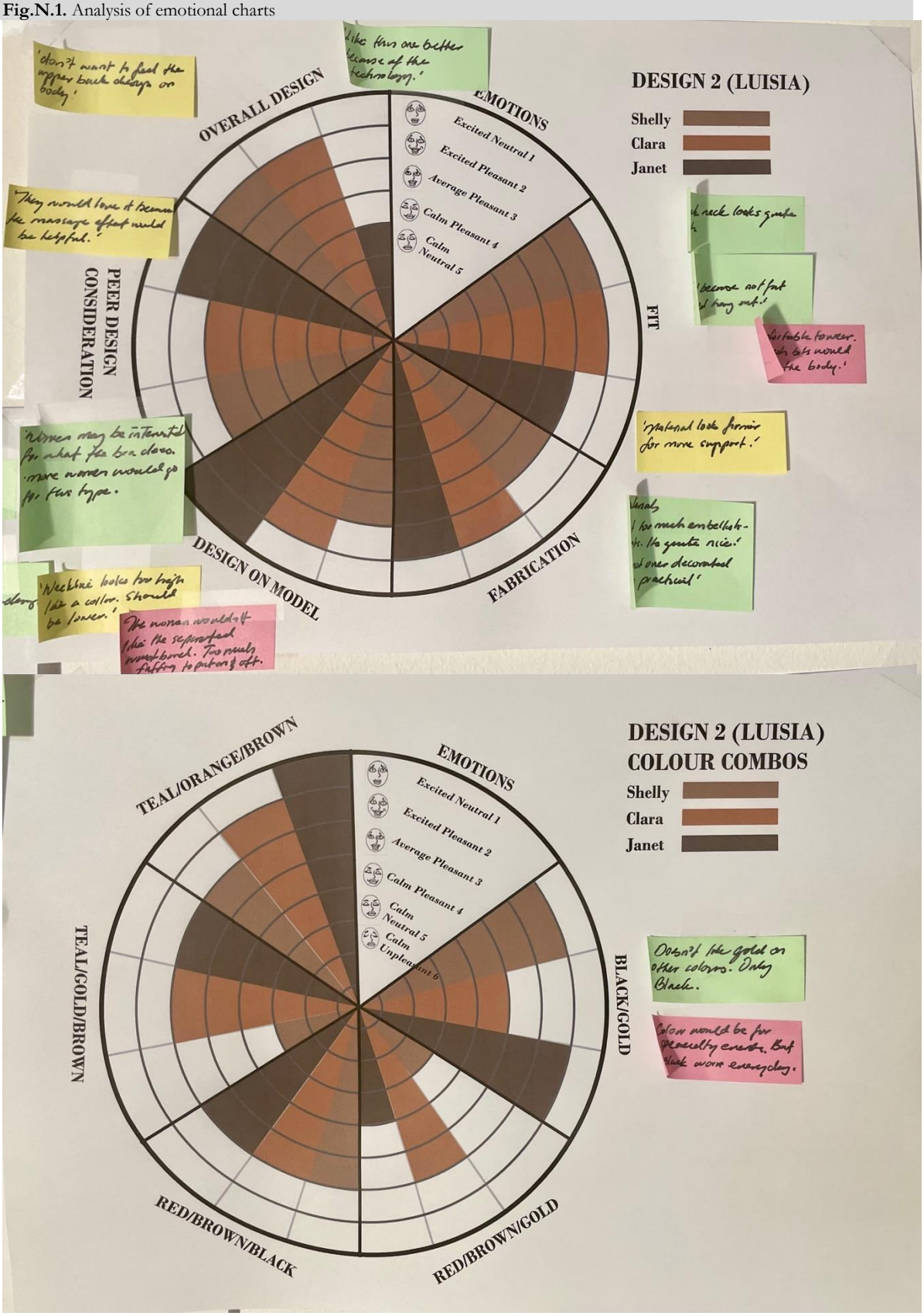
6. How do you think other mature women would consider this design?



7. Do you think the design, or the bra would effectively hide and implement the technology?
8. We will discuss your experience with this meeting. How do you feel having your body measurements reflected back at you in this manner? Do you feel it is an accurate representation of your body shape?
9. Would you have liked to see the model in movement? Why or why not?
10. Would you have liked to see other body shapes?
11. After experiencing this fit process, would you say you are more or less likely to be interested in bra wearables?
12. Do you feel that your input as a fit model in this manner is valuable to the design process? Are there other inputs not asked that you feel should be added?
13. Would you do this process again for bra companies? And would you recommend it to other women?

N. EMOTION ASSESSMENTS

Fig.N.1. Analysis of emotional charts



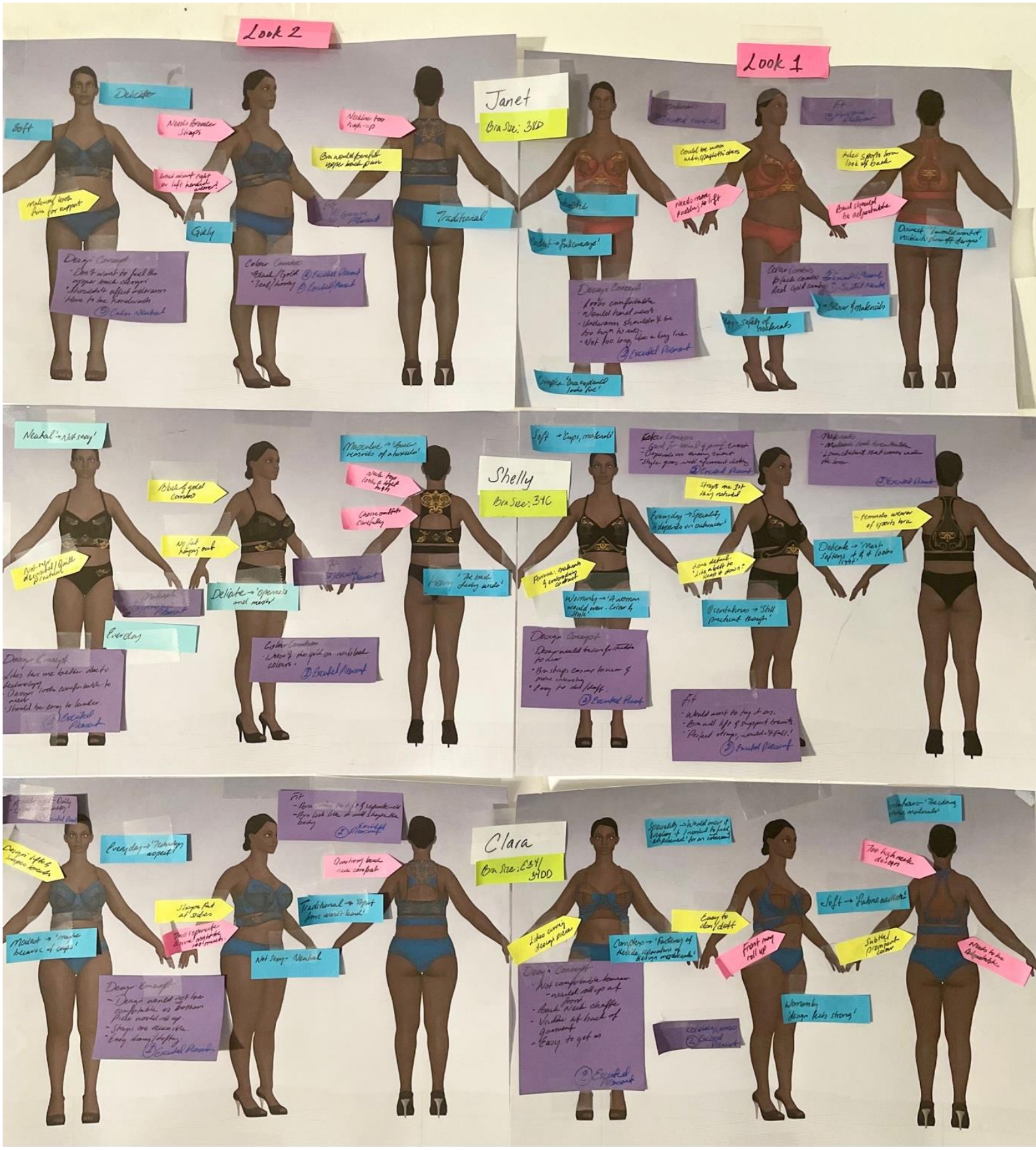
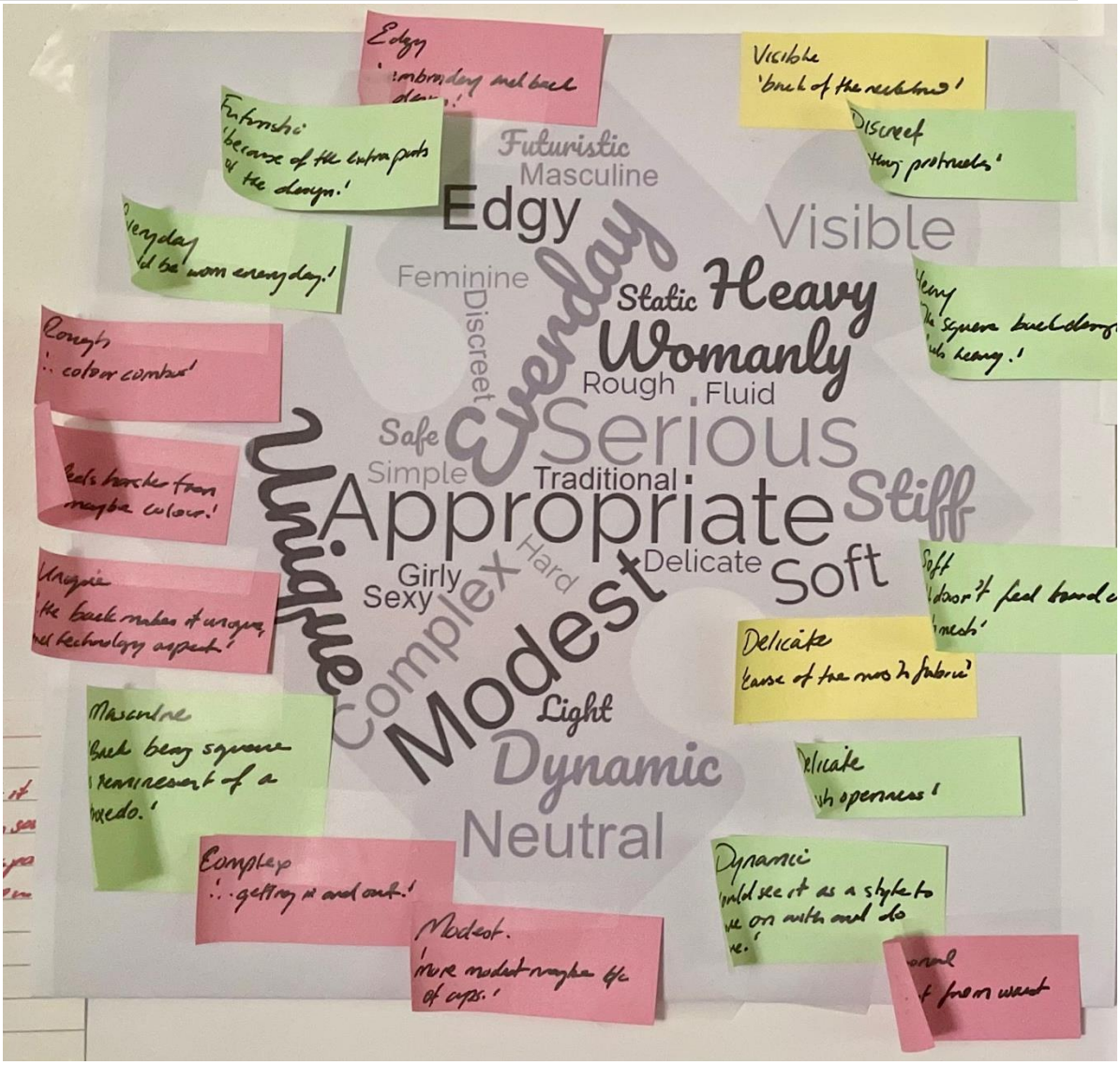
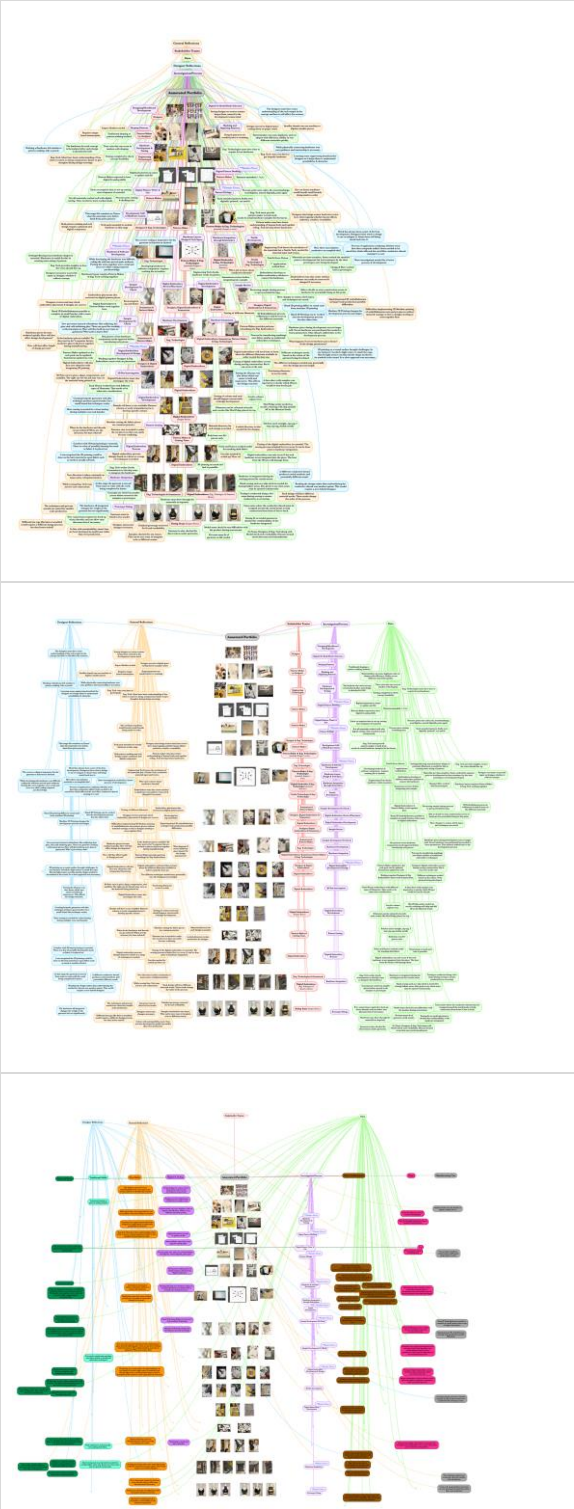


Fig.N.2. Analysis of fit models responses

Fig.N.3. Fit models design emotion word cloud



O. ANNOTATED PORTFOLIO



Three stages of the BW annotated portfolio

To see the images larger please visit the website: https://www.kadiangosler.com/phd-appendices and login in the password: Gosler_KPhD_23

P. UPDATED BWD&DP

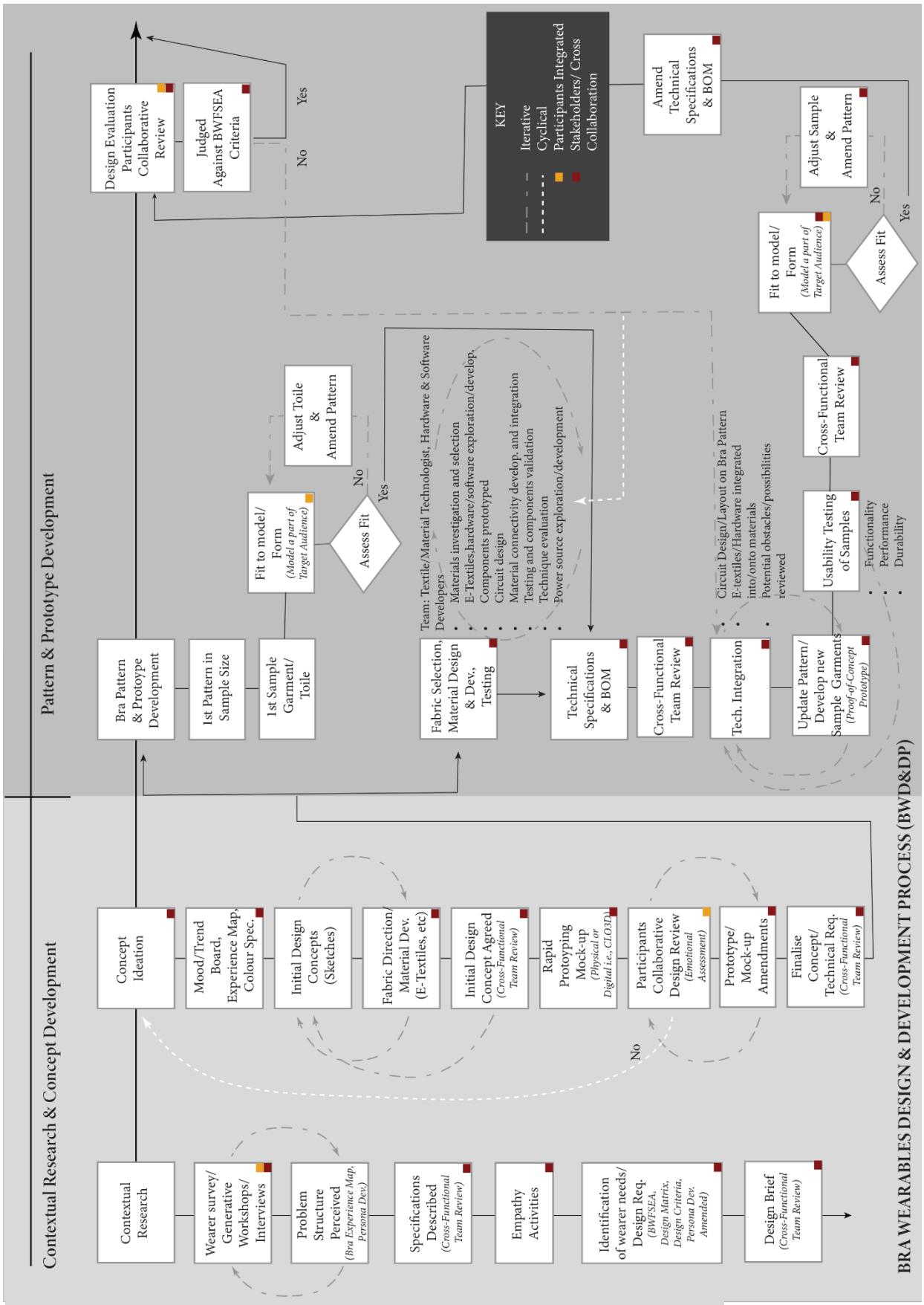


Fig.P.1. Amended BWD&DP

The amended BWD&DP (**Fig.10.3.** and **Fig.P.1.**) expanded from the initial BWD&DP (**Fig.19.** and **Fig.20.,** p.224), illustrating a number of changes. Moreover, the process was updated to include information highlighting what stakeholders may be involved during each stage (**Fig.P.2.**). The contextual research phase was amended, showing more stages are necessary before a design brief is developed. The stages require cross-collaboration with stakeholders led by a design-researcher to understand participants experiences and needs. Empathy activities are significant during the research phase to assist the stakeholders in 'taking the wearer needs into account' and understanding the potential requirements from a first-person perspective (Sipilä et al., 2021). The amended BWD&DP also highlights stages where a cross-functional team review is necessary to guide progression.

The concept development phase was changed to show that many stages are required to move from concept ideation to concept finalisation. During this phase, there are a couple of iterative stages requiring feedback loops to progress. For instance, the initial design concepts stage requires a creative loop where the designer and patternmaker work collaboratively with engineers and technologists to actualise the concept, grounding the sketching phase as iterative and connecting it to fabric/material development. Another change is the addition of participant collaborative review and the inclusion of digital fit models during rapid prototyping. The addition of participants in this phase enables their input during the iterative concept ideation process. The designer, stakeholders, and participants have the ability to insert their creativity, expanding on and ideating the concept.

Once the concept is finalised, the pattern and prototype development phase are initiated. **Fig.P.1.** illustrates through the layout that 'bra pattern and prototype development' and 'fabric selection, material design & dev., testing' are happening simultaneously. The fabric selection, design and testing stages have also been expanded upon validating Islam Molla, Compton, and Dunne's (2020) process (**Fig.3.5.**). During this iterative and collaborative phase, the stakeholders investigate the numerous facets necessary for technology development. The fabric selection and design stage inform the amended design and technical requirements in the 'technical specifications & BOM' stage. Here, multiple teams (i.e., design, pattern, textile, and engineer) are involved to review and progress the development.

Lastly, the prototype phase is expanded upon, illustrating the many stages that are collaborative and iterative in developing the proof-of-concept sample. While the teams work closely together, stages must also occur, exemplified by the cross-functional team review, wherein stakeholders engage in an appraisal of progress, deliberating potential modifications and anticipating impediments prior to advancement. This process provides the beginning of the BWD&DP and prompts an imperative need for further exploration into the distinct contributions brought by stakeholders at each juncture. Moreover, the exigency may arise for the incorporation of additional stakeholders, including a product manager, thus warranting an in-depth inquiry into their indispensable roles within this intricate developmental framework.

Fig.P.2. Amended BWD&DP chart with potential stakeholders and input

STAGE	POTENTIAL STAKEHOLDERS	INPUT
Contextual Research	Marketing Team, Design-Researcher, Designer	Stakeholders: decide on a direction which may include the BW sub-field focus and target audience
Wearer Survey/ Generative Workshops/ Interviews	Design-Researcher, Designer, Participants	Design-Researcher: develops questions and workshops and assess/synthesise data Designer: partakes to engage w/participants Participants: provides input on needs, desires, experiences
Problem Structure Perceived	Design-Researcher, Designer	Design-Researcher: analyses data, develops personas and other useful tools to aid in presenting data to design stakeholders Designer: reflects on experience w/participants to aid in understanding the perceived problem areas
Specifications Described *(Cross-Functional Team Review)*	Design-Researcher, Designer, Lead Hardware & Software Engineers, Material & Textile Technologists	Design-Researcher: utilises and develops methods to display the wearer information, i.e., personas, gained to the design stakeholders Stakeholders: Query the information provided from their respective areas
Empathy Activities	Design-Researcher, Designer, Lead Hardware & Software Engineers, Material & Textile Technologists	Design-Researcher: develops empathy activities and reviews stakeholders assessments of activities with them as a group to provide direction Stakeholders: engage in empathy activities, taking memos and notes to reflect on as a team
Identification of wearer needs/ Design Req.	Design-Researcher, Designer, Lead Hardware & Software Engineers, Material & Textile Technologists	Design-Researcher: facilitates meeting providing data on wearer needs, experiences, design req. and areas for potential innovation
Design Brief	Design-Researcher, Designer, Lead Hardware & Software Engineers, Material & Textile Technologists, IT Specialist	Design-Researcher and Designer: work to develop the design brief which is presented to the leads of the design teams
Concept Ideation	Designer, Leads of Design Teams, Health & Wellness experts (i.e., Physiotherapists, Medical Professionals)	Designer: guide the creative direction Leads of Design Team: provides input on concepts and ideates Health & Wellness experts: Assist in firming up concepts
Mood/Trend Board, Experience Map, Colour Spec.	Designer, Lead Hardware & Software Engineers, Material & Textile Technologists, IT Specialist, Health & Wellness expert	Designer, Material & Textile Technologists: develops mood/trend board and colour spec. Stakeholders: collaborate bringing their expertise to develop the experience map
Initial Design Concepts (Sketches)	Designer, Patternmaker	Designer: conceptualises designs Patternmaker: aids in design conceptualisation providing input and quick patterns
Fabric Direction/ Material Dev. (Hardware/e-textiles)	Lead Hardware & Software Engineers, Material & Textile Technologists, IT Specialist	Stakeholders: provide direction and insights to potential materials, hardware, etc. IT Specialist: provides insight into connectivity
Initial Design Concept Agreed	Designer, Leads of Design Teams	Designer: has final say so on the concept based on input from the leads of the design teams (Lead Hardware & Software Engineers, Material & Textile Technologists)

Rapid Prototyping Mock-ups	Designer, Lead Hardware & Software Engineers, Material & Textile Technologists	Stakeholders: work to create a variety of mock-ups (paper sketches, basic calico mock-ups, etc.,) focused on the potential look, feel, and function of the concept
Participants Collaborative Review	Participants, Design-Researcher, Designer, Lead Hardware & Software Engineers,	Design-Researcher: helps to develop, lead sessions and assess feedback Participants: provides insight on desirable features, expectations and critique of mock-ups Designer: partakes to engage w/participants Stakeholders: takes note on usage, function, etc.
Prototype/Mock-up Amendments	Design-Researcher, Designer, Lead Hardware & Software Engineers, Material & Textile Technologists	Design-Researcher: helps to facilitate reflection after feedback and focus direction for amendments Designer: aids in synthesising and driving progression Stakeholders: work to amend mock-ups, noting areas of tension, potential obstacles, etc.
Finalise Concept/ Technical Req.	Designer, Patternmaker, Seamstress, Lead Hardware & Software Engineers, Material & Textile Technologists	Designer: leads in finalising concept Stakeholders: provide input and direction for technical requirement aiding in concept finalisation
Bra Pattern & Prototype Development	Designer, Patternmaker, Seamstress	Stakeholders: work to actualise the basic concept focused on fit and form
1st Pattern in Sample Size	Patternmaker	Patternmaker: documents and actualise patterns for sample garment
1st Sample Garment/Toile	Seamstress, Patternmaker, Designer	Seamstress & Patternmaker: documents and actualise toile to view concept in materials similar to final design Designer: overseas and assess toile providing valuable input for progression
Fit to model/Form *(Model a part of target audience)*	Fit model, Designer, Fit team	Fit Model: provide feedback on base aesthetic, fit and comfort
Assess Fit	Designer, Fit team, Patternmaker	Fit Team: review & documents fit on fit model Designer & Patternmaker: aid in critiquing fit providing changes necessary for progression
Adjust Toile & Amend Pattern	Patternmaker, Seamstress	Patternmaker: amends pattern for next iteration Seamstress: adjusts toile for next iteration
Fabric Selection, Material Design & Dev., Testing	Lead Hardware & Software Engineers, Material & Textile Technologists, IT Specialist	Hardware & Software engineers: collaborate investigating ways of developing and incorporating technological components into the concept, i.e., integrating sensors, conductive materials, and programming and configuring the smart features Material & Textile Technologists: investigates and develops a selection of appropriate fabrics and materials that can accommodate technological elements IT Specialist: contribute to the connectivity features and data management systems, ensuring secure and efficient operation

Technical Specifications & BOM	Designer, Patternmaker, Lead Hardware & Software Engineers, Material & Textile Technologists, IT engineer	Stakeholders: collaborate to develop the technical specification & BOM from each discipline adding extreme details to aid in concept development Designer: manages the documentation, reviewing all aspects before proceeding
Cross-Functional Team Review	Designer, Patternmaker, Seamstress, Lead Hardware & Software Engineers, Material & Textile Technologists, IT Specialist	Stakeholders: reviews sample garment, developed materials/e-textiles, technical specs/BOM and organises direction to proceed
Tech. Integration	Lead Hardware & Software Engineers, Material & Textile Technologists, IT Specialist	Stakeholders: collaborate to determine types of sensors and electronic components are required, research and select suitable technologies (e.g., sensors, communication modules, microcontrollers), investigate power, size, compatibility of materials, design layout for electronic components into concept, integrate wireless communication facets, develop and integrate power system, etc.,
Update Pattern/Develop new Sample Garments ***(Proof-of-Concept Prototype)***	Designer, Patternmaker, Seamstress, Lead Hardware & Software Engineers, Material & Textile Technologists	Patternmaker: creates pattern w/much input from lead engineers & technologists, developing new rules Seamstress: sews prototype w/input from lead engineers & technologists, developing new ways to connect the materials Designer: reviews process aiding developments progression
Usability Testing of Samples	Designer, Lead Hardware & Software Engineers, Material & Textile Technologists, IT Specialist, Health & Wellness expert	Stakeholders: test proof-of-concept prototype functionality, durability, performance Health & Wellness expert: reviews prototype ensuring its up to safety standards
Cross-Functional Team Review	Designer, Patternmaker, Seamstress, Lead Hardware & Software Engineers, Material & Textile Technologists, IT Specialist	Stakeholders: reviews proof-of-concept sample providing further input and direction for edits towards finalised counter sample
Fit to model/Form ***(Model a part of target audience)***	Fit model, Designer, Fit team, Lead Hardware & Software Engineers, Material & Textile Technologists	Designer & Fit Team: lead fit assessment Fit Model: provide feedback on fit, comfort, functionality, aesthetic, usability Lead Engineers & Technologists: address functionality and usability with model
Assess Fit	Designer, Fit team, Patternmaker	Stakeholders: critique fit providing changes necessary for progression (i.e., design, materials, positions of tech., etc.)
Adjust Toile & Amend Pattern	Patternmaker, Seamstress, Lead Hardware & Software Engineers, Material & Textile Technologists	Stakeholders: collaborate closely to amend pattern, update tech. aspects, adjusts toile for next iteration
Amend Technical Specifications & BOM	Patternmaker, Lead Hardware & Software Engineers, Material & Textile Technologists, Designer	Stakeholders: provides amendments to the technical spec. and BOM based on their respective areas Designer: reviews amendments and signs off

Design Evaluation Participants Collaborative Review	Participants, Design-Researcher, Designer, Fit Model, Lead Hardware & Software Engineers, Material & Textile Technologists	Design-Researcher: develops prompts and workshops for the collaborative review Designer: partakes to engage w/participants, taking notes and memos Participants: engage in workshop providing feedback on aesthetic, functionality, potential usage and experience Fit model: discusses experience w/the prototype, answering questions and providing first-person Design Stakeholders: quietly taking notes and interjecting to understand more about usability, functionality, etc., from the tech perspective
Feedback Judged Against BWFSEA Criteria	Design-Researcher, Designer, Lead Hardware & Software Engineers, Material & Textile Technologists	Design-Researcher: analyses data through the BWFSEA and Four Pleasures framework, aggregates feedback and direction for design team stakeholders Designer & Stakeholder: collaborate discussing revisions and next steps

*Process continues until participants acceptance then a counter sample is developed.

Q. VALIDITY QUESTIONNAIRE

Q1. "What do you think about the Bra Wearables design process shown? Do you think the overall process is novel?"

Q2. "What do you think about employing a woman-centred approach where the target wearers' experience and emotions are centred in developing new concepts?"

Kadian A. Gosler
PhD Candidate - Wearables & Smart Bras
Email: K. Gosler0120171@arts.ac.uk
Web: www.KadianGosler.com
University of the Arts London
20 John Prince's St, London W1G 0BJ

Supervisors:
Prof. Sandy Black
S.Black@fashion.arts.ac.uk

Dr Veronika Kapsali
Veronika.Kapsali@fashion.arts.ac.uk

"HELLO"

I am a PhD candidate at the University of Arts London. My research investigates the development of a design process for bra wearables – a subset of smart bras. As a practice based research I take a woman-centred approach focusing on the wearers' experience and building empathy throughout the process. I am inviting you - an expert in wearable tech or contour design - to take part in this research. Once you have reviewed the short video showing the developed design process and explanation of certain terminology, I ask you to please answer a few short questions.

WHY I NEED YOUR HELP

I am seeking expert feedback on the developed bra wearables design process that integrates bra and wearable tech development. You have been selected as you either have experience designing and developing wearable tech or bras. Your opinions will assist in validating and directing the development of the process. Your opinions will also count towards the PhD research findings and provide insights for those seeking to expand on the design process.

Participation is voluntary and anonymised. There is no obligation to take part and you can withdraw at anytime without a given reason. Questions and suggestions are welcomed at anytime at the above contact details.

CONSENT

I (print name)_____
am over 18 years old and have understood the above information. All queries have been answered to my satisfaction.

I agree to participate voluntarily in this questionnaire and give my consent. I understand my responses may be used in publishing of a PhD thesis, purposes of research related publications.

I understand that all information gathered will be stored securely.

Job Title: _____

Job Description: _____

Date: _____

Kadian A Gosler

THANK YOU!

Q3. "What do you think about empathetic practices such as body-storming (*where the designer experiences aspects of what it feels like for their target audience*) and drawing-as-thinking (*where the designer sketches to empathise with the target audience*) as a means to designing meaningful products?"

Q5. "Do you think the design process can be applied to industry? Why or why not?"

Q4. "Do you think this design process could produce valuable products? Why or why not?"

THANK YOU!!

Kadian A Gosler

R. VALIDITY RESULTS

To validate the amended BWD&DP and approaches within it, an open-ended questionnaire was developed and sent to experts in the fashion tech and bra field (Validity Questionnaire in Appendix Q). Along with the questionnaire, a one-slide PowerPoint featuring the amended BWD&DP and a 2-minute recorded introduction to the research were provided. The questionnaire centred on key areas such as the novelty of the design process, practise approaches, practise methods, application, and industrial applicability (**Table R.1.**). Participant's feedbacks were coded and analysed with the results discussed below.

Table R.1. Expert Validation Questions

#	Subject	Question
1	Novelty of Design Process	"What do you think about the Bra Wearables design process shown? Do you think the overall process is novel?"
2	Practise Approach	"What do you think about employing a woman-centred approach where the target wearers' experience and emotions are centred in developing new concepts?"
3	Practise Methods	"What do you think about empathetic practices such as body-storming (*where the designer experiences aspects of what it feels like for their target audience*) and drawing-as-thinking (*where the designer sketches to empathise with the target audience*) as a means to designing meaningful products?"
4	Applications	"Do you think this design process could produce valuable products? Why or why not?"
5	Industrial Applicability	"Do you think the design process can be applied to industry? Why or why not?"

Table R.2. Expert Validation Participants

	Participant	Job Title
1	MT	Designer in Fashion Tech
2	MG	Creative Technologist
3	RA	Wearable Technologist
4	AK	Lecturer in Fashion Contour
5	CF	Acting Course Leader in Fashion Contour
6	CL	Lecturer & Programme Leader in Fashion Contour

Six participants were recruited, with three from the fashion tech field and the remaining from the contour field (**Table R.2.**). Five of the participants had no expertise in both the wearable tech and contour field. One of the participants (MT, Designer in Fashion Technology) has some experience with SBW. Therefore, the experts are all opining from their experience in the wearables or contour fields with limited perspective in the bra wearables/smart bra field.

Table R.3. Summary of Expert Validation Results

		Classified Codes		
	Comments	Positive (+)	Negative (-)	Neutral (=)
Classified Subjects	Novelty of Design Process	9	0	3
	Practise Approach	14	1	3
	Practise Methods	10	1	6
	Applications	8	0	1
	Industrial Applicability	10	2	9

See Appendix S for an example of coding. A total of 78 comments by the six experts were appropriate for coding. Each expert, on average, provided 13 comments. As illustrated in **Table R.3.**, from the 78 coded comments, 52 were considered positive, 4 were considered negative, and 22 were considered neutral. The neutral comments include additional insights where the experts queried factors not discussed. Below insights are examined further from the expert's feedback on each of the five subjects.

Novelty of the design process. Most (n = 9) of the comments for the novelty of the design process were coded as positive, with 3 coded as neutral.

- 'As far as I could tell, your process looked fairly straight-forward'. (RA, Q1)
- 'The process seems to follow a logical route. … the design and prototype process work together which is correct'. (AK, Q1)
- 'It looks well thought out and similar to the processes we encourage our students to go through…' (CF, Q1)
- 'The bra wearables design process looks comprehensive…' (CL, Q1)
- 'Sounds like a valid process. I am not sure if it is novel. For me this process and approach sounds very logical and daily practice.' (MT, Q1)

As documented in the quotes above, the participants all accessed the design processes novelty as positive. However, in the last example, MT questions the validity based on their experience in fashion tech. While they postulate the process is 'daily-practice', the reader must consider this is from the experts' tech-based experience with non-bra garments.

Practice approaches. The practise approach received favourable responses with 14 positive, 1 negative, and 3 neutral comments.

- 'This is actually the part of the process that I find the most novel…. the idea that the customer is involved in every part of the process is very powerful.' (MG, Q2)
- 'I think all designers can listen and respond to audience needs. … dialogue with the wearer can result in highly creative solutions.' (AK, Q2)
- 'I think where female underwear is concerned this makes sense because of the practical understanding and experiences women have of their own bodies.' (CL, Q2)

- ‘I think we already do this! … need real engagement with a variety of people during the design and realisation processes.’ (CF, Q2)
- ‘I think this is totally valid …But I don't think this is anything new in the field of bra design, do you?’ (MT, Q2)

Albeit positive, with the experts believing a woman-centred approach is warranted, the neutral responses propose the industry already centres the target wearers' emotions and experiences in design development. However, how the industry accomplishes or approaches, this has not been discussed or documented. The speculation is that empathy must already be a part of a bra design process, as noted in participant MT’s question. Similarly, CL shares, ‘*In my experience design teams tend to be mostly female centred and empathy certainly plays an important part of the process, although I have not seen it separated into its own division of the design process as explicitly before’*. Unfortunately, CL does not indicate what methods are employed. The assertion that bra design processes already apply a woman-centred approach centring the target wearers' experiences and emotions without documentation, guidelines, or a framework is a pitfall, especially when evolving into a BWD&DP.

Practice methods. The practise methods received 10 positive, 1 negative, and 6 neutral comments. The rise in neutral comments indicates the unconventional nature of the methods.

- ‘The empathy activities described offer a very interesting approach - I'm curious to better understand body storming, as it must be quite difficult to effectively recreate the physical experiences of particular user sets. This aspect certainly appears novel’. (CL, Q1) | ‘(re drawing-as-thinking) I imagine the efficacy of this practice would depend on the different working preferences of designers. It would certainly be interesting to test’. (CL, Q3)
- ‘I think that these practices are useful additional tools for the designer but should not be too heavily replied upon or replace design research practices. […] The designer needs to retain a level of objectivity in order to be able see the whole problem space and not become too invested in solutions that come about through practices such as body-storming. […] It might be even more useful for the designer to use empathetic practices in later phases of the process’. (MG, Q3)
- ‘Interesting, but do we as designers not have the ability to listen and empathise as part of the design process anyway? Re body storming. Does knowing what a hot (flash) feels like, or post-surgery pain or sensitivity change the way you approach the design? I'm not sure I would need to 'feel' these elements and can design without having done so.’ (AK, Q3)

Responses to the practice methods proved insightful. MG suggested applying empathetic processes to the later stages of the design process, such as the wear trial stage. In agreement, I would suggest during the prototype development stage rather than during testing and pre-production. The contour lecturers provided a lot of the neutral stance querying whether empathetic practices are necessary or can be applied in industry. CL questions whether body-storming can ‘accurately’ portray wearer-experience, while AK doubts its

necessity to help designers empathise. However, the recent issue[142] from the HCI community on First-Person research methods indicates these methods are valid and expanding for designing products for consumers. Moreover, as this design-researcher was able to deeply empathise with participants, the newness of the methods applied to fashion is unfamiliar and may be daunting. Therefore, the empathy methods should be further researched with other smart clothing designers and in an industry setting.

Applications. The applications question received 8 positives, 0 negatives, and 1 neutral comment.

- 'Yes, certainly. Particularly in the market for wearable technology for women'. (MG, Q4)
- 'The product will be valuable to the wearer…' (AK, Q4)
- 'Yes it could, but every person will want different solutions to the design development process.' (CF, Q4)
- 'I fully support your user-centric focus in the methodology proposed. The more in tune with the needs, expectations, and feedback from your consumer group, the more likely you are to create a valuable product.' (CL, Q4)

Overall, the experts believe this design process would provide valuable consumer-driven products. Added suggestions were provided, such as using a 'larger and more diverse[143] group of participants (age, size, etc) …'. This is an area for future research to further validate the BWD&DP.

Industrial Applicability. The industrial applicability resulted in a diverse mix of responses with 10 positives, 2 negatives, and 9 neutral comments.

- 'The Bra Wearables process could certainly be a good roadmap for women-focused body-worn devices. […] The challenge will be in convincing decision-makers to invest more time and resources into the Research & Concept phase and how this will pay off'. (MG, Q5)
- 'If industry were willing to put the time and money into looking at process, the workflow you have described could help them think about aspects of future development and production to concentrate on, and also the needs of the people at the end of the chain who would be wearing it'. (RA, Q5)
- 'Possibly not large scale, but niche and designer level would work'. (CF, Q5)
- 'I think this process could be applied to an appropriate section of industry well, in that only a few adjustments would be needed depending on the existing setup of the company/s implementing them. […] Because of the focus on cost and time within industry, solid findings to endorse the need for any implementation and investment in this area would I'm sure support uptake'. (CL, Q5)

[142] See Desjardins et al 2021 'Introduction to the Special Issue on First-Person Methods in HCI'. https://doi-org.arts.idm.oclc.org/10.1145/3492342
[143] Word omitted due to participants potentially mistaken insertion.

- ‘I think it can be applied to small bespoke brands using a small-scale supply base. Depending on the product there may be specialist construction or adapted accessories which would require a flexible and resourceful production route’. (AK, Q5)

Applying this process to industry prompted two areas of critique time and resources, and the appropriate industry tier. All three contour experts remarked and suggested tiers that were not large-scale and could provide the time necessary to experiment with the developed design process. I agree with this notion and discuss aspects within the develop chapter during reflections. Two of the fashion tech experts commented on the time and resources facet, with time linking to the tier aspect the contour experts mentioned.

Extending aspects of the design process, such as the iterative nature of tech integration. Both MG and RA, as tech experts, highlighted the repetitiveness of tech integration. MG notes, ‘*As a technologist, I was looking for more development iterations on technical functionality. This is addressed in a bullet list at the start of the Pattern & Prototype Dev section, but in my experience it needs to run parallel to sampling and fitting and will follow similar – or more-cycles of testing and adjusting.* (Q1)’. Similarly, RA points, ‘*I feel what might be missing is an indication of the iterative/repetitive process for the research, build and testing of the electronics and code, as this is always a major sticking area for wearables…(*Q1)’. The aspect pointed out was encountered during the enacting of the design process and amended.

S. VALIDITY CODING

[redacted] – Designer in Fashion Tech
[redacted] – Creative Technologist
[redacted] – Wearable Technologist
[redacted] – Lecturer Fashion Contour
[redacted] – Acting Course Leader Fashion Contour
[redacted] – Lecturer & Programme Leader Fashion Contour

Q1. "What do you think about the Bra Wearables design process shown? Do you think the overall process is novel?"	Sounds like a valid process. I am not sure if it is novel. For me this process and approach sounds very logical and daily practice. But I can imagine that making this process explicit is a novel activity. I think that you have to integrate the sales process also in your overview. This is where the user really has to show her appriciation by paying for the product. And I would like to learn from you what you mean by 'Empathy Activities'. There might be a novelty in if you describe the activities explicit and detailed **(MT)** The Bra Wearables design process looks pretty familiar to me as a variation of typical product design/development and apparel design/development workflows. It's clear that real-world experience and knowledge of apparel development and production have contributed to the Bra Wearables process and I was encouraged to see a good amount of attention on user research and understanding the problem space at the start. As a technologist, I was looking for more development iterations on technical functionality. This is addressed in a bullet list at the start of the Pattern & Prototype Dev section, but in my experience it needs to run parallel to sampling and fitting and will follow similar – or more- cycles of testing and adjusting. Depending on the technology, product development for body-worn devices will also require testing with a larger group of subjects than typical apparel development so that the technology use and experience can be evaluated for different body geometries, skin sensitivities, and device interaction.**(MG)** As far as I could tell, your process looked fairly straight-forward. I wondered what your process was for recruiting participants and who they were? For example were they already users of wearable tech? BTW, is 'FEA Criteria' in this context simulating how the garment reacts to wear? I feel what might be missing is an indication of the iterative/repetitive process for the research, build and testing of the electronics and code, as this is always a major sticking area for wearables (and one that is a major factor in my own work). **(RA)** The process seems to follow a logical route. You mention on the audio that the design and prototype process work together which is correct. You ask if I find the overall process 'novel' if that is due to the inclusion of the 'wearer' in the process, then no. I don't find that

• Both MG & RA, wearables expert mention the need to iterate/note the iterative nature of the tech develop.

quote

Review

quote

Novelty of Design Process	Practise Approaches	Practise Methods	Applications	Industrial Applications

Considering this → positive as I am applying to a wider consumer base as per my research.	different from working in bespoke. It would be novel if you applied this to a wider consumer base. **(AK)**
	It looks well thought out and similar to the processes we encourage our students to go through when they are developing their concept proposals and final realised garments in Final Year. We encourage students to undertake extensive primary and secondary research to support design development, and where possible to undetake fit sessions on live models rather than just the contour stands. Although very few of our students created graded sample sets, some do. **(CF)**
	The bra wearables design process looks comprehensive and you have identified the various stages clearly. The empathy activities described offer a very interesting approach - I'm curious to better understand body storming, as it must be quite difficult to effectively recreate the physical experiences of particular user sets. This aspect certainly appears novel. The extent to which the design process is collaborative could also offer innovation, although perhaps a little more insight would be needed here to effectively compare against existing commercial models. **(CL)**
Q2. "What do you think about employing a woman-centred approach where the target wearers' experience and emotions are centred in developing new concepts?"	I think this is totallly valid and lacking a lot in f.e. the field of accessoiries and shoes. But I don't think this is anything new in the field of bra design, do you? **(MT)**
	This is actually the part of the process that I find the most novel. In wearable technology development, this is often overlooked by the engineering team, especially if the team is male-dominated.
Review where the women are apart of the Design process. I thought they were apart of all stages.	Although the Bra Wearables process (understandably) appears to place most of the woman-centred approach in the Research & Concept Development phase, the idea that the customer is involved in every part of the process is very powerful. **(MG)**
	Indeed this is really important, so often women have been an afterthought when it comes to the design of personal technology, or subject to massive generalisations and stereotyping, such as 'pinking' (for choices of colour of devices or marketing) or themes related to domesticity (cookery apps, etc). **(RA)**
	I think all designers can listen and respond to audience needs. Clever design solutions in so many lingerie and contour areas are developed across adaptable, sports, or wellbeing products with the 'needs' of the wearer integrated in to the design. However, dialogue with the wearer can result in highly creative solutions. Woman centred is an interesting concept, especially as many of the younger designers I work with see gender as non defining in design. I think the woman centric concept could challenge bra design further, to follow rules less. Retail and mass production have limited and

Novelty of Design Process	Practise Approaches	Practise Methods	Applications	Industrial Applications

	homogenized bra design. The idea of accepted shapes, wires could be re considered. **(AK)** I think we already do this! We also get students to think about incluing sustainable practice as part of the design process.' Some students have done amazing work creating lingerie for people with disabilities and health issues that require a new apporach to design. This did need real engagement with a variety of people during the design and realsiation processes. I liked your idea of looking at how the menapause might affect women's responses. **(CF)** I think where female underwear is concerned this makes sense because of the practical understanding and experiences women have of their own bodies. There are also potentially fewer barriers when communicating experiences and reviewing products in a female-only group than in a mixed sex group. In my experience design teams tend to be mostly female centred and empathy certainly plays an important part of the process, although I have not seen it separated into its own division of the design process as explicitly before. **(CL)**
Q3. "What do you think about empathetic practices such as body-storming (*where the designer experiences aspects of what it feels like for their target audience*) and drawing-as-thinking (*where the designer sketches to empathise with the target audience*) as a means to designing meaningful products?"	I think that these practices are useful additional tools for the designer, but should not be too heavily replied upon or replace design research practices like diary studies or contextual interviews. The designer needs to retain a level of objectivity in order to be able see the whole problem space and not become too invested in solutions that come about through practices such as body-storming. It might be even more useful for the designer to use empathetic practices in later phases of the process. Being able to try the first samples and perhaps wear prototypes for longer periods will give the designer valuable direct experience using and wearing the product. **(MG)** I think it's really important to do this because in the fashion design workflow and trends for mass manufacture there feels like there is no connection between the designer and the wearer, and so most people shopping for garments have to make the best of what they have access to or can afford from mass production output i.e. garment choices, materials, size or fit. **(RA)** Interesting, but do we as designers not have the ability to listen and empathise as part of the design process anyway? Re body storming. Does knowing what a hot full feels like, or post surgery pain or sensitivity change the way you approach the design? I'm not sure I would need to 'feel' these elements and can design without having done so. I find the process of 'drawing as thinking' interesting and can see that working. I think the dialogue exchange would be really interesting in

Novelty of Design Process	Practise Approaches	Practise Methods	Applications	Industrial Applications

	terms of the initial sketch process. **(AK)** This sounded intriguing! **(CF)** I think body storming is a very interesting concept and in principle I can certainly see positives to applying this practice. I struggle to understand how the experience may be recreated in an authentic manner in some cases, and question whether the cost of any technology needed might be prohibitive for some commercial businesses. However I am not familiar with the practice, nor do I fully understand the expectation from this experience sharing. In relation to 'drawing-as-thinking', I would say this is very much a part of existing practice. Understanding the needs and expectations of consumers is strongly encouraged and facilitated for design teams, more so within companies whose products focus on quality. I can see that creating recordings from focus groups or interviews to listen to may provide a more focused environment to design within - more so than referring to previously taken notes or photography, although I imagine the efficacy of this practice would depend on the different working preferences of designers. It would certainly be interesting to test. **(CL)**
Q4. "Do you think this design process could produce valuable products? Why or why not?"	Yes, certainly. Particularly in the market for wearable technology for women. Not necessarily just "fem-tech" but also for products that are now marketed as unisex but may unconsciously be designed and targetted more heavily toward the male user group. **(MG)** The product will be valuable to the wearer, not sure how it benefits a wider community. **(AK)** Yes it could, but every person will want different solutions to the design development process. The lay person will not neccessarily understand the technical constraints behind the design and realsiation processes. **(CF)** I fully support your user-centric focus in the methodology proposed. The more in tune with the needs, expectations and feedback from your consumer group, the more likely you are to create a valuable product. I would also suggest that the larger and more diverse your group of participants(age, size, etc) the larger would be your pool of satisfied consumers. Recommendations might be welcome on any differences in this area, depending on the type of company implementing your design process. **(CL)**
Q5. "Do you think the design process can be applied to industry? Why or why not?"	The Bra Wearables process could certainly be a good roadmap for women-focused body-worn devices. More emphasis placed on user needs at the start of the design process should produce a better product and reduce the risk of design updates later in the process when changes are more difficult to make. The challenge will be in convincing decision-makers to invest more time and resources into the Research & Concept phase and how this will pay off. Both the

Novelty of Design Process	Practise Approaches	Practise Methods	Applications	Industrial Applications

	apparel and consumer device industries are extremely cost-sensitive, so it's necessary to be able to demonstrate the return on investment in both intangible value like customer satisfaction and tangible value like profit. **(MG)**
	[I think Q 4/5 merge into each other so here's my answer to both] I feel industry is still lacking in understanding of the process and requirements that would make a successful fusion of garments, embedded electronics and the end user, especially for mass scale production and distribution. If industry were willing to put the time and money into looking at process, the workflow you have described could help them think about aspects of future development and production to concentrate on, and also the needs of the people at the end of the chain who would be wearing it. **(RA)**
	I think it can be applied to small bespoke brands using a small scale supply base. Depending on the product there may be specialist construction or adapted accessories which would require a flexible and resourceful production route. Not everyones experience is the same so it would need to be a bespoke solution. **(AK)**
	Possibly not large scale, but niche and designer level would work. **(CF)**
	I think this process could be applied to an appropriate section of industry well, in that only a few adjustments would be needed depending on the existing setup of the company/s implementing them. As indicated, I am not sure of the expense of systems needed for the body storming processes. Because of the focus on cost and time within industry, solid findings to endorse the need for any implementation and investment in this area would I'm sure support uptake. **(CL)**

Novelty of Design Process	Practise Approaches	Practise Methods	Applications	Industrial Applications

Participant	Question #	Novelty of Design Process			Practise Approaches			Practise Methods			Applications			Industrial Applications			Totals			
		+	-	=	+	-	=	+	-	=	+	-	=	+	-	=	+	-	=	Comments
MT	1	2		2						1						1	2		4	6
	2				1	1											1	1		2
	3																			
	4																			
	5																			
	Pts. Total	2		2	1	1				1						1	3	1	4	8
MG	1	1			1						1			1		2	4		2	6
	2				2									1			3			3
	3							1		3							1		3	4
	4										2						2			2
	5													2		2	2		2	4
	Pts. Total	1			3			1		3	3			4		4	12	0	7	19
RA	1	1														1	1		1	2
	2				1												1			1
	3							1									1			1
	4																			0
	5													1	1		1	1		2
	Pts. Total	1			1			1						1	1	1	4	1	1	6
AK	1	2					1							1			3		1	4
	2				5												5			5
	3							2	1	1							2	1	1	4
	4										1						1			1
	5													1		2	1		2	3
	Pts. Total	2			5		1	2	1	1	1			2		2	12	1	4	17
CF	1	1															1			1
	2				2		1										2		1	3
	3							1									1			1
	4										1		1				1		1	2
	5													1			1			1
	Pts. Total	1			2		1	1			1		1	1			6	0	2	8
CL	1	2		1				1									3		1	4
	2				2		1										2		1	3
	3							4		1					1		4	1	1	6
	4										3			1			4			4
	5													2		1	3		1	3
	Pts. Total	2		1	2		1	5		1	3			2	1	1	15	1	4	20
Total Points		9	0	3	14	1	3	10	1	6	6	0	1	10	2	9	52	4	22	78
Average																	8.67	0.67	3.67	13

$\frac{78}{6}$

Positive comments (+), negative comments (-), neutral comments (=)

T. CURRENT WEB RESULTS FOR 'SMART BRA'

As of March 8th, 2023, the top result for a search on 'smart bra' resulted in a Triumph bra and an Embraced bra. Neither bras have any form of passive, active, or very smart capabilities. This further proves the term is being utilised indiscriminately.

Fig.U.1. Google search showing smart bra results

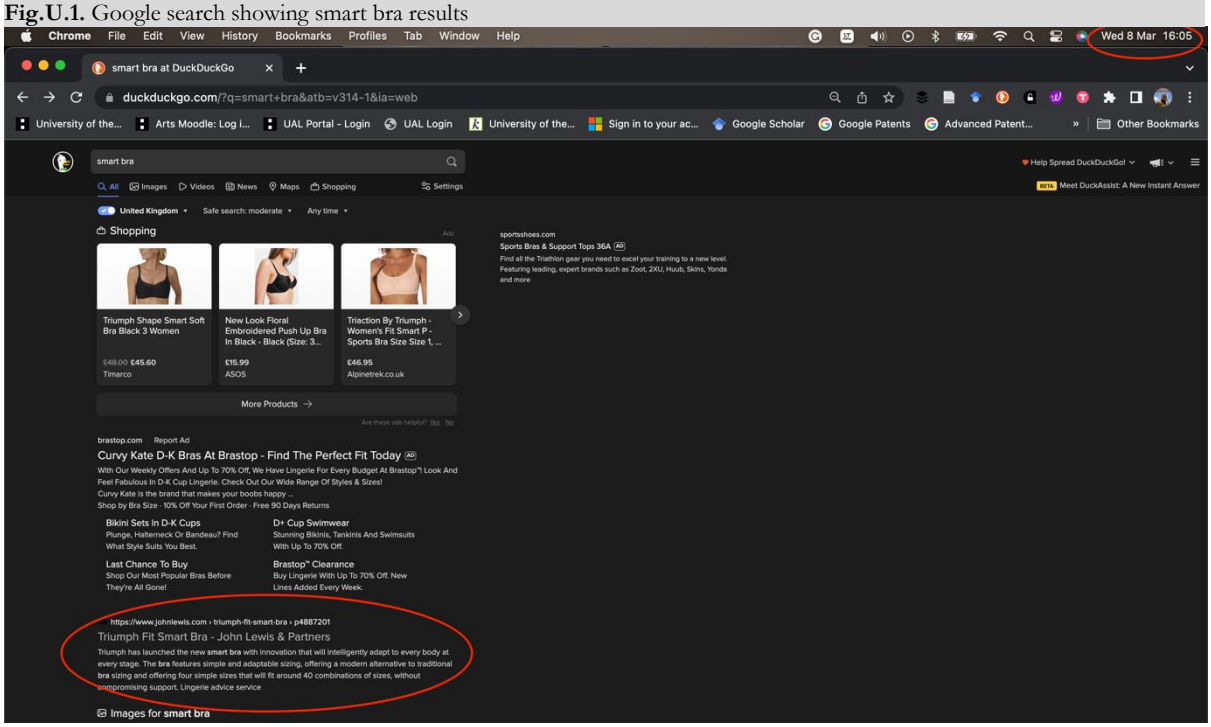


Fig.U.2. Top smart bra result from a Google search

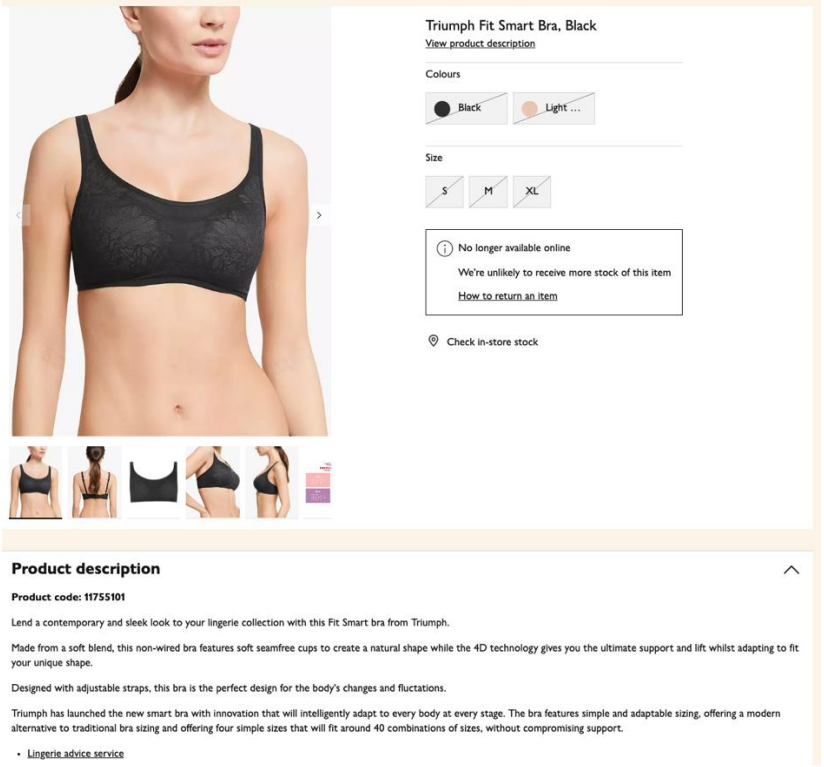
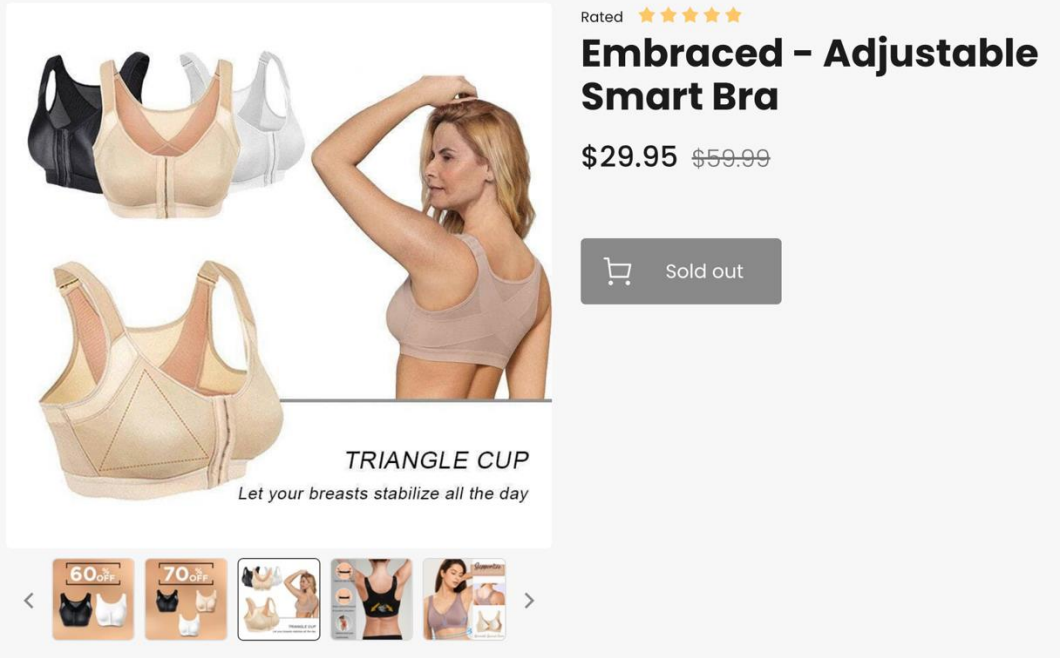


Fig.U.3. Another example of a traditional bra marketed as a smart bra



U. ADDENDUM ON MW BRA SHOPPING

MW focus more on purchasing for utilitarian needs, a necessity, due to a lack of choices in designs and styles available to them (Tsarenko and Strizhakova, 2015). Lingerie designs and styles cater to younger women (Kim, Kim and Ashdown, 2014). Mintel illustrates in the Underwear U.K.- June 2018 Report that women age 55+ desire better size guides, product quality, and product fit (Dover, 2018). They face further challenges as bra fit is inconsistent between brands and within the same brand, making searching for a correctly fitting bra excruciating (Hart and Dewsnap, 2001). To combat mis-purchase, once women found a bra that fit, they would purchase more than one of the same bra or return to repeat purchases from that brand (Hart and Dewsnap, 2001; Yip, Law and Wong, 2007). Risius et al., (2014) established that MW were willing to pay more for a perfect-fitting bra. MW shopped for bras less online as they were more inclined to seek out specialist advice for bra fitting; however, the lack of expert bra fitting knowledge from bra fitters increased frustration in the bra purchasing process (Hart and Dewsnap, 2001; Risius *et al.*, 2014; Tsarenko and Strizhakova, 2015). Thus, bra shopping was treated as functional, not hedonic, for the mature consumer as she may further feel 'disassociated from the marketed symbolism of lingerie products' (Tsarenko and Strizhakova, 2015, p. 44). Many bra manufacturers create bras on mannequins based on younger women's bodies; therefore, the fit may be off, leading to distrust between bra consumers and bra fitters (Kim, Kim and Ashdown, 2014). The fitting process is essential for MW as their breast changes with age, often increasing in size. Tsarenko and Lo (2017, p. 73) suggest they are 'more vulnerable to the bra purchasing process'.

MATURE WOMEN EXPERIENCE CODE BOOK

Theory Labe	Definition	Description	Qualifications	Examples	Kadian's Memos	Codes	Source	Thoughts
Embodied Practise	"a thinking agent (a sense-making mind) adorns his/her body (the material, natural part of the ego) to give the world an intellectually orchestrated representation of the self" (Van Tienhoven p22)	This body/dress awareness is gendered:[...] and dress can either bolster confidence or make one acutely self-conscious and uncomfortable. (Entwistle p.334)	Thinks of self in the presentation and of social aspect	I'm **very self conscious about the size of my breast**. So, this **doesn't make me look bigger.** Uh it makes me look like everything is in proportion. [Clary] p2	As she doesn't note the bra as a minimiser then its the psychological aspect of wearing the bra. By not 'looking bigger' she feels she looks better. Better possibly for her social self and personal self. In terms of embodiment the bra	Cognitive Aspects - Alters Bodily Perception- Enhances/Correction	Clary / Black Woman/ Early 60's	Because Clary is self-conscious about the size of her breasts this may be a filter through which she experiences her bras. They may become more important in how she presents herself.
Embodied Practise	"a thinking agent (a sense-making mind) adorns his/her body (the material, natural part of the ego) to give the world an intellectually orchestrated representation of the self" (Van Tienhoven p22)	This body/dress awareness is gendered:[...] and dress can either bolster confidence or make one acutely self-conscious and uncomfortable. (Entwistle p.334)	Thinks of self in the presentation and of social aspect	...is it going to [...] **give me the shape** that I want cause I think it's quite **important to have a nice shape**. And I think if **you look good then you feel good** and you're **comfortable in your skin**. [Clary] p3	When selecting a bra Clary's first thought is on how she will present. The way her breasts are presented are more important and in turns affects how she feels.	Cognitive Aspects - Alters Bodily Perception- Enhances/Correction - Positive Emotion	Clary / Black Woman/ Early 60's	She has linked looking to how she feels. If she looks well to herself then she can feel good. But looking well is social constructed.
Embodied Practise	"a thinking agent (a sense-making mind) adorns his/her body (the material, natural part of the ego) to give the world an intellectually orchestrated representation of the self" (Van Tienhoven p22)	The dressed body is always situated within a particular context, which often sets constraints as to what is and what is not appropriate to wear. (Entwistle p328)	Thinks of self in the presentation and of social aspect	...and then once I put my dress over that, I'm **comfortable** because uhm it's not going to... **I'm not going to seem revealing.** [...]I didn't feel I was **drawing attention** to my breasts... [Clary] p3	The breasts although not displayed needs to fit a level of 'aesthetic' for both the personal and social self. Clary notes comfort in not seeming too 'revealing' or 'drawing attention' through forethought.	Cognitive Aspects - Comfort - Revealing/Concealing	Clary / Black Woman/ Early 60's	
Affective Theory	The 'mutual implication of body and dress' that acknowledges the experience of dress as implicit or 'in the flesh, and therefore not reducible in a strictly analytical form or vocabulary' Ruggerone 2017 via	the actual experience of the dressed body and to theorize on the feelings of pleasure or displeasure we experience towards clothes in a way that may help an understanding of the extra-cognitive reasons that inform our choices of what to wear.' (Ruggerone 2017)	The body and clothing interaction discussed as feelings when entwined.	And **especially if I'm going to be uhm out in a situation like that**. I think **its unsightly to be tugging at your clothes.** It doesn't - **it doesn't feel right**. [Clary] p3	She references here the importance of the social situation and proper body behaviour. Wearing the 'right' bra based on body knowledge. [Intersects with the social aspects]	Emotion - 'Feeling right'/ 'Not Feeling right'	Clary / Black Woman/ Early 60's	A bit jumbled here: Clary mentions the social linking it to the affect from an ill-fitting bra. But she highlights its 'unsightly' meaning being seen adjusting her garments. Then she stops on it not 'feeling right' being the clothing on the body or the being seen not becoming one with her garment.
Affective Theory	The 'mutual implication of body and dress' that acknowledges the experience of dress as implicit or 'in the flesh, and therefore not reducible in a strictly analytical form or vocabulary' Ruggerone 2017 via	the event of selecting and wearing clothes can thus be interpreted as an encounter between a human body and objects that initiates a process of mutual becoming with either a positive or a negative outcome. ' (Ruggerone 2017)	Speaking of shape is part of the embodied experience. The look and presentation.	It **fits my cleavage** very well-...It **gives me a good shape**. And I **can actually see my waistline**. [Clary] p1	'Good shape' being part of the socio-cultural push. She clarifies this with the waist line statement. So wearing the bra allows her to feel/look closer to the beauty ideal. Or to inhabit some aspect of it. Melly also mentions her waist in relation to her bra. In Tsousi's interviews one of the 65+ woman also mentions a good bra and her confidence in seeing her waist.	Fit - shaping	Clary / Black Woman/ Early 60's	Seeing' of the waist means the breast had lifted and the body could 'feel' closer to the ideal or an ideal. For Black women the thin waif like figure isn't their ideal. It is much more about an hour glass figure with shapely breasts, smaller wasit and fuller hips. Also the visual aspect of 'seeing' ones self as part of the becoming.
Enclothed Cognition	'Enclothed Cognition' to designate the systematic influence of clothes on the wearer's psychological processes and behavioral tendencies. (Adam & Galinsky 2012 P919)	...key tenet of enclothed cognition- clothing can have an effect on how the wearer thinks, feels, and acts-...' [Adam & Galinsky 2019]	Includes changes (i.e., thinking, acting, speaking) made due to wearing or thinking about wearing the clothing.	I actually **think I walk straighter. I stand straighter.** It probably has something to do with my high heeled shoes as well. **Those two things always makes you look tall and feel tall**. Uhm so I know that uhm I'm going to uhm... yeah, **I just felt good and I know that I was standing tall my shoulders back.** [Clary] p5	Wearing the bra had an effect on how Clary acted in how she stood and walked. The feeling of looking good also provided some aspect.	On Body - Actions - Walk/Feel	Clary / Black Woman/ Early 60's	Bra affecting movements or the wearers' perceived movements, thus thoughts.
Enclothed Cognition	'Enclothed Cognition' to designate the systematic influence of clothes on the wearer's psychological processes and behavioral tendencies. (Adam & Galinsky 2012 P919)	...key tenet of enclothed cognition- clothing can have an effect on how the wearer thinks, feels, and acts-...' [Adam & Galinsky 2019]	Includes changes (i.e., thinking, acting, speaking) made due to wearing or thinking about wearing the clothing.	Sometimes uhm **bras can give you a round look which tends to make you look a bit more aged** as well. I think **if it fits well where its shape and... can give you a nice breasts shape then you actually feel younger** . . It doesn't give you a grandmother look, so to speak.[...] Uhm but if it looks shapely, even if people do look at your breasts, **you don't feel self-conscious about it because you know it looks good.** [Clary] p4	Clary points out that wearing the right bra shape makes her feel younger and less self-conscious. She notes here that there are certain bras that give a 'grandmother' look. Young noted the perfect breast shape was youthful 'round, sitting high o the chest... with the look of firmness.' Here there is a discrepancy in the round breast shape.	Aesthetic - Shape/Style - Emotions - Feel Older/Younger	Clary / Black Woman/ Early 60's	In this case, Clary is noting the bras shaping affects how she feels. Less rounder allows her to feel younger. In this scenario when shopping she would seek out bras that she already believes will make her feel younger. 'Bras shaping affects feelings

The codebook illustrates an analysis sample from the mature women interviews (Section 6.1.2.3.). This screenshot focuses on some of Clary's responses which were situated within the embodied practice (blue colour), affective theory (green colour), and enclothed cognition (yellow colour) scaffolded experience-based theories. Although illegible, it demonstrates how the design-researcher analysed the data.

W. BWD&DP OBSTACLES AND OPPORTUNITIES

This D&DP encountered several challenges that affected its progression and altered its course. Dalsgaard (2014, p. 145) reasons that during 'design process, problems and solutions co-evolve'. As noted throughout, Covid-19 and the lockdowns forced many human interactions to move to a digital realm. Therefore, I lacked access to various human expertise and mentorship, industrial and necessary machinery, and time. McCann (2023, p. 364) maintains practitioners must collaborate with a diverse team to truly understand the 'complexity of the interrelated areas'. Nevertheless, the BWD&DP for two prototypes (**Fig.9.25.**) was enacted and brought first-hand insights into challenges and opportunities for the potential industry use situation (Dalsgaard, 2014). Discussed below are the potential challenges and opportunities, including lack of expert knowledge, communication and collaboration, design process length, manufacturing tier and materials.

Lack of expert knowledge for this emerging field and few creatives with expertise present obstacles and opportunities. Unfamiliarity from stakeholders means each organisation will need to create new operation guidelines. Teams will perform from their traditional area of knowledge, creating limitations and barriers. Problems will arise with no team designated to lead the design's focus. Opportunities reside in the disparate teams learning to deviate from the boundaries of their disciplines. For example, patternmakers can extend their knowledge by creating new production markings, tolerance rules, and developing patterns for hardware integration. This requires acquiring an understanding of the hardware utilised by the electronic engineering team. Hardware engineers can learn to create e-textile for better garment comfort. They must collaborate closely with designers, textile engineers, and fitters to comprehend the body's needs. As with the traditional bra field, expertise for teams involved will be gained through experience from designing various BW.

Communication and collaboration become essential in uncharted territories such as BW. Most bra brands consist of various team members such as designers, patternmakers, sewists, fitters, and graders. However, they will require new team members for BW, such as hardware and software designers, machine technologists, and textile engineers – to name a few. Although the members of each team may have expertise in their respective areas, when it comes to the BW field, they would all be novices learning as they go, presenting an obstacle. Tensions may arise with members working from their disciplines' approach and lacking interdisciplinary communication skills. However, an opportunity arises for collaborative decision-making by centring the wearers; each team must reflect on the wearers' needs and the desired wearer experience, placing those first. Actions, therefore, will require clear communication creating an opportunity for those involved to apply a new design process that infuses stages for team integrations to develop meaningful products and evolve as designers.

Design process lengthening causes obstacles and opportunities due to the iterative and trial-and-error nature of the BWD&DP. Initially, this may be seen as an obstacle; however, a lengthened design process is necessary as fashion shifts to create more durable and meaningful garments. The obscureness of the process means some stages will not be clearly demarcated but occur in tandem with others. Furthermore, the design for each bra will modify the process. Unfortunately, the extended processes' applicability to the current industry is incompatible. Mid-tier brands can spend between two to three years developing a well-fitted bra. Incorporating the wearables aspect can extend this laborious process by more years. Initially, this may be an obstacle for new brands seeking investors. However, the opportunity lies in redeveloping the design process – shifting the mentality from a completed product to a well-designed and durable[144] product.

Manufacturing tiers are essential to discuss consistent with the development process. Similarly highlighted in Chapter 3, the bra development process varies by tier and capabilities, such as whether the brand has on-site prototyping facilities or prototypes abroad. Not all bra tiers can transition into developing BW. The process requires time and close collaboration (Dunne, 2010), which tiers such as fast-fashion, mass-market, and budget may not possess. Additionally, while some mid-tiers may have on-site prototyping capabilities, they may not have the setup necessary for wearables. The iterative nature of the BWD&DP and close collaboration requires a manufacturing setup that houses the various stakeholders and their equipment. For example, the hardware and software development cannot be completed separately from the pattern and sample development (Islam Molla, 2020). As shown in the sample development fit check stages (Appendix O), the patternmaker and sewist must understand the hardware properties to develop a cohesive garment. The various teams must work closely to examine all the materials to comprehend the obstacles and possibilities. There are opportunities for established brands to restructure or create new production facilities. The intricacies of the BWD&DP position it as an opportunity to shift the production of the garment. Here possibilities lay to establish a foundation to design more sustainably, research designing for disassembling, and push the boundaries for designing for longevity through physical and emotional durability.

Materials are another area where obstacles and opportunities exist. As shown in the Bra Experience Theoretical Framework (Section 8.2.), selecting the proper materials for the bra is imperative. The material selection affects both the social and physio-affective bra-wearing experience. Selecting the best-suited material will vary by age group requiring comprehension of the target group's experiences. Integrating new materials, including traditional and hardware, poses a significant obstacle requiring a delicate balance between visibility/discreteness, optimal placement, functionality, aesthetics, comfort, ease of repair, and modularity. The balance of comfort and sensing capabilities of the materials has been a considerable barrier for wearables (Dunne and Smyth, 2007). However, this is also an opportunity to explore new materials,

[144] Dunne (2010) warns that durability is closely associated with flexibility in wearables which poses a significant problem when developing garments that frequently need laundering. Specifically, in the case of BW, durability requires lasting through close contact with the body and its natural secretions, such as sweat.

manipulations, and techniques for developing innovative integration methods. Investigating new materials will lead to innovation in machinery and tools.