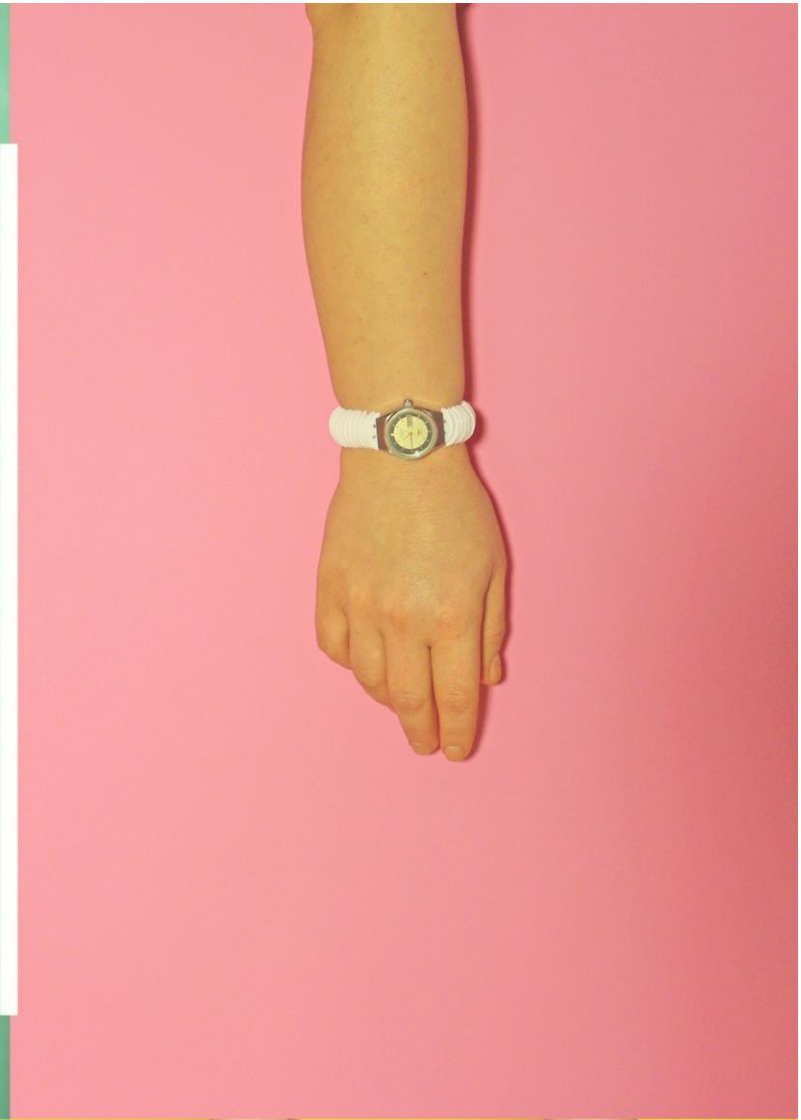
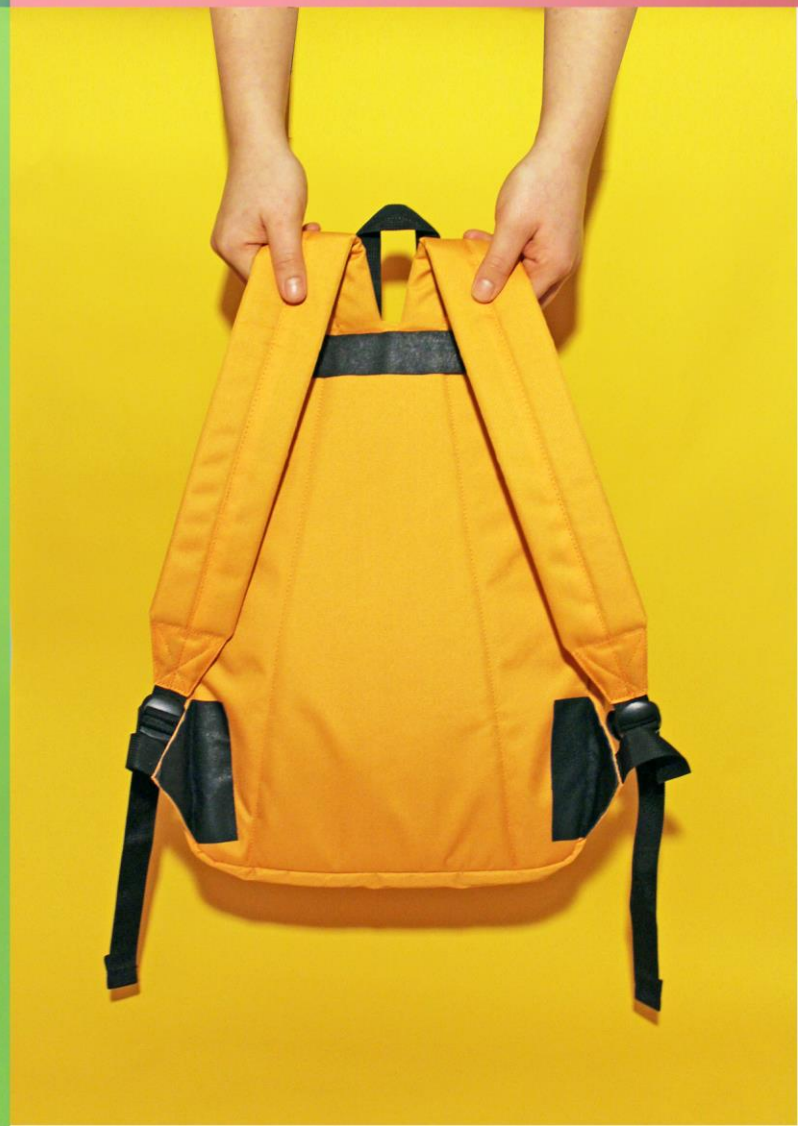




DO-FIX: CREATING DEEPER RELATIONSHIPS BETWEEN USERS AND PRODUCTS THROUGH VISIBLE REPAIR

A THESIS SUBMITTED TO
THE ROYAL COLLEGE OF ART

BY

NAZLI GÖKÇE TERZİOĞLU

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR
THE DEGREE OF DOCTOR OF PHILOSOPHY
IN
INNOVATION DESIGN ENGINEERING

MARCH 2017

ABSTRACT

DO-FIX: CREATING DEEPER RELATIONSHIPS BETWEEN USERS AND PRODUCTS THROUGH VISIBLE REPAIR

Terzioğlu, Nazlı Gökçe
Innovation Design Engineering Programme
School of Design
Royal College of Art
Supervisors:
Clare Brass, Assist. Prof. Dan Lockton

This PhD by practice explores the possibilities of visible repair using a design-led methodology that aims to bring a new consciousness to the relationship between consumers and products, as part of an approach to 'circular' product design. Through a series of workshops in which participants repaired broken products, Do-Fix repair kits were developed and trialled; these kits combine new technologies such as 3D printing with traditional repair methods such as kintsugi, darning and patching, focused on making repairs both visible and engaging to carry out.

Current economic systems depend on large quantities of resource and energy use that cannot be sustained with the planet's finite resources. Producing long-lasting, purposeful and 'circular' products is essential in order to decrease the rate of consumption and its negative environmental impacts. Repair is an effective strategy for extending product lifespan and closing the material loops. However, increasing the product's lifespan is also dependent upon the attitudes and behaviour of users. Therefore, the aim of this research is to explore the role of repair in user-product engagement and create a product or service that encourages people to repair products more for the purpose of awakening human sensitivity to environmental and societal problems. Conventional repair methods, such as kintsugi (a Japanese repair method using gold), darning and patching are combined with new technologies and materials, including 3D printing, with the help of 'research through design' methods. All the repair techniques were tested in workshops with users. The results were fed back into the research, which was then used to develop Do-Fix repair kits, providing users with the opportunity to give a second life to an object. Here the aim is not to disguise the damage, but to make something artful out of it. The Do-Fix repair kits include four different kits, namely (1) the kintsugi kit, (2) 3D-printed patches, (3) plaster patches for mending textiles, and (4) textile patches for fixing shoes and bags. The value of this research for design practice is in its exploration of potential methods and materials of product repair by providing concrete examples, as well as the creation of the Do-Fix repair kits. For academics and researchers its value lies in reframing the position of repair in the circular economy and developing design considerations related to product repair.

Keywords: Product Repair, Visible Repair, Product Longevity, Circular Economy, Design for Sustainable Behaviour

Author's Declaration

During the period of registered study in which this thesis was prepared the author has not been registered for any other academic award and qualification. The material included in this thesis has not been submitted wholly or in part of any academic award or qualification other than that for which it is now submitted.

Nazli Gökçe Terzioğlu

TABLE OF CONTENTS

ABSTRACT iii
TABLE OF CONTENTS v
LIST OF FIGURES viii
LIST OF TABLES xii
ACKNOWLEDGEMENTS xiii
CHAPTER 1 1
INTRODUCTION 1
1.1. Design Background and Motivation 2
1.2. Aims of the Research 3
1.3. Research Questions 3
1.4. Structure of the Thesis 3
CHAPTER 2 7
LITERATURE REVIEW 7
2.1. Introduction 7
2.2. Consumption Strategies and their Effects on the User-Product Relationship 9
2.3. Circular Economy 11
2.4. Origins of Circular Economy 11
2.4.1. Cradle to Cradle 12
2.4.2. Natural Capitalism 12
2.4.3. Biomimicry 12
2.4.4. Performance/Sharing Economy: 12
2.4.5. Industrial Ecology 13
2.5. Limits of Linear Consumption 13
2.5.1. Grounding Principles of the Circular Economy 14
2.6. Advantages for Users and Companies 15
2.7. Challenges of Circular Economy 16
2.8 The Transition to a Circular Economy 16
2.9. The Role of Repair in the Transition Stage 17
2.10. Innovative Business Models 20
2.10.1. Product Service Systems 21
2.10.2. Hire and Leasing 23
2.10.3. Repair Business Models 23
2.11. Visible Repair of Ordinary Everyday Objects 23
2.12. Case Studies 28
2.13. Design Activism and Repair Platforms 37
2.14. Existing Research Related to Repair 40
2.15. User-Product Relationship 43
2.16. Motivation 44
2.16.1. Intrinsic and extrinsic motivation 45
2.16.2. Fogg's Behaviour Model 46
2.17. The Gap in Knowledge 48

CHAPTER 3 51
METHODOLOGY 51
3.1 Epistemology and Theoretical Perspectives 51
3.1.1 Constructivism 51
3.1.2 Phenomenological Research, Materiality and Existential Engagement with a Product 51
3.1.3 The Structure of the Phenomenological Research 52
3.2 PhD by Practice and Links between the Textual and Practical Components of this PhD 54
3.3 Research Methods 55
3.3.1 Cultural Probes 55
3.3.2 Research Through Design (Design Studies) 56
3.3.3 Workshops 57
3.3.4 Affinity Diagrams 58
3.4 Participant Selection 58
3.5 Validity and Reliability 59
3.6 Summary 60
CHAPTER 4 61
RESEARCH 61
4.1. Introduction 61
4.2. Cultural Probes 61
4.2.1. Development of the Cultural Probes Toolkit 61
Research Outcomes 66
4.2.2. Categories of Motivation 66
4.2.3. Product Repair Barriers 68
4.2.4. Types of Repair 71
4.2.5. Design Considerations 71
4.3. Design Studies 73
4.3.1. Repair Methods 73
4.3.2. Design Considerations 88
4.3.3. Four Design Ideas 91
4.4. Workshops 92
4.4.1. Workshop Plan 94
4.4.2. Workshop Tool-bag 95
Research Outcomes 97
4.4.3. Repair Experience 103
4.4.4. Design Considerations 110
CHAPTER 5 115
DO-FIX REPAIR KITS 115
5.1. Introduction 115
5.2. Why Kits? 115
5.2. Kintsugi Kit 118
5.3. 3D Printed Patches 122
5.4. Textile Patches 125
5.5. Plaster Patches 127

CHAPTER 6 133
DISCUSSION 133
6.1. Research Questions Revisited 133
6.2. Reframing the Function and Position of Repair in the Circular Economy and Adaptation of the System Diagram 134
6.3. Scaling up Do-Fix Repair Kits to a Broader Design Field 137
6.4. The Scope of This Research on the Spectrum of Maintenance and Repair 138
6.5. Limitations of This Research and Recommendations for Further Research 139
CHAPTER 7 143
CONCLUSION 143
7.1. Original Contributions to Knowledge 143
7.1.1. Development of Do-Fix Kits 143
7.1.2. Development of Design Considerations in Relation to Product Repair 144
7.1.3. Reframing the Role of Designer in the Circular Economy and Contributions to the Design Practice 145
7.1.4. Reframing the Position of Repair in the Circular Economy and Contributions to the System Diagram 145
REFERENCES 147
APPENDIX A (1) 162
APPENDIX A (2) 163
APPENDIX B 164
APPENDIX C 165
APPENDIX D 166
APPENDIX E 167
APPENDIX F 168
APPENDIX G 169
VIVA VOCE EXAMINATION 170

LIST OF FIGURES

Figure 1. Thesis structure diagram shows the four phases of the PhD process. 5

Figure 2. Methodology diagram shows main research studies, the results and the iterations between these studies. 6

Figure 3. Literature Review Diagram including the subject areas related to this PhD. 8

Figure 4. Linear economy and circular economy diagram (Ellen MacArthur Foundation, 2011). 14

Figure 5. Transition stage diagram illustrating the role of repair. 18

Figure 6. Biological and Technical materials in an interactive system diagram (Ellen MacArthur Foundation, 2011). 19

Figure 7. Innovative business model map (WRAP, n.d.). 20

Figure 8. Pay Per Lux, an intelligent lighting system designed to fit the requirements of the office environment (Phillips, 2012). 22

Figure 9. Patchwork porcelain (Bailey, 2016). 24

Figure 10. Cardigan mended with woolfiller (Klopper, n.d.). 25

Figure 11. Chair 'fitted' with prosthetic seat (5.5 designstudio, 2004) 25

Figure 12. Stabbed, cut and stitched back together (Kwakkel, 2013). 26

Figure 13. David Chipperfield Architects' Castello Sforzesco restoration project in Milan (David Chipperfield Architects, 2005). 27

Figure 14. Astley Castle was converted into a holiday home, blending old and new, by the Landmark Trust in 2012 (Wainwright, 2013). 27

Figure 15. Patagonia Clothing Company (Patagonia, n.d.). 28

Figure 16. Patagonia Clothes Repair Instructions prepared by iFixit (McCrigler, 2012). 29

Figure 17. Patagonia Expedition Sewing Kit (Patagonia, n.d.). 30

Figure 18. Fairphone is a social enterprise that aims to create a fairer economy and transform how we produce and use objects (Fairphone, 2014). 31

Figure 19. Fairphone has collaborated with iFixit and developed 10 repair guides for different malfunctions of the Fairphone (iFixit, 2014). 32

Figure 20. Fairphone 2 is the world's first modular smart phone (Fairphone, 2016). 32

Figure 21. Riva 1920's Piano bookshelf is designed in a way to allow easy replacement and upgrading of the components (Riva 1920, n.d.). 33

Figure 22. The maintenance set that comes with Riva 1920's Piano bookshelves (Riva 1920, n.d.). 34

Figure 23 'Do hit chair', designed by Marijn van der Poll, is a customisable piece of furniture that has to be shaped with a sledgehammer (Droog Design, n.d.) 35

Figure 24 'Do break', designed by Frank Tjepkema, emphasises the beauty of cracks (Droog Design, n.d.). 35

Figure 25. Repair of a joystick handle (MakerBot Industries, 2013). 38

Figure 26. Repair of a tripod quick release mount replacement (MakerBot Industries, 2012). 38

Figure 27. Stove knob 3D digital models are available for download (MakerBot Industries, 2010). 38

Figure 28. A Repair Cafe in Germany. Volunteers are teaching people how to fix broken household items (Repair Café Foundation, n.d.). 40

Figure 29. The Fogg Behavior Grid describes 15 ways behaviour can change, including sample behaviours (Behaviour Wizard Team, 2014) 47

Figure 30. I had been taking notes about my supervision meetings, the articles I read, perceptions and reflections in four personal notebooks. 53

Figure 31. Cultural probes toolkit design process. 62

Figure 32. Cultural probes toolkit design process. 62

Figure 33. Cultural probes toolkit: final design. 63

Figure 34. I printed the photographs which were sent by participants to attach to the related booklets. 64

Figure 35. User motivation categories. 65

Figure 36. User barriers categories. 65

Figure 37. Participant 9's hairdryer and participant 2's earphones. 66

Figure 38. Repairing is more satisfying than buying a new product for participant 9. 68

Figure 39. Participant 6's mobile phone and Participant1's kettle. 69

Figure 40. Participants 2 and 10 did not want to get their products repaired again because they both thought that they would break again. 70

Figure 41. Products repaired with 3D printed parts. 75

Figure 42. The toy sword repaired with a 3D-printed part. 77

Figure 43. 3D-printed two-dimensional patches. 78

Figure 44. 3D-printed two-dimensional patches on clothes. 78

Figure 45. Lace doily repair with 3D printing pen. 79

Figure 46. Kintsugi was applied to twenty products during design studies. 80

Figure 47. Origami vase repaired using kintsugi. 81

Figure 48. Kintsugi applied onto textiles in order to test the aesthetic qualities. 82

Figure 49. I applied this method to a broken mug and to a broken, antique plate that I bought from an antique shop. 82

Figure 50. The application of darning to socks. 83

Figure 51. I used gold thread to darn the holes in the knitted gloves. 84

Figure 52. Boro is used and maintained throughout its owner's lifetime and passed down through generations (Mathias, S. & Stephen, 2013). 85

Figure 53. I used Boro to mend the holes in the espadrilles. 85

Figure 54. Patching example on a backpack. 86

Figure 55. I tried to fix this beanie but sugru did not stick to it properly. 87

Figure 56. Rattan chair repair inspired by basket weaving. 87

Figure 57. I wove the rattan reed through the side walls of this yellow basket. 88

Figure 58. Field notes were used to collect data during the design studies. 89

Figure 59. The small teapot wit 3D printed lid. 90

Figure 60. Workshops 1, 3 and 4 were conducted in two sessions and Workshop 2 was conducted as one session. 93

Figure 61. Workshop tool-bag including materials and tools such as fabric, 3D printing pen, patches, Sugru and sewing tools. 96

Figure 62. The first session of Workshop 1 took ninety minutes. 100

Figure 63. Eighteen people participated in Workshop 2, which lasted for three hours. 101

Figure 64. Nine participants attended the first session of Workshop 3. 102

Figure 65. Four participants attended the first session of Workshop 4. 102

Figure 66. Participant 28 was concerned about fixing his girlfriend's dress 104

Figure 67. Participant 15 said her knitted jumper became personal, unique and valuable after the repair. 104

Figure 68. Participant 5 explained her colour choices, design ideas and possible material selections through ideation drawings. 105

Figure 69. Participant 36 had difficulty in coming up with repair solutions. 106

Figure 70. Participant 23 was hesitating to repair his laptop case as he did not know how to sew. 107

Figure 71. Participant 4 repairing his watch strap. 108

Figure 72. Participant 27 was afraid of taking any risks while repairing his favourite shirt. 109

Figure 73. Participant 48 used the kintsugi kit and repaired the ramekin in the kit. 112

Figure 74. Participant 50 brought her damaged tights to workshop 4 and used plaster patches to mend them. 113

Figure 75. Participant 49 repaired his socks with a big red circle shaped patch. 114

Figure 76. The repair methods naturally evolved into repair kits throughout design studies and the workshops. 116

Figure 77. Do-Fix Repair Kits.....117

Figure 78. Inspired by the Japanese traditional method kintsugi, this kit makes it more accessible and easy to apply. 118

Figure 79. Kintsugi kit contains metal powder, ceramic glue, an application stick and gloves. 119

Figure 80. Step by step instructions on how to use the kintsugi kit. 121

Figure 81. 3D printed patches were inspired by conventional mending techniques for textiles such as darning and patching. 122

Figure 82. 3D-printed patches applied on clothes. 123

Figure 83. Step by step instructions on how to use the 3D printed patches. 124

Figure 84. Textile patches kit contains textile or faux leather patches, a needle, thread and textile glue.....125

Figure 85. Textile patches applied on a backpack. 126

Figure 86. Step by step instructions on how to apply the textile patches. 127

Figure 87. Inspired by putting on plasters and the ease of applying them, plaster patches were designed for low skill level users. 128

Figure 88. I conducted a mini workshop with participant 19 to test the plaster patches on his sweatshirt. 128

Figure 89. Plaster patches applied on products. 130

Figure 90. Plaster patches applied on products. 130

Figure 91. Step by step instructions on how to apply the plaster patches. 131

Figure 92. Ellen MacArthur Foundation's original system diagram (Ellen MacArthur Foundation, 2011). 136

Figure 93. Adapted system diagram by Nazlı Gökçe Terzioğlu reframing the function and position of repair in relation to the significance of users in a circular economy where the inner loops including maintain, repair and reuse are illustrated as a part of user's active role. 137

Figure 94. A closer look at the user in the adapted system diagram. 137

LIST OF TABLES

Table 1. Colours of product categories. 65

Table 2. The workshop participants in numbers with the products they repaired and the repair methods they used. 98

Table 3. Fifteen categories of design considerations. 110

Table 4. Fifteen categories of design considerations with explanations. 111

ACKNOWLEDGEMENTS

It has been three and a half years since I started this research. Now, I want to thank people who have contributions in this thesis. The first half of my PhD journey was like a nightmare and the second half was like a dream including my viva. First of all, I would like to express my extreme gratitude to the people who made this change possible: my supervisors Clare Brass, Dr Dan Lockton and our research leader Prof Ashley Hall.

I am deeply grateful to Clare Brass, who has offered her comprehensive knowledge and constant support throughout. Her great criticisms and suggestions during the supervisory meetings helped me pursue my studies confidently. Thank you for your interest in my research subject and for sharing great conversations with me. It was a genuine pleasure to work with you.

I would like to express my gratitude to Dr Dan Lockton for his full support and positive attitude and generosity of time enabling me to pursue this study. You were there whenever I needed your assistance, and our discussions always brought me one step further. His comprehensive knowledge helped me relate my research to other subject areas. Thank you for the organising the most enjoyable seminars as those were some of the most enjoyable parts of my PhD journey. I feel privileged to have the chance to work with you.

I want to thank Prof Ashley Hall for his endless support and invaluable advice throughout my research, his feedback during my interim and transfer exams. Thank you for always being there whenever I needed your assistance. Thank you for reading my thesis and giving me detailed and supportive feedback. Thank you for your support before the viva including mock viva, feedback session and all the creative questions which encouraged me to work harder and feel confident for my viva. I think my viva experience would have been different without your support and guidance. Thank you to Dr John Stevens for his support and feedback during my mock viva. I also want to thank Dr Catherine Dormor for her guidance during the viva.

I would also like to express my deepest gratitude to my examiners Prof Conny Bakker and Prof Jonathan Chapman for their detailed insights and for making the viva an enjoyable experience.

My PhD experience would not have been the same without some great friends. A huge thank you to all my peers in design research studio for their support and encouragement during my PhD. In particular, I want to thank Dr Tibor Balint and Yoony Choi for reading my thesis and giving me invaluable feedback. Robert Pulley, thank you for your great criticisms and suggestions before the viva. Emine Gökçek and Ece Tosunoğlu for sharing great canteen conversations with me. Kensho Miyoshi, Chang Hee Lee, Olivia Fletcher Vane, Daisy Ginsberg, Marcos Soares, Sam Cottrell, Friedmann Schaber, Graham Hutchison, Shalini Sahoo, thank you for making life much more enjoyable at the college and putting up with my everlasting stories and complaints about the first half of my PhD experience. I want to thank Cathy Johns for her advice and support with regards to formatting for the final thesis.

Thank you to the Istanbul Exporters' Association who contributed towards the payment of my tuition fees and living expenses, thus enabling me to do my PhD.

Last but not least I would like to thank all my friends and family. Thank you to all my family, especially my father, mother and brother for always believing in me. Aslıhan Tokat and Dilruba Oğur for their endless love and support. You were always with me although distance separated us. In particular, I would like to thank Buğra Özkan who was the invisible actor of this research. You always trusted and encouraged me during this process.

CHAPTER 1

INTRODUCTION

A multitude of sociological and psychological motivators urge people to consume significant quantities of products continuously. The contemporary manufacturing system has worked against the environment throughout the twentieth century and into the twenty-first, with the availability of cheap, mass-produced goods, planned obsolescence, repairs which are more expensive than buying a new item and technological developments that quickly outdate products (Brook, 2012; Gill & Lopes, 2011; König, 2013). Since products have become cheaper and globally available, it has become normative consumer behaviour to dispose of products which are less than perfect, even if the problem is easy to fix (Middleton, 2012). As a growing body of work emphasises, it should be considered essential to manufacture long-lasting and purposeful products if global rates of consumption are to be lowered (McDonough & Braungart, 2002; Fletcher, 2008).

Over two and a half billion tonnes of waste are generated annually in the EU, according to Eurostat Data (Eurostat, 2016). According to the European Union's Road Map, it would take the equivalent of more than two planets to sustain humanity by 2050 if we continue to consume resources at the current pace. It is a complicated task to determine the countries responsible for climate change today, because there are various factors affecting this, such as historical emissions, current emissions per capita or in absolute figures, and the carbon footprint of consumption, including imported products (Clark, 2011). Besides, deforestation and extraction of fossil fuels can also be counted, as they have significant implications for the environment. Although each measure gives a different insight, we cannot determine those who are responsible and those who are innocent, because environmental destruction is now happening at a global level. For example, China has the highest amount of CO2 emissions, with 9697 million tonnes (MT) or 28.6 per cent, followed by the US and India, but these results are misleading considering the sizes and populations of the nations (Clark, 2011). The data on emissions per person shows that Qatar has the highest figure, followed by the US and Australia (Clark, 2011).

Governmental organisations and business representatives offer multiple scenarios with a range of technological and behavioural options that aim to decrease consumption rates (IPCC, 2014; WBCSD, 2016). The European Commission presented an EU action plan for what is termed a *circular economy* (see Section 2.3) on 2 December 2015. The plan contains a series of actions: four proposed new pieces of legislation on waste, targeting reuse, recycling and landfill, to be achieved by 2030.

The UK Government's Department for Environment, Food and Rural Affairs, DEFRA, proposed a new approach towards waste policy, highlighting the advantages of increasing product

lifetimes and offering repair and reuse before replacing products, and also encouraging businesses to produce products that are long lasting, repairable and easy to disassemble (DEFRA, 2011).

The Waste and Resources Action Programme (WRAP) is a UK government-funded institution that studies product lifetimes. It has developed a series of programmes, including reuse, repair and refurbishment strategies for users and businesses such as an online product life optimisation tool (WRAP, 2009). WRAP argues that one of the most effective strategies to increase resource efficiency is to extend product lifetimes.

Despite all these efforts the amount of waste generated in the EU does not seem to be declining. According to the Eurostat data, the total amount of waste per year was 2,547,590,000 tonnes in 2004, but this had increased to 2,598,140,000 tonnes per year in 2014 (Eurostat, 2016).

Most consumer goods are nevertheless still considered as throwaway items. It is essential to understand and change our wasteful attitude and our insufficient engagement with products to overcome these problems (Chapman, 2005; Lockton, Harrison and Stanton, 2008). The 'circular economy' (see Section 2.3) is a system-based approach to the industrial economy which offers an opportunity to help reduce our global sustainability pressures (European Commission, 2015; Ellen MacArthur Foundation, 2013). Strategies such as 'closing the loop' with reuse, repair, recycling and remanufacturing can enable zero-waste circular manufacturing systems (Stahel, 2010; Bocken, de Pauw, Bakker, & van der Grinten, 2016). Resource consumption can be mitigated by prolonging the utilisation period of products (Bocken et al., 2016).

The transformation to a circular economy will require huge shifts in terms of regulations, inputs, product design and consumer behaviour. Solutions offered should be in accord with the needs and wants of consumers to make the transition possible and sustainable. Repair is a highly effective strategy for extending the lifespan of products. However, the decision whether or not to repair something is affected by complex factors, and is dependent upon users' motivations, perceptions and choices. Consequently, this research aims to explore different ways of encouraging people to repair products more often, as well as exploring the complex factors that influence repair behaviour.

1.1. Design Background and Motivation

I have grown up in a small town. When I was a child, shopping malls, global companies and their strategies had not invaded my hometown yet. I have met with the consumerist society when I moved to Ankara to study industrial design at Middle East Technical University (2006 - 2011). In my second year, I saw that our deep fryer was left next to the bin. I asked my father why he did not repair it as always or take it to a technician. His answer raised some questions in my head: 'The products are low quality and cannot be repaired anymore. It is very cheap to buy a new one for the sake of my budget and our country's economy.' I felt guilty leaving the deep fryer back next to the bin because this idea was against my values. I began to get interested in sustainable design and my interest helped to form my research

proposal for the Master of Science in Industrial Design (2011-2013). I conducted a research with twenty repair technicians about the breakdown reasons of small kitchen appliances. This research helped me to improve my knowledge about sustainable design and form my research proposal to study PhD at RCA. My dream was to design sustainable, long lasting and modular small kitchen appliances that users can repair by themselves. In my first year, I collaborated with Jon Kuster who was a Master of Arts student in design products at RCA. We designed the CE Kettle, a repairable, long-lasting kettle for the circular economy. After reviewing the literature and conducting some pilot studies in my first years, I realised that the challenge for designers is not designing circular products, which was already achieved. The challenge is connecting people with products again and overcoming their problematic relationship. We are in a world in which objects are valued for their symbolic meaning based on what dominant social and economic system says. Design practice needs to enable people to extend their understanding of products' real value. My design practice has rapidly evolved in the first two years of my PhD and I decided to explore how repair might enrich our relationship with products and connect us with their materiality.

I attempt to provide an open account of my role in this research throughout the thesis. I have included this biographical explanation of the path that led me to this research to enhance the transparency of the research process and allow the reader to assess the trustworthiness of this study. As I explained above, throwaway mentality is against my values. I acknowledge my biased position of being an environmentalist and conducting this research from this standpoint. My interest in environmentalism, sustainable design and circular economy helped me form and complete this research.

1.2. Aims of the Research

- To design a product or service that encourages people to repair products more often

- To create a new aesthetic language around repair in order to enable a different way of looking at damaged/broken products and product repair

- To develop design considerations by exploring the complex factors which influence user behaviour in order to motivate people towards repairing products

1.3. Research Questions

- How can we encourage people to repair products in order to experience deeper relationships with things and create greater engagement with environmental problems?

- What are the motivations and barriers that people experience in relation to product repair?

1.4. Structure of the Thesis

Figure 1 outlines the structure of the thesis and methodology diagram (Figure 2) shows main research studies, the results and the iterations between these studies. This thesis is organised into seven chapters, which are briefly described below.

Chapter 1 constitutes a brief introduction and the aims and objectives of the study, and presents the research questions.

Chapter 2 includes the literature review. The aim of this chapter is to provide an overview to the background of the research topic and establish the focus of the research. The chapter starts by exploring the concepts of planned obsolescence and the circular economy. Existing product examples and case studies are included in this part. It continues with a review of the literature on product repair. This chapter concludes with the identification of a gap in the knowledge.

Chapter 3 presents the systematic structure of the research and the methodology conducted to answer the research questions. The chapter first presents the explanation of my epistemological stance and the theoretical perspectives applied in this thesis. Then the links between the textual and practical components of this research are explained, as well as the 'PhD by practice' approach employed in this thesis. After describing participant selection methods the chapter presents the research phases, including data collection and analysis methods. The chapter concludes with an explanation of the validity and reliability of the research.

Chapter 4 reports on the research processes and findings. It starts with the cultural probes study, and it explains the design studies where various repair techniques were explored using a design-led methodology. Then the workshops are presented before the chapter concludes with the overall findings and conclusions from the primary research.

Chapter 5 introduces the design projects, namely the Do-Fix repair kits, which are the main outcomes of this PhD, answering the research questions, and the aims and results of the participants' involvement in this research, The kits include four different variants, namely a kintsugi kit, 3D-printed patches, plaster patches and textile patches. The design projects and their development process are explained thoroughly in this chapter.

Chapter 6 brings together all the previous chapters, which constitute the PhD thesis. This is achieved by outlining how the research questions have been answered and summarising the overall conclusions. The chapter concludes by describing recommendations for further research.

Chapter 7 presents the original contributions to knowledge and discusses their relevance to wider fields, including product design discourse and practice and the circular economy.

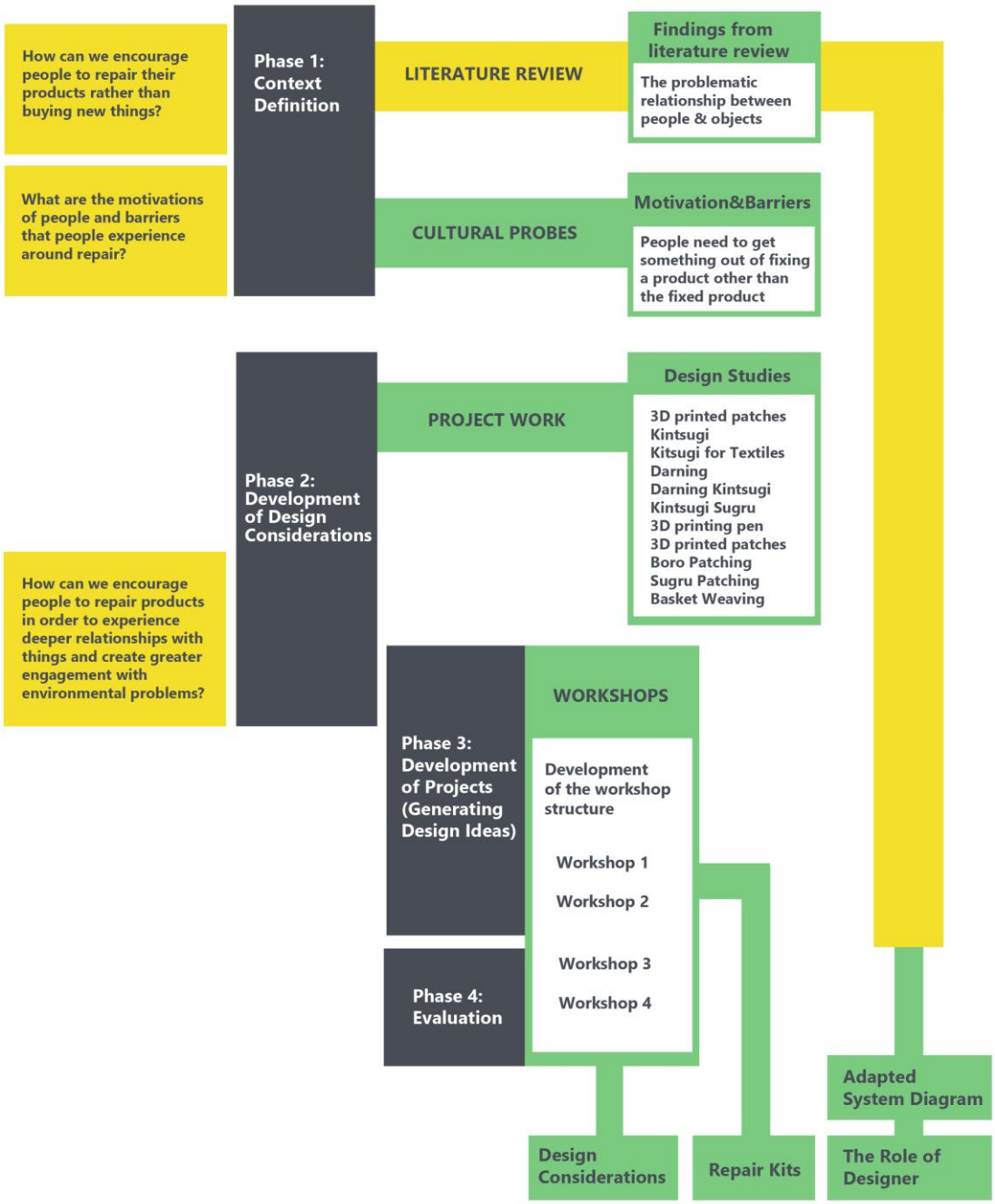


Figure 1. Thesis structure diagram shows the four phases of the PhD process.

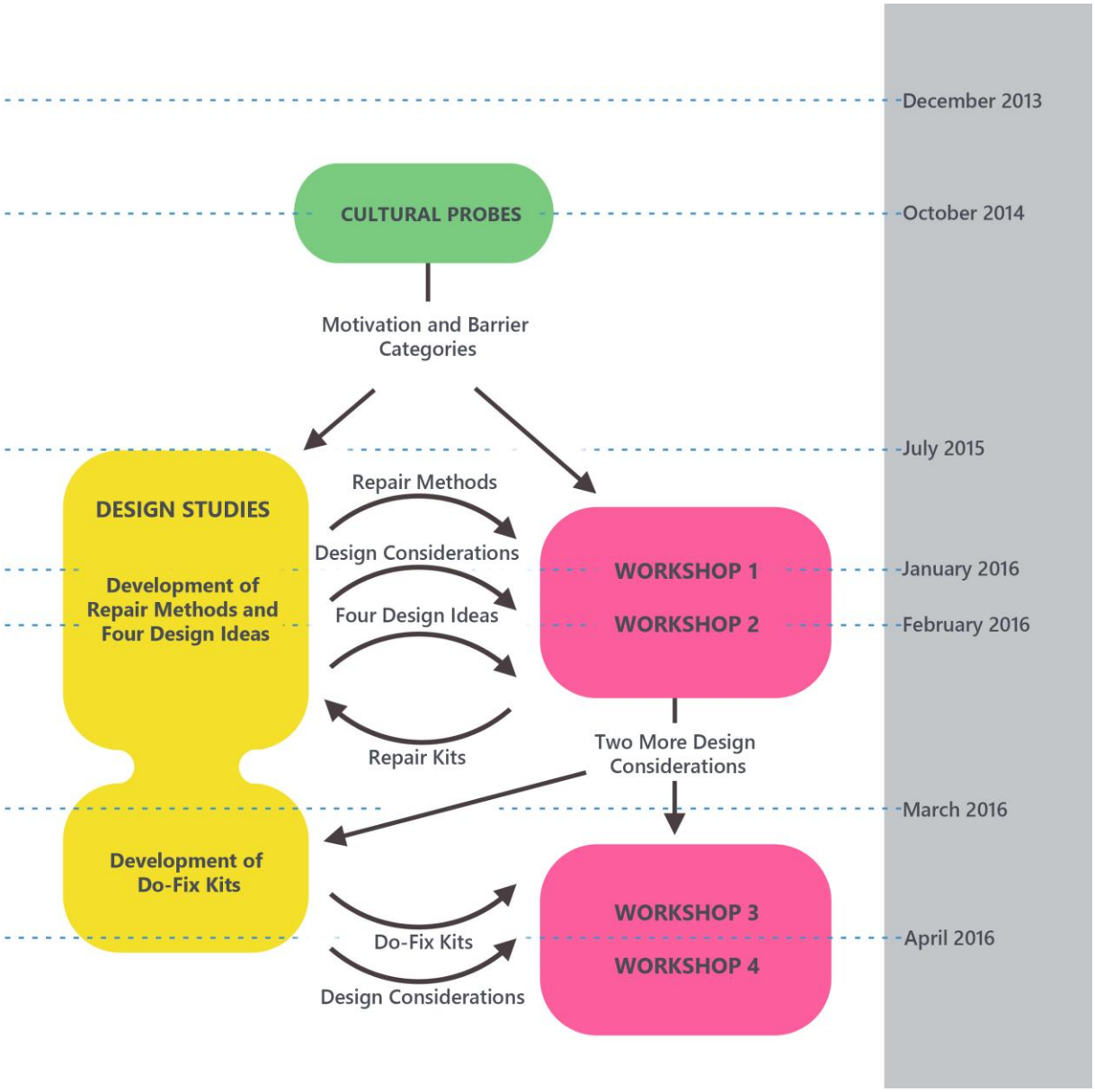


Figure 2. Methodology diagram shows main research studies, the results and the iterations between these studies.

CHAPTER 2

LITERATURE REVIEW

2.1. Introduction

The Earth, which is widely considered to be limitless and generous does not now work as it used to. Climate change, ozone depletion, an increased incidence of cancer and toxins, found even in the bodies of new-born babies, are all clues directing us towards serious problems (UNEP, 2011). Nature tries to inform us, and we should not ignore it, because migrating to the edge of another river is not an option. Human beings meet their all needs, both the basic ones of food, water, clothing, and shelter and the more recently emerging ones of shopping and consuming, by drawing on the materials of the earth. We are hastily consuming the only place we have to live in. Unfortunately, these issues are not new to us; experts have been aware of the human effect on the environment from the early stages of industrialisation (Stahel, 1994). In 1962, Rachel Carson brought significant environmental issues to light by documenting the detrimental effects of using pesticides on the environment in her book *Silent Spring*. Similarly, Donella Meadows, lead author of the influential book *The Limits to Growth*, predicted the current stituation and questioned the Earth's capacity to support economic growth. Since then, the environment has been the academic focus of a wide range of disciplines, and within design it has led to notions such as eco design, green design, environmentally friendly design and sustainable design. A wider concept, known as the circular economy, has emerged, which proposes optimising systems rather than components by taking insights from living beings.

Day by day, the circular economy is becoming a part of a new business agenda for companies worldwide. Rather than selling significant numbers of low-cost products, innovative business models focus on 'closing the loop', by reusing and repairing products, selling services instead of items, and proving to us that it is possible to generate financial profit while respecting both the environment and society.

The literature review diagram (Figure 3), outlines the subject areas related to this research. I started by reading about consumption strategies with the aim of gaining a deep understanding of how the system of production and consumption evolved into its current state. I then reviewed the literature related to the circular economy and repair studies. Finally, I focused on research related to motivation and behaviour change.

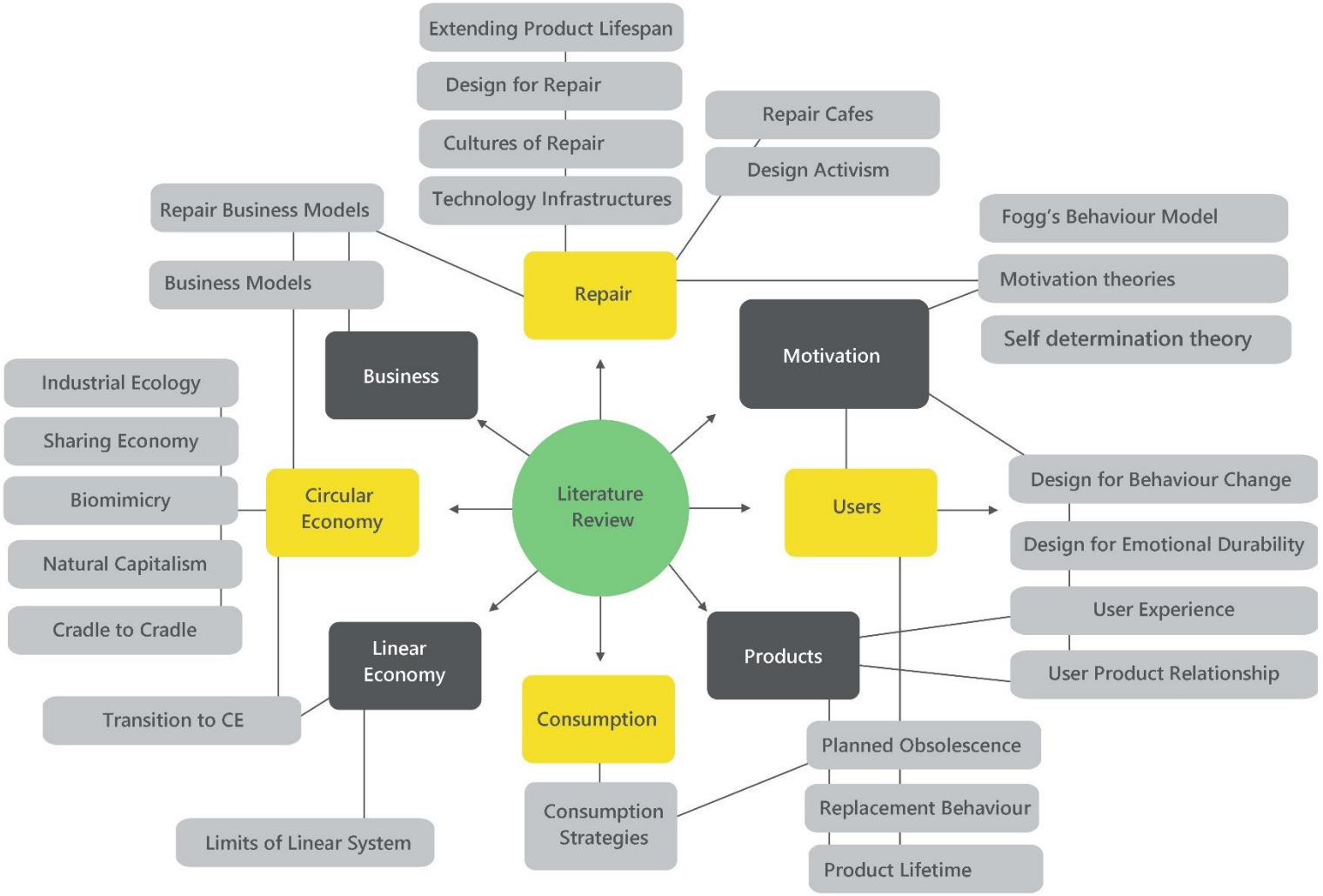


Figure 3. Literature Review Diagram including the subject areas related to this PhD.

2.2. Consumption Strategies and their Effects on the User-Product Relationship

In the Oxford English Dictionary, planned obsolescence is defined as the policy of producing consumer goods that rapidly become obsolete by virtue of a change in their design, and thus need to be replaced by the use of inferior materials, without the supply of spare parts (Planned obsolescence, 2006). The term first appeared in the United States in the late 1920s (Slade, 2006). Planned obsolescence is arguably the basis of many current environmental and socioeconomic problems. How has the strategy of planned obsolescence worked so well and become one of the building blocks of our current economic system?

Technological obsolescence is the earliest version of product obsolescence: it was first seen when cars with self-starting engines were produced, replacing the hand-cranked versions, in 1923 (Kline & Pinch, 1996). After this manufacturers realised that obsolescence worked very well for their commercial aims, and they found other ways of utilising it, such as psychological obsolescence and deliberate obsolescence. People are always willing to pay for fashion and style, as they think these enable them to present themselves as superior to others (Slade, 2006). At this point General Motors, in the United States, took the rapidly growing fashion and textiles industry as a model and identified and implemented psychological obsolescence (Packard, 1960). Their success again proved that obsolescence sells.

The least ethical version of obsolescence, namely deliberate obsolescence, prevailed during the Great Depression (Slade, 2006). Bernard London published three essays offering planned obsolescence as an effective solution for ending the Depression in 1932. During this time manufacturers were looking for different ways of selling commercial goods, as warehouses were overstocked with products (Slade, 2006). They used inferior materials and mimicked failure to shorten the product lifespan. Other consumer strategies followed deliberate obsolescence, including advertising, packaging and branding methods, when the manufacturers realised that it was successful in creating repetitive consumption of their brands.

In August 1927, advertising expert Earnest Elmo Calkins, founder of the Calkins and Holden agency, wrote the following in his article 'Beauty, the new business tool' for *The Atlantic* magazine:

> People buy a new car, not because the old one is worn out, but because it is no longer modern. It does not satisfy their pride. They refurbish the house, not because the old furniture is unable to perform its duties as furniture, but because it is out of date, out of style, no longer the thing. You cannot produce this state of mind by mere efficiency. You cannot make people substitute a new car that runs well for an old car that runs well unless it has some added quality. The new quality must be borrowed from the realms of good taste—smarter lines, newer design, better colour, more luxurious upholstery, more art, or at least more taste. (p.153)

Here the advertiser argues that it is not possible to sell a substitute car, even if it is more efficient than the one the user owns. This quote shows that style is the selling point for consumers because they are willing to pay for a new car just because it is modern, even if

their old one works fine. Since then, people have followed the manipulations and consumption strategies which are current at any time.

Vance Packard (1960) and Victor Papanek (1971) realised this manipulation and wrote about consumption strategies and how they affect people psychologically. In a hierarchical society in which everyone assesses and compares themselves with others, this system created a state of anxiety where old things are not valued and are regarded as embarrassing (Slade, 2006). Papanek (1971) discusses repetitive consumption and its environmental, social, economical effects and asserts, in his book *Design for the Real World: Human Ecology and Social Change*:

> There are professions more harmful than industrial design, but only a very few of them. And possibly only one profession is phonier. Advertising design, in persuading people to buy things they don`t need, with money they don't have, to impress others who don't care, is probably the phoniest field in existence today. (p.9)

Similarly, John Thackara says, in the documentary film *Pyramids of waste* directed by Dannoritz (2010), 'Our role in life seems to be just to consume things with credit, to borrow money to buy things we don't need. That makes no real sense to me at all.' (23:39)

So is it possible to imagine an economy without planned obsolescence? During the nineteenth century most engineers and manufacturers designed and created products to last (Slade, 2006). The world's longest-burning lightbulb is one of the great examples of this period (Ubeda, Barrat, & Cosima, 2010). This was produced in 1895 and is still alight in Livermore, California. Similarly, DuPont nylon stockings were sturdy and ladder-free when they were first produced (Rivera & Lallmahomed, 2016). Manufacturers tried to make nylon weaker so that they would not last as long. Today's equivalent tights do not generally last for more than about three uses.

Some people may argue that without planned obsolescence we would not have access to contemporary prosperity: there would be no designers, architects, cleaners, or shopping malls and none of these jobs would be required.

The economic system that is based on planned obsolescence produces a constant stream of waste. Waste has been hidden during the industrial age, but we can no longer avoid it. The waste economy is, perhaps, reaching its last stage. John Thackara fights against planned obsolescence and shows us examples of existing alternative systems, citing Lagos kiosk traders, Indian jugaad tinkerers, Central American cooperative farmers, Danish bike-sharers and others (Thackara, 2015). He states that the notion of throwing away a product just because it breaks is completely unheard of and unthinkable in India, and he explains the *jugaad* tradition in India, which refers to fixing everything regardless of its complexity (Thackara, 2015).

This historical overview is very important in order to understand that planned obsolescence is man made, and to realise how it became a part of our lives. People have no control over this problem and its detrimental effects; actually, the majority is inured to it. The throwaway mentality affects the way we experience and think about objects, the environment and ourselves, in a negative way, of course. Unfortunately, the trajectory of consumption has resulted in 'other forms of cultural obsolescence including languages, cultural practices,

traditions, vernacular knowledge and skills, farmed and wild genetic diversity and so on.' (Maycroft, 2016, p.4).

Planned obsolescence has become more and more complicated since the industrial era, and now it encompasses numerous applications, such as programming electronics to stop functioning and the intentional design of many objects so that they cannot be repaired or adapted for alternative uses; many products now require and promote the subsequent consumption of extra goods and services (Maycroft, 2016). As opposed to dominant consumerist system various design approaches have developed supporting an environmentalist perspective. One of the newest approaches is circular economy which has drawn a growing attention over the last decade as a way to overcome current economic and environmental problems (Ghisellini, Cialani, & Ulgiati, 2016). The next section explains its origins, grounding principles, advantages and disadvantages.

2.3. Circular Economy

The circular economy is an industrial system that is based on 'closing material loops in an economically attractive way to decouple wealth from resource usage.'(van den Berg & Bakker, 2015, p.365). It changes the understanding of the end of life of products, employs renewable energy and eliminates the use of toxic chemicals (Webster, 2013; Ellen MacArthur Foundation, 2012). The circular economy is receiving increasing attention in the last few years. As Prendeville et al. (2016) argue 'Its integration in international policies from China, through its 11th and 12th 'Five Year Plans' (Su et al., 2013), to Europe through its Circular Economy Roadmap (European Commission, 2015) reflect the increasing importance of CE globally.' (p. 278). Many circular economy studies including scientific reports, case studies, reports of government organisations and business representatives, etc. have been published (DEFRA, 2011; Ellen MacArthur Foundation, 2012; Su et al., 2013; IPCC, 2014; European Commission, 2015; Prendeville et al., 2014; WRAP, 2015; WBCSD, 2016).

Closed loop system refers to a manufacturing model which does not produce waste and involves reverse flow of materials back to the system (e.g. repair, reuse, remanufacture, recycling) as well as forward flows of materials for production (Schenkel et al., 2015; Prendeville et al., 2016). With the aim of creating effective material and energy flows, two types of material flows are defined in the circular economy, including biological nutrients and technical nutrients (Bocken et al., 2016). Biological nutrients are organic materials, so they can be disposed of safely in the environment. Technical nutrients, however, are inorganic materials and cannot biodegrade. They are produced with high-quality materials and designed to have long lifespans, reused many times in the system with no loss of quality.

2.4. Origins of Circular Economy

The circular economy is a synthesis of environmentalist approaches, including William McDonough and Michael Braungart's 'cradle-to-cradle'; Amory B Lovins' 'natural capitalism'; Janine Benyus's 'biomimicry', Walter Stahel's 'performance/sharing economy', and 'industrial ecology'. These approaches are briefly explained in this section.

2.4.1. Cradle to Cradle

Cradle-to-cradle is a practical design framework for developing products and systems that aim for maximal economic value with zero adverse ecological impact (Braungart, McDonough & Bollinger, 2007). In this approach, all material inputs and outputs are seen as technical or biological nutrients. Each nutrient group has its own closed-loop cycles in an industrial or natural system. The avoidance of toxic materials and intelligent material pooling enables the elimination of waste by utilising it as a resource for production (McDonough & Braungart, 2002). Technical nutrients are recycled or reused with no decrease in quality, and biological nutrients return to the biosphere and are composted.

2.4.2. Natural Capitalism

Natural capitalism focuses on the changes which have occurred in natural resources, the pattern of scarcity we face today and the ever-decreasing natural capital. It offers a business model which involves four major shifts in business practices (Hawken, A. B. Lovins & L. H. Lovins, 2013). 'Radically increasing the productivity of natural resources' refers to savings in operational costs, capital investment, and time by changing companies' production, design and technology. 'The shift to biologically inspired production models and materials' means eliminating the very concept of waste in closed-loop production systems inspired by nature. The outputs return to the ecosystem or are reused as a resource for manufacturing processes. 'Moving to a 'service-and-flow' business model' refers to delivering value as a service instead of selling products. Finally, 'reinvesting in natural capital' means making the most of natural capital by restoring, sustaining and expanding it.

2.4.3. Biomimicry

Biomimicry is an innovative approach towards considering nature as model, measure and mentor to provide innovative and sustainable solutions for industry and research development.

Imitating the systems and 'designs' found in nature, or taking inspiration from them, aims to solve identified problems (Benyus, 1997). The idea behind this approach is that nature has evolved highly efficient systems and processes that can inform solutions to many of the waste, resource efficiency and management problems that we encounter today. There are nine basic laws underpinning the concept of biomimicry: 1. Nature runs on sunlight; 2. Nature uses only the energy it needs; 3. Nature fits form to function; 4. Nature recycles everything; 5. Nature rewards cooperation; 6. Nature banks on diversity; 7. Nature demands local expertise; 8. Nature curbs excesses from within; 9. Nature taps the power of limits (Benyus, 1997).

2.4.4. Performance/Sharing Economy:

The performance economy refers to an economy where the majority of the value is provided by services, and majority of jobs are in service activities (Stahel, 1997). The success of the present economy is measured by throughput and profit, whereas the performance economy

is based on optimising the use of products and services and management of existing wealth (Stahel, 1997). Unlike the throughput economy, this system enables reduced resource consumption without waste, externalisation of costs and risk (Stahel, 2008). Greater competitiveness can be achieved through a functional service economy in which users pay per unit of service they receive and service providers reduce the resource flows and this, of course, will increase their profits by decreasing their material and energy costs (Stahel, 2008).

2.4.5. Industrial Ecology

Industrial ecology is a system-based multidisciplinary framework that serves to identify and implement strategies to reduce the environmental impacts of products and processes (Thomas, 1997). It studies material and energy flows in an industrial system, changing its linear nature to a closed-loop approach, and tries to eliminate by-products and waste. This framework provides an understanding of the global impacts of industrial systems by measuring and analysing the physical, chemical, and biological interactions and interrelationships within industrial systems (Graedel, Allenby, & Linhart, 1993). The production processes designed and organised by industrial ecology mimics living systems, with the ultimate goal of sustainable development.

2.5. Limits of Linear Consumption

The linear 'take, make and dispose' system depends on large quantities of resource and energy use that cannot be sustained with the planet's finite resources (Figure 4). Many companies have recently been aware of the risks and damage that the current economic model is causing to both them and the environment. Cisco and Philips can be highlighted as examples of these businesses that have generated circular economy teams. One of the major problems for manufacturers is the acquisition of raw materials, because of gradually decreasing resources (Dobbs et al., 2011; Ongondo et al., 2011, Ellen MacArthur Foundation, 2012). According to an Ellen MacArthur Foundation report, the price volatility of metal, food and non-food agricultural outputs was higher in the first decade of the twenty-first century than any decade in the twentieth century (2012). More and more businesses face unpredictable prices in resources markets and high competition in the market. Therefore, business leaders are in search of better industrial models and more efficient raw material usage (De los Rios, & Charnley, 2016; Ellen MacArthur Foundation, 2012). These facts imply that action should be taken to fulfil the needs of business, and particularly to overcome the ever-growing environmental problems.

The linear type of economy has been dominant in the world since the beginning of industrialisation, but according to circular economy experts it is reaching its end (Ellen MacArthur Foundation, 2012). Unlike the circular economy, the value the linear economic model creates is neither long lasting nor sustainable, either in terms of users or manufacturers.

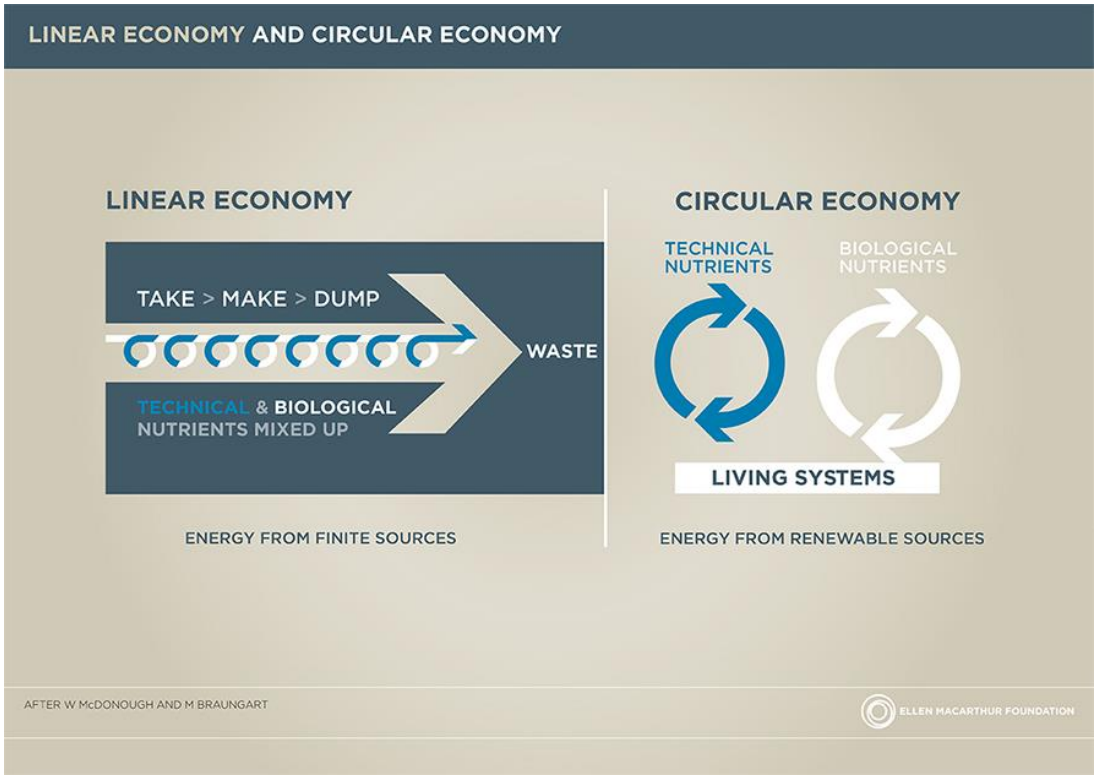


Figure 4. Linear economy and circular economy diagram (Ellen MacArthur Foundation, 2011).

2.5.1. Grounding Principles of the Circular Economy

Design out waste

There is no such a thing as waste, according to this principle. According to this principle, products are designed and produced for disassembly and reuse through the 'product cycle' and the 'component cycle' (Ellen MacArthur Foundation, 2012). This feature is different from disposal and recycling in many aspects because both disposal and recycling rely on a significant amount of labour and energy usage.

Consumable and Durable Components

The circular economy differentiates products or their components as consumables or durables. Consumable products are made of biological ingredients or nutrients, while durables are produced with technical nutrients like metals and plastics (Ellen MacArthur Foundation, 2012). Biological nutrients are non-toxic and can safely dissolve in the biosphere. Technical nutrients, on the other hand, are detrimental for the biosphere and they are designed to be reused from the beginning of their life.

In the current economic model, companies do not admit much responsibility after selling their products. The circular economy offers a different relationship between customers and business for technical nutrients. Durable products can be leased, rented or shared when possible (Ellen MacArthur Foundation, 2012). If they are sold, the company makes a contract

with the user that ensures the return of the product to the manufacturer at the end of its primary use. This principle replaces the term 'consumer' with 'user' and enables the reuse of the products.

2.6. Advantages for Users and Companies

Besides its significant environmental benefits, the circular economy model offers value not only for companies but also for users. The circular economy's advantages for users include reducing the costs associated with planned obsolescence, increased choice and convenience (Winkler, 2011; Ellen MacArthur Foundation, 2012; Schenkel et al., 2015). Premature obsolescence costs disappear when products are designed for durability and a long lifespan. Planned obsolescence means that users pay for low-quality, short-lifespan goods repeatedly. Total ownership reduces the cost for users, as companies retain the ownership of products. Additionally, high-quality, non-toxic, circular products will improve customers' quality of life. For example, MUD Jeans, a denim company based in the Netherlands, offers a leasing option to customers for their jeans, aiming to increase the circularity of jeans production. First, customers benefit from the use of high-quality, durable and ethically produced products. Second, customers do not need to worry about the costs of premature obsolescence, such as paying the whole price for a pair of jeans and then finding the product becomes obsolete, gets damaged and they can no longer wear it. Here customers only pay for the period during which they wear the jeans. Thirdly, the company offers a free repair service if the product gets damaged, and a recycling service at the end of its use phase (MUD Jeans, n.d.). The circular economy changes the 'style' of buying. Unlike the current purchasing system, there are diverse choices for users, which are presented and sold with contracts. As users decide how long they use the products and how they use them, choice and convenience increase. Users can choose the product parts and functions that they need from a range of diverse solutions. In the case of MUD Jeans, the user signs a contract with the company before leasing the jeans. According to this contract, the customer can swap their jeans for a new pair, continue using the same jeans without paying for them or return the jeans to the company. The company makes a profit by leasing the jeans: they lease the newly produced jeans as well as the returned ones that are in good condition and recycle the rest (MUD Jeans, n.d.). Recycling lowers the material costs, mitigates the effects of price fluctuations and at the same time decreases the environmental impacts of cotton production.

Companies are currently facing many challenges, such as increasing bills for materials, the price volatility and the growing waste problem, and these problems are expected to increase in the near future (Schenkel et al., 2015). Additionally, the ethical issues, including *conflict minerals* (see Section 2.12.2), human rights abuses, labour rights and many others, cause a real risk of complicity in these abuses on the part of multinational companies who come into contact with these problems (Ellen MacArthur Foundation, 2013). The most important benefit of the circular economy for companies is mitigating the challenges they face today. These benefits include reduced materials bills and warranty risks, improved customer interaction and loyalty, less product complexity and more manageable lifecycles (Ellen MacArthur Foundation, 2013). Of course, producing durable and long-lasting products affects warranty

costs positively. A decrease in material costs is also an expected result, with the help of the reuse of products and technical materials.

2.7. Challenges of Circular Economy

The challenges or barriers to achieve the circular economy have been largely discussed in the literature (Geng & Doberstein, 2008; Preston, 2012; Prendeville et al., 2014). The majority of the scholars mainly focus on practical issues of implementation (Grant & Banomyong, 2010; Kuo, 2011; Kuik et al., 2012; Souza, 2012). I discuss these challenges according to four groups: high up-front costs, complex supply chain, a completely closed loop system and behaviour change issues.

High up-front costs: The circular economy would offer higher profits for the businesses in the long-term, however, the up-front investment costs and risks are inevitable and high (Preston, 2012, Prendeville et al., 2014). These costs include purchasing new machinery, building new distribution arrangements, transforming a company's business model etc.

Complex supply chain: Another significant challenge is the supply chain management. Manufacturing operations and consumption take place in different countries in the current global system (Preston, 2012). The entire network of resources, manufacturers and customers may have to be reorganised in a circular economy.

A completely closed loop system: The aspects that influence the recycling and remanufacturing activities are complicated ranging from economic to technical factors. Therefore, some experts argue that it is difficult and expensive to achieve a completely closed loop circular economy (Hopewell et al., 2009).

Behaviour change issues: The circular economy requires a different and more active relationship between users and products as well as users and producers (Shah, 2014). Users need to understand and value the circular system and products to be able to participate in it (Preston, 2012, Prendeville et al., 2014). This research draws attention to the complex nature of this relationship and presents examples which can be compared with current products and systems, exploring values different from those currently espoused. Products will only last longer when people consider them as worthy objects, see their material value and realise their immaterial aspects, and understand opportunities for products to age in a dignified way. More research, strong policy frameworks and incentives are needed to encourage users to change their behaviour as well as businesses to invest in a circular system and take the risks (Preston, 2012).

2.8 The Transition to a Circular Economy

It is not possible for companies to transform their business into a circular model overnight. For both companies and users the transition will take time and effort, and we are at the beginning of this process (Dobbs et al., 2011; Ellen MacArthur Foundation, 2013; De los Rios, & Charnley, 2016). There are two different scenarios observed in this transformation period offered by the Ellen MacArthur Foundation (2013). First, in a transition scenario, companies utilise existing technologies and services in order to transform the product design into a

circular model. In this scenario, companies aim to increase recycling, refurbishing and remanufacturing activities. The second, more advanced, scenario is different from the first, as it requires a radical transformation. This scenario is radically disruptive because, like the Industrial Revolution, it transforms the way we currently produce and consume and allows the new solutions to supersede the established system. Developing infrastructure, creating cross-sector collaboration and legal frameworks are essential conditions of the advanced scenario (Ellen MacArthur Foundation, 2013). With the help of a structural shift, this scenario provides net material cost savings for the company.

2.9. The Role of Repair in the Transition Stage

The verb 'to repair' is defined as: 'To restore (a damaged, worn, or faulty object or structure) to good or proper condition by replacing or fixing parts; to mend, fix.'(Repair, 2009) in the Oxford English Dictionary. This research studies self-repair which refers to user's repairing a product by himself/herself according to instructions or his/her skills and knowledge. Again in the Oxford English Dictionary, the noun maintenance is defined as: 'The action of keeping something in working order, in repair, etc.; by providing means for equipment, etc.; the state or fact of being so kept up; means or provision for upkeep.' (Maintenance, 2000). The main difference between maintenance and repair is the 'breakdown' which can be defined as the disruption of perceived function of the product or its value in the context of this research. As damaged products may not always perceived as broken, two types of damages can be identified the ones that reduce the appeal of the product and the ones that enhance it. One of the most common examples for these types of damages is ripped jeans. Ripped parts might enhance the appeal of the jeans if they are in the knees. However, it might reduce the appeal if the jeans rip in the inner thigh. Repair comes after the breakdown. It refers to developing a solution for restoring the product back to its perceived functionality and value. Sewing holes in the socks, glueing broken parts of a plate and changing spare parts are examples of repair. Maintenance refers to all activity for keeping something in working order. Cleaning, lubricating and polishing are examples of maintenance acts.

The transition stage has just begun, and the world is now full of low-quality and short-lifespan products that are not designed for repair, disassembly and recycling. These products cannot just be discarded because they are not suitable for the circular system. The most environmentally friendly product is the one you already own, because it does not require raw materials extracted from the earth and energy for manufacturing. As I illustrated in the transition stage diagram (Figure 5), the aim should be to lower the rate of production and make the most of existing products during the transition stage.

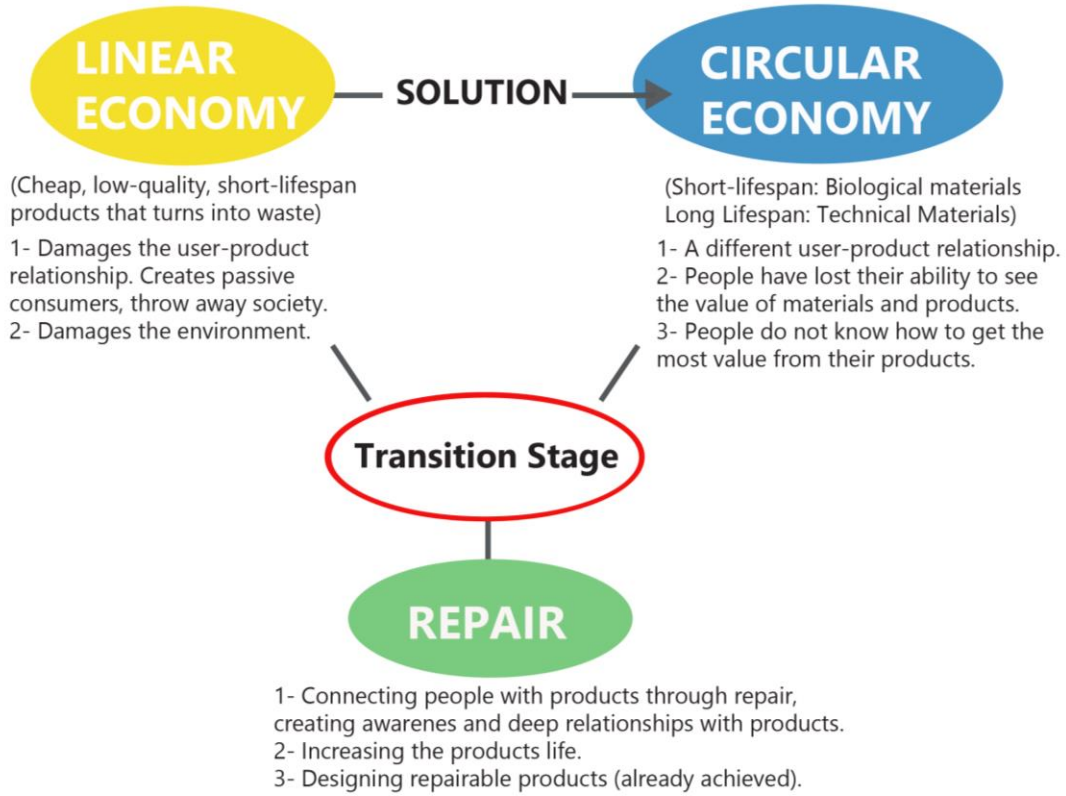


Figure 5. Transition stage diagram illustrating the role of repair.

One of the main principles of the circular economy is 'zero waste', which means that the waste from one system is the food of another. This principle is most effectively achieved by repair and reuse, where no virgin materials are used. However, two fundamental aspects are required here: product design requirements and active users (Shah, 2014; Ghisellini et. al., 2016). First, the products must be designed in accordance with the basic principles of the circular economy, also considering the users' needs and wants. Second, awareness should be created among users in order to enable their participation in closing the loops by repairing products, returning the products back to the producer and creating a demand for circular products. The first condition has already been achieved: designers are capable of designing high-quality, long-lasting, circular products that can be repaired and disassembled easily. The challenge for product designers is to connect people with products again and overcome the problematic relationship between humans and objects.

The relationship between people and products has completely changed with the throughput economy and the linear system, and it has become a continuously problematic relationship. The conditions of the current system have created a society of 'passive consumers', expected to become 'active users' in the circular economy. The circular economy offers a rethinking of ownership in which a need for a shared responsibility among all stakeholders exists,

including consumers, in order enable the return of products for reuse, repair and remanufacturing, as well as collection of waste for recycling (Ghisellini et al., 2016). This transition requires a change in user behaviour, attitudes and understanding. However, most people perhaps do not even realise the value of products or their materials any more. Additionally, they are not aware of the methods of getting the most value from their products.

As can be seen from the Ellen MacArthur Foundation's system diagram (Figure 6), repair ('maintain', in the diagram's terminology) is the inner circle of the circular system. It may be easier for users to relate to this complex economic system through the inner circle. The inner circle is where consumer thinking and behaviour can be changed, as it is easy to communicate this issue with people around the topic of repair.

One of the goals of the circular economy is to keep products in circulation for longer and use tighter inner loops. This means maximising the time spent in each cycle by prolonging the use life and enabling maintenance, repair and reuse, rather than recycling. Maintenance and repair preserve the embedded energy and value in the product (Ellen MacArthur Foundation, 2015a). Thus, recycling and remanufacturing can be a source of value creation if repair is no longer feasible. When the cycles are lengthened, the material, energy and labour needed to manufacture a new product are avoided (Ellen MacArthur Foundation, 2015a).

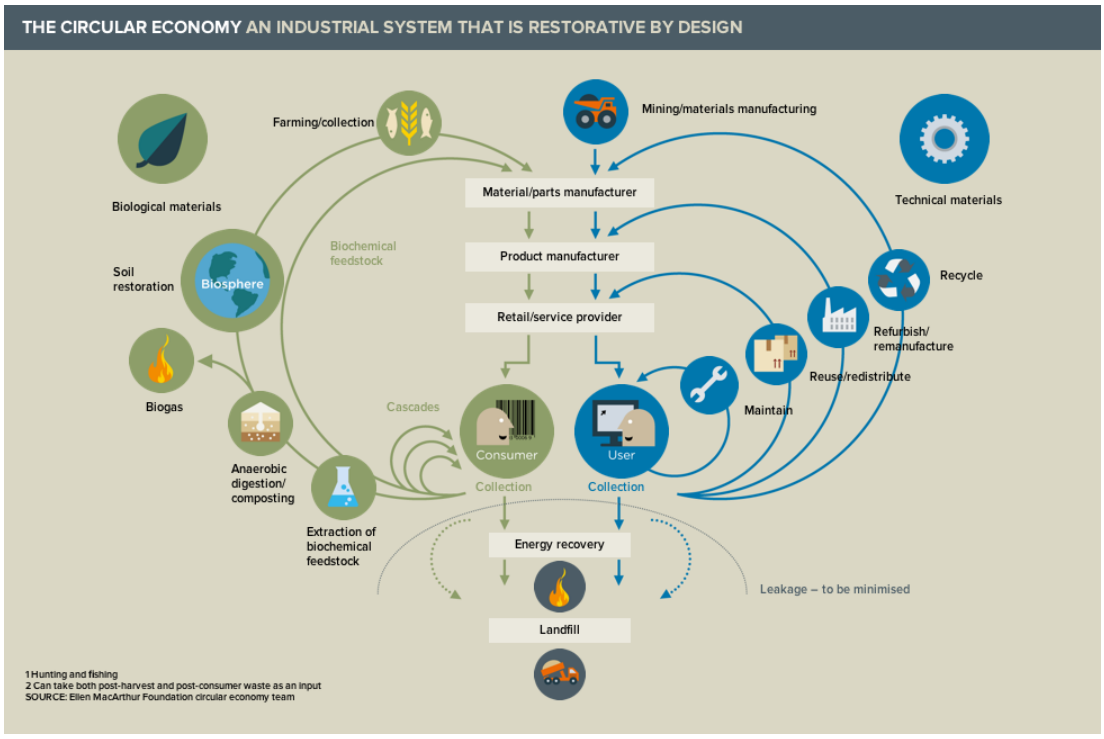


Figure 6. Biological and Technical materials in an interactive system diagram (Ellen MacArthur Foundation, 2011).

2.10. Innovative Business Models

The circular economy offers a systematic solution to many environmental problems, covering in particular the economic dimension of sustainability, including planned obsolescence. It presents different business models that transform the relationship between customers and business (Bocken et al., 2016).

Alternative business models that develop environmental benefits while fulfilling economic constraints have begun to claim the attention of business leaders. These alternative models are beneficial in many aspects, including extending product life and preventing resources and materials from becoming waste (WRAP, 2014; De los Rios & Charnley, 2016). Companies can launch a new business model that they have never considered before, or they can transform an existing business model into a circular one according to its requirements. These business models are also beneficial and effective for experimenting with the embedding of sustainability into the underlying structure of commercial businesses. Philips' Pay Per Lux project is an example relating to this statement; it is explained in a case study in Section 2.10.1.2. The innovative business model map in Figure 7 shows the diversity of business models available.

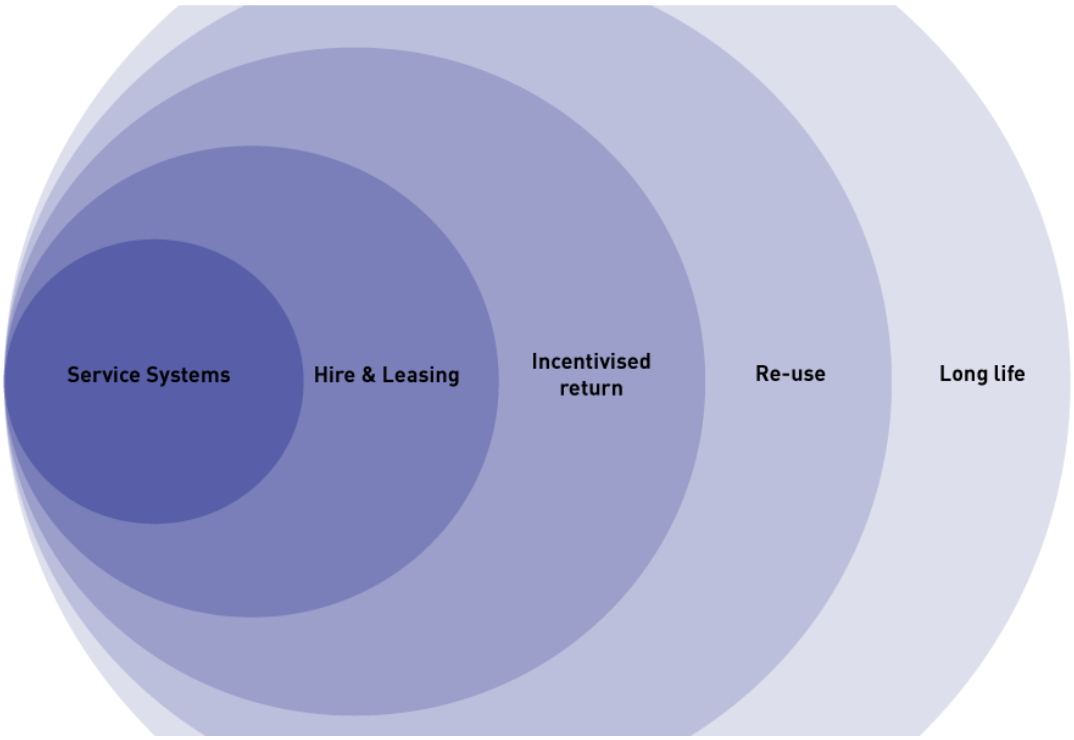


Figure 7. Innovative business model map (WRAP, n.d.).

2.10.1. Product Service Systems

Quite different from the selling of physical products, Product Service Systems (PSS) is a business model that focuses on providing a system of products and services that respond to the needs and demands of the client (Manzini & Vezzoli, 2002). The transition from physical products to PSS means developing a new way of interacting with users. Companies that implement this business model provide additional services in order to ensure utility and endurance. These additional services may include maintenance, repair or upgrading for a specified period and are applied according to the service contract signed between the company and the client. The system of products and services can be designed to offer long life or short life options for the products, depending on the requirements. They can be designed for disassembly, remanufacture and reuse, as companies take the products back at the end of the contract to reuse or recycle them.

2.10.1.2. Case Study: Philips Pay Per Lux Solution

Philips is a Dutch technology firm that consists of three main divisions: Philips Consumer Lifestyle, Philips Healthcare, and Philips Lighting. It has a diverse product range that includes electronics and electrical products (smartphones, televisions, small domestic appliances, etc.); healthcare products (MRI scanners, ultrasound equipment, CT scanners, etc.); and lighting products (indoor and outdoor luminaires, automotive lighting, etc.). Philips values sustainability and focuses on reducing the environmental impact of its operations. The firm sees the transition from the linear economy to the circular economy as one of the most important conditions for a sustainable world (Philips, 2014). Philips have been exploring circular innovation within their company, aiming to pioneer the circular economy in the areas of healthcare, consumer lifestyle and lighting.

RAU Architects is an architectural firm in Amsterdam that has been working for sixteen years in both the public and private sectors (RAU Architects, n.d.). The studio adopts an environmental approach and values making a positive contribution to the world. Thomas Rau, founder of the RAU Architects, wanted to change the lighting at his agency and contacted Philips Lighting. He did not want an expensive lighting structure that needed maintenance and eventual replacement. He wanted to have light as a service that suited the building. Philips Lighting developed a new sustainable and cost-effective way of delivering light for RAU Architects. Through the project, called Pay per Lux, users get the exact amount of light they need in their workspaces and rooms and pay as they use it (Philips Lighting, 2012).

The Solution

Philips Lighting presented two lighting scenarios to RAU Architects. In the first design that Phillips proposed, the level of lighting was high and there were personally dimmable areas. However, Thomas Rau wanted to make more use of natural light, and accordingly reduce the amount of artificial light as much as possible in the office. After these negotiations, his requirements led the project in a different direction. Philips decided to develop a new kind of lighting plan focusing on the services provided.

Figure 8. Pay Per Lux, an intelligent lighting system designed to fit the requirements of the office environment (Phillips, 2012).

In the end, Philips created individual lighting modules floating over workplaces, which could illuminate the required areas while the rest of the office remained dim. LED light fittings for ceiling systems are hung in the high-roofed offices. Sensor and controller systems are utilised together to minimise the energy use. As the project team wanted to benefit from natural sunlight as much as possible, sensors were used to control the intensity of artificial lighting according to motion and the amount of available daylight (Figure 8).

Moving away from the one-off sale to a performance-based model, the project provided a variety of benefits for both Philips Lighting and RAU Architects. The lighting system resulted in a thirty-five to fifty-five per cent reduction in total energy use following the installation (Philips Lighting, 2012). A further twenty per cent reduction in energy use was also observed after the optimisation carried out by Philips (Philips Lighting, 2012). Furthermore, maintenance, repair and the upgrade of the products are included in the Pay per Lux concept. Philips maintains ownership of the materials and is responsible for fixing broken parts and upgrading the existing system when the users need it. Philips reclaims the materials and products at the end of their use life and directs them to LightRec, Philips' partner organisation responsible for the reuse and recycling of lighting components.

The most important benefit of this collaboration for Philips is that they now have a new and sustainable model for lighting. Many architectural agencies and installers contacted them to learn more about the project and requested the installation of LED luminaires for projects of their own (Philips Lighting, 2012). After seeing the potential of a performance offering, Philips is now further developing the business that underpins this model and drawing up contracts that systemise the concept.

2.10.2. Hire and Leasing

This is a usage-based business model where companies retain the ownership of the product and lease or share the usage of it. Companies keep the resources and the value of energy and labour embedded in the products. This model improves the longevity of products with services such as maintenance, repair, upgrading and the use of high-quality materials in manufacturing. According to the Innovative business model map (WRAP, 2014), long life, reuse and incentivised return circles encapsulate the two other business models (Figure 7). In order to extend the product lifespan, companies should design and produce them for maintenance, repair and upgrade. Incentivised return encourages users to return the products to manufacturers for a specified value (WRAP, 2014). Users benefit from gaining value from an unwanted product. Companies get the value of materials, energy, and labour embodied in the products back, and they refurbish these products and reuse them.

2.10.3. Repair Business Models

Fixed Price Repair Repair service is offered to customers at a fixed price independent of the nature of the damage.

Repair Service Offered by Reuse Organisations

This business model is currently used for electrical and electronic items. Organisations collect second-hand, damaged or malfunctioning items. They then repair those items and prepare them for reuse, selling them online or in a shop.

Exchange Repair Service

This business model suits high-volume and high-technology products. The company provides the same model or an equivalent of the product to the customer after receiving the faulty product. The damaged product is diagnosed and repaired as new. Finally, it is sent to another customer.

2.11. Visible Repair of Ordinary Everyday Objects

This research does not focus on a single product category: rather, it focuses on physical damage. Physical damage refers to damage and defects which disturb or intervene with the usual ways a product is used. Broken, cracked or worn-out products, and also torn-apart, unstitched or frayed textiles are examples of physical damage. This categorisation does not include electrical or electronic problems; however, electronic and electrical products, of course, can be physically damaged: a mobile phone with a broken plastic housing, for instance. Although there is no single product category focus, this study mainly explores fast-moving consumer goods such as textiles, shoes and leather goods, and ceramic and medium-lifespan products such as glass products, small furniture, utensils and toys. Such objects are the ‘ordinary everyday objects’ referred to in the thesis.

This research is mainly focused on visible repair, which refers to the creative act of fixing an object with the aim of making something unique and beautiful out of it without hiding the damage, creating a new aesthetic language that honours the traces of the object's life. Visible repair encourages thoughtful assessment as well as aesthetic appreciation of the act of repairing and the repaired object. The act of repair itself becomes an experience which goes beyond mere personalisation of products, enabling people to develop both skills and confidence (Spelman, 2003). Visible repair forms a challenge to our ways of thinking about things, giving us a much fuller knowledge about a product than buying a new one, since it involves engagement with its materiality.

Examples of visible repair can be seen in art, design or everyday life. An example from art can be artist Charlotte Bailey's (2016) method to repair broken ceramic products. Inspired by the Japanese traditional repair method kintsugi, she covers the broken parts with fabric pieces and patchworks them together with gold metallic thread (Figure 9).

Figure 9. Patchwork porcelain (Bailey, 2016).

Woolfiller is a visible repair example from design. It is a darning kit to repair holes and cover stains in woollen clothes with special wool, a felting needle and a poke needle (Figure 10). The fibres of wool are pricked with a felt needle to create a patch on the damage. Heleen Klopper (n.d.) used woolfiller as a part of an exhibition about sustainability. She started to design it as a kit after so many visitors were interested in the method and wanted to use it.

Figure 10. Cardigan mended with woolfiller (Klopper, n.d.).

Similarly, 5.5 designstudio from France uses the visible repair approach in their project called Reanim (Figure 11). This project is a collection of prosthetic seats and legs to repair damaged furniture (5.5 designstudio, 2004). The bright green colour and transparent product parts transform the damaged and old objects into an interesting hybrid suggesting a new aesthetics of imperfection and actively involving users in the repair process.

Figure 11. Chair 'fitted' with prosthetic seat (5.5 designstudio, 2004)

The examples in Figure 12 show how old the visible repair approach could be. Erik Kwakkel is a book historian who investigated book producers from medieval times and discovered how they turned damaged parts of parchment into art. As parchment is made out of thin

membranes of animal skin, it would get damaged during the manufacturing process (Kwakkel, 2013). These examples show how book producers used embroidery with coloured threads to tie the holes together.

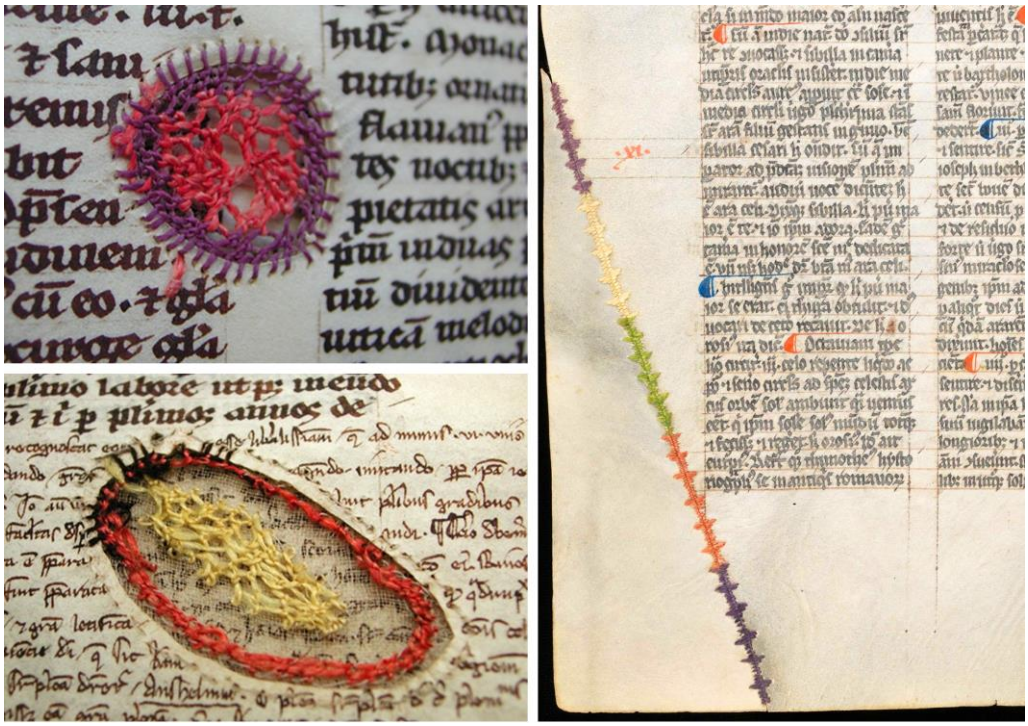


Figure 12. Stabbed, cut and stitched back together (Kwakkel, 2013).

The approach related to visible repair used in this thesis can also be seen in similar examples in architecture. Materials that differ from those in the original in terms of texture and colour are used to differentiate the reconstructed parts, while the remaining elements of the heritage are consolidated in this type of restoration. David Chipperfield Architects' (2005) Castello Sforzesco project in Milan is an example of this approach (Figure 13). The architects restored the medieval building in accordance with its historic form. The new additions were made out of brick and stone with no decoration, expressing the difference between old and new.

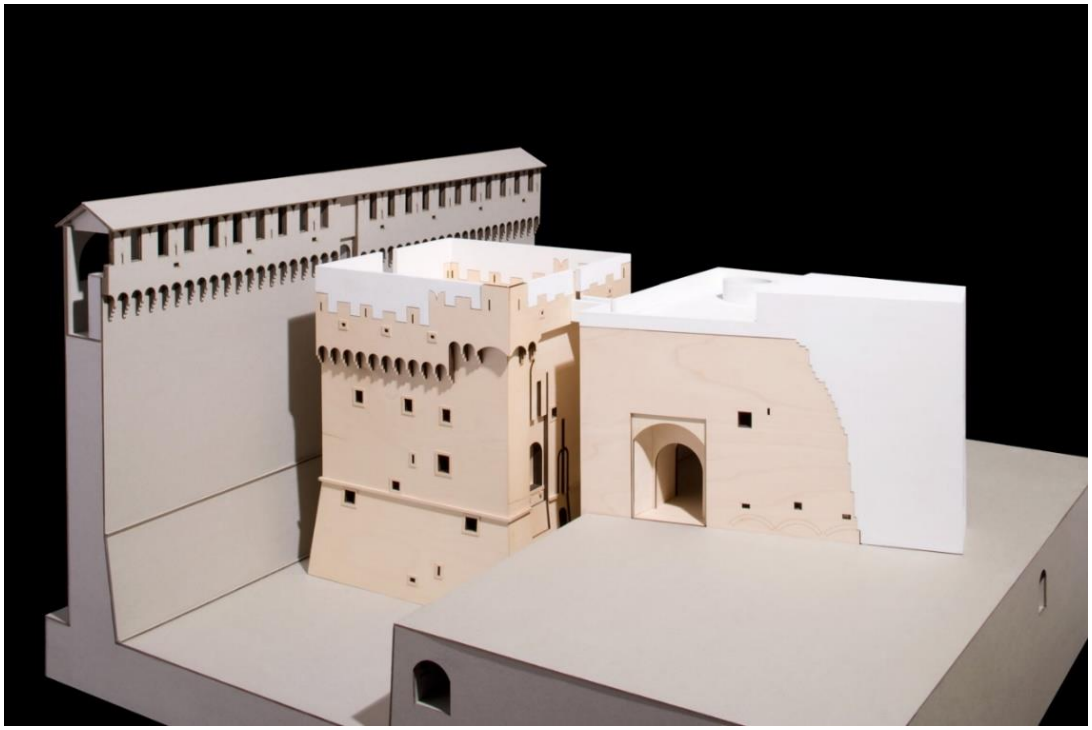


Figure 13. David Chipperfield Architects' Castello Sforzesco restoration project in Milan (David Chipperfield Architects, 2005).

Figure 14. Astley Castle was converted into a holiday home, blending old and new, by the Landmark Trust in 2012 (Wainwright, 2013).

The Astley Castle restoration project, shown in Figure 14, is another example, and this project won the Royal Institute of British Architects Stirling Prize for the greatest contribution to British architecture in 2013 (Wainwright, 2013). Astley Castle was converted into a holiday home, blending old and new, by the Landmark Trust in 2012 with the architect Witherford Watson Mann (Wainwright, 2013). In this approach, the remaining structure, with ruined parts and traces of previous restorations, reflects the history of the building. Differentiating the restoration in this way provides valuable information, such as the effect of, or the reason for, the damage, and the building becomes more meaningful with this historical background, like the traces of a product's life which can tell its story.

2.12. Case Studies

2.12.1. Case Study: Patagonia

Patagonia is an American outdoor clothing company that produces high-quality, environmentally friendly garments that can be repaired and have a lifetime guarantee (Figure 15). It was founded in the 1970s, and was one of the first environmentally conscious companies in the clothing industry. They incorporated repair into their business system to save their sustainably made clothes from becoming waste, because even the most durable and well-made clothes can tear. Patagonia operates the largest garment repair facility in North America and carries out more than 40,000 individual repairs a year (Marcario, 2015).

Figure 15. Patagonia Clothing Company (Patagonia, n.d.).

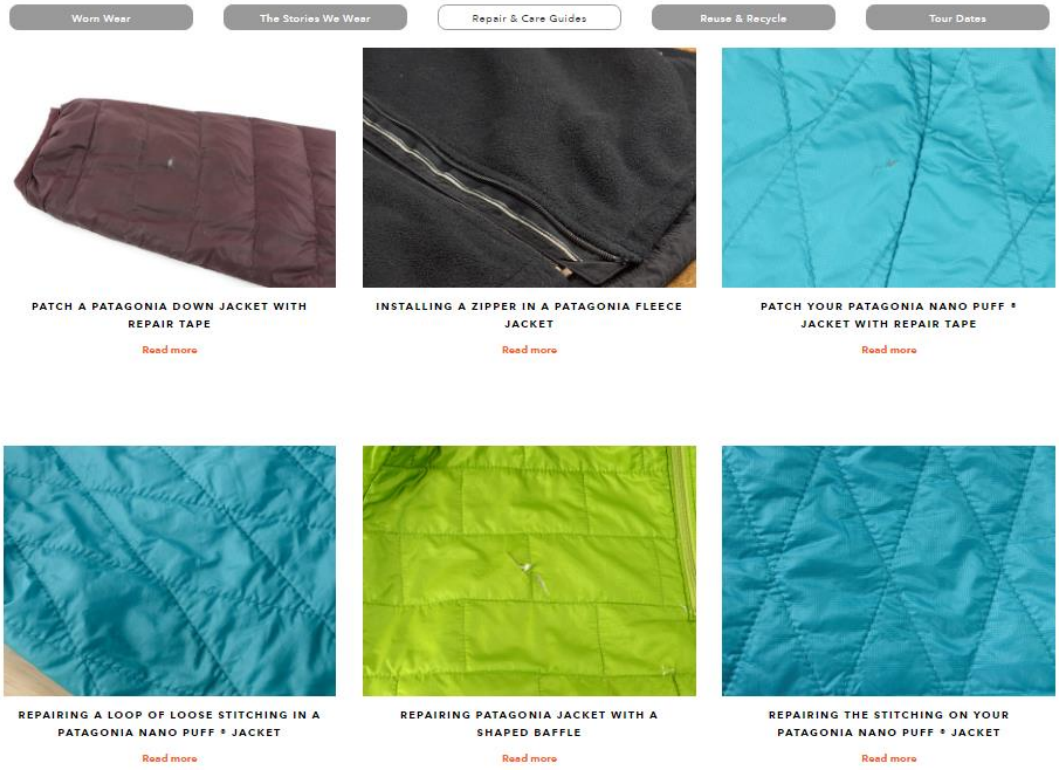


Figure 16. Patagonia Clothes Repair Instructions prepared by iFixit (McCrigler, 2012).

Patagonia offers more than forty 'repair & care' guides and repair tools on their website, besides the repair service they provide in their repair centre (Figure 16). For example, the Patagonia expedition sewing kit has been developed in collaboration with the iFixit company in order to encourage users to repair their clothes by themselves (Figure 17). The company also has a Worn Wear programme that presents stories about the repaired garments and provides an easy way to recycle them when they are beyond repair.

Figure 17. Patagonia Expedition Sewing Kit (Patagonia, n.d.).

The company launched a cross-country mobile repair tour in 2015 with a repair truck. They offered a repair service for any piece of clothing, regardless of the brand. The tour's ultimate goal was not to achieve a certain number of repairs but to spread the 'if it's broken, fix it' mantra.

2.12.2. Case Study: Fairphone

Fairphone is a social enterprise that aims to create a fairer economy and transform how we produce and use objects, starting with the mobile phone (Fairphone, 2014). Revealing the story behind the electronics supply chain, Fairphone focuses the world's attention on the severe environmental and social problems in the industry (Figure 18).

Figure 18. Fairphone is a social enterprise that aims to create a fairer economy and transform how we produce and use objects (Fairphone, 2014).

Fairphone started as a campaign within the Amsterdam-based digital media cultural organisation Waag Society in 2010 to raise awareness among consumers and in the mobile phone industry about conflict minerals (Fairphone, 2014). It was established as an independent social enterprise in 2013 in order to take the campaign a step further and produce mobile phones responsibly with regard to the environment and society. The enterprise became successful. 25000 Fairphones were sold in 2013 and now a second batch of 35000 Fairphones is on sale. Crucial problems exist in the mining sector, where precious minerals such as tin, gold, tantalum and tungsten are extracted and transferred to the electronics industry. Illegal mining of these minerals perpetuate the conflicts and wars between various governmental and rebel armed groups in a number of African countries. Working conditions in the mines are harsh and dangerous, with problems such as child labour, neglected workers' rights and pollution. The Fairphone team works closely with suppliers and manufacturers in order to improve the working conditions of miners and other workers and increase local wages (Fairphone, 2014). They strive to decrease the degradation caused by mining practices. Fairphone only uses tin which has been certified by the Conflict Free Tin Initiative in its production. Designing a smartphone with a longer lifespan is one of Fairphone's main considerations. They aim to achieve this goal by making it easy to open, with replaceable product parts. Fairphone has been selling spare parts for the phones via their website since January 2014. Moreover, Fairphone has collaborated with iFixit to provide people with guidance for the repair process. Ten repair guides for different malfunctions of the Fairphone are available on the ifixit.com website.

Figure 19. Fairphone has collaborated with iFixit and developed 10 repair guides for different malfunctions of the Fairphone (iFixit, 2014).

Users can follow the step-by-step instructions and photographs to repair their phones (Figure 19). As well as complex operations like changing the display or the motherboard, easier replacements that require fewer steps, such as the replacement of the back cover, battery and SIM card are explained in detail. This website provides users with the opportunity to ask questions and open conversations. Questions are answered by Fairphone technicians, experts and other users who have encountered similar problems.

Figure 20. Fairphone 2 is the world's first modular smart phone (Fairphone, 2016).

The company designed the world's first modular smartphone, the Fairphone 2, which will appear in stores in May 2017 (Figure 20). The company has focused on longevity and repairability. Fairphone 2 was designed in a way that encourages users to access the inside of the phone. This phone offers a different relationship to users from that of the other consumer electronics products on the market. It invites people to look inside and repair or upgrade the phone when necessary. Modular parts give the user more control over their phone, as it can be easily opened and no special tools are required (Oliver, 2015).

2.12.3. Case Study: Riva 1920

Riva 1920 is an Italian wooden furniture company characterised by reliable and long-lasting products. This company is included in this thesis because it provides maintenance sets with its products in order to prolong their use life. Moreover, the company offers maintenance and repair instructions on their website for dents and scratches, and videos with stain removal instruction.

The maintenance set that comes with Riva 1920's Piano bookshelves is an example of users being encouraged to take care of their products. The bookshelves are designed in a way that allows easy replacement and upgrading of the components (Figure 21). With the aim of providing lifelong maintenance, the bookshelves are sold together with a maintenance kit that includes a set of small tools and materials such as oil-based paints and natural wax to finish surfaces, which can be used if the product is scratched or damaged (Figure 22).

Figure 21. Riva 1920's Piano bookshelf is designed in a way to allow easy replacement and upgrading of the components (Riva 1920, n.d.).

Figure 22. The maintenance set that comes with Riva 1920's Piano bookshelves (Riva 1920, n.d.).

2.12.4. Case study: Droog Design

Droog Design is a Dutch design company founded in 1993 by product designer Gijs Bakker and design historian Renny Ramakers. This company critiques over-consumption and materialist culture through their design ideas that focus on recycling and reusing materials and found objects (Ramakers, 2002). Droog Design's approach has been followed by prominent designers, artists and architects (Ramakers, 2002). Challenging the dominant culture, they value everyday mundane objects and celebrate the qualities of inferior things (Ramakers, 2002). As Ramakers has said: 'They leave room for decay, for improvising, for chance, for familiar, the archetypical. Products are allowed to wear out and fade away' (2002, p.6).

The experiential dimension of products was emphasised in the Droog collection. Significantly, in the 'Do create' project the experience comes before the products (Ramakers, 2002). 'Do create' is a collaborative project that started in 2000 and features a range of design ideas from different designers that aims to make consumer products more active (Ramakers, 2002). Users are able to interact with the products and influence the design. The products are completed with the action of the users. These actions include shaping a chair with a sledgehammer, in the case of the 'Do hit' chair by van der Poll (Figure 23), breaking a vase in 'Do break' by Frank Tjepkema (Figure 24) and Peter van der Jagt and swinging on a lamp in the case of 'Do swing' by Thomas Bernstrand. The 'Do create' project is an example of enabling people to have relationships with objects that are different from those the dominant system allows. It encourages people to engage with the products in a creative way, and the results of this engagement are spontaneous, special and challenging.

Figure 23 'Do hit chair', designed by Marijn van der Poll, is a customisable piece of furniture that has to be shaped with a sledgehammer (Droog Design, n.d.)

Figure 24 'Do break', designed by Frank Tjepkema, emphasises the beauty of cracks (Droog Design, n.d.).

2.12.5. Case study: iFixit

Ifixit.com is the world's first free repair manual, containing thousands of online repair instructions for various items, including consumer electronics and household appliances (Wiens, 2015).

The company provides repair guides, product teardowns and a forum for users on the website. Effective knowledge and guidance are offered about product repair through tutorial videos, repair guides and product teardowns (Getto & Labriola, 2016). Teardowns are detailed, and the repair process is illustrated step by step, with related visuals. Repair guides target people at every skill level and inform users by providing a scale for the level of difficulty. Even instructions on how to use a screwdriver are included. A forum enables users to share their experience and discuss the difficulties they face during repair work.

The company partners with a number of manufacturers such as Patagonia and Dell to make their products more repairable, develop repair guides for their products and provide tools and spare parts (http://ifixit.org/resources). They also work with other organisations, including Repair Cafes and the Ellen MacArthur Foundation.

IFixit's aim is to facilitate a future where people have the legal right to repair their stuff and the resources and the confidence to carry out the repairs (Wiens, 2015). The company empowers customers and creates awareness by encouraging self-repair (Scott & Weaver, 2014). IFixit emphasises the value in repair practices to business and customers, which is central to circular economy thinking. What this company is doing is crucial in terms of creating awareness and empowering people, and it represents a great example of a very successful business based on fixing objects in a world where local repair shops have closed and companies do not provide repair manuals and spare parts.

The case studies presented here are six successful business examples from five different sectors: electrical and electronic products, textiles, consumer electronics, furniture and the service sector. The most important fact that these examples demonstrate is that the throughput-based, linear type of economy is not the only option for a successful business. There are only a small number of companies following this environmental and ethical path, because most manufacturers argue that it is not possible to make a profit if they produce and sell long-lasting, high-quality products. However, the linear economy is an ancient system that is detrimental to the environment, society and the economy. Since industrialisation, experts and researchers have developed various economic approaches, like the circular economy, which offers benefits for manufacturers as well as users and the environment. The approaches these companies employ can be scaled up to other product types, and other companies can also take these approaches as models. For example, a significant reduction in e-waste would be enabled if other consumer electronics companies sold spare parts on their website in the way that Fairphone does. Additionally, the sewing kits that Patagonia developed, and Riva 1920's maintenance set, are great examples that encourage users to fix their products. Similarly, this research looks at different ways of encouraging people to repair their products.

2.13. Design Activism and Repair Platforms

Activism refers to taking actions to inculcate change for the purpose of generating social, cultural or political transformations (Fuad-Luke, 2009). Design activism similarly aims to change society, the economy or culture in a positive way and presents and supports possibilities other than those that already exist (Fuad-Luke, 2009). Design activism has the potential to bridge the gap between people's behaviour and emotions and enable them to make the connection between 'what they do' and 'what they feel about doing this' (Markussen, 2013). As a result of this, an awareness of environmental and social problems can be created, and the current system can eventually be disrupted.

A large number of design activist cases exist, with various applications. Thorpe argues that design lacks a theoretical framework for activism (2008). Then, based on sociological studies, she develops a framework and presents six different categories: design activism as a 'demonstration artifact', that provides alternative products superior to the existing ones; 'info/communication' category, that refers to making information visible; 'conventional actions', acts such as proposing legislation, conducting research and testifying at political meetings; 'service artifacts', which refers to providing humanitarian aid; the 'events' category includes conferences, exhibitions and talks; finally, 'protest artifact' is a confrontational object that critiques the morality of the status quo.

Repair is already an act of activism, because it challenges the status quo or 'normal behaviour' as perceived by society. It suggests a different way of valuing artefacts and creating a different relationship with them. As an example of design activism, the Repair Cafes organisation (explained in a Case Study below) aims to raise awareness about environmental and social problems and empower people by teaching them how to repair. The Repair Cafes around the world organise events to bring together people who need a specialist repair service with repair technicians and enable people to give their products another chance. Restart Project is a platform similar to Repair Cafes that encourages people to repair their electronic products by organising repair events. Information and techniques for people who want to repair their own products are available across the internet. Websites such as ifixit.com, fixya.com, howstuffworks.com, fixperts.org, thingiverse.com and familyhandyman.com provide useful information about fixing various objects. Similarly, eSpares is a UK-based retailer which provides spare parts, consumables and accessories for electrical appliances.

A considerable number of people contribute to this online repair movement. People repair broken products in various creative ways and post images of the process on websites. They also provide 3D computer-aided design (CAD) models of different products. Thingiverse is one of the websites on which users share digital design files for 3D printers, laser cutters and milling machines, etc. The broken handle of the joystick in Figure 25 is an example from this website. It is repaired by using a 3D printer. The tripod quick-release mount replacement in Figure 26 is repaired in the same way, by 3D-printing the broken product part. There are more than 25,000 digital things, ranging from a lens cap to a stove knob (Figure 27), available to download and make (Makerbot, 2012). From 2008 to 2012 digital files of things on Thingiverse had been downloaded more than 8.5 million times (Makerbot, 2012).

Figure 25. Repair of a joystick handle (MakerBot Industries, 2013).

Figure 26. Repair of a tripod quick release mount replacement (MakerBot Industries, 2012).

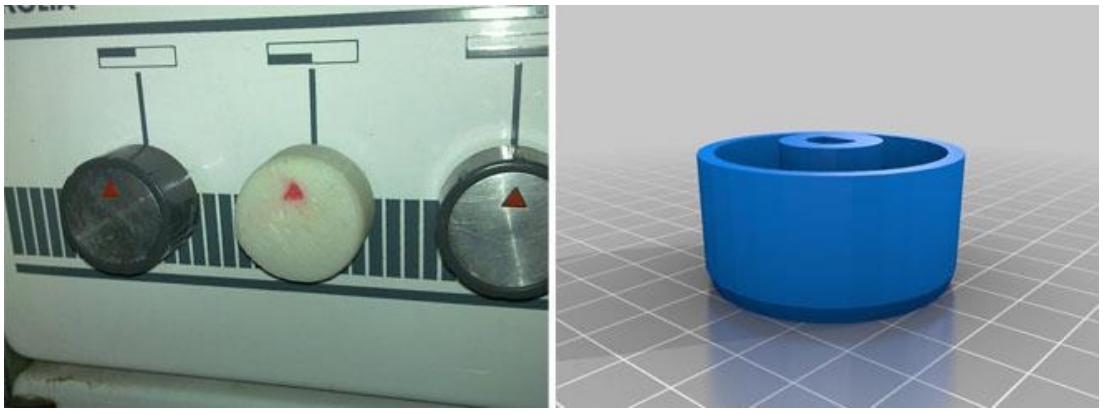


Figure 27. Stove knob 3D digital models are available for download (MakerBot Industries, 2010).

It can be seen from online user platforms that there are people who want to fix their broken stuff. However, factors such as the design of products, unavailable spare parts and the high cost of repair prevent some of them from doing so. Chapter 4 includes a cultural probe study of people who want to fix their products and I explore their motivations: some of the factors mentioned here are considered as barriers that people experience around the activity of repair.

2.13.1. Case study: Repair Cafes

Repair Cafes are among the most influential new platforms and places emerging from a new wave of grassroots organisations (Charter & Keiller, 2014). They are meeting places in which people bring damaged products and fix them with the help of volunteer repair specialists (Figure 28).

Five hundred Repair Cafes are active around the world. Visitors learn a range of details relating to repair and product use while working with repair specialists. According to a recent study, sustainability is one of the main drivers of participation in relation to the activities undertaken in Repair Cafes (Charter & Keiller, 2014). According to results of the study, more than eighty per cent of the volunteers in Repair Cafes are motivated by encouraging others to live sustainably and provide valuable services to the community to help product repairability and longevity (Charter & Keiller, 2014).

Tools and materials are available in these meeting places to enable participants to carry out any repair they need, on clothes, furniture, electrical appliances, toys, etc. Participants not only get their objects repaired in Repair Cafes; they can also modify clothes, and electrical and electronic equipment and components are upcycled – in other words, reused for different purposes or transformed into new products in a creative way (Charter & Keiller, 2014). According to the responses which were given on a five-point Likert scale from *always* to *never*, the five categories of products that are most frequently brought to Repair Cafes for repair are small kitchen appliances, lighting, clothing, bicycles, and DVD/CD players (Charter & Keiller, 2014).

Providing the means to repair products, Repair Cafes perform a very effective task in terms of environmental responsibility. They enable, encourage, and inspire people to look at objects differently and help to divert waste from landfill through repair and reuse.

Figure 28. A Repair Cafe in Germany. Volunteers are teaching people how to fix broken household items (Repair Café Foundation, n.d.).

2.14. Existing Research Related to Repair

Among several different areas of research that study product repair, two main areas stand out: sustainable design practices and studies that aim to inform Human-Computer Interaction (HCI). Product repair is frequently mentioned in the literature on sustainability and the circular economy as a way of extending product lifespan and 'closing the loops'. However, few of them study repair in detail; in other words, the majority of these studies go no further than mentioning it as a strategy for product longevity.

Researchers have mainly explored ways of decreasing the number of products in circulation by prolonging their use life through repair and reuse (Cooper, 2013; Fletcher, 2012, Mont, 2002). Repair is also included in the literature on the circular economy that looks at business models and strategies as a strategy for closing the loops (WRAP, 2014). With an approach similar to circular business model studies, Vezzoli and Manzini (2008) suggest after-sales services as a more eco-efficient way of marketing than providing more products. They look at the issue of product longevity and study it in correlation with services offering maintenance, repair and upgrading (2008). In this case, product services are offered and controlled by the producers; this rationalises the production of durable products for them, because they retain ownership of the products.

Repair is currently experiencing a revival, as a consequence of grassroots organisations and initiatives which seek to promote repair, reuse and other creative forms of waste prevention (Charter & Keiller, 2014; Middleton, 2012). Charter and Keiller conducted an online survey of the members of Repair Cafes and hackerspaces around the world to understand the importance of sustainability as a driver for participating in these organisations. They found that the strongest motivation for volunteers to take part in these organisations is the desire to do something for others.

The literature on product repair is primarily focused on self-repair, and mainly addresses the context of the workplace (Orr, 1996; Suchman, 1987; Balka & Wagner, 2006) and the home (Maestri & Wakkary, 2011; Crabtree & Rodden, 2004; Taylor & Swan, 2005). Maestri and Wakkary's research, for instance, explores how creativity plays a role in the repair and reuse of objects in the home (2011). This study aims to enable design technologies to extend product life through repair and further shows that design is an ongoing activity that includes the repair, appropriation and modification of objects.

Apart from product design, repair has been studied within various disciplines such as textiles, clothing, architecture and others. (Cooper et al., 2013; Fletcher, 2012; Laitala, Boks, & Klepp, 2015). For example, Laitala et al. explore the possible extension of product lifespan to provide reasons to delay the disposal of clothing by improving its design. They discovered seventy reasons for disposal and developed design solutions for the most significant ones. Similarly, Middleton studied a technological system for smart wardrobes that extends the garment's lifespan (2012). She states that the repair activity demonstrates the impact of things on humans because products make humans think they worth mending (2012). Similarly, Graham and Thrift say that repair represents the power of things, as the thing draws attention to itself and manifests itself existentially according to Heideggerian thinking (2007). Their paper focuses on modern cities and all the processes of repair and maintenance that keep cities going. The authors aim to give these repair and maintenance processes in cities the attention they deserve, as they are hidden from view and not currently acknowledged or known about (Graham & Thrift, 2007).

A growing body of research in HCI has been studying repair to explore and understand the human-technology relationship further (Houston et al., 2016). One of the most influential studies is Suchman's (1987) ethnographic research in which she demonstrated that breakdowns challenged the dominant understanding of human action in artificial intelligence and HCI work. Plans and goals were used to describe and design human-machine interaction at the time. However, Suchman has shown how human-machine interaction is extraordinarily complex and based on 'situated actions': it rarely goes according to the plan that the designers had assumed. Suchman's work has influenced artificial intelligence, cognitive science and human-computer interaction, and its influence can also be seen in Julian Orr's (1996) workplace studies on Xerox repair technicians. Similarly, Orr focused on the situatedness and contingent nature of repair and the challenging process of diagnosis.

More recent work, in Rosner and Ames's ethnographic study (2014), explores repair in social contexts. They conducted two pieces of fieldwork, including the One Laptop per Child project's 'XO' laptops in Paraguay and repair platforms in California, for fifteen months. This

paper shows how designers and engineers working remotely from the context of use may fail to understand the social context of breakage and repair, and it reveals the contingent nature of these processes. The XO laptop was designed and manufactured to be very difficult to break and to be so easy to repair that a child could do it. However, a number of unanticipated factors, such as the way children used laptops, the environment in which they were used and the manufacturing limitations, caused problems. For example, laptop screens often broke when they were dropped because of Paraguay's hard cobblestone streets. The keyboards, AC adaptors and trackpads were too weak to withstand heavy use. Consequently, children were not able to repair such damage, and the spare parts were expensive, so it was not possible for children's families to afford the repairs. At the end of the research, they conclude that breakdown and repair cannot be anticipated and scripted by designers beforehand, but emerge spontaneously in everyday practice.

The book *Invisible Users: Youth in the Internet Cafes of Urban Ghana* is another example of ethnographic studies about repair (Burrell, 2012). Burrell looks at the e-waste scavengers in Ghana and provides a richly observed case of these 'invisible users' who are not considered in the design process (2012). He touches on the skills they developed to retrieve parts from electronic products such as mobile phones and computers and reuse these parts and precious metals.

Similarly, Jackson, Pompe and Krieshok (2012) explore in their ethnographic fieldwork how information technology infrastructures are maintained and repaired in sub-Saharan Africa. Information technology devices and networks have spread from Europe and other developed countries to different parts of the world. The effect of this spread has created a local maintenance and repair culture in various parts of the world (Jackson et al., 2012). Jackson et al. developed a concept of 'repair worlds' in order to recognise, study and analyse this overlooked area, which offers valuable practical and theoretical knowledge (2012).

Rosner, Jackson and their colleagues conducted the research project 'Reclaiming repair' (Rosner, Jackson, Hertz, Houston, & Rangaswamy, 2013). This is an ongoing three-year-long project which aims to advance the understanding of maintenance and repair practice by strengthening the connection between design and repair (Rosner et al., 2013). The project mainly studies the growing amateur repair movement in North America and Europe and repair knowledge in Bangladesh and sub-Saharan Africa to enhance the understanding of how repair and breakage relate to wider design practices.

Jackson's (2014) paper 'Rethinking repair' starts a discussion by asserting that breakage and repair are both part of technological systems: they are inevitable, and cannot be ignored. He critiques the dominant view that ignores the activities of maintenance and repair, which sustains technologies and practices in the world. Departing from Heidegger (1996), Jackson proposes a concept called 'broken world thinking', which puts maintenance and repair at the centre of thinking, rather than 'innovation, development and design', in media and technology studies. First, according to Jackson, broken world thinking enables us to have a wider perspective than the one offered by the current dominant binary structure of technology studies. Second, repair helps us change our production, with a new focus on sustainability and the meaning of objects. Third, it changes our thinking about the

'timeliness' of technology. And finally, repair transforms our relationship with technological artefacts and systems and makes it deeper and richer.

Influenced by Jackson's 'Rethinking repair' paper, Houston et al. explored the transformation of values through repair and how new values are elicited. Valuation is a cognitive process involving an assessment of the significance of objects and the rendering of their importance. Values are not established and fixed at the point of design or purchase: but is a continuous process evolving throughout the object's lifespan (Houston et al., 2016). Houston et al. conducted ethnographic studies of mobile phone repair communities at four sites: in Uganda, Bangladesh and amateur fixers' collectives in Brooklyn and Seattle in the US. They highlighted the centrality of values in repair and discussed a different way of understanding values from that found in HCI studies and design. They found out that the valuing of products is not static, in the way that it is studied in design and HCI. Conversely, it is an ongoing process. As a result of this, repair can help us transform how we think about values. Moreover, through repair alternative valuation processes can be embedded into products, changing the human relationship to technology in a way that strengthens the human relationship to technology by building attachment and meaning. This study provides significant information for this thesis, as one of the main arguments in the literature review is that repair enables a different way of thinking and understanding.

2.15. User-Product Relationship

Repair connects people to products. People engage with products on a material level through repair. In other words, they observe and better realise the materials, form and structure of a product because they consciously think about the product as they need to understand the damage before developing a solution for it. Accordingly, we can say that repair enables a deeper engagement with objects and bring a new consciousness to the user in terms of their relationship with products.

I reviewed the existing research about the user-product relationship before exploring the ways that can be used to encourage people to repair products in order to experience deeper relationships with things. The literature in this subject area focuses on the user experience, which has mainly been studied by the human-computer interaction community (e.g. Desmet & Hekkert, 2007; Hassenzahl & Tractinsky, 2006; Forlizzi & Battarbee, 2004; Schifferstein & Hekkert, 2008). Understanding experience is a complex task (Forlizzi & Battarbee 2004), and many approaches exist in this subject area (Alben, 1996; Forlizzi & Ford, 2000; Kerne, 1998; Desmet & Hekkert, 2007).

Product experience refers to the awareness of psychological effects elicited through interaction with a product (Schifferstein & Hekkert, 2008). It is a subjective process because experiences differ according to individuals and situations, and may vary over time (Hassenzahl, 2003). A product cannot be merely seen as a thing with functions and benefits, because it is a part of a complex system and network of relationships (Hassenzahl, 2003). According to Desmet and Hekkert, there are three different levels of product experience, including aesthetic experience, experience of meaning and emotional experience (2007). The *aesthetic level* is the user's sensory perception of the object, while the *experience of meaning*

refers to the process of assessing the personal or symbolic significance of products through many cognitive processes (Hekkert, 2006). Finally, the product experience also leads to *emotional* responses such as love, hate and frustration.

Crilly, Moultrie and Clarkson (2004) explain the consumer response to the visual appearance of products in their article 'Seeing things: consumer response to the visual domain in product design.' They define cognitive response as 'the judgements that the user or consumer has about the product based on the information perceived by the senses.' (2004, p. 552). There are three cognitive response categories: aesthetic impression, semantic interpretation and symbolic association. Aesthetic impression refers to the sensation that is the outcome of the perceiving an object as attractive or unattractive (Crilly et al., 2004), whereas semantic interpretation refers to cognitive responses about product affordances. It can be defined as the practical aspects of a product and what it tells to the user about itself, its features and how it is used. Lastly, symbolic association refers to what a product symbolises to its owner or user and what it symbolises about its cultural context of use, such as status and power. Symbolic associations are culturally defined as the personal or social significance of products. For example, the experience of luxury is a social significance and it refers to a comfortable and sumptuous lifestyle, while the product attachment corresponds to the personal significance that occurs when products have profound emotional meaning for us. As an example of product attachment, Chapman (2009), indicated that products could be designed to sustain the attachment between users and products by providing the user with an evolving experience that allows the development of empathic relationships with objects.

2.16. Motivation

Many theories exist that aim to understand the concept of motivation. The main point in the majority of these theories is that people have limited energy that must be directed towards certain goals (Hirschman, 1983). According to educational psychologist Johnmarshall Reeve (2008), motivation refers to 'the processes that give behaviour its energy and direction' (p.8). Based on this definition of motivation, this thesis has explored the different ways that energise and direct people's behaviour towards repairing products. In this context, energy concerns the strength of the behaviour, and direction implies that the behaviour has a purpose (Reeve, 2008).

Psychological factors that affect motivation and desire have been studied widely to understand consumer behaviour, and knowledge acquired from this research is widely used in the marketing sector. The insights gained are valuable for this field to identify the needs of consumers, as they are used to provide appealing products and advertising. Deep feelings, such as needs, passions and wants, are studied to understand consumer motivation.

Early studies of motivation in the field of psychology were based on biological-psychological analysis (Reeve, 2008). These studies claimed that motivation was driven by instinct, and innate behaviour related to biological and learned needs (Solomon, Bamossy, Askegaard, & Hogg, 1999/2006). According to this theory, it is suggested that the consumer who purchases products because of his or her desire to attain a certain type of lifestyle has this

urge as an instinct. This theory is no longer credited, as it is not possible to test the existence of instinct (Solomon et al., 1999/2006).

The second theory to address motivation was known as the 'drive theory'. It explains motivation as a result of biological needs that creates an unpleasant state (Solomon et al., 1999/2006). According to this theory, human behaviour is governed by the desire to reduce tension, eliminate this unpleasant state, and return to a balanced one. If a person's consumption needs are not satisfied, he or she may be angry or sad and want to reduce these feelings. Drive theory has limited scope (Reeve, 2008), because people often do things that enhance the tension rather than reducing it. This theory cannot explain some human behaviour, such as when people act in a way which contradicts their biological needs (Solomon et al., 1999/2006). The field of psychology then adopted a new understanding of human beings in motivation studies as active agents, replacing the earlier, passive view of human nature (Reeve, 2008). Studies now focus on cognitive factors rather than biological needs to explain motivation: this is known as 'expectancy theory' (Solomon et al., 1999/2006).

2.16.1. Intrinsic and extrinsic motivation

Intrinsic and extrinsic motivation are two different types of motivation, first described by White (1959) and further developed by Ryan and Deci (2000). Intrinsic motivation is the tendency which occurs naturally, such as interest and curiosity (Ryan & Deci, 2000). Extrinsic motivation refers to behaviour that is driven by external factors, such as rewards or avoiding negative results (Ryan & Deci, 2000). 'Self-determination theory' is a framework that studies human motivation (Ryan & Deci, 2000). It also explores how social and cultural conditions affect human motivation. This theory argues that individuals have needs, including autonomy, competence and relatedness, to achieve intrinsic motivation. Autonomy concerns making a choice and acting according to one's own decision (Ryan & Deci, 2008). Competence refers to the capability of achieving desired outcomes and relatedness is the need to establish reliance on others (Ryan & Deci, 2008). The social and cultural conditions supporting these needs foster internalisation and construct intrinsic motivation, whereas when any of these three psychological needs is thwarted there will be an opposite impact on human natural inclination (Ryan & Deci, 2008). For example, factors such as positive feedback, rewards and compliments enhance the feeling of competence and foster intrinsic motivation. However, an individual experience of only the feeling of competence cannot increase intrinsic motivation by itself. There should also be the feeling of autonomy and relatedness: Deci and Ryan (2008) demonstrated that these three needs should be fulfilled to achieve intrinsic motivation.

In the case of this research, self-repair was encouraged, as it allows the feeling of autonomy. Competence is also a significant factor for this thesis, based on both self-determination theory and Fogg's behaviour model (see Section 2.16.2). This study focused on starting with simple repairs – in other words, low skill-level repair work that aims to enhance the feeling of competence so that people can eventually improve their skills through practice.

This thesis aims to explore different ways of encouraging people to repair products by using a design-led methodology. Associating design with human motivation, Bisset (2011a)

explored the role of design in motivating and engaging human behaviour and the potential of intrinsically motivating design for changing human behaviour through the design of services and products. Bisset (2011b) sees motivation as a 'dynamic and malleable entity', and the role of the designer in the process of achieving intrinsic motivation, and he visualised this as like a sports coach or a film director supporting an athlete or an actor and controlling their performance (p. 304). He developed six personas, engaging different levels of motivation, from amotivated to intrinsically motivated (Bisset, 2011b).

2.16.2. Fogg's Behaviour Model

Fogg (2009) presented a model, known as Fogg's Behaviour Model, to understand human behaviour and the factors underlying behaviour change. In this model, he identifies motivation, ability and triggers as the three factors which form behaviour. In other words, a person should be motivated, have the ability to perform the behaviour and have a trigger. A trigger can be a reminder, a sign which tells people to perform the target behaviour at a certain time. This psychological model can also be used to control or change the behaviour by controlling these three factors. In order to do that, first a behaviour target is selected. It is important to target a simple behaviour to increase the possibility of success. Secondly, after selecting the target behaviour, what is preventing it must be identified. Thirdly, the barriers should be removed. Fogg says that one should target simple behaviour and start with small steps in order to be successful with behaviour change, and then grow in time. The barriers should be investigated and determined as to whether this is lack of motivation, lack of ability or lack of a trigger. In the case of this thesis, I chose the target behaviour as repairing products when they are broken rather than throwing them away. When a thing breaks, some people inherently think about ways to bring it to its original state. However, they do not or cannot usually repair it, because of the lack of motivation and lack of ability. In my research, I recruited people who have the trigger to repair products, in other words, people who want to repair products. The trigger was thus not identified as a barrier.

Fogg and Hrena (2010) presented a method for identifying different types of target behaviours, called The Behaviour Wizard, and proposed solutions to achieve those behaviours. They also developed the Fogg Behavior Grid, in Figure 29, which includes fifteen types of behaviour targets. Encouraging people to repair products corresponds to the Green Path type of behaviour change. Green Path represents a long-term commitment to a new behaviour, such as starting to grow one's own vegetables or leading a vegan lifestyle. This type of target behaviour brings a life change and it is not easy to achieve. Thus, Fogg and Hrena (2010) identified two significant challenges in this change process: commitment and fulfilment. Commitment refers to the willingness to spend time and energy for something and do it for a long time, and fulfilment signifies achieving the target behaviour. Fogg provides the solution to achieving Green Path behaviour as increasing the motivation and ability level by simplifying the behaviour.

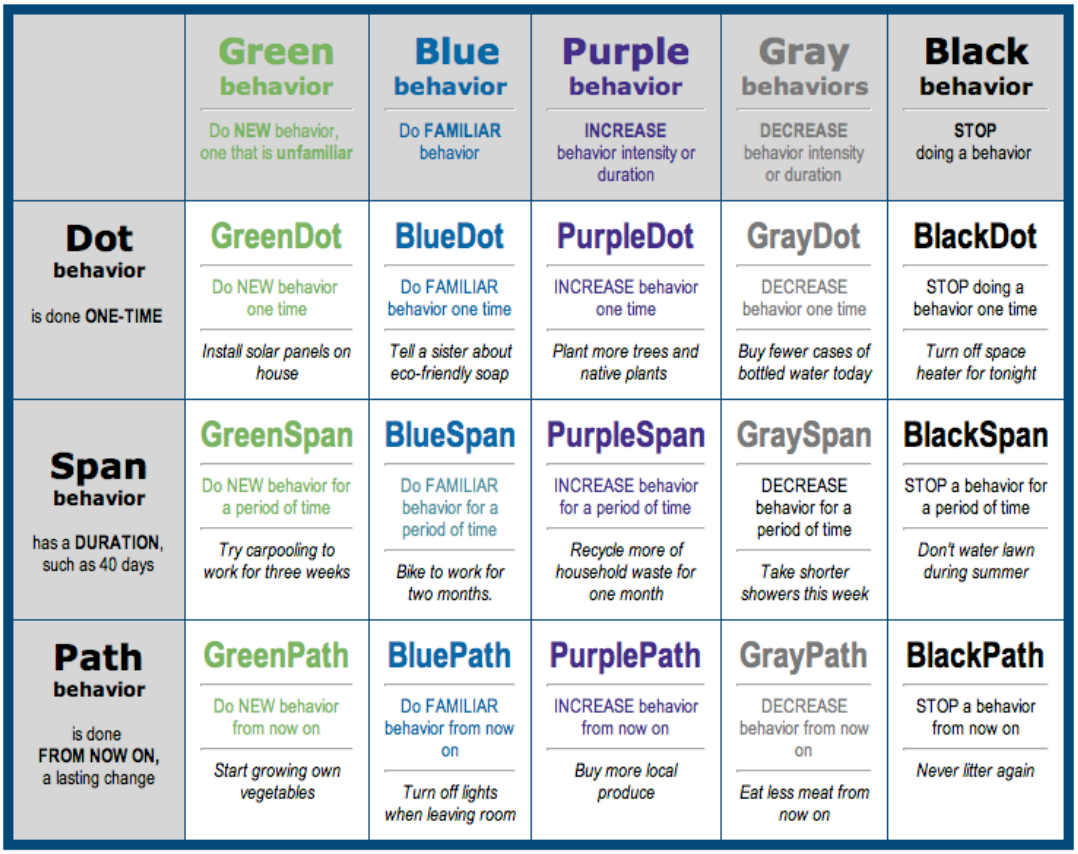


Figure 29. The Fogg Behavior Grid describes 15 ways behaviour can change, including sample behaviours (Behaviour Wizard Team, 2014)

Bisset and Lockton state that services and products should be designed by considering users' different levels of motivation and in a way that supports their sense of autonomy for the behaviour change to be successful and sustainable (Bisset & Lockton, 2010). Lockton (2013), in his doctoral thesis, developed an approach that helps designers visualise the different models of users easily and understand their various needs and wants. This approach models users as 'Pinballs', 'Shortcuts' and 'Thoughtful Users', and provides different ways of influencing people's behaviour. Pinball users are assumed to be the simple components of the system who do not think about their actions (Lockton, 2013). This view creates fast but unsustainable behaviour change, as users are not aware of the main reasons for their action (Lockton, 2013). The problem with considering users as pinballs is that it thwarts people's sense of autonomy and can cause poor user experience (Bisset & Lockton, 2010). Shortcut Users are assumed to get things done in the easiest way possible, and their actions are based on 'intuitive judgements' (Lockton, 2013, p.149). This view is based on the fact that people's irrational and heuristic behaviour occurs in patterns, and 'the basic example of this is that people take shortcuts' (Lockton, 2013, p.149). Thoughtful Users are considered as mindful of their behaviour (Lockton, 2013). They internalise the values related to the target behaviour and are aware of the main reasons behind it. Although enabling the internalisation of the values behind the target behaviour by the user is a challenging task in behaviour change, it is

crucial for sustained motivation (Bisset & Lockton, 2010). Lockton (2013) suggests that thoughtful users can be motivated by providing information and feedback. In the case of this PhD, the participants were assumed to be Thoughtful Users, but at the same time I also considered the other models, as people may show different levels of motivation.

2.17. The Gap in Knowledge

Governmental organisations, business representatives and researchers propose various approaches to overcome growing environmental problems and encourage businesses to produce long-lasting, circular, purposeful products (IPCC, 2014; WBCSD, 2016; Ellen MacArthur Foundation, 2013; McDonough & Braungart, 2002; Fletcher, 2008; Bakker et al., 2014a; Cooper, 2013; DEFRA, 2011). It may be helpful and desirable for commodities to be designed for closed loops and in such a way that they can be repaired, but consumers need to have the desire, knowledge and skills to repair and maintain these goods once they are in the system (Middleton, 2012; Brook 2012; Lilley, 2007). In order to enable the transition towards a circular economy, all aspects of the system – environmental, social and economic – should be considered together as a whole, with the interaction between these aspects (Preston, 2012; Bakker et al., 2014a; Shah, 2014; Ghisellini et al., 2016). Significantly, an increase in a user's awareness and responsibility as well as the producer's awareness and responsibility is crucial to the success of this transition (Ghisellini et al., 2016). Circular economy relies on users to be active participants in reuse, recycling or return of products, this is the opposite version of the passive, throwaway society of current linear system (Shah, 2014). Although both producers' and consumers' roles and responsibility are crucial for the change, existing research in the field has mainly studied the economic and business aspects of the problem and excluded social issues and consumer participation.

Although they are not common, high-quality, long-lasting, repairable products are available, as well as repair services and repair organisations. However, environmental and social gains may not be strong enough to motivate people to use their products longer, compared to individual desires to buy new ones, as the current hegemonic ideology values and emphasises what is new and despises what is old and damaged. Today's 'passive consumers' of the linear economy are expected to become 'active users' of the circular economy, yet there is not much research exploring this change. Research on design needs to be oriented towards understanding the implications of the circular economy on the users' side, particularly the effects of the transition from selling products to selling services and to leasing, repair, reuse and remanufacturing (Ghisellini et al., 2016; Bakker et al., 2014b). The transition from 'passive consumers' to 'active users' requires a change in user behaviour, a different way of thinking about products and eventually a transformation of the value system relating to products. Additionally, recent research suggests self-production (e.g. users' reusing, repairing, repurposing and appropriating products by themselves) as an opportunity to foster positive environmental and social change through extending the product lifespan (Salvia & Cooper, 2016).

People do not throw away products because they are broken, they do so because their relationship with products has malfunctioned (Cooper, 2013; Chapman, 2005). So how can

we fix people's problematic relationship with products and enable them to see the value of the things that already exist? Valuation is a continuous process evolving throughout the object's lifespan. My aim is to design a service or system to encourage users to repair products more often because repair is an important field of activity and knowledge through which values are maintained and transformed, and new values are elicited (Jackson, 2014; Houston et al., 2016). Houston et al. (2016) further explain, 'At the same time, repair can change its human participants, transforming "mere users" into something slightly more, better versed and engaged with the object worlds around them'(p. 2). Therefore, this research aims to bring a new consciousness to the relationship between people and objects through repair that enables them to see the value of things that already exist.

The current problematic situation and circular economy thinking are complicated for laypeople to relate to. However, repair brings this major social problem down to a human level. It is the inner loop in a circular system where they can participate actively, and it is where we can shift consumer thinking and behaviour.

Few examples of materials and methods such as kintsugi (see Section 4.3.1.4) and Sugru (see Section 4.3.1.6) exist that improve the value of damaged products. Both examples suggest a different aesthetic understanding of repaired objects. By investigating the conventional repair methods and new technologies, and testing them with users, this research aims to identify other possibilities that challenge the stigma attached to repair and provide concrete examples.

The literature review highlights the lack of research into ways of encouraging people to repair products. As I described in section 2.14, the majority of research that study repair is sustainable design practices and studies that aim to inform HCI scholarship. These studies did not explore repair methods or motivations and barriers in relation to repair. However, there are two papers that explore user barriers in relation to clothing repair. Gwilt (2014) investigates the community-based approaches aiming to revive the clothing mending practices. She examines online and offline activities to enable knowledge exchange and build communities. Rather than having one focus this paper discusses many subjects related to clothing repair including the methods that would revive the community-based approaches to clothing repair, potential roles of online and offline activities, what people do with damaged clothes, repair barriers. She identifies one barrier to clothing repair namely 'lack of skills' (Gwilt, 2014). Finally, the author claims that a larger study is needed to investigate the ways to encourage people to engage in repairing (Gwilt, 2014, p.5). Similarly, McLaren and McLauchlan (2015) focuses on clothing repair and investigate the barriers to mending and suggest solutions. This paper presents a detailed and clear historical review of clothing repair. It provides a more detailed investigation in relation to clothing repair barriers compared to Gwilt's paper (2014). The barriers they identified are financial cost, lack of time and skills, negative stigma attached to repaired clothes and psychological barriers which refer to the psychological effects of the availability of endless cheap products on users (McLaren & McLauchlan, 2015). To conclude and make the gaps in knowledge more clear, these two studies only focus on clothing repair. The barriers they identified are limited. They are not focused on motivations which people experience in relation to product repair.

Therefore, two important gaps are identified throughout the literature review: 1) I have not come across to research that studies different repair methods to create a new aesthetic language around repair; 2) few and limited research exists that explores the motivations and barriers which people experience in relation to product repair.

This section has identified a gap in the research relating to the circular economy and repair. The next chapter will outline the methodology of this research that is best suited to achieve its aims and to meet this gap in knowledge.

CHAPTER 3

METHODOLOGY

3.1 Epistemology and Theoretical Perspectives

Crotty uses the terms 'epistemologies' and 'ontologies' (1998), while others have called it 'worldview' (Guba, 1990) and 'paradigms' (Mertens, 2010). 'Epistemological stance' refers to the theory of knowledge that the researcher employs in a study (Creswell, 2013). Crotty identified three major epistemological stances: objectivism, constructionism, and subjectivism (1998). The theoretical perspective is the philosophical position of the researcher about the nature of the research which informs the methodology. An approach that uses mainly constructivist research methodology (Crotty, 1998), together with a phenomenological perspective (Giorgi, 2009; Moustakas, 1994), was considered most appropriate for this research.

3.1.1 Constructivism

According to the constructivist stance, truth and meaning do not exist in the external world: they are not discovered – rather, subjects construct their own meaning through interactions in the world (Gray, 2013). Human beings can construct different meanings, even with the same phenomenon (Gray, 2013). The constructivist stance is a typical approach to qualitative research (Creswell, 2013). The researcher aims to understand meanings others have about the world (Creswell, 2013) through inquiries. From the point of view of this thesis, the constructivist stance dominates the methods and methodology employed, since my main intent was to make sense of and interpret how people understand and experience the repair process, in order to find the ways of encouraging them to repair their products. The subjectivist stance might also be apparent during the design studies (Section 4.3), but the objective was still the same in this section. As discussed in Section 4.3, I aimed to study the repair experience intuitively and understand my own experience before exploring other people's experience and analysing the data received from them. Researchers who employ a constructivist stance develop a theory or pattern of meaning intuitively rather than generalising and narrowing the data. It is important to include the complexity of perspectives that individuals construct.

3.1.2 Phenomenological Research, Materiality and Existential Engagement with a Product

As Sokolowski (2000) states, 'Phenomenology is the study of human experience and of the ways things present themselves to us in and through such experience' (p. 2). Phenomenology is a disciplinary field in philosophy. It is directly related to design as it studies the ways we

experience things and the meaning things have in our experience (Gallagher, 2013). Based on Gallagher 's work (2013), I identified a phenomenological method as the best means for this PhD because the preliminary focus of this research is to gather data regarding the perspectives of people about the phenomenon of product repair and ways that encourage people to repair products in order to create deeper relationships with things. In the course of this PhD, I have needed to perceive these phenomena intuitively, without preconceived ideas, and consequently reflect on my experience and interpret these phenomena through insight gained from participants.

Husserl is considered to be the founder of twentieth-century phenomenology, with influence extending to thinkers such as Martin Heidegger, Jean-Paul Sartre, and Maurice Merleau-Ponty (Smith & Thomasson, 2010). In Husserl's view the central structure of an experience is its intentionality, its being directed at something or being about something (Smith & McIntyre, 1982). 'Noesis' and 'the noema' constitute the two aspects of the intentional structure of experience. Noesis refers to mental acts such as judgement, memory and desire, whereas the noema is the 'something' as it appears to the consciousness (Gallagher, 2013). Heidegger approaches from a different angle to that of phenomenology (Gallagher, 2013). He states that the aim of phenomenology is to make an ontological analysis of our 'being in the world' (Heidegger, 1996). 'Dasein' refers to being in the world, and human beings' existence is different from that of non-human beings. Dasein discovers itself in specific possibilities and in interacting with others in an intersubjective way. This is a part of their existential nature. Heidegger argues that the way we exist involves being related to our environment, not detachedly observing it (Gallagher, 2013). He asserts that we see things in terms of their relevance to our pragmatic use (1996). However, we do not look at the object to observe. We tend to pick up and experience it. From this perspective the things around us appear as 'ready to hand' (Zuhanden), and Heidegger uses a hammer as an example of this idea (1996). A hammer is not something that a carpenter theorises about or thinks about. It is something that he picks up and uses. And when he does that, the hammer becomes experientially transparent and barely noticeable. It dissolves into the carpenter's project. Thus it is regarded as a tool, instrument or a piece of equipment that supports a project or act. However, when the hammer breaks, or is badly designed, it is experienced in a different way, which is known as 'present at hand' (Vorhanden). It becomes something that is noticed and theorised about. It turns into a problem that prevents one from pursuing an action or aim. Repair becomes significant between the breakage and restoration. It bridges the two realities – the visible tool and the concealed tool – and also demonstrates to us the power of things (Graham & Thrift, 2007).

3.1.3 The Structure of the Phenomenological Research

This part includes an explanation of phenomenology as a research method. The specific phenomenon that this research focused on is the relationship between user and product, which encapsulates the rich, subjective and diverse aspects of human experience. Phenomenology helps to explain the dynamic character of human experience (Gallagher, 2013). Each repair activity is unique and spontaneous in nature. I explored the dynamic

character of repair and subjectivity with the help of phenomenology. This part explores the structure of the phenomenological research, including the stages and main concepts central to this method.

Epoche:

Epoche is the first stage of the phenomenological study. The researcher should become free from their own assumptions when reporting life experiences. Here the primary source of knowledge is researcher's own perception: things cannot be known before internal reflection (Moustakas, 1994).

Phenomenological Reduction (Bracketing):

This stage involves describing exactly what you see and experience, focusing on the relationship between the phenomenon and the self. The researcher must bracket his/her own preconceptions and use self as an experiencing interpreter (Miller & Crabtree 1992). I used field notes (memo-ing) (Miles & Huberman, 1984) as a data source during practice work and workshops. This process includes taking notes on what I experience, including what I hear and see during the research process and reflecting on what is happening without judgmental evaluation. Validity is obtained by re-examining the notes a number of times, avoiding preconceptions and considering different perspectives. Truth depends on pure perception in this method.

In the case of this research, field notes and phenomenological reduction were used to collect data for the purpose of answering the research question. Since 2013 I had been taking notes about my supervision meetings, the articles I read, perceptions and reflections. These notes were recorded in four personal notebooks (Figure 30). Photographs of objects were taken before each repair was carried out and included in the field notes. Field notes helped me collect and organise data and remember every process without missing the details.

Figure 30. I had been taking notes about my supervision meetings, the articles I read, perceptions and reflections in four personal notebooks.

Explicitation of Data

The term 'explicitation' is more appropriate to use in this research method than analysis: this is because analysis implies the systematic process of identifying the essential features and relationships of a phenomenon (Coffey & Atkinson, 1996), whereas explicitation is the elucidation of components of a phenomenon as a whole (Hycner, 1999).

Imaginative Variation

This is the phase of explicating frames of reference and perspectives, including polarities and reversals (Hycner, 1999). The units of meaning are clustered to create structured themes (Moustakas, 1994). Although units of meaning are grouped together, it is crucial for this research method to identify the significant parts, which are called units of significance.

Synthesis

Synthesis is the summary of the research that includes all the themes and individual variations that have been created. This phase is the reconstruction of the essence of the experience of the subject (Hycner, 1999). This part also includes a validity check, returning to the data and checking whether the essence of the research has been correctly derived.

A validity check provides the truth value of this qualitative research method, together with the bracketing stage. Throughout the research, I bracketed myself consciously in order to perceive the experience that I was studying. Then I compared this perception with the final essence of the process. The video recordings and bracketing myself during the transcription of the workshops further contributed to the reliability of this research.

3.2 PhD by Practice and Links between the Textual and Practical Components of this PhD

The terms 'research through design' or 'practice-based research in design' are used in various academic discourses to describe an inquiry process through making and designing a product, service, or system (Durrant, Vines, Wallace, & Yee, 2015). Although the term holds different meanings in different contexts (Rust, 2007), it refers to using the making and designing process as a knowledge-generating activity.

Debates in design research about how knowledge can be created through design paved the way for the development of this approach as a design method. Nigel Cross was one of the pioneers exploring the relationship between design and science (Durrant et al., 2015). He argued that designers must concentrate on forms of knowledge particular to designers, noting the emergence of 'designerly ways of knowing' (Cross, 2001). Christopher Frayling (1993) further advanced the discourse on design research and developed three different approaches, including research into (art and) design, research for (art and) design and research through (art and) design. 'Research into design' refers to understanding the activity of design while 'research for design' aims to improve design practice (Frayling, 1993). Finally, 'research through design' focuses on the process of designing artefacts. Much of the work undertaken for this PhD can be identified as 'research through design'. However, research *for*

design is also a possible description for some parts of this PhD, as this research is valuable in improving design practice.

The design approach, which is the core of the creative process of a designer, was used to explore the ways we can encourage people to repair products in order to have deeper relationships with things. The question is explored throughout the three studies: design and research evolved simultaneously by informing each other and resulted in the creation of new knowledge. In other words, research generated the knowledge to feed the design and design created the means to achieve the research goals. Insights into how people experience repair, including their motivations and barriers, were produced by the research. Accordingly, design ideas were developed in the light of these insights. During the design studies, I experienced the repair process from different angles and used my ability to reflect and create emphasis to develop various design ideas. Key to the design process was the workshops study, because the design ideas and all the data generated became meaningful after testing them with the participants during workshops.

3.3 Research Methods

This section describes the three main data collection methods used in this thesis: cultural probes, design studies (research through design) and workshops.

3.3.1 Cultural Probes

Cultural probes is an exploratory research method designed to inspire people to respond to designers in creative ways (Gaver, Dunne, & Pacenti, 1999). This method involves developing a probes kit, which can be seen as a physical metaphor of the question asked, and a tool for participants to reflect their answers (Wallace, McCarthy, Wright, & Olivier, 2013). The probes approach is applied in this research to explore participants' motivations and barriers and to inspire them to reflect on and report their experiences and concerns about repaired and broken products. I have considered using techniques such as collages, asking open-ended questions and voice recording, by means of items such as postcards, cameras, journals and diaries. Finally, I decided to ask participants to tell me stories of products in their homes that were broken or repaired, and to take photographs of them.

Advantages and limitations of cultural probes as a research method

As an exploratory research method, cultural probes was applied in the early phase of this research, and it enabled me to broadly map the participants' motivations and barriers in relation to product repair. I designed a booklet for the cultural probes kit, which includes open-ended questions. I asked participants to take photographs of broken and repaired products and answer questions about why they have or have not repaired the product. The kit stayed with the participant for up to a month in this research, allowing people to thoughtfully consider and answer the questions.

Cultural probes is a flexible and open-ended method. Thus it can be designed in various ways, according to the research question and the characteristics of participants, in order to

get the best results. For example Gaver et al. created a cultural probes kit to identify the views of elderly people in a study looking at interaction techniques to increase their presence in local communities (1999). Their kit included various items such as postcards, maps, a photo album, a media diary and a disposable camera for the purpose of learning about participants' everyday life. Mapping activity is an interesting technique which has been used to explore elderly people's attitudes towards their environment. In this activity, researchers asked the participants to mark the places where they meet with others, the places they dream of going but cannot. This example shows that rather than creating a list of facts about participants, cultural probes enable us to understand their stories and find out about their everyday life (Martin & Hanington, 2012)

Another limitation is that the results might be impossible to analyse or even interpret, as they could be unclear, incomplete or biased. Although it might be very hard to grasp participants' responses, these nebulous qualities are valuable for design and differentiate the cultural probes approach from other traditional research methods (Gaver, Boucher, Pennington, & Walker, 2004).

3.3.2 Research Through Design (Design Studies)

'Research Through Design' starts by determining the problematic situation and verifying that it requires a design inquiry rather than an engineering approach (Frayling, 1993). Then the researcher explains the characteristics of the project that makes the 'research through design' method the most effective approach for the project. The results of this method take the form of artefacts, design theories, conceptual frameworks, new research methods and so on (Frayling, 1993).

I identified the problematic relationship between users and products throughout the literature review (Section 2.14) and concluded that besides using natural resources and filling the earth with waste, badly designed, low-quality products which shape our world also negatively affect our value system, including the way we value products.

Things cannot be known before internal reflection has taken place (Moustakas, 1994). The aim of the practice is not to design products or analyse the making process to develop frameworks: the practice in the case of this research focuses on the making process in the form of visible repair, and explores the ways in which we can encourage people to repair products in order to have deeper relationships with products and raise awareness about environmental problems.

3.5.2.1 Advantages and limitations of research through design as a research method

The problematic situation determined in the context of this thesis can be most effectively explored with a systematic design inquiry because of four characteristics of this research. Traditional research is usually concerned with understanding the world as it is, but designer-researchers attempt to change it. In Frayling's words, 'Where artists, craftspeople and designers are concerned, the word 'research' - the r word - sometimes seems to describe an activity which is a long way away from their respective practices. The spoken emphasis tends

to be put on the first syllable -the re- as if research always involves going over old territory, while art, craft and design are of course concerned with the new.' (1993, p. 1). First, together with other consumption strategies, the product design profession has played a significant part in the development and expansion of the problematic situation which is the subject of this research. Therefore, as design is a part of this problem, we need an environmentally conscious design inquiry that takes into account the nature of human behaviour to overcome this problematic situation and accelerate the transition to a circular economy. Second, the problematic situation that this research addresses is between users and products. It is the subject of design discourse, and cannot be studied effectively other than through a design inquiry. Third, the way to encourage people to repair more products can only be studied effectively through practice. Finally, providing people with inspiring tangible artefacts is an effective strategy to encourage them to repair products. This can only be done through practice.

'Research through design' methods requires time and effort, as the researcher is the main creative agent embedded in the process. The researcher is in the middle of a knowledge network that is informed by literature, the ongoing research and practice. This process is completely different from doing research and compiling a list of results, as the researcher should thoroughly understand, internalise and finally synthesise the raw data to create new knowledge.

3.3.3 Workshops

Workshops are a type of participatory design technique created for a certain number of participants, and which includes several activities such as collage, mapping and sketching, for the purpose of understanding the user's world (Martin & Hanington, 2012).

This method can be used for design exploration such as generating ideas, testing a product or an idea. Co-design exercises are also common and useful in workshops to collect data about the user's world, needs and wants. The number of facilitators should be determined according to the participants and the workshop structure (Laurel, 2003). A workshop may start with an introductory presentation to explain the process and reason for conducting the workshop. As workshops include intense creative activity, the workshop structure should be carefully planned and required materials should be prepared before the workshop in order to successfully reach the research objectives. Video recorders, cameras and voice recorders can be used to document the process.

Advantages and limitations of workshops as a research method

Workshops are efficient and enjoyable ways to gain data from participants, which provides a wealth of insights (Martin & Hanington, 2012). Involving multiple participants particularly enhances the potential diversity of perspectives and ideas generated (Lockton, 2013), which affects the quality of the data.

The workshops as a research method facilitates the environment that enables the researcher to observe the participants' experience and collect the data on the spot, rather than expecting them to remember and reflect on their previous experiences.

The main difficulty of this method is that it is labour intensive to organise and run, but the results were worthwhile. It is critical to plan the process, gather necessary materials and set the scene before the workshop. Timing is another significant issue: workshops should stay on track with the plan in order to meet the goals successfully.

3.3.4 Affinity Diagrams

The affinity diagrams approach is a bottom-up research method which is used to draw out common themes from a large amount of information (Martin & Hanington, 2012). It is an effective method for designers: previously unseen connections can be uncovered, which allow a design direction to be established (Moggridge & Atkinson, 2007). Additionally, this method provides 'a focus as a whole' to the design team while they are working on complex problems (Beyer & Holtzblatt, 1998). In this method, observations, insights or requirements acquired from the data are put on sticky notes, and these notes are put on a wall or a large paper. They are clustered into meaningful categories which form themes based on the data. This allows the researcher to make meaningful connections and identify the problems. The affinity diagrams method is useful in revealing the scope of the problem and making connections between diverse subjects, as different data can be analysed together to reveal commonalities while retaining individual characteristics (Beyer & Holtzblatt, 1998).

3.4 Participant Selection

When choosing the sampling method, the question that the researcher aims to answer is of the utmost importance, as it defines the basis of the methodology. The researcher first decides whether to study the entire population or to choose a sample population efficiently. As the research question of this PhD investigates ways of encouraging people to repair products more frequently, the participants are selected from the group of people who are interested in repair, and want to repair products. The purpose of this is to identify their motivations and the barriers to repair activity which are the building blocks of this research. The people who are not interested in repair and who do not see the advantages of this activity are not included. I decided to sample the population and concluded that purposive sampling is the most suitable tool for the study. Purposive sampling is a non-random technique for choosing participants with certain characteristics deliberately (Robson, 1993). The researcher considers what needs to be known, according to the research questions. Then s/he determines what the characteristics of the population for this activity in terms of specific qualities. Finally, the researcher finds people who can, and are willing to, provide related data (Bernard, 2011).

Participant recruitment involved two stages in this study: defining an appropriate study population, and identifying strategies for recruiting participants from this study population. Professional repair technicians are not included as participants in this research. The participants in this research are users who are interested in product repair activity. They were

recruited for two research studies, the first being the cultural probes study (Section 4.2) and the second the workshops (Section 4.4).

For the cultural probes study the participants were mainly found from repair parties which were held in London. Additionally, advertisements were hosted on websites in order to reach a wider range of people. The websites I used were callforparticipants.com, twitter.com and facebook.com.

I put up posters and placed advertisements on various websites to recruit participants for workshops. The posters included information about the aim of the workshops and the workshop schedule. They were posted around my college and neighbourhood, and were also put on websites, including callforparticipants.com, twitter.com and facebook.com. I accepted all the participants who were willing to attend workshops because none of them were professional repair technicians. The people who asked to attend the workshops were people who wanted to repair products. This sampling method might be regarded as random sampling. However, it can be best described as purposive sampling because the recruitment strategy attracted people with certain qualities who had some level of interest in repairing things.

No limit exists on participant numbers in purposive sampling, as long as the researcher realises the data to answer the research question (Bernard, 2002). It is crucial to decide on the correct sample size to decrease the bias and allow for variation for relevant results. Fifty people were recruited for the cultural probes study and thirty-two of them completed and sent the cultural probes kit back. The sample population was sixty per cent female and fourty per cent male and was between the ages of twenty and fifty-seven. The participants included people with various occupations, such as designers, university students, electrical engineers and teachers.

For the workshops fifty-two people were recruited. Workshop participants were between the ages of eight and sixty-six, with a range of different occupations, including university students, designers, and retired teachers. The sample population was fifty-four per cent female and fourty-six per cent male participants. To conclude, participants were from diverse age groups and occupations who represented potential users of the repair kits. They provided the relevant and necessary data for the development of this research.

3.5 Validity and Reliability

Validity and reliability are both used as measures of the research quality of qualitative and quantitative research. Validity refers to how well an assessment tool measures the intended proposition under study, while reliability is concerned with how consistent the assessment is, and the degree to which an assessment tool produces stable and accurate results over time (Fusch & Ness, 2015). In a phenomenological approach, validity and reliability are established differently from the way these are in quantitative research. Phenomenology aims to describe the human experience as it is. This aim is based on the guiding term of phenomenology, 'back to things themselves' (Husserl 2001/1970, p. 252). Giorgi (1988) proposes two strategies to establish validity and reliability in phenomenological studies, namely bracketing

and intuiting. He defines bracketing as setting aside one's own presuppositions about the phenomenon studied. Bracketing, in the case of this research, was accomplished through field notes that were written throughout the design studies and workshops, reflecting on what was happening without judgmental evaluation. Notes regarding presuppositions and assumptions were eliminated by re-reading and considering the data several times. Besides achieving bracketing, the notes were useful in recording the data and increasing the quality of the results. Intuiting refers to studying the phenomenon carefully and capturing logical insights, and only accepting what is found, rather than relying on preconceived ideas or interpretation (Giorgi, 1988). Intuiting is critical to understanding the meanings in the phenomenological study and can only be achieved through bracketing (Giorgi, 1988).

Aiming to include diverse perspectives and improving the quality of the research, the continuous process of imagining variations (Moustakas, 1994) of the motivations for, and barriers to, repair activity took place during design studies and workshops. With the help of this process, the polarities and reversals are included in the categories during the explication of data. Additionally, throughout the workshops the aspects that were considered essential were recorded, which helped to validate the quality of the inquiry.

Another important factor in terms of establishing validity is to reach data saturation. In their article 'Are we there yet? Data saturation in qualitative research', Fush & Ness (2015) explain the point at which data saturation is achieved in the case of a phenomenological study. Creating the state of epoche, the first stage of the phenomenological study, in which the researcher becomes free from suppositions, is crucial in the search for data saturation (Fush & Ness, 2015). Reaching the aim of the study is also a significant factor for arriving at data saturation (Fush & Ness, 2015). Although there are no established rules for reaching data saturation (Giorgi, 1988), some general principles exist that inform the researchers in this quest. The point of reaching data saturation is achieved when further data adds no new information to the research aim, and when there is enough information to replicate the study (Fush & Ness, 2015). Data saturation was achieved in this research when the data became repetitive, and did not necessarily add anything new to the aim of the PhD. In the last two workshops, no additional data can be found to develop new properties or categories.

3.6 Summary

This chapter has described the epistemological stance, theoretical perspective and research methodology adopted in this PhD. This thesis adopts a mainly constructivist stance, with a phenomenological perspective. The chapter continues by explaining what 'PhD by practice' means, and the links between the textual and practical components of this PhD. The knowledge generated through the research studies was used to inform the design, and the design studies helped to create the means of reaching the goals of this PhD. The research methods employed in this research are then presented, with their advantages and limitations. After explaining the participant selection process, this chapter concludes by explaining the validity and reliability of research. The next chapter presents the way in which the cultural probes, workshops and 'research through design' methods were applied in this thesis.

CHAPTER 4

RESEARCH

4.1. Introduction

This chapter introduces the three research studies, including cultural probes, design studies and workshops, which are the building blocks of this research. These studies are presented by explaining the aims, context, process, participant involvement and the results of each one. A paper, including parts of Section 4.2, was published as a part of my presentation at the Sustainable Innovation 2015 Conference.

4.2. Cultural Probes

The throughput-based linear economy has created a society where people are programmed to pursue an endless cycle of buying and disposing of products. This is expensive and inconvenient, and it is mostly impossible to get products repaired. However, there are people who still want to repair things despite the fact that many existing factors and strategies implicitly force them to buy new products. I wanted to explore these people's motivation, and also the barriers that they experience in relation to repair in the early stages of this research. This part presents the cultural probes method, including the development of the toolkit and the results of the research.

4.2.1. Development of the Cultural Probes Toolkit

'What do people repair?' and 'Why do people repair things?' were the initial questions in my mind before I decided to use the cultural probes method. It is not easy for people to express their motivations and barriers because these experiences have a multi-layered, complex structure. Simple tasks are thus required to prompt participants to think in a broad, lateral way and enable them to say what they want to say.

In this research, I wanted to identify the things that people repair, and also the things that they want to repair but cannot because of certain barriers. Thus, I asked the participants to take photos of their objects that were repaired and the broken things that they save to repair in the future. Taking photographs helps people to remember the experiences, to inspect the product and include the aspects that they usually do not reflect on. Additionally, the photos also help the researcher to access fragmentary clues about participants' thoughts and experiences. Clues about people's repair stories provide crucial knowledge for the future of this research in terms of understanding participants' motivations and the barriers that exist in relation to repair.

After taking the photos, I asked participants to explain in the booklet how the product was repaired and why they repaired it/got it repaired, and if it is a broken product I asked why they have not repaired it or got it repaired. The first design of the cultural probes kit involved question cards (Figure 31). Stickers with numbers were included to understand which answer belonged to which photograph (Figure 31). I decided to present the questions in a booklet instead of the cards to keep the questions and the answers orderly (Figure 32). Figure 33 shows the final, printed design of the booklets.

Figure 31. Cultural probes toolkit design process.

Figure 32. Cultural probes toolkit design process.

Figure 33. Cultural probes toolkit: final design.

Task 1

The first task aimed to acquire demographic information about the participants: their age, gender and occupation.

Task 2

For the second task, participants were asked to take photos of their broken and repaired objects and answer the questions for each object.

- How was it repaired?
- Why have you repaired it/had it repaired?
- Why have not you repaired it or had it repaired?

A camera was provided for the participants who did not have a camera or mobile phone. Taking photos helped people to remember the experiences, inspect the product, and include the aspects that they did not normally reflect on.

Task 3

In this task, participants were asked to return the kits in the self-addressed envelopes provided in the kit. I also asked the participants who were not sent a camera to email the photographs to the email address provided in the booklet. The rest of the photographs were received with the camera.

Participant selection strategies and the process of cultural probes research are explained in detail in Section 3.4. The participants were mainly recruited from the repair parties held in London. Advertisements were also put on websites, such as callforparticipants.com, twitter.com and facebook.com. In total, fifty people were recruited and the information about the research was provided to participants via e-mail; twenty-eight probes kits were mailed to participants' addresses and twenty-two of them were delivered by hand. Thirty-two of the probes kits were completed and received. Participants were between the ages of twenty and fifty-seven, sixty per cent female and forty per cent male. The probes kits contained one hundred and three objects in total; ninety-three of these were included in the analysis. Ten objects were not included because four of them were regarded not as repairs but temporary adjustments, such as putting a cardboard piece under the table, and six of them were building repairs such as painting the walls of a room. After receiving the kits, the photographs which had been sent by participants were printed and attached to the related booklets (Figure 34).

Figure 34. I printed the photographs which were sent by participants to attach to the related booklets.

Photographs of repaired and broken objects and participants' answers in relation to these objects were analysed. Insights were derived from these answers and each insight was put on an individual sticky note to evaluate each, both on its own and as a whole. I numbered each note because it was important to reference each note to the original data in case a question arose about it. As different product types are included in this research, I used different coloured sticky notes for each product type (Table 1). I put the notes on a sheet of paper and hung the paper on the wall in order to see all of the notes together and interpret them easily (Appendix A). The notes were divided into two different affinity diagrams because there were two types of questions in the cultural probes kit, referring to both motivations and barriers in relation to repair. The notes with similar content were grouped together, and finally the categories of motivation and barriers were developed.

Table 1. Colours of product categories.

	Furniture and Other Goods
	Consumer Electronics
	Electrical Household Appliances
	Textiles
	Glass and Ceramic Products
	Shoes and Leather Goods

Figure 35 and 36 illustrate two affinity diagrams corresponding to repaired and broken objects. Seven categories of consumer motivation and six categories of barriers were developed in regard to the affinity diagram clusters.

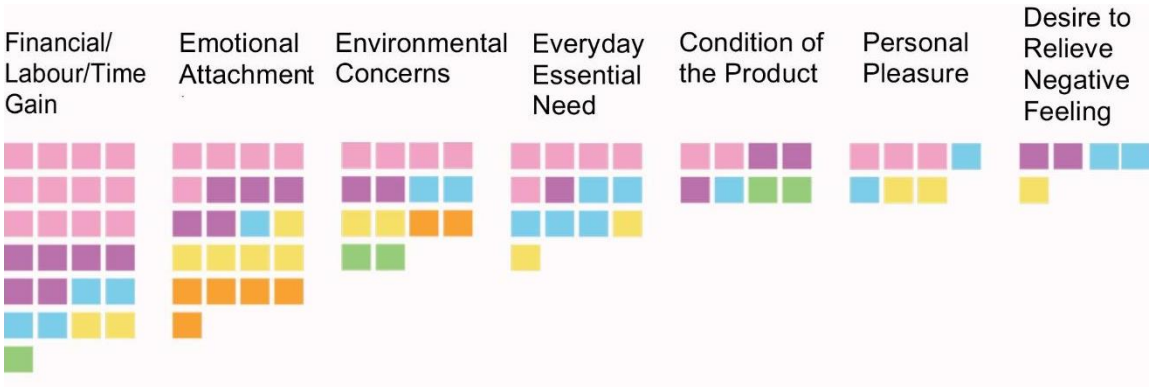


Figure 35. User motivation categories.

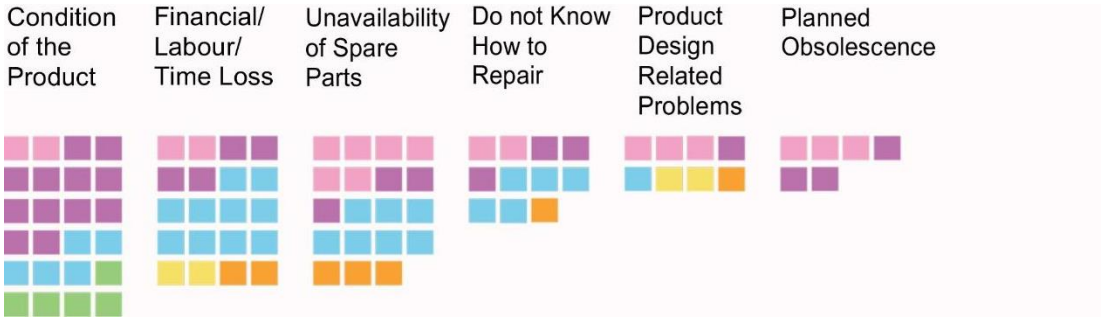


Figure 36. User barriers categories.

4.2.2. Categories of Motivation

1. Financial/Labour/Time Gain

Motivation derived from financial, time and labour gain arose as a result of the cost and benefit calculation that participants made while considering these three aspects. People might want to repair an expensive product even if the repair cost was high, depending on the cost of a new one. For example, Participant 19 had her espresso machine repaired because the cost of a new one was very high compared to the repair cost.

2. Emotional Attachment

Some participants said that they repaired their damaged products because of the emotional connection they feel to them. Users are emotionally attached to the product 'due to the service it provides, the information it contains, and the meaning it conveys.' (Chapman, 2009, p.33). This category includes products that have a special meaning for the user, such as gifts or products that have been used for a long time. For example, Participant 9 received her hairdryer as a gift nearly 30 years ago. She explained that she had it repaired when it stopped working because she loved the object, it was a gift and she had had it nearly for thirty years. (Figure 37). Similarly, Participant 2 repaired her earphones because they were a birthday gift and had emotional value (Figure 37).

Figure 37. Participant 9's hairdryer and participant 2's earphones.

3. Everyday/Essential Need

Everyday/essential need is the motivation category that refers to the desire to meet an urgent necessity. Boilers, beds, and cookers are some of the products without which users cannot fulfil their everyday essential needs. Thus, they might prefer to repair these kinds of

products immediately when they break. For example, Participant 13 called the repair technician to have her boiler fixed because she needed hot water urgently. The first category, financial/time and labour gain, is also an important factor in this case. Users might prefer the fastest solution in this case in order to get hot water. They might get the boiler fixed even if the repair is expensive but quicker.

4. Condition of the Product (New/Warranty)

Participants tended to get the products that were new and under warranty repaired. For example, Participant 6 said that he had his dishwasher repaired as it was under warranty and new. He contacted the technical service department about the problem and the repair technicians collected it from his house and returned it after repairing. He said if it had not been under warranty, the repair and the transportation would have been expensive and taken longer. Similarly, Participant 27 had his shoes repaired. He said he would not have spent time and money on getting his shoes fixed if they had not been under warranty.

5. Desire to Relieve Negative Feeling

This motivation originates from users' desire to relieve negative or aversive feelings triggered by throwing a product away before the end of its use life. For example, Participant 20 explained the process of getting his toaster fixed, with the reasons for this. He took the toaster to a technical service department after it stopped working and learnt that the problem was a disconnected cable inside the appliance. He had it repaired, although the labour cost was more than half of the price of a new toaster. He explains the reason: 'I would feel bad if I junked it when all the other parts were working well'. Sometimes users try to repair their products themselves when the labour cost is high and they do not want to dispose of the product. Participant 15's laptop battery stopped working. The repair service was expensive and he thought it was not right to throw a laptop away just because of a damaged battery. Eventually, he changed the battery by himself by watching a repair instruction video.

6. Personal Pleasure/Satisfaction

Some participants were inspired to repair products by being able to display their skills, and this process gave them personal pleasure and satisfaction.

Participant 9 said, 'I thought a drying rack was not something that you show everyone so I repaired the broken plastic connection parts because trying to get an old object to work is more satisfying than buying a new one' (Figure 38). She also had a broken hairdryer that she could not repair, and added that 'I really want to know how to fix things and what causes them to fail. The learning process is awesome, and after something is fixed I am filled with pride and happiness'. Participant 17 helped his mother by fixing the cable connection of a lamp. He expressed his feelings of pleasure that he had the skill to fix it, accomplish the task and help his mother.

Figure 38. Repairing is more satisfying than buying a new product for participant 9.

7. Environmental Concerns

Some participants' environmental concerns motivated them to repair their products. Most of the participants were aware of the damage the current economic system causes to the environment and they wanted to reduce it. Participant 10 said that he was interested in repairing small appliances and he wanted to learn more about fixing objects in order to decrease environmental problems, and added, 'I came from a background where you first of all attempt to repair broken stuff before replacing them'. Participant 17 had his luggage repaired after its wheels broke. Although he complained that it took too much time to find for a repair technician to fix it, he said that he was happy about doing the right thing for the environment.

4.2.3. Product Repair Barriers

1. Financial/Time/Labour Loss

Participants decided whether to have the product repaired or not by calculating their loss or gain in terms of time, money and labour. The prevalence of cheap, low-quality products, in particular, directs users' behaviour towards buying a new product instead of maintaining and repairing it even if they know it is not environmentally friendly behaviour. Participant 6 reported that he did not want to have his kettle repaired because he thought it would cost more than buying a new product. Similarly, Participant 13's camera's flash did not work. She said she did not have her camera repaired because of the high repair cost.

2. Condition of the Product (Old/Low Quality/Technologically Outdated)

The condition of the product (old/low quality/technologically outdated) refers to the situation in which a product becomes old, unfashionable and behind technological trends, losing the identity and status it once had. Sometimes products fail to satisfy the human search for new experiences, so they become despised (Chapman, 2009). Finally, the relationship between the user and the object fails and leads to disposal. For example, Participant 18 stated that he did not want to have his mobile phone repaired as he had a more technologically advanced one. Some participants thought that products had a certain use life that ends when they are worn out because of long-term use. Participant 11 stated that she would not have her shoes repaired since she thought they were old and had reached the end of their life.

3. Unavailability of Spare Parts

Currently, most repair processes actually take place as replacement of product parts. However, it is not a widespread practice for manufacturers to provide spare parts to users. This fact made the unavailability of spare parts one of the main barriers that participants encountered. Participant 17 stated that he could not find the spare part needed because it was not provided by the producer, as the mobile phone was technologically outdated.

4. Lack of Knowledge

Participants were discouraged from the repair process when they did not have the required knowledge about repairing the product, or could not find someone to repair it.

Figure 39. Participant 6's mobile phone and Participant1's kettle.

For example, Participant 6 stated that he tried to repair his mobile phone but he could not, due to a lack of correct information (Figure 39). He explained, 'I ordered a new screen from China. I didn't realise it was important to wear insulating gloves while fixing, but the phone is now completely dead, due to my body electricity'. Participant 1 predicted that the problem with his kettle was the loose cable connection (Figure 39), but he did not have it repaired because he did not know where to take it.

5. Design-Related Problems

Attaching product parts permanently during the manufacturing process with methods such as gluing and welding was one of the most prominent design-related problems. This increased the cost of repair and amount of waste as functioning parts had to be removed with the broken ones. Participant 9 complained about the old worn-out appearance of her hair straighteners. She wanted to change the outer part but this was not possible because of the way the product was designed. Participant 1 wanted to have the broken water tank of his iron changed but this was not possible as it was permanently attached to the product.

6. Planned Obsolescence

Participants were discouraged from repairing products if the product had been broken more than once. They thought the product was designed to last for a pre-determined time and that other parts would continue breaking down.

Figure 40. Participants 2 and 10 did not want to get their products repaired again because they both thought that they would break again.

Participant 2 stated that she had the same problem with her last two pairs of boots (Figure 40). She had the first one repaired. However, after one week they had torn again. She did not want to repair her newer boots because she thought that they would not last long after repair, like the previous ones. Similarly, Participant 10 indicated that he had his loudspeaker

repaired twice (Figure 40). He did not want to spend time on taking it to a technical service department for the third time because he thought it would break down again. Moreover, he complained about how users were dependent on manufacturers, indicating his desire to be self-sufficient and to have the ability and the knowledge to carry out repairs.

4.2.4. Types of Repair

Depending on the level of skill of the person carrying out specific repair activities, these were categorised into three different types.

Assembly repair: This repair type requires no particular skill or knowledge. A good example here would be putting product parts together and gluing or binding them.

Medium-level repair: This repair type consists of activities which require some level of skill and knowledge, such as gluing knowledge and material knowledge: sewing and darning, for example, are medium-level repairs.

Advanced-level repair: This repair type includes activities that require advanced skill and knowledge, such as changing a laptop screen.

According to the research results, a correspondence between the barriers to product repair and the major problems associated with the current linear economic system can be seen. The unavailability of spare parts, expensive repair services, most design-related problems and planned obsolescence have been widely studied in the literature. Business models of a circular economy that can overcome these major problems have been known since the mid-1970s, and currently prevail in some sectors (Stahel, 2012). The implications of the results of this research can be used by stakeholders in the circular economy system: product designers, researchers, policy makers and companies.

To conclude, this research project has shown that the act of repair is not limited to fixing faults but is also a generative process that is motivated by complex emotional drivers and behavioural aspects. It gives a sense of accomplishment, teaches how things are made and informs about their material qualities. The insights raised from this research can be applied to explore these various dimensions of product repair.

4.2.5. Design Considerations

The motivation and barriers that relate to product repair were specified and divided into categories at this stage of the research. These categories were utilised as design considerations and were developed throughout this research. They were employed to evaluate and explore the repair methods during the design studies (Section 4.3) and the workshops, and were used as the building blocks of the Do-Fix repair kits. However, some of the motivation and barriers were not included as design considerations. First, 'design-related problems' and 'planned obsolescence' are two categories of barrier which could not be answered within the scope of this research, as this research focused on users' perspectives and experience. Second, 'emotional attachment', 'everyday/essential need' and 'condition of the product' were three categories of motivation which were not included as design

considerations, since they could not be controlled, altered and measured in relation to product repair methods and the scope of this research. They are formed between user and product throughout the product lifespan. Specifically, the user's emotional attachment to the product is a powerful motivation that directs the user to repair the product. Moreover, the activity of repairing a product can itself prompt this attachment between user and product. However, these topics were outside the scope of this research.

The repair decision is a complex process, like any other human behaviour. Therefore, these design considerations should not be evaluated and explored as independent variables. People consider them as a whole before making a decision about the repair process, so these considerations are a part of a complex network. Categories of motivation and barriers which will be used as design considerations in the next stages are:

1. **Financial Cost**

The first three design considerations were developed with regard to the financial/time and labour loss/gain categories. This consideration refers to the cost of the repair, materials and tools that were used in the process. If the process requires expert knowledge or any kind of repair service, its cost is also considered under this title.

2. **Repair Duration**

Repair duration represents the time required for completing the repair process. Participants preferred to carry out repairs which do not take a long time.

3. **Ease**

Ease represents the amount of work required to complete the repair. Participants preferred to carry out repairs which do not require great labour or effort. This category is closely related to that of required knowledge and skills. For example, some kinds of damage may be regarded as easy for a person who is experienced and has the required skills; however, it may also be thought of as a difficult repair when the user has no actual hands-on experience.

4. **Personal Pleasure/Satisfaction**

Personal pleasure/satisfaction refers to the pleasure experienced by carrying out the repair and the pride felt as a result of doing the repair. It includes the enjoyable aspect of the process, and emotions such as the feeling of relaxation and enjoyment it triggers. Additionally, people often feel proud as a result of accomplishing the repair and enjoy receiving praise from others when they share the experience of the process. These aspects of the 'desire to relieve negative feelings' category of motivation are included within the category.

5. **Required Knowledge**

The consideration of required knowledge involves aspects of the 'lack of knowledge' category. This category refers to the knowledge that is required about the repair methods, where to get the necessary materials and tools and how to use them.

6. Required Skills

Using one's hands and fingers to make and manipulate things is a natural human ability. Anyone can repair objects using their natural skills and creativity. The quality of work improves in time with practice.

All these considerations have huge potential to be addressed through research and design. Some of the participants indicated that they cannot repair their products because they do not have the required knowledge, or they do not know where to take the broken products. There are a number of implications for design in improving the content of product maintenance and repair manuals. Moreover, repair kits for products could be developed during the design process, taking into account potential future faults. These design considerations were developed during the design studies, and tested in detail and finalised during the workshops.

4.3. Design Studies

This section includes the design studies that I completed, and the various repair methods that I tried and tested. Here I present twelve of these repair methods which were relevant to the context of this research and had the potential to answer the research question. Examples were given for each repair method with 'before' and 'after' images of these objects.

The repair methods were explored throughout the design studies in order to identify the feasible and infeasible aspects of each method to encourage people to repair products and develop the design considerations further.

The repairs can be described as the materialisation of theoretical ideas that I reviewed in the literature on tangible objects. Initially, various traditional repair techniques were explored. Traditional repair methods have survived for centuries through numerous implementations, and incorporate the accumulated knowledge of centuries of experience. In time, they have evolved according to the human capacity for creativity and skill. Some of the conventional methods were applied in a similar way to the original process, while others were applied with new technologies and materials. The resulting artefacts were intended to help to stimulate my exchanges with the workshop participants.

4.3.1. Repair Methods

It is possible to find repair instructions or related videos on various websites such as YouTube regarding most of the objects that need fixing. iFixit is one of the best examples of websites focusing on electronic product repair (see Section 2.12.5). Besides providing repair instructions, iFixit sells repair kits, including specialised tools. Repair methods included and developed in this research are briefly explained, with examples, because this is not a repair methods book and the instructions, materials, processes and examples of various repair methods are available elsewhere in books and online. The focus here was a phenomenological analysis of the repair experience to identify different ways to encourage people to repair products.

There is an immense number of breakable objects in this world. Each of these objects can become damaged in various ways. It is not possible to cover all these possibilities; however, the methods applied in this research could be applicable to many types of damage. The repair methods and instructions involved in these design studies come from my own observations, some of them invented by combining different methods. The next section includes examples of practical repair, together with the repair methods applied in design studies, as well as how and why they were used. A paper, including parts of Section 4.3.1, was published as a part of my presentation at the Sustainable Innovation 2016 Conference.

4.3.1.1. 3D Printed Product Parts

Three-dimensional (3D) printing is an additive manufacturing process that builds objects from individual layers of material based on a digital file (Warnier, Verbruggen, Ehmann, & Klanten, 2014). A wide variety of 3D printers exists, using different technologies and materials (Warnier et al., 2014). Since its invention twenty years ago, 3D printing has drawn attention from a wide range of disciplines, used in diverse areas of application (Manyika, Chui, Bughin, Dobbs, Bisson, & Marrs, 2013), and has affected the way we think about manufacturing. The interest in 3D printers has grown further since the maker movement has become widespread (Hagel et al., 2014). The technology has developed very fast and paved the way for businesses that provide a 3D printing service as well as low-cost desktop 3D printers. Although the main application area of 3D printing is prototyping in product design, today many products are produced by this method, including bicycles, buildings, cars – and even organs, using living cells as a raw material.

Figure 41. Products repaired with 3D printed parts.

3D printing embodies numerous possibilities of extending product lifespan through product repair particularly in terms of physically damaged products. This method can also be used as an effective way to draw people's attention to repair activity. These include technology 'geeks', who are not specifically interested in the repair, and children, as it is easier to sustain their attention with entertaining products.

The unavailability of spare parts was one of the barriers that participants specified in the results of the cultural probes research (see Figure 36). This barrier could be overcome in relation to physically damaged products by 3D printing the damaged parts. Moreover, these parts could be designed in a different way to improve the product or personalise it. Distinctive and complex designs are also possible, as 3D printing enables the easy production of intricate shapes.

I repaired shoes, teapots and watches, by 3D printing the spare parts (Figure 41). This was an experiential process in which I explored the different solutions that 3D printing can offer to the repair of products, rather than exploring the best ways and methods of repairing a product. Some of the repairs were unsuccessful, and this gave me the opportunity to see the advantages and disadvantages of this method. For example, the shoe heel in Figure 41 was slippery to walk in. Digital precision is one of the advantages of 3D printing. However, it can be difficult to create a precise computer-aided design (CAD) model, especially in the case of

products with organic shapes. For example, it took a long time to create a spare part that fits the broken spout of the teapot in Figure 41.

3D printing is capable of creating complex shapes, unlike conventional manufacturing methods, which are restricted in the types of shapes that can be achieved (Warnier et al., 2014). 3D printing offers the potential to create even eccentric designs. The spare parts do not have to be the same as the originals; instead, they could be designed in a different way to improve the products or personalise them. The toy sword in Figure 42 are examples of this category. The owner of the sword wanted it to be stronger and longer than before. Additionally, he wanted his name written on it.

Although 3D printing is an effective method, with endless possibilities for producing different shapes, there are some difficulties that should be addressed. Developing 3D CAD models requires skill, knowledge and precision. The 3D modelling service is also very expensive. However, there are open-source websites such as Thingiverse where users can find CAD models of various product parts. Instructions for repairing products with 3D-printed parts are also available. As the opportunities of 3D printing rapidly improve, it may be possible for manufacturers to provide downloadable 3D models of spare parts in the near future.

Figure 42. The toy sword repaired with a 3D-printed part.

4.3.1.2. 3D Printed Patches

The idea of 3D printed patches was initiated by designing and trying different shapes of patches that could be pinned or sewn onto holes in fabric. The starting point of this method was conventional repair techniques such as darning and patching (see Section 4.3.1.7 and Section 4.3.1.10). The first patches were two-dimensional, and similar to badges. After this, I explored the flexibility of 3D-printed parts. Inspired by 3D-printed textiles, I worked on patches with joints and chain-like structures (Figure 43). After experimenting with various fabrics, results showed that 3D-printed patches which are rigid or had a certain level of flexibility are more suitable for mending purposes than chain-like patches because they do not move together with the fabric. Chain-like patches were too flexible: they creased the fabric and the garment looked deformed (Figure 44).

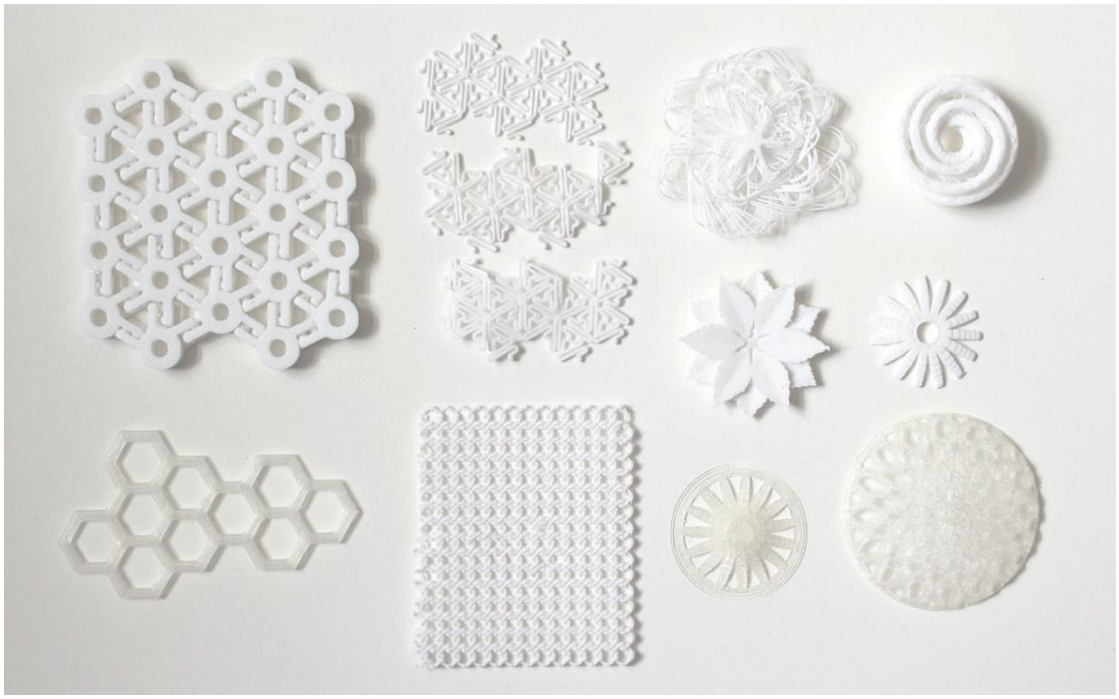


Figure 43. 3D-printed two-dimensional patches.

Figure 44. 3D-printed two-dimensional patches on clothes.

Creating the CAD model and finding a 3D printer are difficulties associated with fixing products with 3D printing. However, these issues could be addressed in the future with the increasing prevalence of 3D printing technology. This technology has been developing fast, and people's interest in 3D printing indicates that it could penetrate more into our everyday life. Repairing our products might thus become more convenient than buying a new product, and this might change typical user disposal behaviour.

4.3.1.3. 3D Printing Pen

A 3D printing pen was employed in the design studies, most importantly because it is an interesting new technology that is likely to attract people's attention and encourage them to engage in the repair activity. Moreover, involving technological products might be an effective way to combat the negative stigma attached to repair.

The working mechanism of a 3D printing pen is similar to that of a glue gun. It heats up in one minute after it is plugged in. A PLA or ABS plastic string inside the pen melts with the heat and comes through the nozzle. The product is easy to operate, but it is very hard to create neat shapes with it.

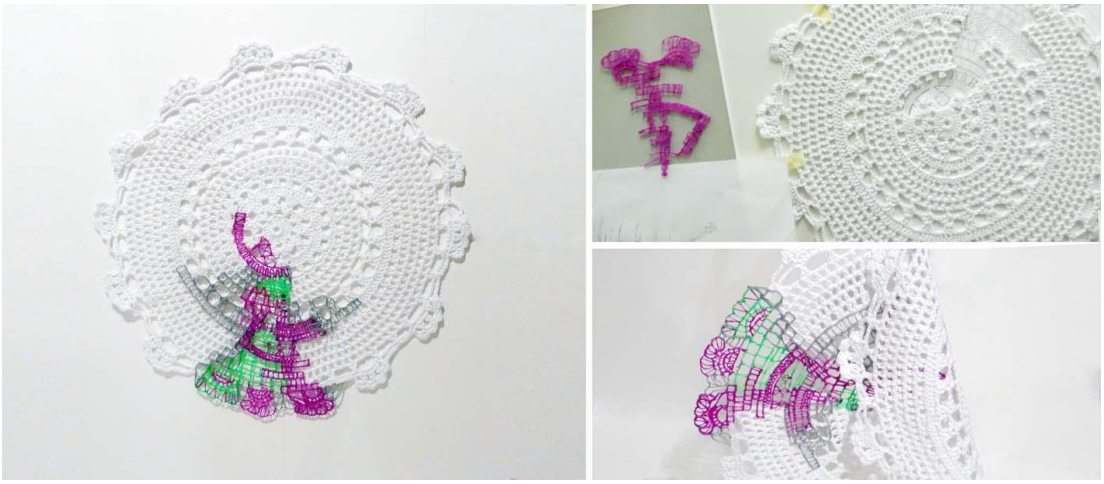


Figure 45. Lace doily repair with 3D printing pen.

I repaired a damaged lace doily with the 3D printing pen as I thought it would be fun and easy to create intricate shapes with the narrow nozzle (Figure 45). I draw the pattern on a paper and followed the lines with the 3D printing pen. Although the pattern was two dimensional, it was hard to create the exact shapes. However, the final result was aesthetically pleasing and interesting. It is not effective to buy this product for repairing textiles or other products but it could be available in repair cafes and maker spaces. People can lease or use it when they need it. I decided to test the method in the workshops and use it as a way to attract people's attention and help the process of engaging people in repair activity.

4.3.1.4. Kintsugi

Kintsugi is a traditional Japanese repair method employed to mend cracked or broken ceramics with precious metals like gold and silver. Broken ceramic parts are joined together using Japanese lacquer. This lacquer is made out of the natural resin of the urushi tree. Afterwards, the crack lines are filled with gold powder and varnished. The gold, the labour and the time spent on the object make it more valuable than before it was broken. This

technique was applied to mainly ceramic products during the design studies (Figure 46). The origami vase in Figure 47 was one of these products.

Figure 46. Kintsugi was applied to twenty products during design studies.

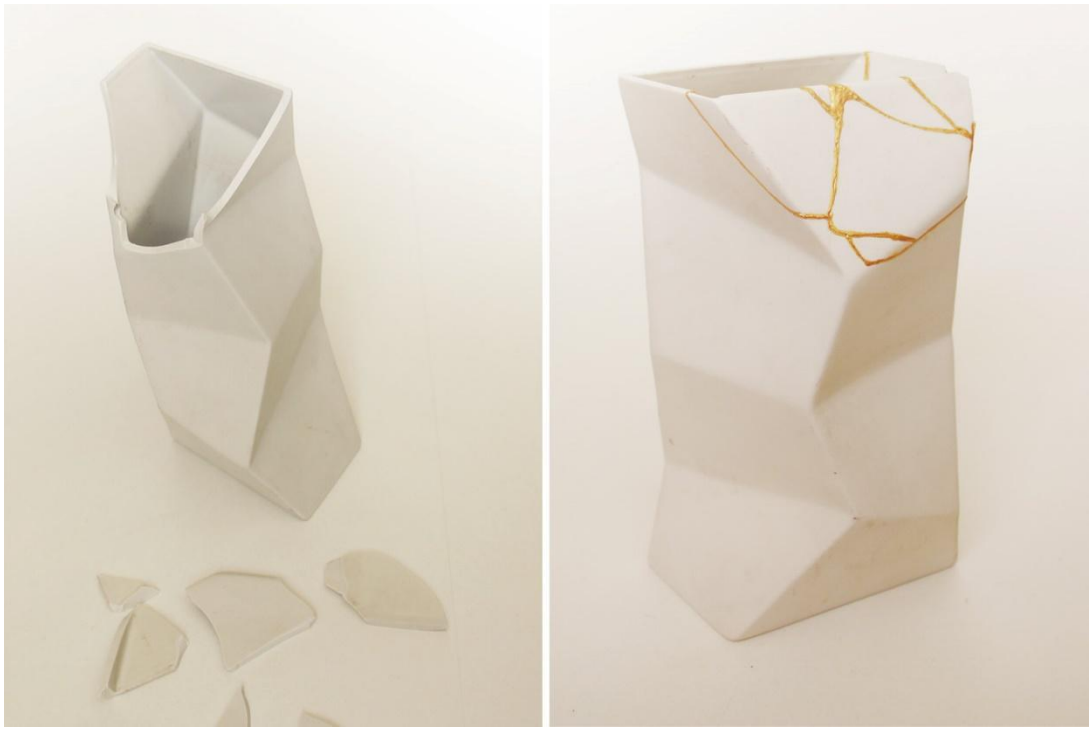


Figure 47. Origami vase repaired using kintsugi.

I found this vase after moving to a new flat. I thought it shouldn't be thrown away, as it was beautiful. I mixed gold-coloured liquid and glue and applied it on each piece. This produced results similar to kintsugi. The original method is rarely applied today because it is labour intensive and the materials are difficult to find. The kintsugi method that was used here was easy to apply: the materials were low-priced and the process was not time intensive. The pieces were joined together with gold-coloured glue. The only difference from glueing was that I added a gold-coloured liquid to the glue and put more glue than necessary in order to get the 'raised' gold effect.

4.3.1.5. Kintsugi for Textiles

The philosophy behind the kintsugi correlates strongly with the aim of this research. This led me to think about different versions of the same method, such as applying it to different products or using different materials. I applied the material onto textiles in order to test the aesthetic qualities. The results can be seen in Figure 48. The material definitely showed the texture of the tear underneath it and the result did not change when the tear was sewn up. The process was easy to apply and enjoyable. However, it was messy and the final appearance did not satisfy my expectations.

Figure 48. Kintsugi applied onto textiles in order to test the aesthetic qualities.

4.3.1.6. Kintsugi Sugru

Sugru is a kind of mouldable glue that turns into rubber (Ball, 2013). It is an inspiring material that can be used for many purposes, from repairing to personalising products. It can be also used like kintsugi to join ceramic products: this is called kintsugi Sugru. I applied this method to a broken mug and to a broken, antique plate that I bought from an antique shop (Figure 49). Kintsugi Sugru is included in the design studies and workshops, as people might want to try it, and it might inspire different methods of repair.

Figure 49. I applied this method to a broken mug and to a broken, antique plate that I bought from an antique shop.

Sugru is an amazing material. It is easy to apply, like play-dough; however, some difficulties exist in the process. If the object is broken into more than four or five big pieces, the Sugru between the pieces creates a thickness, and makes it hard to join the pieces neatly. Although, as noted, Sugru is similar to play-dough, it should be applied directly and quickly as it collects dust and loses stickiness. Finally, no research exists into whether Sugru is food safe, and the company is currently working on this issue ('Sugru's Amazing Properties', n.d.). The object thus cannot currently be used to contain food until this is resolved.

4.3.1.7. Darning

Darning is a fabric repair technique involving sewing holes and worn areas in fabric or knitted textiles using a needle and thread. It is done by hand and it is also possible to apply using a sewing machine. The thread is woven in rows along the grain of the fabric. I have used this technique all my life but I was improvising. I researched instructions to improve my skill and technique for this research. The instructions seemed complicated at first but once I started doing it the process was enjoyable and relaxing. The application of this method on socks can be seen in Figure 50.

Figure 50. The application of darning to socks.

4.3.1.8. Darning Kintsugi

The results of trying kintsugi on textiles did not completely correlate with the design considerations of this research in relation to either 'aesthetic' or 'ease' (see Section 4.3.1.5). After the success of the darning method (see Section 4.3.1.7) on repairing knitted jumpers and socks, I wanted to combine kintsugi and darning together and to try gold and silver thread (Figure 51). This method could be studied in the darning section; however, darning kintsugi would interest more people as a separate method and inspire different repairs during workshops.

Figure 51. I used gold thread to darn the holes in the knitted gloves.

4.3.1.9. Boro

Boro is the name given to traditional clothes worn by Japanese peasants since the seventeenth century, and it also refers to the special way of repairing these traditional clothes (Figure 52). They are passed down through generations, become damaged or worn out, and then amply repaired and reused. It has a strong effect that invites people to reassess the concept of value and consider the meaning of fixing in our consumer society.

Figure 52. Boro is used and maintained throughout its owner's lifetime and passed down through generations (Mathias, S. & Stephen, 2013).

This method originates from the theory of *mottanai*, meaning 'too good to waste' (Wada, 2004). Boro fabric is woven with cellulose fibres and dyed with natural indigo. It is used and maintained throughout its owner's lifetime and passed down through generations. These clothes are also tangible remnants of the humble stories lived by the common people who are the owners of these clothes (Wada, 2004). Hence, they convey emotional power as well as authentic aesthetic value. Family histories can be traced through their patterns which have been darned by successive generations. Today, these objects are valued and presented as art.

Figure 53. I used Boro to mend the holes in the espadrilles.

Boro was studied in this research as it is an inspiring and stimulating method. I used this method to mend the holes in the espadrilles in Figure 53.

4.3.1.10. Patching

Patching is a widespread mending technique and has various versions of its application in different cultures. A selection of decorative patches can be found anywhere with sewing and craft supply stores. Hence, at first I did not know how to incorporate this ancient and widely applied repair method into this research in a creative way. However, in the end, this method was the starting point for some of the most engaging repair methods in this research, such as Sugru patching, kintsugi textiles, textile patches and 3D-printed patches.

Figure 54. Patching example on a backpack.

First, I started experimenting with this method on shoes and then used it on backpacks. For example, I tried fixing the torn straps of the backpack in Figure 54 with textile glue. However, it was not strong enough to carry the weight. I sewed the torn parts and joined them. I glued a leather patch on it to cover the damaged parts. I tried to sew the corners of the patch, but the leather was too thick to sew. After this attempt, I concluded that I should use thin patches that were easy to sew.

4.3.1.11. Sugru Patching

Various applications of this method are available on the Sugru website on knitted jumpers, shoes and bags. This method is included in the design studies and workshops, as it is easy to apply and a very effective solution. To apply Sugru patching repair on fabric, the repairer tears off a small pea-sized amount of Sugru and smears it through the fabric to create a strong bond. After that, the repairer adds more Sugru to work on the desired shape. It is machine washable and tumble-dryer safe. This method worked with jeans and thick cotton but the result was not successful with synthetic textiles and knitted garments. For example, I tried to fix the beanie in Figure 55 but sugru did not stick to it properly.

Figure 55. I tried to fix this beanie but sugru did not stick to it properly.

4.3.1.12. Basket Weaving

Basket weaving is one of the oldest craft activities in the history of humankind. This process involves weaving pliable materials into three-dimensional artefacts. This method was used in the design studies because it is easy to apply, low cost and sturdy.

Figure 56. Rattan chair repair inspired by basket weaving.

I was inspired to try basket weaving methods after finding the damaged rattan chair in Figure 56. Its backrest was damaged and some of the parts were missing. I wove the missing parts in the same pattern and used a rope in a contrast colour to emphasise my contribution. I used the same method to fix the yellow basket in Figure 57. I wove the rattan reed through the side walls of the basket. The unity of different materials and colours was emphasised in these two examples, highlighting the work of the repairer.

Figure 57. I wove the rattan reed through the side walls of this yellow basket.

Both the feasible and infeasible aspects of various repair methods were examined and the design considerations were developed with a phenomenological perspective. The next section describes how the design considerations were developed during the design studies.

4.3.2. Design Considerations

The first six design considerations were formed, considering the results of the cultural probes research and explained in Section 4.2.9. Seven more design considerations were also developed, based on the repairs I completed in the design studies.

1- Financial Cost

2- Repair Duration

3- Ease

4- Personal Pleasure/Satisfaction

5-Required Knowledge

6-Required Skills

The aim of the design studies was to study my repair experience in detail and understand it thoroughly before attempting to understand other people's repair experience. Phenomenology helped me explore the unique and complex character of each repair activity.

The process started with phenomenological reduction (see Section 3.1.2). Becoming aware of the preconceived ideas is the first and a crucial step to bracket them. Field notes were used to collect data during the design studies (Figure 58). Taking field notes is an effective method that helps researchers to eliminate personal bias and preconceptions during phenomenological studies, which are essential for establishing validity and reliability (Miles & Huberman, 1984).

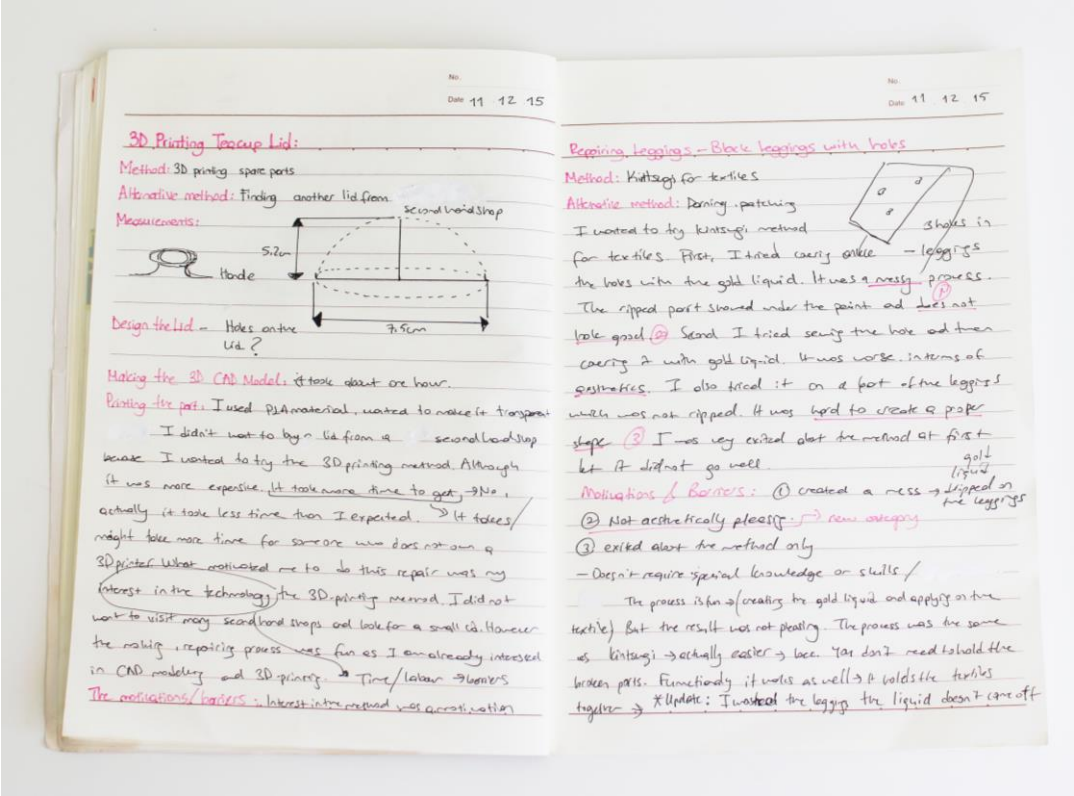


Figure 58. Field notes were used to collect data during the design studies.

I want to explain how the design considerations were created with an example. 'The interest in the method' category was developed while I was working with the small teapot in Figure 59. I bought it from an antique shop and its lid was missing. I started the research process by analysing the product, taking measurements and thinking about the repair solutions. My first repair idea was 3D printing the lid. I also developed an alternative idea which was finding another lid from second-hand shops or antique shops. I designed the lid and created the CAD model. Finally, the repair process was completed after 3D printing the part.

My perception (epoche, see Section 3.1.2) was the primary source of knowledge in this phenomenological research (Moustakas, 1994). I took notes on what I perceived during the research process and reflected on what was happening, without judgemental evaluation (phenomenological reduction). My brief thought process can be seen in my field notes (Figure 58). After the repair is finished I thought about the barriers and motivations that I

experienced. I asked myself questions about my choices, the enjoyable parts of the process and the difficulties. I realised that I wanted to try the 3D printing method because I was interested in the technology and CAD modelling. 3D printing technology attracts other people's attention as well. This method can be effective to encourage people to try repairing and to overcome the barriers and negative stigma attached to repair activity. Consequently, the 'interest in the method' category has been created.

Figure 59. The small teapot wit 3D printed lid.

Objects were photographed before and after they were repaired. The collected data was analysed and seven categories of design considerations were developed. Finally, I visited the field notes again, to make sure that I had included all the polarities and individual variations.

7. Aesthetics

During the design studies, I enjoyed the repair process more and wanted to complete it more enthusiastically when the final product was aesthetically pleasing, leading to the development of the 'aesthetics' category. This refers to the pleasure which results from the sensory perception of the repaired object. As physical damage is the focus of this research, the aesthetic quality is mostly related to sight and touch.

8. Attracting Interest

'Attracting interest' refers to the incorporation of interesting contemporary methods or new technologies into the repair activity. Using interesting methods is an effective strategy to overcome the stigma attached to the act of repair. If people focus on the interesting techniques they are using, it might be easier for them not to experience the barriers, and engage in the activity.

9. **Accessibility of materials and methods**

In the current economic system, it is often easier and cheaper to buy a new product rather than repairing one that is broken. As a result of this, the methods, materials and tools for repair should be made easily accessible if we want people to repair products more often.

10. **Functionality**

Products might become non-functional after being damaged. This category refers to restoring the damaged product to working order as much as possible.

11. **Negative stigma attached to repair**

This category refers to the socioeconomic perception of repair (Middleton, 2014). Damaged, frayed and repaired products are associated with economic hardship and poverty (Kelley, 2009; McLaren & McLauchlan, 2015). Therefore, people might feel ashamed of repaired products. This fact might also affect user's motivation to use a repaired object and discourage him/her from repairing.

12. **Improving the design of the object**

This category refers to making a product more valuable and more beautiful than a new product by repairing it. Is it possible to make the product 'better than new' through repair? The stigma attached to repair is a socially constructed idea that relates to the current social value system. For example, in a different social context a repaired product could be regarded as more valuable because it represents our respect for the environment.

13. **Storytelling**

Every repaired object tells a story. The main aim of this research was to encourage people to repair products more often and to create an awareness towards environmental problems. Stories are a significant part of creating awareness and spreading the message. As a result of this, one of the design considerations was the creation of a conversation piece through visible repair.

4.3.3. Four Design Ideas

After the design studies, I developed four ideas with the potential to address the research questions:

1. **Online social repair platform:** The first idea was to create a platform such as a website or a mobile application to bring 'people with repair skills' together with 'people with damaged products'. I designed the website and worked with a software engineers to develop it. The fully working website was completed within one month (see Appendix B). This website has two types of users: the repairers and people with damaged products. Repairers register on the website by clicking the 'Join' link and creating a profile. They can present the objects they repaired, their repair skills and contact information. Similarly, users who want to access the repair service also need to register and create a profile. They can look for certain products by using the search bar or the 'Categories' link. The newly completed repairs are shown on the

home page and are listed according to popularity. Users can view the repairers' profiles and 'like' their works. They contact the repairers whose work they like best to access the repair service or to learn how to repair their damaged item by themselves. I presented the website to participants in the first two workshops. I did not pursue this idea subsequently for three reasons: first, workshop participants did not register on the website; second, it requires a lot of effort to create the user network, and third, repair kits that addresses the research questions emerged naturally during the workshops.

2. **Repair Products:** Designing products that users need to repair before they use them. For example, products which have parts that are incomplete or broken, and which become complete after users repair them using the methods I developed during the design studies.
3. **Inspirational Repair Booklet:** This booklet presents practical and visible repair examples, repair instructions and interesting stories to inspire people to repair products more often. I planned to include the repairs that I completed during design studies, together with the workshop results.
4. **Repair Kits:** These repair kits are designed based on the repair methods I developed during the design studies, and aim to inspire and encourage people to repair products more often.

Various repair methods were explored during the design studies. I briefly explained twelve methods, including 3D printing product parts, kintsugi, darning and patching. The aim of this process was to identify the repair activities that have the potential to encourage people to repair products more and to study the repair experience in detail before the workshops. Some similarities, repetitions and patterns started to emerge among the repair methods and the types of damaged products during the design studies. I will explore these patterns further in next section, which includes the workshops and how the findings of the design studies and workshops led to the four design projects. Finally, design considerations were employed to evaluate and explore the repair methods during the workshops.

4.4. Workshops

This section presents Phases 3 and 4, namely the project development and the evaluation phases of this research (see Figure 1). First, the structure of the workshops and the participants' experiences are described with examples. Then the research outcomes and concludes the testing of the design ideas are presented.

Four repair workshops were conducted in this research, in which participants were asked to bring their damaged products. The workshops were conducted at the Royal College of Art. Each workshop process started with booking the room and continued by putting up the posters (Appendix C) and placing advertisements to recruit participants, printing worksheets, hiring the recording equipment, arranging the workshop tool bag (see Section 4.4.2), including the required materials, and finally setting the scene. Because of the workload, it was convenient for me to organise two sessions in one workshop rather than running two

separate workshops on different days. Additionally, the ideal number of participants for the workshop is between six and eight if there is only one facilitator. Thus, I divided Workshops 1, 3 and 4 into two sessions; Workshop 2 was conducted as one session because there were two facilitators (Figure 60). The workshops were video-recorded, with a camera situated in the corner of the room. Photographs of the repair processes and the 'before' and 'after' phases of the repaired objects were taken during the workshop.

Figure 60. Workshops 1, 3 and 4 were conducted in two sessions and Workshop 2 was conducted as one session.

Each session started with an introductory presentation explaining the outline and the aims of the workshop, the scope of my research and finally the repair techniques developed during the design studies. The first two workshops primarily intended to:

- Explore both the feasible and the impractical aspects of four design ideas developed after the design studies.
- Investigate the motivations and barriers (design considerations) that people experience in relation to repair.
- Test the product repair techniques developed during the design studies (investigate how participants make use of these methods and materials).

The first two workshops aimed to identify the most appropriate answer for the research question among the four design ideas developed after the design studies (see Section 4.3.3). For this, I explored the specific repair methods which participants chose and were interested

by, the activities they were successful at and the parts they either struggled with or enjoyed during the repair process. I also presented the idea of the online repair platform to observe the participants' reaction and thoughts in the first two workshops. I explained the website and said that anyone who was interested could register and upload the repair works s/he had completed. Participants were not interested; no-one registered or asked any questions about the website. Thus, I did not pursue this idea after the second workshop.

Participants were interested in the repair methods and asked questions about where to get the materials and the tools. Some of the participants stated that they wanted to learn the details because they wanted to practise these methods by themselves. Additionally, the repair methods started to turn into kits, as some examples of damage started to emerge repeatedly. For example, certain shapes were used more frequently than others in textile patches. Consequently, I decided to work on these methods further and to design the repair kits, because they were the most appropriate answer to the research question in the context of this research.

4.4.1. Workshop Plan

I first introduced myself and presented the repair methods, with examples, in order to inspire the participants and help them visualise the methods they were going to apply. I explained the repair methods briefly by showing examples and describing the advantages and disadvantages of using each method.

Before the workshops, I prepared a worksheet to collect data and guide the workshop process (Appendix D). The worksheet explained the four tasks of the workshop. I handed out the worksheet to participants after the presentation. After the participants chose the most suitable methods to repair the products, they repaired them and filled in the worksheet according to their experience.

Task 1-Discover: The first task was for the participant to observe the object and understand the problem. Each participant explained his/her product and answered the questions: What is your product? Can you explain its features? Can you describe the broken part?

Task 2-**Ideation:** This task represented the generative stage, focusing on developing repair ideas. It oriented the participants to quickly visualise their design and the repair process by using the available tools and materials (play-dough, post-its, coloured pencils, markers, cardboard, paper, textiles etc.). Participants also did some sketches during this task before implementing their idea.

Task 3-**Feedback:** This task aimed to discuss the participants' ideas and to develop them further. Participants received feedback from the facilitator and also gave feedback to each other.

Task 4-**Implementation:** Participants implemented the ideas and concepts from the previous creative stage with the help of the facilitator and other participants.

Final Discussion: Each participant explained and evaluated the process by answering the questions: Can you please explain to us your process and your work?

4.4.2. Workshop Tool-bag

During the design studies, I explored various traditional repair methods, together with new materials and technologies. The more products I repaired, the more materials and tools were collected. I organised these materials in a tool-bag and redesigned the tool-bag for the repair workshops to conveniently inform and inspire the participants. This package of materials included fabric, a 3D printing pen, patches, Sugru, sewing tools, etc., which would be needed for the repair activities (Figure 61).

Figure 61. Workshop tool-bag including materials and tools such as fabric, 3D printing pen, patches, Sugru and sewing tools.

Research Outcomes

This section describes the outcomes of the workshops, covering the participant information and the workshop tasks: discovery, ideation and implementation.

Fifty-two participants attended the workshops: fifty-four per cent were female and forty-six per cent were male. They were between the ages of eight and sixty-six and were from a range of different occupations, including university students, designers, and retired teachers. Table 2 shows the workshop participants in numbers with the products they repaired and the repair methods they used. Participant selection strategies for the workshops are explained in Section 3.4 in detail.

The data about participants' experience was collected from the worksheets and through my observations. First, in the worksheet, I asked them to explain their repair process, including the parts they enjoyed and the difficulties they encountered (Appendix E). After the workshops, I wrote each participant's answer on a sticky note and put all the notes on a paper on the wall to explicitate the data (see Section 3.1.2) and see it as a whole (Appendix F). Secondly, I took notes on the conversations I had with the participants and my observations. These notes also enabled me to better understand participants' motivation and the barriers they experienced in relation to repair. In phenomenological studies, validity is obtained by looking at the field notes multiple times. This helps the researcher to become free of preconceptions and merely report what s/he sees and experiences (see Section 3.1.2). Meaningful clusters started to emerge from the participants' answers and two design considerations were developed after the analysis. The outcomes are presented below with examples from the repair processes and participants' quotes, to explain the contribution of the workshops in answering the research questions.

It is important to include the diverse aspects of human experience in phenomenological studies (see Section 3.1.2). In the context of this research, the motivations and barriers were explored considering the polarities and reversals of participants' experience. The motivation and barrier categories were finalised after the second workshop and tested in the last two workshops to investigate and search for further individual perspectives. Four workshops were conducted because I observed that the research had reached data saturation. In other words, the data started to repeat itself, and it did not add anything new to the objectives of this research (see Section 3.5).

Table 2. The workshop participants in numbers with the products they repaired and the repair methods they used.

Participant number	Gender	Repaired Product	Repair Method
WORKSHOP 1			
P1	M	Ceramic bowl	Kintsugi Sugru
P2	M	Clothes hanger	Repaired with metal wire
P3	F	Macbook charger	Sugru
P4	M	Silicone watch strap	Sugru
P5	F	Boots	Sugru and T- patches
P6	M	Grater	Repair ideas were generated - not repaired
P7	M	Ceramic plate	Kintsugi
P8	M	Leather bag	Textile patches
P9	M	Ceramic cup	Kintsugi
WORKSHOP 2			
P10	F	Trousers	Patching
P11	F	White long dress	Textile patches
P12	M	Wood necklace	Repaired with glue
P13	F	Mobile phone	Sugru
P14	F	Socks	Textile patches
P15	F	Knitted jumper	Darning
P16	F	Nike shoes	Sugru
P17	F	Sneakers	Textile patches, Sugru
P18	F	Striped orange jumper	Textile patches
P19	M	Sweatshirt	Repaired after the workshop with Plaster patches
P20	M	Backpack, broken clips	Sewing, velcro
P21	F	Jeans	Textile patches
P22	F	Green cardigan – Macbook charger	Darning - Sugru
P23	M	Laptop case	Textile patches
P24	F	White women's top	Not repaired
P25	F	Red backpack	Textile patches
P26	F	Socks	Textile patches
P27	M	Blue shirt	Patching
P28	M	Blue Dress	Sewing
WORKSHOP 3			
P29	F	Computer Mouse	3D printing pen
P30	M	White earphones	3D printed part
P31	M	Sunglasses	Not repaired
P32	M	Plastic lid	Sugru
P33	F	Ceramic cup	Sugru
P34	F	Leather Jacket	T- patches

Participant number	Gender	Repaired Product	Repair Method
P35	F	Slippers	T- patches
P36	F	Black Jumper	3D printed patches
P37	M	IPad Case	Sugru
P38	M	Teddy bear toy	Textile patches
P39	F	Ceramic egg holder	Kintsugi
P40	M	T-shirt	Plaster patches
P41	M	Pencil case	3D printed patches
P42	M	Socks	Plaster patches
WORKSHOP 4			
P43	F	Ceramic spoon holder	Kintsugi kit
P44	F	Teapot	3D printed part
P45	F	Plate	Kintsugi kit
P46	F	Tray	Repaired with glue
P47	F	Watch strap	3D printed patches
P48	M	White ramekin	Kintsugi kit
P49	M	Socks	Plaster patches
P50	F	Tights	Plaster patches
P51	M	Blue backpack	Textile patches
P52	F	Jumper	3D printed patches

Workshop 1

This workshop consisted of two sessions. There were three participants in the first session and six participants in the second (Figure 62). The first session took ninety minutes, and participants repaired three objects, while the second session took two hours and participants repaired six objects.

Figure 62. The first session of Workshop 1 took ninety minutes.

Workshop 2

Eighteen people participated in Workshop 2. It was conducted in one session because I had another person to help me facilitate this workshop. It lasted for three hours. The participants were divided into five groups, but they repaired their products individually (Figure 63). Eighteen objects were repaired in total.

Figure 63. Eighteen people participated in Workshop 2, which lasted for three hours.

Workshop 3

Fourteen people participated in the two sessions of Workshop 3 (Figure 64). Unlike the introductory presentation in the first two workshops, I explained the Do-Fix repair kits in Workshops 3 and 4. After the idea generation stage, I asked participants to choose the appropriate kit or repair method to repair their damaged products. The first session took two hours and a half and included nine participants. The second session lasted about an hour and a half, and there were five participants. Three participants used textile patches, two participants used plaster patches and two participants used 3D-printed patches to repair their products.

Figure 64. Nine participants attended the first session of Workshop 3.

Workshop 4

Workshop 4 was conducted in two sessions and included four participants in the first session and six participants in the second. Both sessions took ninety minutes. Three participants repaired their objects with the kintsugi kit, two participants with 3D-printed patches, two participants with plaster patches and one participant with textile patches (Figure 65).

Figure 65. Four participants attended the first session of Workshop 4.

4.4.3. Repair Experience

The repair process in the workshops was guided by the tasks on the worksheet. I asked participants to observe and explain the object and the damage to it at the beginning of the workshops. Participants wrote their observations on the worksheet, including the product features and details about the damage (Appendix E). In the second stage they developed their repair ideas, considering the repair methods I presented. Finally, they repaired their products and explained the process on the worksheet.

4.4.3.1. Discovery (Constructing the Repair Decision)

Based on Desmet and Hekkert's (2011) framework of product experience, participants defined their products according to three aspects: the meaning of the product, its aesthetic features and emotional value. The meaning of the product refers to its symbolic value that a human gives to the product. For instance, Participant 4 explained that his watch was an 'impressive' watch from a well-known brand. Other participants focused on the aesthetic aspects of the products: Participant 1, for instance, explained that his product was an antique bowl with a gold rim, and participant 15 defined hers as one hundred per cent wool jumper. Lastly, some of the participants described their products by considering their emotional value. For instance, Participant 28 was concerned about fixing his girlfriend's dress, which had an emotional value for the couple (Figure 66). He phoned his girlfriend before every step he took and repaired it carefully and slowly. The emotional value was not only a factor that affected participants' repair processes, it was also a result of it. In other words, an object might become emotionally valuable after repairing it because of the unique memory users share with the product. Chapman (2009) explains that a product possesses a narrative when users share a unique personal history with it (p.33). Participant 15's knitted jumper was a good example of this: she said, 'It has become very personal, unique and valuable to me now' after repairing it (Figure 63).

Figure 66. Participant 28 was concerned about fixing his girlfriend's dress

Figure 67. Participant 15 said her knitted jumper became personal, unique and valuable after the repair.

4.4.3.2. Ideation

Participants explored various repair solutions for their damaged products at this stage. They explained their colour choices, design ideas and possible material selections (Figure 68). For example, Participant 5 brought her brown leather boots to the first workshop. One of the pair was frayed on the front right-hand side and had a small tear on it. She considered repairing it with textile patches and Sugru. She designed star-shaped and lightning bolt shaped patches to repair it. After discussing this with me and other participants, she decided to use both of

the materials. She made the frayed parts stronger with a textile patch glued inside the boot and also put a Sugru patch covering the torn part on the outside.

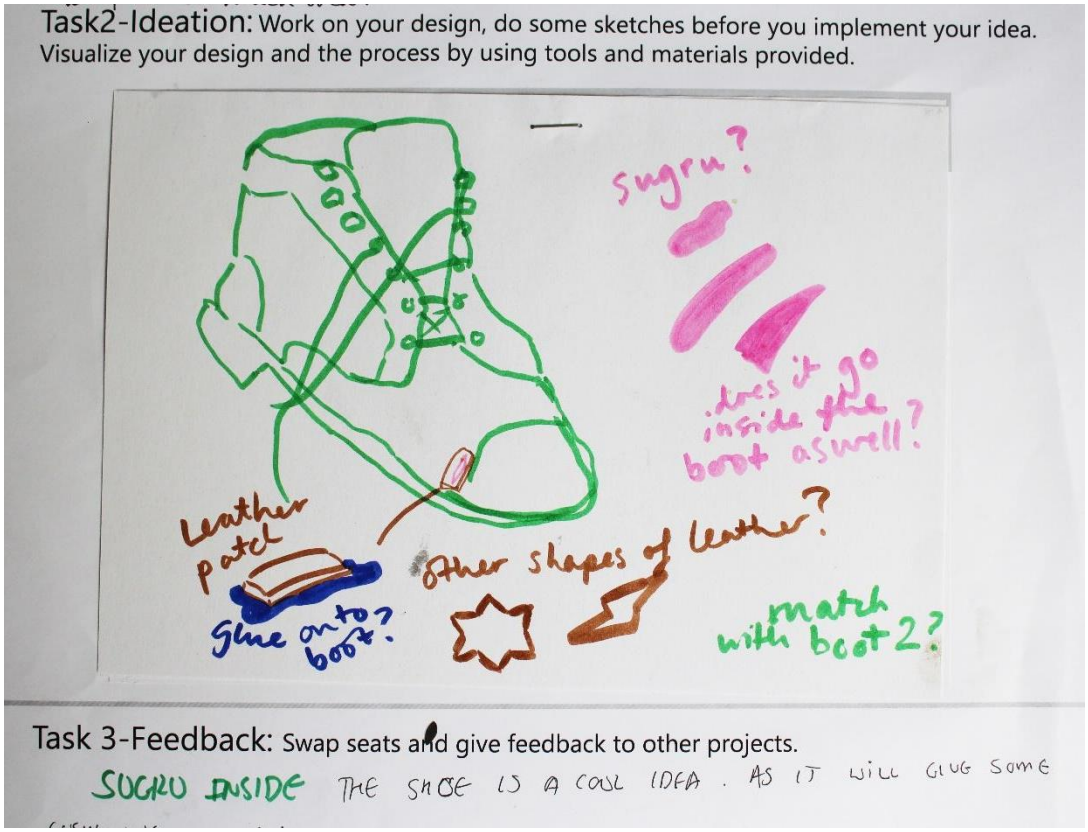


Figure 68. Participant 5 explained her colour choices, design ideas and possible material selections through ideation drawings.

Some of the participants identified the ideation part as the most enjoyable part of the workshop (P5, P6, P11, P13, P14, P19, P24, P27, P34, P38, P49, P51). Participant 14 said that making design choices while fixing the object was entertaining. Similarly, Participant 27 stated that he enjoyed searching for new possibilities and trying design ideas during the idea generation stage.

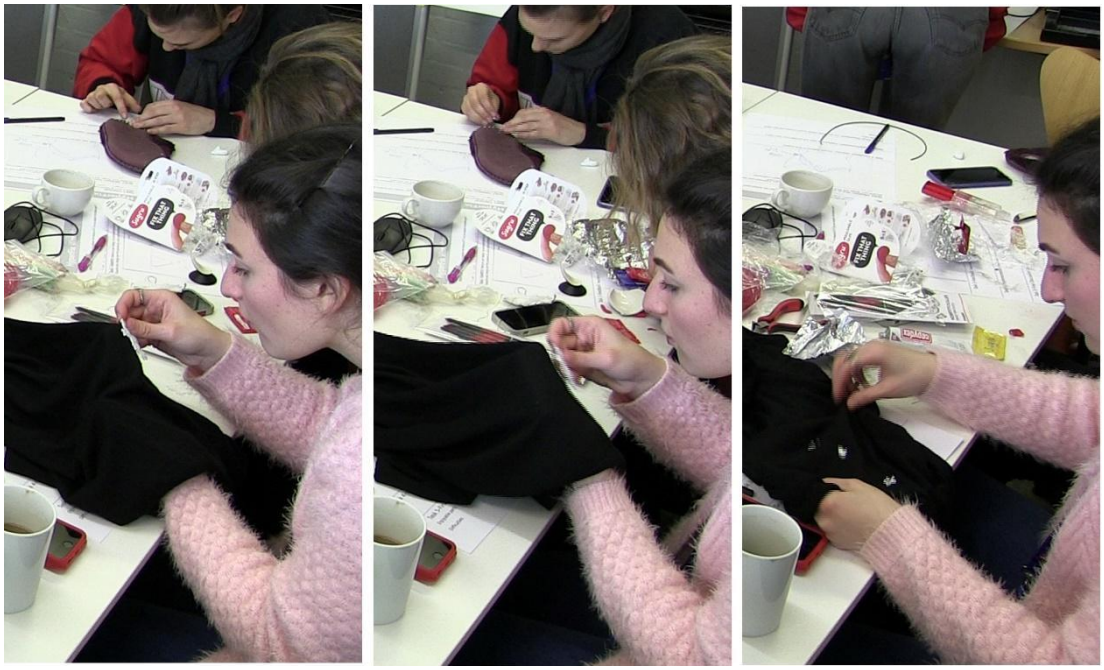


Figure 69. Participant 36 had difficulty in coming up with repair solutions.

Besides the enjoyable aspects, participants also stated that they had some difficulties in coming up with solutions and choosing the right techniques and materials during the ideation part (P2, P19, P20, P23, P25, P32, P36, P37). Participant 36 explained her struggle as 'Finding a solution about how I could fix this sweater was difficult. I think if the sweater were not expensive I would not fix it' (Figure 69). Another thing was that although most of the required materials were available, some participants struggled in choosing the appropriate technique. Participant 32 stated that he had difficulty with choosing the right method for the product and he did not want to spend time and money on trying different materials and methods. Similarly, Participant 37 asserted, 'Finding the right material to fix was difficult'. This feedback demonstrated that providing the materials and instructions required for the specific repair activity via repair kits could be helpful in encouraging people who were not experienced at doing repairs. Consequently, after I explained the process and gave suggestions about the materials, they easily repaired their products.

Figure 70. Participant 23 was hesitating to repair his laptop case as he did not know how to sew.

Some participants said that they had never tried fixing an object before so they needed basic information about the repair process. For example, Participant 23 was hesitating to repair his laptop case, and he said, 'I do not know how to join leather. I had difficulty in thinking about the ways to join leather' (Figure 70). This showed that repair kits should provide the basic instructions for all skill levels and the materials which were adequate for the purpose. The textile patches technique was developed as a kit after the conversation with Participant 23. The design and development process of textile patches kit is explained in Section 5.4 in detail. The kits aimed to give people the confidence that the repair would be successful, so that eventually they would not worry about the time and money spent.

4.4.3.3. Implementation

The implementation stage was the active part of the workshops. Participants implemented the ideas which they had developed during the idea generation.

People usually think repair is about disguising damage. One of the reasons for this idea could be the negative stigma attached to the act of repair and repaired products. Although there were some participants who wanted to hide the traces of the repair, the majority of the participants declared that they liked the idea of making the repair visible. For instance,

Participant 4 stated that he enjoyed repairing his watch strap with contrasting colours and different patterns instead of trying to hide the fixed part (Figure 71). He added that trying diverse materials and generating possible solutions in order to make the damage beautiful was satisfying and fun. Similarly, Participant 1 said, 'I like the idea of making the repairing visible with other materials'. At the end of the workshops, participants stated that they were pleased with the repaired products (P1, P2, P4, P6, P13, P15,). Participant 15 explained her feelings as 'Very happy with the result' (Figure 67). Similarly, Participant 49 stated that 'I enjoyed the design and implementation stage and I loved the idea of fixing visibly and emphasising that the object is different now'. Contrary to this, some participants wanted to repair their products in a way that would make the damage and repair invisible. For example, Participant 27 wanted to return his product to its original appearance and he said he wanted to make it perfect again (Figure 72). He described his shirt as a business shirt in blue, perfectly tailored. The area around one of the buttons of his shirt was ripped. We discussed various visible repair solutions, such as Sugru, sewing and patching, but he stated that he did not want to repair his shirt visibly and stated, 'The solution is not matching my perfectionism either in craftsmanship or in look'. However, he changed his mind after other participants persuaded him. He was afraid of taking any risks while repairing his favourite shirt, although there were many reversible repair methods, such as sewing and patching. After this case occurred, and in discussion with Participant 27, I decided to include 'reversibility' as a new category to the design considerations. Finally, Participant 27 preferred patching the ripped part with a neon yellow fabric, as the method was reversible, and in the worksheet he stated that it was fun to try new things.

Figure 71. Participant 4 repairing his watch strap.

Figure 72. Participant 27 was afraid of taking any risks while repairing his favourite shirt.

Similarly, another participant was worried about taking risks during the repair process. Participant 5 said, 'I am scared of doing something that I cannot go back on if I change my mind'. Consequently, these cases showed that if the repair process was reversible participants found it easier to engage in the activity. Another category, 'endurance', was also added to design considerations after the first two workshops as some participants stated that they were worried about the strength of the repaired part and how long the repair was going to last (P1, P3, P4, P10, P20). For example, Participant 3 said that she needed the product and was worried about whether the repair would last.

Although most of the participants stated that they enjoyed the implementation, it was one of the most challenging parts of the workshop. Participant 19 was one of the participants who struggled during this process. He had brought his sweatshirt to the second design workshop to repair. It had some small holes in it. After deciding together to use darning method to mend it, I left the table to talk with other participants. After a while, I observed that he was hesitating to start mending the sweatshirt. Then he stated that he could not sew. When I suggested to him that he could glue on small patches he replied that he was not good at glueing and would mess it up. He did not repair the sweatshirt at the end. This incident again showed that the real problem is not the damage, but is rather human behaviour and people's relationship with the products. After this case, I focused on thinking about ways that could encourage people like Participant 19 to repair their products easily. Consequently, the idea of plaster patches emerged, which is explained in Section 5.5.

4.4.4. Design Considerations

Design considerations were finalised with the two categories generated through the workshops.

14. Reversibility: If the repair method is reversible it is possible to restore the product to its previous state. If the repair was reversible this might reduce users' negative feelings, such as worry and stress, which is usually seen when the users are not confident about their skills and experience, or when the product has special value for the user.

15. Endurance: This consideration refers to the strength of the repair and how long it lasts. Participants preferred long-lasting repair solutions, as they might get frustrated in spending time on the same damage repeatedly.

Table 3. Fifteen categories of design considerations.

Design Considerations		
Cultural Probes	**Design Studies**	**Workshops**
1-Financial cost 2-Repair duration 3-Ease 4-Personal pleasure 5-Required knowledge 6-Required skills	7-Aesthetic 8-Interest in the method 9-Accessibility of materials and methods 10-Functionality 11- Negative stigma attached to repair 12-Improving the object's design 13-Storytelling	14-Reversibility 15-Endurance

Table 4. Fifteen categories of design considerations with explanations.

Design Considerations		
Cultural Probes	**Design Studies**	**Workshops**
1-Financial cost This consideration refers to the cost of the repair, materials and tools that were used in the process. If the process requires expert knowledge or any kind of repair service, its cost is also considered under this title.	**7-Aesthetic** This refers to the pleasure which results from the sensory perception of the repaired object.	**14-Reversibility** If the repair method is reversible it is possible to restore the product to its previous state. If the repair was reversible this might reduce users' negative feelings, such as worry and stress, which is usually seen when the users are not confident about their skills and experience, or when the product has special value for the user.
2-Repair duration Repair duration represents the time required for completing the repair process.	**8-Interest in the method** Using interesting methods is an effective strategy to overcome the stigma attached to the act of repair. If people focus on the interesting techniques they are using, it might be easier for them not to experience the barriers, and engage in the activity.	**15-Endurance** This consideration refers to the strength of the repair and how long it lasts. Participants preferred long-lasting repair solutions, as they might get frustrated in spending time on the same damage repeatedly.
3-Ease Ease represents the amount of work required to complete the repair. Participants preferred to carry out repairs which do not require great labour or effort.	**9-Accessibility of materials and methods** In the current economic system, it is often easier and cheaper to buy a new product rather than repairing one that is broken. As a result of this, the methods, materials and tools for repair should be made easily accessible if we want people to repair products more often.	
4-Personal pleasure Personal pleasure/satisfaction refers to the pleasure experienced by carrying out the repair and the pride felt as a result of doing the repair. It includes the enjoyable aspect of the process, and emotions such as the feeling of relaxation and enjoyment it triggers.	**10-Functionality** Products might become non-functional after being damaged. This category refers to restoring the damaged product to working order as much as possible.	
5-Required knowledge This category refers to the knowledge that is required to carry out the repair activity. It can be about the repair methods, where to get the necessary materials, tools and how to use them.	**11- Negative stigma attached to repair** This category refers to the socioeconomic perception of repair. Damaged, frayed and repaired products are associated with economic hardship and poverty. Therefore, people might feel ashamed of repaired products. This fact might also affect user's motivation to use a repaired object and discourage him/her from repairing.	
6-Required skills Using one's hands and fingers to make and manipulate things is a natural human ability. Anyone can repair objects using their natural skills and creativity. The quality of work improves in time with practice.	**12- Improving the object's design** This category refers to making a product more valuable and more beautiful than a new product by repairing it.	
	13-Storytelling This category refers to revaluing an object as a conversation piece through visible repair. Every repaired object tells a story. Stories are a significant part of creating awareness and spreading the message.	

4.4.4. Testing the Do-Fix Kits and Design Considerations

This section presents the testing of Do-Fix kits during Workshops 3 and 4. These workshops were focused on how participants use the Do-Fix kits, as well as exploring the parts they enjoyed and the difficulties they encountered during the repair process. I asked participants to choose one of the repair kits to fix their product and fill the questions in the worksheet according to their repair process. The results are based on participants' answers, and my observations are explained for each repair kit.

Kintsugi is an inspirational repair method that transforms the damaged product into a beautiful and interesting object. The kintsugi kit was designed for low skill level users and requires a low level of repair knowledge. The majority of the participants stated that they enjoyed the process and they were pleased with the final product. For example, Participant 48 wanted to try the kintsugi kit and repaired the small ramekin that comes with the kit (Figure 73). At the end of the process, he said that 'Preparing the mixture, mixing the gold powder with glue and turning it into a gold liquid, was enjoyable'. Similarly, Participant 45 repaired her broken plate with the kintsugi kit and said that 'When I fixed the plate with glue and gold particles it looked really nice, like a new plate with a new design'. However, some participants found it difficult to hold two broken pieces together for two to three minutes until the glue dried. Here, it is important to be patient and careful, otherwise the gold glue smudges and creates an undesirable result.

Figure 73. Participant 48 used the kintsugi kit and repaired the ramekin in the kit.

The textile patches kit was designed after similar damage was seen frequently among bags, shoes and other leather goods during the design studies and workshops. Participants brought these kinds of products to workshops with the aim of using them for longer rather than creating a decorative object. Therefore, in the case of textile patches, functionality is one of the most significant categories of the design considerations. For example, Participant 34 brought a faux leather jacket to Workshop 3. Although it was frayed on the shoulders, she said that she wore it frequently. She used green faux leather patches to cover the frayed area.

After the repair, she stated that she liked the idea of giving new life to a damaged object by redesigning the damaged parts.

The majority of the participants were interested in 3D printed patches. They asked questions about this method and wanted to try it. Some participants said that the object turned into something different and original with these patches (P41, P47, P52). For example, Participant 47 used the patch to create a strap for her watch. She declared that she chose that particular kit as the 3D printed pieces look like a piece of jewellery, such as a bracelet. Similarly, Participant 52, who used this patch on the edges of the sleeves of her jumper, said that the patches transformed her jumper into something extraordinary.

Plaster patches were designed for enabling easy and low-cost repairs. Using this kit requires neither skill nor knowledge, and users can create different designs by using patches in different colours and shapes. For example, Participant 50 brought her damaged tights to Workshop 4 (Figure 74). She said she has nearly fifteen pairs of tights: all of them were laddered and she did not want to throw them away. She wanted to find an easy, quick and cheap way to mend them. After applying plaster patches, she stated that the repair was very easy and the end result was surprising. She added that she enjoyed choosing different colours and shapes of patches and creating her design.

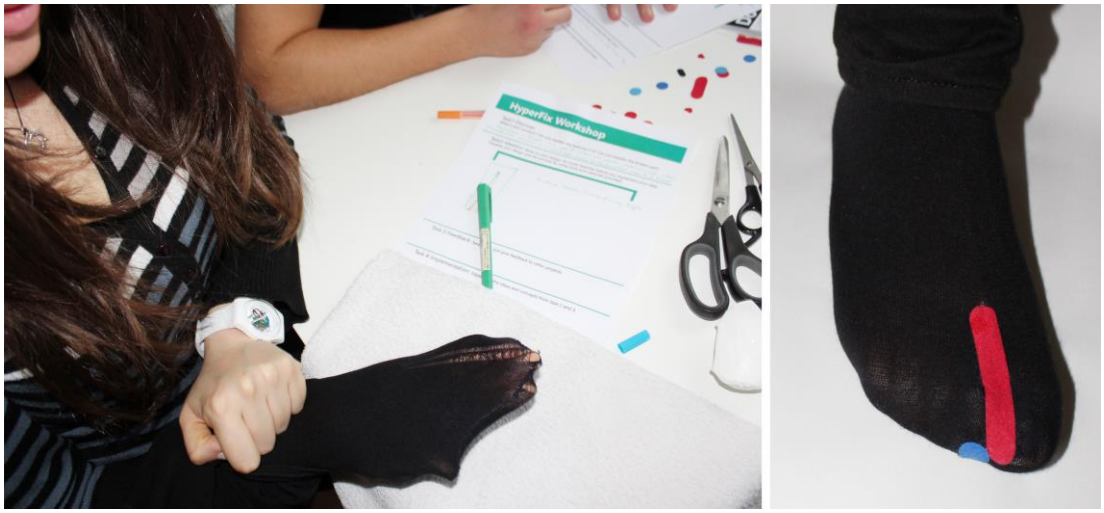


Figure 74. Participant 50 brought her damaged tights to workshop 4 and used plaster patches to mend them.

As this kit is specifically designed to make the repair easy, participants did not find it difficult to apply. For example, Participant 29 declared that the process was very easy, adding, 'I just pressed the patch with an iron'. Some participants preferred using bright colours: for instance, Participant 49 repaired his socks with a big red circular patch (Figure 75). He said that 'I loved the red patch. I think it looks really nice on a light grey sock'. On the other hand, some participants wanted to make their repairs less visible and used the patches of the same colour with their clothes.

Figure 75. Participant 49 repaired his socks with a big red circle shaped patch.

To conclude, participants used Do-Fix kits to repair their products during Workshops 3 and 4 and reflected on their experience, based on the repair process they used and the repaired product. As the majority of damages were fixed and the participants' responses were positive, we can say that Do-Fix kits were successful at empowering and encouraging the participants to repair their products.

CHAPTER 5

DO-FIX REPAIR KITS

5.1. Introduction

This chapter presents the Do-Fix repair kits, reflecting on how the findings of the design studies and workshops led to these design projects. Do-Fix consists of four kits, namely a kintsugi kit, 3D-printed patches, plaster patches and textile patches, which were designed to help people fix products more often and encourage them to have a deeper relationship with things through repair. The Do-Fix kits were designed for the transition stage towards a circular economy, and for products that are not designed for a circular economy. We are currently at the beginning of this transition stage, and the majority of the products that we are using today are not designed for repair, remanufacturing or recycling. Although they are not circular, we cannot throw all of them away and start using circular products. This transformation will take time and we need to get the most value from the products to minimise their negative environmental impacts. Do-Fix kits are a solution for keeping these non-circular products in use for longer through repair. Moreover, this 'throwaway' mentality has damaged the relationship between people and products. People have become passive users who consume products for their symbolic value and socially constructed meaning, and cannot see the real value of things anymore. These kits also enable people to engage with products at a material level through repair, and help them to better realise the value of products and the material embodiment of meaning.

The ultimate aim of these design projects was not to find the best repair methods suitable for a range of damage. It was to identify ways that would enable people to repair more products and experience deeper relationships with products to create awareness. 3D-printed patches might not be the best solution for mending a knitted jumper; however, it was one of the methods that drew participants' interest and helped them engage in the repair. Participants focused easily on the process of fixing, and did not engage with their preconceptions and negative assumptions, such as the idea that the repaired products were tainted or scarred, or their lack of skill and confidence.

5.2. Why Kits?

The repair kit concept is common for certain products, such as bicycles, clothes and wooden furniture. The bicycle kits and sewing kits are usually designed for unexpected situations and urgent repairs. For example, bicycle kits include tools and materials for fixing tyres quickly. As mentioned in Section 2.12.1, the clothing company Patagonia developed a pocket-size expedition sewing kit in collaboration with iFixit, for the purpose of encouraging self-repair. Similarly, this kit is for quick fixes during expeditions. Scaling these examples up and creating

more kits for various products and other types of repairs would be helpful in encouraging people to repair more products.

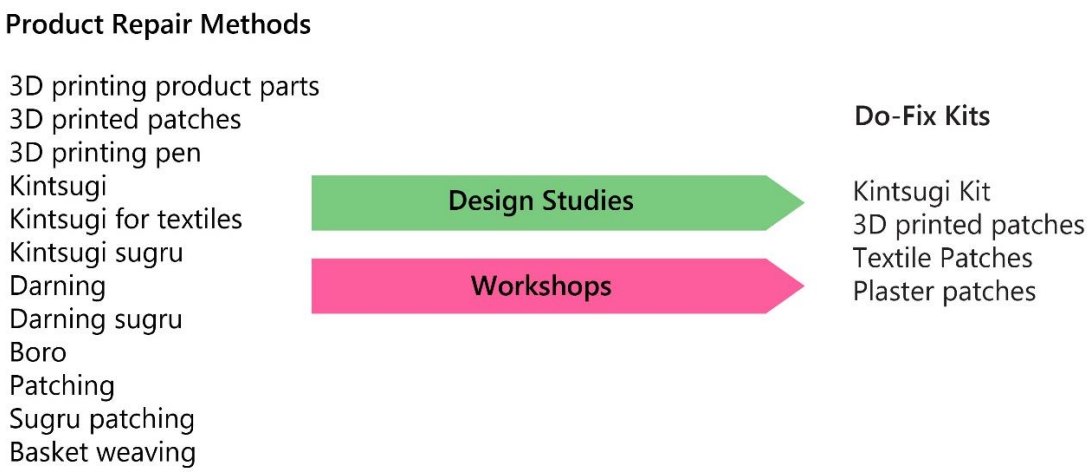


Figure 76. The repair methods naturally evolved into repair kits throughout design studies and the workshops.

After the design studies, I developed four design ideas to address the research question (see Section 4.3.3). However, considering participants' reactions and comments after Workshops 1 and 2, I concluded that repair kits were the most suitable way to addresses the research question, for a number of reasons. First, the workshop participants were interested in the repair methods rather than the other design ideas. They asked questions about the materials and where they could get them. Second, the repair methods that I developed during the design studies started to become like repair kits as more participants used them for similar damages during the workshops. In other words, the repair methods naturally evolved into repair kits throughout the design studies and the workshops (Figure 76). Third, the kit concept is the best way to reach the objectives of this research, as it encourages people to repair products more often by offering methods, materials and instructions in a convenient way to guide users through the process. Fourth, visible repair gives voice to everyday ordinary objects to spread their story and value. It enables people to create powerful stories which spread the message and raise awareness about environmental problems.

Figure 77. Do-Fix Repair Kits

5.2. Kintsugi Kit

The Japanese repair method known as kintsugi is employed to mend cracked or broken ceramics using precious metals such as gold and silver. Kintsugi transforms the damaged object's value, meaning and appearance. Inspired by this traditional method, the kintsugi kit makes this method more accessible and easy to use by offering instructions (Figure 78). It contains metal powder, ceramic glue, an application stick and gloves (Figure 79). Also included is an instruction booklet with examples and a pre-broken ramekin (Figure 80).

The conventional kintsugi method is a labour-intensive art and requires skill, knowledge, experience and a lot of time. This method requires a number of materials, most of which originate from Japan, and which are expensive and hard to access elsewhere. However, kintsugi-like repair can be accomplished with other materials, thanks to recent polymer technology. In the design studies I had worked on broken ceramics, including the origami vase (see Section 4.3.1.1), using two-part, food-grade epoxy to join ceramic pieces together. I had tried many acrylic and oil-based paints to imitate the gold and silver. Although the final objects looked good, their appearance did not reflect the metallic effect. I then experimented with powdered brass and aluminium on various ceramics, and they looked similar to the real kintsugi repairs.

Figure 78. Inspired by the Japanese traditional method kintsugi, this kit makes it more accessible and easy to apply.

Figure 79. Kintsugi kit contains metal powder, ceramic glue, an application stick and gloves.

My specification for a 'kintsugi kit' took final shape after considering comments from the workshop participants. The most frequent enquiry I received was about where they could get the materials. Thus, the idea of providing the materials and instruction methods in a kit came up. Users would be able to achieve a kintsugi effect without struggling to find the right materials. Some of the participants said that they wanted to try this method, but they did not have any broken ceramic products: when any ceramic or glass objects break they throw them away. In addition to this, some of the participants who did have broken ceramic goods, and wanted to apply kintsugi, hesitated to do so. They asserted that they had no experience and were worried about their skills. After these comments, I decided to include a 'testing piece' in the kit, a broken ramekin. Users can experiment and gain confidence using the broken ramekin provided in the kit, and after fixing it they can confidently fix their own objects. As the kit has more kintsugi materials than those which are needed to fix a small ramekin, the remaining materials could be used to fix other objects when they break. Providing a *pre-broken* object as a part of the kit enables the user to learn and gain confidence, while s/he also ends up with a repaired ramekin. The experiential dimension of providing a pre-broken object can be compared with Droog Design's 'Do create' project (see Section 2.12.4). For example, in the case of the 'Do Hit' chair the user hits a metal box with a sledgehammer to transform it into a seat. The final product depends on the user's strength and imagination. Users are invited to engage with the product, and accordingly their engagement completes the product. Moreover, this engagement enables the user to experience a relationship with the product which is different from, and deeper than, the passive user-product relationship allowed by the dominant linear system.

Figure 80. Step by step instructions on how to use the kintsugi kit.

5.3. 3D Printed Patches

3D printing is a relatively recent manufacturing technology with definite potential for enabling product longevity through repair. This technology potentially drives people to focus on the 'fun' and 'cool' aspects of the technology instead of thinking about barriers, such as their lack of experience and skill level.

3D-printed patches were inspired by conventional mending techniques for textiles, such as darning and patching (Figure 81). Initial designs were two-dimensional pieces that could be sewn on fabric (see Section 4.3.1.8). I also worked on flexible structures including chain-like designs and patches with joints (see Section 4.3.1.8). These patches were developed and tested during the workshops (see Section 4.4.4).

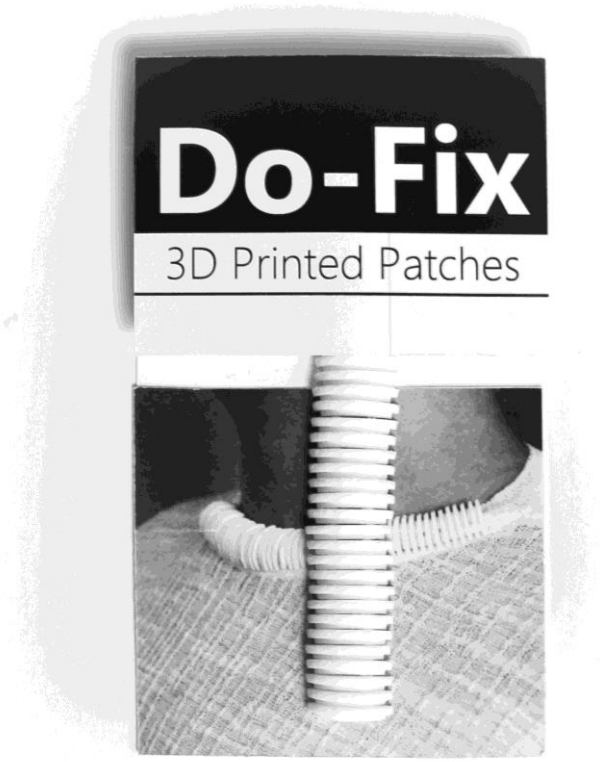


Figure 81. 3D printed patches were inspired by conventional mending techniques for textiles such as darning and patching.

Seeing endless possibilities of sizes and shapes of damage, and considering workshop participants' feedback, I concluded that the 3D-printed patch design should be adjustable for different examples. However two-dimensional one-piece designs did not answer all of these problems, as they were rigid. For example, a one-piece patch does not offer a range of

solutions for different kinds of damage, and it was too rigid for mending textiles that bend in three dimensions. Thus, I worked on modular designs that users can play with according to the type of damage.

Figure 82. 3D-printed patches applied on clothes.

An exploration of the movement of sewing and the form that thread creates inspired this design. The 3D-printed patch is made out of semicircular button-like 3D printed parts, strung on a fishing line (Figure 82). Each button has two holes. Users can adjust the length of the patch by adding and removing beads as required. The 3D-printed patch is sewn onto the fabric through the buttons (Figure 83).

Fishing line is used in this design because it is stronger and durable than using small joints between 3D-printed parts. Fishing line enabled the seam-like shape of the design. As the 3D printed buttons are small, adding joints to them would change the design completely. Additionally, small joints can get worn or damaged during the assembling and disassembling. Moreover, these patches are designed to be reused several times.

The kit was designed to take into account people's worries about sewing perfectly, as elicited through discussions in the workshop sessions (see Section 4.4.1). The sewn parts stay between the beads, so that they are not visible, which eliminates the worry for users about their level of skill.

The length of this 3D printed patch can be adjusted by removing or adding the beads. Tie the end if the patch tightly before using it.

3D printed patches can be used as a watch strap.

Sew through the beads to use it on garments. Cut the stitches to remove the 3D printed patch and keep reusing it on other objects.

Figure 83. Step by step instructions on how to use the 3D printed patches.

5.4. Textile Patches

Initially, I did not know how to include this conventional repair method in this research in a creative way when I started experimenting with patching. Then it inspired various new repair methods. For example, textile patches were designed for pragmatic reasons. The need to fix bag straps, damaged belts and holes in shoes during both the design studies and workshops informed this kit design. The kit contains textile or faux leather patches, a needle, thread and textile glue. The patches are used to join the ripped parts with textile glue. After this, depending on the damage, they are sewn in order to make the repair durable (Figure 84).

Figure 84. Textile patches kit contains textile or faux leather patches, a needle, thread and textile glue.

Figure 85. Textile patches applied on a backpack.

This repair method was frequently applied during the design studies and workshops as it is very practical for mending bags and shoes. I initially experimented with this method on a backpack. The straps were torn apart, and I tried using textile glue, sewing and patching. Then a repetitive pattern started to emerge regarding the types of damage types to bags and shoes during the workshops. Most of them were fixed easily and effectively with textile patches (Figure 85). One of the most common problems was torn straps and worn parts of the bags. As the damage became repetitive, I designed a range of differently shaped patches to make the process easier. The patterns were also designed with sewing dots to make the mending easier, and the result more aesthetically pleasing (Figure 86). Users who already have the materials and tools can download the patterns with instructions to apply this method, as they are available on open-source websites.

The kit worked very well for bags made out of textiles such as cotton, synthetic fabric and thin leather during the testing process in workshops. Participants found the sewing patterns practical, and at the same time enjoyable to apply. However, some users faced difficulty in sewing the patches when the bag's material was thick. In some cases there was no need to sew, as the patch adhered strongly to the bag.

Figure 86. Step by step instructions on how to apply the textile patches.

5.5. Plaster Patches

Inspired by putting on plasters and the ease of applying them, this kit is designed for users with a low level of skill (Figure 87). Throughout this research I aimed to overcome perceived barriers, to encourage people to mend their products. Changing certain behaviour or adopting a new behaviour is not always an easy task; therefore, I aimed to target what is preventing the behaviour, and started with simple tasks, as suggested by Fogg (2009) (see Section 2.16.2).

The idea of the plaster patches came up after a conversation with a participant in the second design workshop. Participant 19 had brought his sweatshirt to the second design workshop to repair. The fabric had some small holes in it. After deciding together to use the darning method to mend it, I left the table to talk with other participants. After a while, I observed that Participant 19 was hesitating to start mending the sweatshirt. Then he stated that he could not sew. When I offered to glue small patches, he replied that he was not good at glueing either, and would mess it up. Afterwards, he added that he had never repaired anything before. I tried to help him but he had the idea that he was not skilled and experienced enough for this task. As the purpose of the workshops was to encourage users to repair their own items, the sweatshirt ended up being unmended. This incident again showed that what we are dealing with is not just the damage, but human behaviour and its relationship with the product. Anyone can find a way to fix any damage; however, the challenge is to make repair part of our relationship with products again.

Figure 87. Inspired by putting on plasters and the ease of applying them, plaster patches were designed for low skill level users.

Figure 88. I conducted a mini workshop with participant 19 to test the plaster patches on his sweatshirt.

We live in a world which is constantly in need of repair, so anyone can be called a mender (Spelman, 2002). Rewriting the research question specifically for this case, 'How can we encourage Participant 19 to repair his sweatshirt?' I thought about the possible repairs that he could have managed without considering the processes as an explicit 'repair', such as healing a wound or a cut in a finger. That reminded us of plasters. The majority of people are experienced in putting plasters on cuts. So, I decided to use it as a metaphor, as anyone can fix things in the same way as they might apply a plaster.

The material of the plaster patches is vinyl. This patch is suitable for many fabric types. However, fabrics like cotton provide the best base for iron-on patches. The patch is positioned on the fabric and ironed for 15 seconds with pressure over a thin towel. It is ready to use after being allowed to cool down (Figure 91).

After finishing experiments with the patch, I tested it with the workshop participants. I also contacted Participant 19 and conducted a mini workshop with him to test the plaster patches on his sweatshirt (Figure 88). The result was positive and he was pleased with the repair; he wrote on the worksheet that 'I have never fixed anything before. This was my first attempt. It was pretty easy to fix with these patches, I just put an iron on it. I am glad that I have managed to fix it before the holes get bigger'. To conclude, the plaster patches can have a wide area of application, from umbrellas to shoes and tights (Figure 89, Figure 90). They are significantly effective for small holes in the fabric and designed for users with a low level of skill.

Do-Fix repair kits invite people to reassess the concept of value and consider the meaning of repair in our throwaway culture. They are potentially important for consumers in terms of helping them to understand the value of objects and materials and their relationship with things through the lens of repair activity.

Figure 89. Plaster patches applied on products.

Figure 90. Plaster patches applied on products.

Figure 91. Step by step instructions on how to apply the plaster patches.

CHAPTER 6

DISCUSSION

This chapter discusses the research questions and how they were answered based on the results of three research studies and design projects. It continues by presenting the discussion of how Do-Fix repair kits can be scaled up to a broader design field or can be of use to other stakeholders of the circular economy. The chapter concludes by describing the limitations of this research and suggests recommendations for further research.

6.1. Research Questions Revisited

The importance of repair in the circular economy and during the transition stage toward the circular economy in terms of creating awareness about the value of products and materials in society was described in Section 2.9. However, the scholarship on the circular economy pursues a business-focused approach in which the relationship between people and products is neglected. Based on the gap in knowledge identified in Section 2.17, the first research question was formalised as:

How can we encourage people to repair products in order to experience deeper relationships with things and create greater engagement with environmental problems?

The research questions are closely connected to each other. Thus, in order to answer the first research question I needed to identify the motivation and barriers that people experience in relation to repair. Accordingly, the second research question was formalised as:

- What are the motivations and barriers that people experience in relation to product repair?

Fogg's behaviour model (2009), with its focus on removing the barriers and boosting motivation, was useful as a framework for determining the effective methods by which to address the first research question. Destmet and Hekkert's (2007) framework of product experience, together with Crilly et al.'s (2004) cognitive response categories, were also instrumental in forming my approach to and understanding of, this research, and exploring how people experience the product repair process. This answered the research questions, in the light of these theoretical building blocks, through the systematic research conducted including the literature review, cultural probes, design studies and workshops.

A rich collection of insights about the motivation and barriers that people experience in relation to product repair were generated throughout this research. First, the motivation and barriers that people experience in relation to product repair were investigated through the cultural probes research (Section 4.2). This research was successful in giving me an idea about what people repair and an initial idea about their behaviour. Additionally, the participants provided rich and diverse data which helped me to set the scene for the rest of

the research. Seven motivation and six barrier categories were developed as a result of this research. Six of these categories were included in the design considerations. After the cultural probes research, I further explored the motivation and barriers that people experienced in relation to repair by reflecting on my own experience through phenomenological research, in which I visibly repaired damaged objects during the design studies. Six more design considerations were developed during the design studies. Two more design considerations were developed with a phenomenological perspective by observing the interactions of people with products during Workshop 1 and 2. The development of the design considerations was finalised after testing them with participants during Workshops 3 and 4 (see Section 4.4.4). Finally, fifteen categories of design considerations which influence people's repair decision were identified. Consequently, the second research question was answered by systematically bringing the repair methods and motivation and barrier categories together as design considerations.

These considerations were the building blocks of the Do-Fix repair kits. Together with the theoretical knowledge from the literature review, the design considerations were incorporated into the design of these repair kits. The core of every stage of their design process was choosing a simple behaviour target and removing the barriers (Fogg, 2009). I developed simple repair methods by taking into consideration the barriers. These methods were tested with participants during the workshops. I explored whether they were encouraged to repair their products with the help of these methods, and found out which methods were preferred taking into account the enjoyable experiences and difficulties they faced.

Throughout the workshops, a wide variety of user perspectives were collected. Feedback from the participants confirmed that the repair methods which were designed as repair kits were found to be useful by the majority of the participants. Most respondents also said that their confidence increased, and their knowledge and skills were improved as a result of using the Do-Fix Kits. Participants used them to repair products throughout the workshops, which indicated that these kits enabled and encouraged them to repair their products and engage in a deeper relationship with things through repair. These results suggested that the Do-Fix repair kits were useful, and had an encouraging effect on participants. Consequently, the first research question was answered.

6.2. Reframing the Function and Position of Repair in the Circular Economy and Adaptation of the System Diagram

The role of repair in the circular economy in relation to the significance of users in the circular economy was discussed in the literature review (see Section 2.9). Based on the existing research, I concluded that the majority of the circular economy scholarship ignores user participation while focusing on the business aspects. For example, the Ellen MacArthur Foundation has developed a wide range of publications and learning materials with a view to promoting circular economy thinking to businesses and higher education institutions (Ellen MacArthur Foundation, 2015). However, users have not been directly included in the transition plan that it follows. A contradiction can be seen here, as the Ellen MacArthur

Foundation, in its publications, emphasises that the circular economy requires a transformation from ownership to usership (Ellen MacArthur Foundation, 2013) and also 'the user' is situated in the centre of the system diagram created by the foundation, emphasising the user's role further. Additionally, Pitt and Heinemeyer (2015), in their article documenting a case study of the work of the Ellen MacArthur Foundation, compared the systems thinking approach and behavioural change studies in terms of their impact on change towards the circular economy. They argued that the focus should be on the economy and system thinking rather than user behaviour and 'persuading consumers' (Pitt & Heinemeyer, 2015, p. 245), and the authors stated that 'Its [Ellen MacArthur Foundation's] priority has been to reach new audiences, both in business and education, with a novel approach based on design, systems thinking and economics, rather than individual behaviour change' (Pitt & Heinemeyer, 2015, p. 258). It was outlined during literature review that all aspects of the system – environmental, social and economic – should be considered to successfully transition to the circular economy (Ren et al. 2013, Bakker et al., 2014a, Ghisellini et al., 2016). This research focuses on persuading and encouraging people to engage in the system through repair in order to create consciousness about the value of products and raise awareness about environmental and social problems. The 'active user', who is responsible and aware of his/her actions, is the basic unit of the circular system (Shah, 2014). S/he maintains the product to make it last longer, repairs it when it breaks, and s/he can also reuse or repurpose the product, with the aim of to making the most of its value. At the end of the use phase, the active user is responsible for returning the product back to the manufacturer for remanufacturing or recycling.

Similar to the argument above, the system diagram (Figure 92) relating to the Ellen MacArthur Foundation does not completely reflect the changing role from the passive consumer to the active user. The system diagram based on Michael Braungart and William McDonough's (2002) 'cradle to cradle' diagram illustrates the continuous flow of technical and biological materials. One side of the system diagram illustrates the consumption flow of biological materials while the other side shows the technical materials which are revalued through continuous cycles. The user who is in the centre of the diagram is the last destination of products before they go into the loops. The system diagram illustrates the responsibilities of the user towards the manufacturers, such as returning the product back to the service provider, product manufacturer and parts manufacturer. However, it only shows the 'maintain' loop among the active user's inner loops (Figure 92). In other words, 'the user' has its own loops, including 'maintain', 'repair' and 'reuse', which make them an active participant, but the systems diagram illustrates the active user as a point in the system through which products pass. Additionally, the inner loops are different from the outer loops, and they are as important as the outer loops for the system because the user creates value himself/herself with his/her labour.

To reflect these deficiencies, I have adapted the diagram (Figure 93) to illustrate the user as an active unit with the inner loops, by which s/he engages with the system and returns value to it. The 'repair' and 'reuse' loops were added to the inner loop of 'maintain'. These inner loops were illustrated as a part of the user's active role (Figure 94).

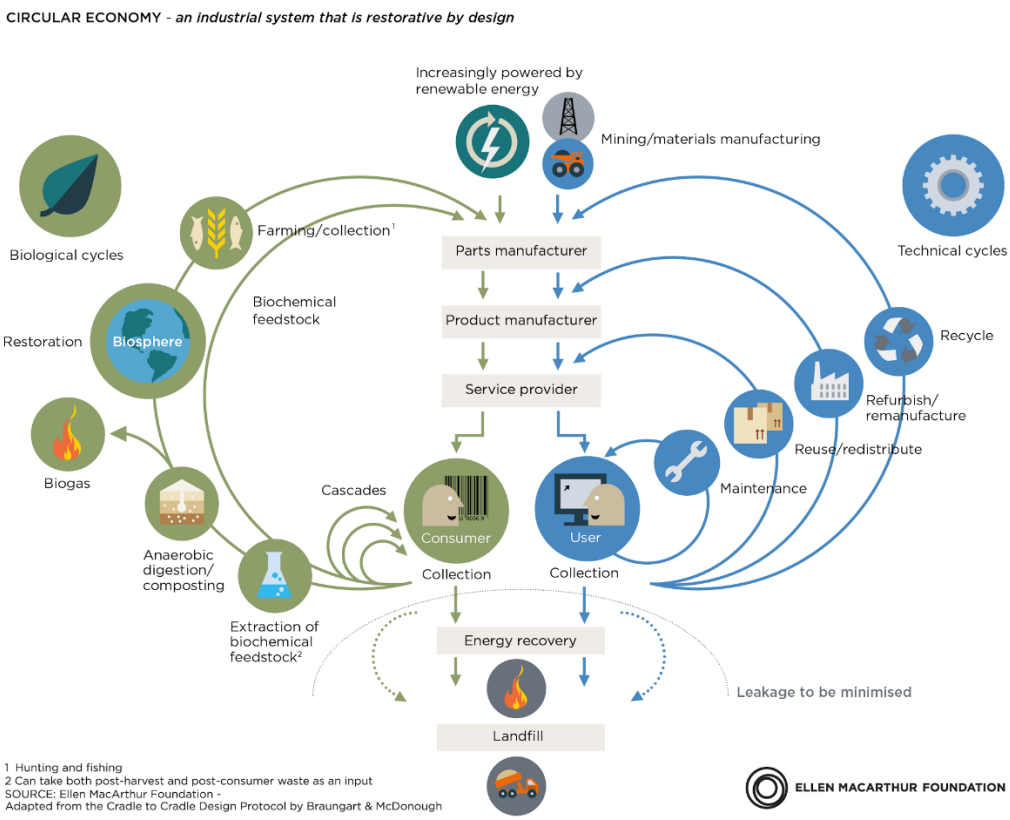


Figure 92. Ellen MacArthur Foundation's original system diagram (Ellen MacArthur Foundation, 2011).

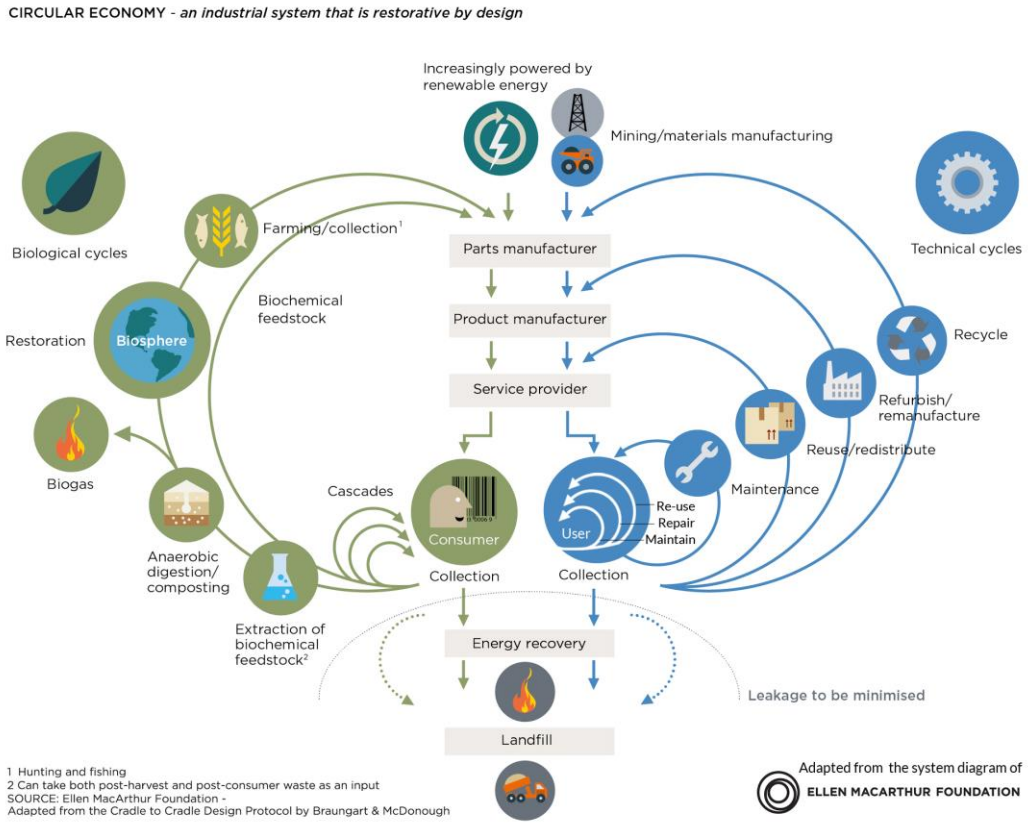


Figure 93. Adapted system diagram by Nazlı Gökçe Terzioğlu reframing the function and position of repair in relation to the significance of users in a circular economy where the inner loops including maintain, repair and reuse are illustrated as a part of user's active role.

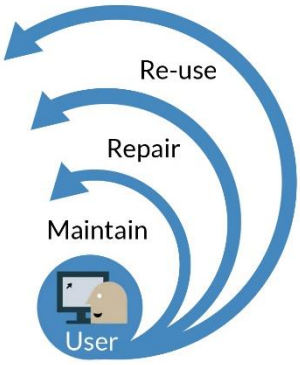


Figure 94. A closer look at the user in the adapted system diagram.

6.3. Scaling up Do-Fix Repair Kits to a Broader Design Field

How often do we think about products? The majority of people do not pay attention to the material value of things in our current throwaway society, which has engendered significant

environmental, social and economic problems. This research highlights the consumer society's disengagement from the materiality of things and their material value. It is not possible for the current linear system to continue, in the context of the earth's finite resources. People can learn to perceive the real value of products beyond their symbolic meaning, and they can create new relationships with their environment, not mediated merely by signs but through consciousness that can be created via a physical engagement with products. New values can be created by repairing products and interacting with them at an existential level. The most important thing here is to create an awareness and confidence that they can change the current problematic state. This explanation sounds reasonable from an environmentalist researcher's perspective, but why would a company be interested in repair kits or product life extension? Perhaps because it might be a way to create increase its market share, and might reduce competition by getting customers to return back to the company. For example, a backpack company is well aware of the fact that the backpack they sell is going to wear out over time and need replacing. When a company provides long lasting, high-quality products that enable a deeper relationship with objects, it might increase the possibility of customer loyalty. If it provides a repair kit customised to the product, it might increase the likelihood of the user repairing the product by him/herself. Accordingly, this would increase the warranty costs. When we consider the same example in the circular economy, there are more benefits in a business model in which the company retains ownership of the backpack and users have monthly subscriptions. In this case, the company sends a backpack to the user every year, repairs the old backpacks or recycles the ones beyond repair. Besides the advantage of increasing the customer loyalty and decreasing the warranty costs, the company saves on the repair service costs. As the possibility of the user creating a deeper relationship with the product increases, the user might keep the product for longer, which means that it is more resource-efficient for the company and results in a reduction in material costs. Consequently, there are four important reasons for a company to provide repair kits with their products: the possibility of increasing customer loyalty, decreasing warranty and repair service costs and enabling resource efficiency.

6.4. The Scope of This Research on the Spectrum of Maintenance and Repair

Although repair and maintenance are two closely related, they differ in terms of the state of the product that requires one of these activities. The spectrum of maintenance and repair is divided into two parts with the line of 'breakdown/damage'. This research is located on the repair side of this spectrum. The products that require maintenance and any maintenance acts were not included.

This research aims to create awareness about the problematic relationship between users and products. Repair addresses this aim as it is an activity that engages people with the products materiality and helps them create deeper relationships. This can be achieved by maintenance as it also requires a materialistic engagement with products. However, I wanted to focus on repair because of the creativity involved in visible repair, the visible aspect of it that enables storytelling and it is an act of design activism (Section 2.13). A visible repair is a creative act of fixing an object aiming to create something artful and beautiful out of it. It

enables people to spread the message about environmental problems through creating powerful stories. Additionally, a product demands immediate attention when it breaks. This might create a stronger trigger for people to spend the effort and time for it. On the other hand, a product requiring maintenance can be more easily ignored than a broken product. As I explained in Section 2.16.2, motivation, ability and triggers are the three factors which form a behaviour change according to Fogg's Behaviour Model (Fogg, 2009).

As I explained in Section 4.2.1, I received one hundred and three photographs of broken and repaired object from participants. Ninety-three of these were in the scope of this research. I did not receive any product maintenance photographs. Ten objects which were not included were regarded not as repairs but temporary adjustments, such as putting a cardboard piece under the table, and six of them were building repairs such as painting the walls of a room. I focused on repairing physically damaged products during design studies (Section 4.3). Similarly, participants brought their broken products to the workshops and they repaired them (Section 4.4). As I explained in Section 2.11 there is no single product category focus in this research. However, the focus is on physical damage which defines the scope of this research as repair. Mainly, physically damaged textiles, ceramic products, shoes and leather goods were repaired. Small furniture, glass products and toys were also included. Patching, sewing, and darning are three examples of the repair methods utilised to repair textiles. Maintenance acts such as cleaning and removing pilling from clothes were not included. As the focus of this research was physical damage, electrical or electronic problems were not included. However, two mobile phones, three MacBook chargers and one computer mouse were repaired as they were physically damaged.

6.5. Limitations of This Research and Recommendations for Further Research

This research aimed to design a product or service that empowers people to repair products more often, and accordingly started with certain research questions. While these questions were addressed through systematic inquiry, new questions emerged which are not possible to address within the time limits. In this section, these new questions are discussed and a number of topics are presented on which further research would be beneficial.

This research is focused on the transition stage towards a circular economy. Do-Fix kits are designed for non-circular products, aiming to make the most of their value and decrease their negative environmental impacts. Further studies might explore the development of repair kits for circular products that are suitable for each product's technical and biological materials. As the relationship between users and products and businesses will change after the transition, it will become easier to get users' insights and collect data about product use and disposal. This in-depth data would be beneficial for developing repair kits customised to each product, taking into account users' needs and wants and the reasons why products break.

I developed four repair kits out of the twelve repair methods that I explored during the design studies. These four kits were chosen based on the design considerations; however, some of the remaining methods can also be designed as repair kits. Further studies can be done to develop more repair kits by focusing on various types of damage.

In this research, I explored the different ways to enable users to repair their damaged products by themselves. Further research in terms of the business aspects of self-repair would provide opportunities for increasing the product lifespan and empowering users to repair more products. The repair business models were explained in Section 2.10.3 and include the repair service offered by manufacturers and reuse organisations. Self-repair can be developed as a business model and incorporated into other circular business models. Throughout this research, I studied motivated people and the things that motivate them to repair products as well as the perceived barriers that prevent them from fixing things. Further research can be carried out on the people who are not interested in repairing things. Identifying their insights and why they think and behave in this way would be helpful for a better understanding of human behaviour to change it to a more sustainable approach.

Do-Fix kits were developed in a social setting during the workshops. Participants used the kits to repair their products by themselves which indicated that these kits enabled them to repair their products. However, there are some limitations of this research which require further studies. First, it is not known whether the kits will be used by individuals, outside of this social environment. The workshop provides a social environment that might have a more encouraging effect on the participants compared to repairing alone in their everyday environment. As there were other participants with different skills level, they had the chance to help each other. They talked to each other. Accordingly this gave them the opportunity to solve the problems momentarily. Otherwise, it is more likely that people give up before completing the repair when they stuck with a problem outside this social environment. Second, it is not known whether customers would decide to buy the kits when they see them on the shelf of a shop. People might not feel the need to buy a repair kit when they have not got any damaged product. It is also unknown whether they would like to shop online or go to a shop to buy these repair kits when any of their products break. Third, it is unknown whether they would remember to use these kits or not when any of their products break before throwing them away. It is a common user behaviour in today's consumerist society to discard products when they are damaged. The answer to this question changes according to the product category and the type of damage. For example, it takes a while a backpack shoulder strap to rip off. The strap does not loose its functionality instantaneously giving the time to its user to think about solutions. This can act as a trigger to remind the user to buy textile patches and mend his/her backpack. On the other hand, the case might change for a ceramic plate. The user might prefer to throw away the broken pieces of the plate rather than keeping them until s/he thinks a repair solution like buying a repair kit. The fourth limitation is similar to the third one. It remains unknown whether they would like to use these repair kits instead of throwing them away when any of their products break. This research showed that Do-Fix kits had an encouraging effect on participants to repair their damaged products in the workshop environment. However, it cannot be said that they have the same effect outside the workshop setting. To account for these discussions future work is recommended to explore the consumer adoption of the Do-Fix kits. Further research can be conducted to explore the individual interest in these kits. Do-fix kits can be distributed to people who want to try them. Advertisements can be put on the websites such as callforparticipants.com, facebook or twitter to reach wider audiences. Repair parties could be a good opportunity to

present these kits to people who are interested in repair activities. Then, data about the kits and how these participants make use of them can be collected to address the questions about enabling people to repair their damaged products in everyday context.

Additionally, further studies can be conducted by collaborating with businesses. Do-Fix kits can be produced to explore the adoption of these kits by people in the everyday environment. The kits can be provided to consumers in two ways. First, they can be sold or given to consumers by companies such as MUD jeans and Patagonia similar to the way spare parts are provided. In this case, kits can be adapted tailored to the company's products. Second, they can be sold separately like a sewing kit or bicycle repair kit in shops. Besides testing the consumer adoption, further research might explore the consumer demand and the results of the use of kits in the home environment without the presence of experts or other people.

CHAPTER 7

CONCLUSION

7.1. Original Contributions to Knowledge

This research makes four original contributions to knowledge that presents value for researchers, users and design practice.

7.1.1. Development of Do-Fix Kits

The problematic relationship between users and products is a widely studied topic, as identified in the literature review (see Section 2.15). This research directly addresses this topic by developing a range of product repair kits that help encourage people to engage in repair activity to create a different relationship with products. A contribution to knowledge in design practice is offered by Do-Fix repair kits. These kits were developed based on the motivation and barriers that users experience in relation to repair, in order to motivate users towards repairing more products and empowering them to fix their products without the presence of an expert by making the repair process easier, thus decreasing the required skill level. This research is important for users in terms of helping them to understand the value of objects and the problematic relationship with products through the lens of repair activity.

This research makes an original contribution to knowledge through 'using already known material but with a new interpretation' (Phillips & Pugh, 2010, p.63). Kintsugi and patching are not new methods, but they have been adapted in a new way, I provided an original design for each kit customised to the user's needs and wants. Providing these methods as kits with required materials and instructions is an original contribution that removes barriers for users in order to encourage them to fix things.

The **Kintsugi kit** transformed a labour-intensive traditional method into a practical one. I decided to include a pre-broken object for testing after considering the participants' comments during workshops. This is a strategic design decision because people have a habit of throwing broken things away when they think it is impossible to repair, as they do not know how to repair it. Ceramic and glass products, in particular, lose their value after sustaining physical damage. However, the possibility of a user fixing a broken ceramic object might increase if s/he has access to the kintsugi kit. The second situation is that during workshops some participants wanted to test the kintsugi repair method on another product before repairing their own object, because they said that their object held value for them and they might have ruined it, as they thought they were not skilled or experienced enough to fix it properly. The test piece addresses both of these issues. Additionally, it adds an experiential dimension to the kit as it encourages the user to engage with the product through repair, and in end the product becomes complete with the user's involvement.

3D-printed patches have an original design mainly based on the design considerations 'interest in the method', 'personal pleasure/satisfaction' and 'aesthetic' (see Section 4.3.2). The aim of creating this kit is to design a repair kit that attracts people's attention in order to overcome the barriers and negative stigma attached to repair activity.

A fabric patch is not an original idea. Various types of textile patches are available on the market. **Textile patches,** however, are designed out of necessity during the design studies and workshops as a result of repetitive damage to backpacks and shoes.

The Plaster patches kit is an original design idea which is developed for users with low levels of skill inspired by the ease of putting on plasters. This kit provides quick and easy fixes for various types of fabric and damage.

A diverse set of repair methods and examples were synthesised and organised during the design studies. These were then tested and further developed into repair kits. The value of this research for designers is that it helps them to understand the possible application of various repair methods and materials. For academics and researchers, the value is in implementation and exploration of practice-based research methods.

7.1.2. Development of Design Considerations in Relation to Product Repair

The literature review shows the lack of research into user motivation and barriers in relation to product repair and ways of encouraging people to repair damaged products. An original contribution to knowledge in design research is made in this research by 'carrying out empirical work that has not done before' (Phillips & Pugh, 2010, p.63) through the development of categories of motivation and barriers based on user experience of repair. The cultural probes method (Gaver, Dunne & Pacenti, 1999) was used in order to initially explore the motivation and barriers that users experience in relation to repair, and to inspire them to reflect and report their experiences and concerns about repaired and broken products. A range of motivation and barrier categories were developed in diverse contexts that suggest opportunities to understand and change user behaviour, through design, to reduce their environmental impact. These motivation and barrier categories were then developed further as design considerations through the design studies. Finally, the workshops helped to test the motivation and barrier categories and also to frame the process of product repair experience by enabling participants' engagement with products.

The second research question was answered by organising the data developed through three research studies into design considerations. Answering this question resulted in the original contribution to design research. The design considerations can be of value for design researchers as it can facilitate future attempts to 'design for repair', and they can serve as a baseline for future research in this area. Furthermore, this research serves as baseline research for future investigations in how to integrate repair into design processes and business models in order to extend product lifespan.

7.1.3. Reframing the Role of Designer in the Circular Economy and Contributions to the Design Practice

Products are not designed and manufactured for the activities including repair, reuse, recycle and remanufacturing which enables us to restore and regenerate their value. Conversely, manufacturers use various strategies to intentionally make them obsolete. They produce with low-quality materials, permanently attach product parts with glueing or welding in order to decrease the production costs. Additionally, special and various types of screws are used in one product to make the disassembly harder. Most of the manufacturers do not provide spare parts. Finally, the repair knowledge is not available to users. In the context of this research, I am proposing that first the design of products should enable circularity: repair, reuse, remanufacture and recycle. Second, the information about circularity should be available to users.

This research makes an original contribution to knowledge through 'making a synthesis that hasn't been made before' (Phillips & Pugh, 2010, p.63) as I synthesised the existing knowledge and offered two different roles for designers based on this knowledge.

Designing enabling products: Designing enabling products refers to designing products that are possible to repair, considering frequently broken product parts, and designing products suitable for self-production. Salvia and Cooper (2016) explains self-production as enabling users' reusing, repairing, repurposing and appropriating products by themselves by considering their skill level, motivations and barriers. It is a common saying in sustainable design literature that designers should consider products' after-use phase as well as the use phase. I want to repeat this saying and add that designers should also consider the breakage rather than ignoring it (Jackson, 2014). The breakdown is a part of the object's life and Jackson (2014) describes it as 'broken world thinking' in his paper 'Rethinking Repair'.

Designing enabling solutions: Designing enabling solutions refers to accessibility and applicability of repair information for each product designed. Guiding users who want to repair their products through online tutorials, instructions, invitations is important to help them improve their confidence. Fairphone 2 can be given as an example of this approach. It invites the users to repair their phone with its transparent back cover, modular parts and the saying 'Yours to open, yours to keep' on the back cover.

7.1.4. Reframing the Position of Repair in the Circular Economy and Contributions to the System Diagram

It is suggested in Section 6.2 that Ellen MacArthur Foundation's work on the circular economy mainly focuses on the economic aspects, ignoring the user's role in the system. This approach can also be seen in the foundation's system diagram. The diagram does not show the inner loops where the user directly creates value for the system. An original contribution to knowledge is made through 'making a synthesis that hasn't been made before' (Phillips & Pugh, 2010, p.63) as I synthesised the existing knowledge and changed the system diagram based on this knowledge. The system diagram is adapted in a way that the active user's

integration to the system and responsibilities are represented, as well as his/her relationship to the other stakeholders in the system.

REFERENCES

Alben, L. (1996). Quality of experience: Defining the criteria for effective interaction design. *Interactions*, *3*(3), 11-15. doi: 10.1145/235008.235010

Bailey, C. (Artist). (2016, September). Patchwork porcelain [Online image]. Retrieved from https://www.facebook.com/media/set/?set=a.986544564733814.1073741839.206291629425782&type=3

Ball, P. (2013). The art of maintenance. *Nature Materials*, *12*, 480. doi: 10.1038/nmat3666

Balka, E., & Wagner, I. (2006). Making things work: Dimensions of configurability as appropriation work. In *Proceedings of the 2006 20th Anniversary Conference on Computer Supported Cooperative Work* (pp. 229-238). doi: 10.1145/1180875.1180912

Bakker, C., Wang, F., Huisman, J., & den Hollander, M. (2014a). Products that go round: Exploring product life extension through design. *Journal of Cleaner Production, 69*, 10-16.

Bakker, C., den Hollander, M., van Hinte, E., & Zijlstra, Y. (2014b). *Products that last: Product design for circular business models*. Delft, Netherlands: TU Delft Library.

Behaviour Wizard Team.(2014). The Fogg Behavior Grid describes 15 ways behaviour can change, including sample behaviours [Online image]**.** Retrieved from http://www.behaviorwizard.org/wp/behavior-grid/.

Benyus, J. M. (1997). *Biomimicry: Innovation inspired by natur*e. New York: Perennial.

Bernard, H. R. (2011). *Research methods in anthropology: Qualitative and quantitative approaches*. New York: Altamira.

Beyer, H., & Holtzblatt, K. (1998). *Contextual design: A customer-centered approach to systems designs*. San Francisco, CA: Morgan Kaufmann.

Bisset, F. (2011a). *An investigation into the concept of motivation within design*. (Unpublished MPhil dissertation). Brunel University, London). Retrieved from http://bura.brunel.ac.uk/handle/2438/6497

Bisset, F. (2011b). Integrating service design thinking and motivational psychology. In M. Stickdorn, J. Schneider, K. Andrews, & A. Lawrence (Eds.). *This is service design thinking: Basics, tools, cases.* (pp.300-304). Hoboken, NJ: Wiley.

Bisset, F., & Lockton, D. (2010). Designing motivation or motivating design? Exploring service design, motivation and behavioural change. *Touchpoint: The Journal of Service Design*, *2*(1), 15-21.

Bocken, N. M., de Pauw, I., Bakker, C., & van der Grinten, B. (2016). Product design and business model strategies for a circular economy. *Journal of Industrial and Production Engineering*, *33*(5), 308-320.

Braungart, M., McDonough, W., & Bollinger, A. (2007). Cradle-to-cradle design: Creating healthy emissions–a strategy for eco-effective product and system design. *Journal of Cleaner Production*, *15*(13), 1337-1348.

Brook, I. (2012). Make, do, and mend: Solving placelessness through embodied environmental engagement. In E. Brady & P. Phemister (Eds.), *Human-environment relations* (pp. 109-120). Dordrecht: Springer.

Burrell, J. (2012). *Invisible users: Youth in the Internet cafés of urban Ghana*. Cambridge, MA: MIT Press.

Calkins, E. E. (1927, August). Beauty the new business tool. *The Atlantic*, *140*, 145-156. Retrieved from https://www.theatlantic.com/magazine/archive/1927/08/beauty-the-new-business-tool/376227/

Carson, R. (1962). *Silent spring*. New York: Houghton Mifflin Harcourt.

Chapman, J. (2005). *Emotionally durable design: Objects, experiences and empathy.* London: Earthscan.

Chapman, J. (2009). Design for (emotional) durability. *Design Issues*, *25*(4), 29-35.

Charter, M., & Keiller, S. (2014). Grassroots innovation and the circular economy a global survey of Repair Cafés and Hackerspaces. Retrieved from http://cfsd.org.uk/site-pdfs/circular-economy-and-grassroots-innovation/Survey-of-Repair-Cafes-and-Hackerspaces.pdf

Clark, D. (2011, April 21). Which nations are most responsible for climate change? Retrieved from https://www.theguardian.com/environment/2011/apr/21/countries-responsible-climate-change

Coffey, A., & Atkinson, P. (1996). *Making sense of qualitative data: Complementary research strategies*. Thousand Oaks, CA: Sage Publications.

Cooper, T. (2013). Sustainability, consumption and the throwaway culture. In S. Walker & J. Giard (Eds.), *The handbook of design for sustainability (pp.* 137-155). London: Bloomsbury.

Crabtree, A., & Rodden, T. (2004). Domestic routines and design for the home. *Computer Supported Cooperative Work (CSCW)*, *13*(2), 191-220.

Creswell, J. W. (2013). *Research design: Qualitative, quantitative, and mixed methods approaches*. Thousand Oaks, CA: Sage.

Crilly, N., Moultrie, J., & Clarkson, P. J. (2004). Seeing things: Consumer response to the visual domain in product design. *Design Studies*, *25*(6), 547-577.

Cross, N. (2001). Designerly ways of knowing: Design discipline versus design science. *Design issues*, *17*(3), 49-55.

Crotty, M. (1998). *The foundations of social research.* Thousand Oaks, CA: Sage Publications.

David Chipperfield Architects. (2005). Castello Sforzesco restoration project in Milan [Online image]. Retrieved from https://davidchipperfield.com/project/ravelins_of_castello_sforzesco.

David Chipperfield Architects. (2005). Ravelins of the Castello Sforzesco. Retrieved from http://www.davidchipperfield.co.uk/downloads/projects/14/ravelinsofcastellosforzesco_dca.pdf

De los Rios, I. C., & Charnley, F. J. (2016). Skills and capabilities for a sustainable and circular economy: The changing role of design. *Journal of Cleaner Production*. Retrieved from http://www.sciencedirect.com/science/article/pii/S0959652616317619

Department for Environment, Food and Rural Affairs (DEFRA). (2011). The economics of waste and waste policy. Retrieved from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/69500/pb13548-economic-principles-wr110613.pdf

Desmet, P., & Hekkert, P. (2007). Framework of product experience. *International Journal of Design*, *1*(1).

Dobbs, R.,Oppenheim, J.,Thompson, F., Brinkman, M., & Zornes, M. (2011). Resource revolution: Meeting the world's energy, materials, food, and water needs. McKinsey Global Institute. Retrieved from http://www.mckinsey.com/business-functions/sustainability-and-resource-productivity/our-insights/resource-revolution

Droog Design. (n.d.). 'Do break', designed by Frank Tjepkema, emphasises the beauty of cracks [Online image]. Retrieved from http://www.droog.com/project/do-break-frank-tjepkema-peter-van-der-jagt.

Droog Design. (n.d.). 'Do hit chair', designed by Marijn van der Poll, is a customisable piece of furniture that has to be shaped with a sledgehammer [Online image]. Retrieved from http://www.droog.com/webshop/product/do-hit-chair-non-hitnew

Durrant, A., Vines, J., Wallace, J., & Yee, J. (2015). Developing a dialogical platform for disseminating research through design. *Constructivist Foundations*, *11*(1), pp.8-21.

Ellen MacArthur Foundation. (2011). Linear economy and circular economy diagram [Online image]. Retrieved from http://www.ellenmacarthurfoundation.org/circular-economy/circular-economy/rethinking-the-economy.

Ellen MacArthur Foundation. (2011). Biological and Technical materials in an interactive system diagram [Online image]. Retrieved from

http://www.ellenmacarthurfoundation.org/circular-economy/circular-economy/interactive-system-diagram.

Ellen MacArthur Foundation. (2012). Towards the circular economy Vol. 1: An economic and business rationale for an accelerated transition. Retrieved from https://www.ellenmacarthurfoundation.org/publications/towards-the-circular-economy-vol-1-an-economic-and-business-rationale-for-an-accelerated-transition

Ellen MacArthur Foundation. (2013). Towards the circular economy Vol. 2: Opportunities for the consumer goods sector. Retrieved from https://www.ellenmacarthurfoundation.org/publications/towards-the-circular-economy-vol-2-opportunities-for-the-consumer-goods-sector

Ellen MacArthur Foundation. (2015a). Towards a circular economy: Business rationale for an accelerated transition. Retrieved from https://www.ellenmacarthurfoundation.org/publications/towards-a-circular-economy-business-rationale-for-an-accelerated-transition

Ellen MacArthur Foundation. (2015b). Circular economy and curriculum development in higher education. Retrieved July 2 2016 from https://www.ellenmacarthurfoundation.org/assets/downloads/higher-education/EMF_HE-Curriculum-Brochure-17-JUNE_SINGLES.pdf

Eurostat. (2016). Generation of waste by waste category, hazardousness and NACE Rev. 2 activity. Retrieved from http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=env_wasgen

European Commission. (2015). Closing the loop - An EU action plan for the circular economy. Retrieved from http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52015DC0614

Fairphone. (2014). Fairphone is a social enterprise that aims to create a fairer economy and transform how we produce and use objects [Online image]. Retrieved from https://www.fairphone.com/blog/.

Fairphone. (2014). Together we're creating demand for fair product. Retrieved from http://www.fairphone.com/about/

Fairphone. (2016). Fairphone 2 is the world's first modular smartphone [Online image]. Retrieved from https://shop.fairphone.com/en/.

5.5 designstudio. (2004). Chair 'fitted' with prosthetic seat [Online image]. Retrieved from http://www.5-5designstudio.com/en/project/2004-55designers-reanim

Fletcher, K. (2008): *Sustainable fashion and textiles: Design journeys*, London: Earthscan.

Fletcher, K. (2012). Durability, fashion, sustainability: The processes and practices of use. *Fashion Practice*, *4*(2), 221-238.

Fogg, B. J. (2009). A behavior model for persuasive design. In *Proceedings of the 4th International Conference on Persuasive Technology*. doi:10.1145/1541948.1541999

Fogg, B. J., & Hreha, J. (2010, June). Behavior wizard: A method for matching target behaviors with solutions. In *Proceedings of the 5th International Conference on Persuasive Technology* (pp. 117-131). doi: 10.1007/978-3-642-13226-1_13

Forlizzi, J., & Battarbee, K. (2004). Understanding experience in interactive systems. In *Proceedings of the 5th Conference on Designing Interactive Systems: Processes, Practices, Methods, and Techniques* (pp. 261-268). doi:10.1145/1013115.1013152

Forlizzi, J., & 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* (pp. 419-423). doi:10.1145/347642.347800

Frayling, C. (1993). Research in art and design. *Royal College of Art and Design Papers, 1*(1), pp.1-5. Retrieved from http://researchonline.rca.ac.uk/384/3/frayling_research_in_art_and_design_1993.pdf

Fuad-Luke, A. (2009). *Design activism: Beautiful strangeness for a sustainable world*. London; Sterling, VA: Earthscan.

Fusch, P. I., & Ness, L. R. (2015). Are we there yet? Data saturation in qualitative research. *The Qualitative Report*, *20*(9), 1408.

Gallagher, S. (2013). Phenomenology. In Soegaard, M., & Dam, R.F. (Eds.), *The encyclopedia of human-computer interaction*. Retrieved from https://www.interaction-design.org/literature/book/the-encyclopedia-of-human-computer-interaction-2nd-ed/phenomenology

Gaver, B., Dunne, T., & Pacenti, E. (1999). Design: Cultural probes. *Interactions*, *6*(1), 21-29. doi: 10.1145/291224.291235

Gaver, W. W., Boucher, A., Pennington, S., & Walker, B. (2004). Cultural probes and the value of uncertainty. *Interactions*, *11*(5), 53-56. doi: 10.1145/1015530.1015555

Geng, Y., & Doberstein, B. (2008). Developing the circular economy in China: Challenges and opportunities for achieving 'leapfrog development'. *The International Journal of Sustainable Development & World Ecology*, *15*(3), 231-239.

Getto, G., & Labriola, J. (2016). IFixit myself: User-generated content strategy in "the free repair guide for everything". *IEEE Transactions on Professional Communication*, *59*(1), 37-55.

Ghisellini, P., Cialani, C., & Ulgiati, S. (2016). A review on circular economy: The expected transition to a balanced interplay of environmental and economic systems. *Journal of Cleaner Production*, *114*, 11-32.

Gill, A., & Lopes, A. M. (2011). On wearing: A critical framework for valuing design's already made. *Design and Culture*, *3*(3), 307-327.

Giorgi, A. (1988). Validity and reliability from a phenomenological perspective. In W. Baker, L. Mos, H. Rappard, & H. Stam (Eds.). *Recent trends in theoretical psychology* (pp. 167-176). New York: Springer.

Giorgi, A. (2009). *The descriptive phenomenological method in psychology: A modified Husserlian approach*. Pittsburgh, PA: Duquesne University Press.

Graedel, T. E., Allenby, B. R., & Linhart, P. B. (1993). Implementing industrial ecology. *IEEE Technology and Society Magazine*, *12*(1), 18-26. doi: 10.1109/44.192717

Graham, S., & Thrift, N. (2007). Out of order: Understanding repair and maintenance. *Theory, Culture & Society*, *24*(3), 1-25.

Grant, D. B., & Banomyong, R. (2010). Design of closed-loop supply chain and product recovery management for fast-moving consumer goods: The case of a single-use camera. *Asia Pacific Journal of Marketing and Logistics*, *22*(2), 232-246.

Gray, D. E. (2013). *Doing research in the real world*. London: Sage.

Guba, E. G. (1990). The alternative paradigm dialog. In E. G. Guba (Ed.), *The paradigm dialog (pp 17-30)*. Newbury Park, CA: Sage.

Gwilt, A. (2014). What prevents people repairing clothes?: An investigation into community-based approaches to sustainable product service systems for clothing repair. *Making Futures Journal*, *3*.

Hagel, J., Brown, J. S., & Kulasooriya, D. (2014). A movement in the making. Westlake, TX: Deloitte University Press. Retrieved from https://dupress.deloitte.com/content/dam/dup-us-en/articles/a-movement-in-the-making/DUP_689_movement_in_the_making_FINAL2.pdf

Hassenzahl, M. (2003). The thing and I: Understanding the relationship between user and product. In Blythe, M.A., Overbeeke, K., Monk, A.F., Wright, P.C. (Eds.), *Funology* (pp. 31-42). Dordrecht: Springer.

Hassenzahl, M., & Tractinsky, N. (2006). User experience: A research agenda. *Behaviour & Information Technology*, *25*(2), 91-97.

Hawken, P., Lovins, A. B., & Lovins, L. H. (2013). *Natural capitalism: The next industrial revolution*. New York: Routledge.

Hycner, R. H. (1999). Some guidelines for the phenomenological analysis of interview data. In A. Bryman & R. G. Burgess (Eds.), *Qualitative research* (Vol. 3) (pp.143-164). London: Sage.

Heidegger, M. (1996): *Being and time* (J. Stambaugh & D. J. Schmidt, Trans.). New York: State University of New York Press.

Hekkert, P. (2006). Design aesthetics: Principles of pleasure in design. *Psychology Science*, *48*(2), 157.

Hirschman, E. C. (1983). Aesthetics, ideologies and the limits of the marketing concept. *The Journal of Marketing*, 45-55. doi: 10.2307/1251196

Hopewell, J., Dvorak, R., & Kosior, E. (2009). Plastics recycling: challenges and opportunities. *Philosophical Transactions of the Royal Society of London B: Biological Sciences*, *364*(1526), 2115-2126. Retrieved from http://rstb.royalsocietypublishing.org/content/364/1526/2115.short

Houston, L., Jackson, S. J., Rosner, D. K., Ahmed, S. I., Young, M., & Kang, L. (2016, May). Values in repair. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems* (pp. 1403-1414). New York: ACM. Doi: 10.1145/2858036.2858470

Husserl, E. (2001). *Logical investigations (Vol. 1),* (J. N. Finley, Trans.) New York: Routledge. (Original work published 1900)

iFixit. (2014). Fairphone has collaborated with iFixit and developed 10 repair guides for different malfunctions of the Fairphone [Online image]. Retrieved from https://www.ifixit.com/Device/Fairphone.

Intergovernmental Panel on Climate Change (IPCC). (2014). Summary for policymakers. In O. R. Edenhofer, Y. Pichs-Madruga, E. Sokona, S. Farahani, K. Kadner, A. Seyboth, I. Adler, S. Baum, P. Brunner, & B. Eickemeier (Eds.), Climate Change 2014, Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Geneva, 1–18. Retrieved from https://www.ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_summary-for-policymakers.pdf

Jackson, S. J. (2014). Rethinking repair. In T. Gillespie, P. J. Boczkowski, K. A. Foot (Eds.), *Media technologies: Essays on communication, materiality, and society*, (pp. 221-40). Cambridge, MA: MIT Press

Jackson, S. J., Pompe, A., & Krieshok, G. (2012, February). Repair worlds: Maintenance, repair, and ICT for development in rural Namibia. In *Proceedings of the ACM 2012 Conference on Computer Supported Cooperative Work* (pp. 107-116). New York: ACM. doi: 10.1145/2145204.2145224

Kelley, V. (2009). The Interpretation of surface: Boundaries, systems and their transgression in clothing and domestic textiles, c.1880–1939. *Textile.* 7(2), 216–235

Kerne, A. (1998). Cultural representation in interface ecosystems: Amendments to the ACM/interactions design awards criteria. *Interactions*, *5*(1), 37-43. doi: 10.1145/268986.268991

Kline, R., & Pinch, T. (1996). Users as agents of technological change: The social construction of the automobile in the rural United States. *Technology and Culture*, *37*(4), 763-795.

Klopper, H. (Artist). (n.d.). Cardigan mended with woolfiller [Online image]. Retrieved from http://www.woolfiller.com/examples.php

König, A. (2013). A Stitch in time: Changing cultural constructions of craft and mending. *Culture Unbound: Journal of Current Cultural Research*, *5*(4), 569-585.

Kuo, T. C. (2011). The study of production and inventory policy of manufacturing/remanufacturing environment in a closed-loop supply chain. *International Journal of Sustainable Engineering*, *4*(4), 323-329.

Kuik, S. S., Nagalingam, S. V., & Amer, Y. (2011). A framework of product recovery to improve sustainability in manufacturing. *Lecture Notes in Information Technology Vols*, *1*, 2.

Kwakkel, E. (Photographer). (2013, October). Stabbed, cut and stitched back together [Online image]. Retrieved from http://erikkwakkel.tumblr.com/post/65552828979/halloween-4-stabbed-cut-and-stitched-back

Laurel, B. (2003). *Design research: Methods and perspectives*. Cambridge, MA: MIT Press.

Laitala, K., Boks, C., & Klepp, I. G. (2015). Making clothing last: A design approach for reducing the environmental impacts. *International Journal of Design*, *9*(2), 93-107.

Lilley, D. (2007). *Designing for behavioural change: Reducing the social impacts of product use through design* (Doctoral dissertation), Loughborough University, Loughborough). Retrieved from https://dspace.lboro.ac.uk/dspace-jspui/handle/2134/8092

Lockton, D. (2013). *Design with intent: A design pattern toolkit for environmental and social behaviour change* (Doctoral dissertation), Brunel University, London. Retrieved from http://bura.brunel.ac.uk/handle/2438/7546

Lockton, D., Harrison, D., & Stanton, N. (2008). Making the user more efficient: Design for sustainable behaviour. *International Journal of Sustainable Engineering*, *1*(1), 3-8.

London, B. (1932). Ending the depression through planned obsolescence. [Pamphlet} New York. Retrieved from https://babel.hathitrust.org/cgi/pt?id=wu.89097035273;view=1up;seq=26

Maestri, L., & Wakkary, R. (2011, November). Understanding repair as a creative process of everyday design. In *Proceedings of the 8th ACM Conference on Creativity and Cognition* (pp. 81-90). New York: ACM.

Maintenance. (2000, June). In *www.oxfordenglishdictionary.com*. Retrieved from http://www.oed.com/view/Entry/112568?redirectedFrom=Maintenance&.

MakerBot Industries (2010, March). Stove knob 3D digital models are available for download [Online image]. Retrieved from http://www.thingiverse.com/thing:1962

MakerBot Industries (2012, October). Repair of a tripod quick release mount replacement [Online image]. Retrieved from http://www.thingiverse.com/thing:32638

Makerbot. (2012, November 7). Introducing Makerbot Thingiverse dashboard and follow features. Retrieved from http://www.makerbot.com/blog/2012/11/07/introducing-makerbot-thingiverse-dashboard-and-follow-features/

MakerBot Industries (2013, February). Repair of a joystick handle [Online image]. Retrieved from http://www.thingiverse.com/thing:53331.

Manyika, J., Chui, M., Bughin, J., Dobbs, R., Bisson, P., & Marrs, A. (2013). Disruptive technologies: Advances that will transform life, business, and the global economy (Vol. 12). New York: McKinsey Global Institute. Retrieved from http://www.mckinsey.com/business-functions/digital-mckinsey/our-insights/disruptive-technologies

Manzini, E., & Vezzoli, C. (2002). *Product-service systems and sustainability: Opportunities for sustainable solutions.* Paris: UNEP.

Marcario, R. (2015, November 25). The most eco-friendly clothes are the ones already in your closet. Retrieved from http://qz.com/553614/the-most-eco-friendly-clothes-are-the-ones-already-in-your-closet/

Markussen, T. (2013). The disruptive aesthetics of design activism: Enacting design between art and politics. *Design Issues*, *29*(1), 38-50.

Martin, B., Hanington, B. (2012). *Universal methods of design: 100 ways to research complex problems, develop innovative ideas, and design effective solutions*. Beverly, MA: Rockport.

Mathias, S. & Stephen S. (Curators). (2013). Boro is used and maintained throughout its owner's lifetime and passed down through generations [Online image]. Retrieved from https://www.boisbuchet.org/boro-the-fabric-of-life/

Maycroft, N. (2016). Consumption, planned obsolescence and waste. Retrieved from https://www.researchgate.net/publication/267767238_Consumption_planned_obsolescence_and_waste

McCrigler, B. (2012, May). Patagonia Clothes Repair Instructions [Online image]. Retrieved from https://www.ifixit.com/Guide/Patch+a+Patagonia+Down+Jacket+with+Repair+Tape/19431

McDonough, W., & Braungart, M. (2002). *Cradle to cradle: Remaking the way we make things*. New York: North Point Press.

McLaren, A., & McLauchlan, S. (2015). Crafting sustainable repairs: practice-based approaches to extending the life of clothes. In T. Cooper, N. Braithwaite, M. Moreno, & G. Salvia (Eds.) Proceedings of the *Product Lifetimes and the Environment Conference* (pp. 221-228). Retrieved from http://www.plateconference.org/conference-2015/

Mertens, D. M. (2010). *Research and evaluation in education and psychology: Integrating diversity with quantitative, qualitative, and mixed methods (3rd Ed.).*Thousand Oaks, CA: Sage.

Middleton, J. (2012). Long live the thing! Temporal ubiquity in a smart vintage wardrobe. *Ubiquity: The Journal of Pervasive Media*, *1*(1), 7-22.

Middleton, J. (2014). Mending. In K. Fletcher & M. Tham (Eds.) *Routledge handbook of sustainability and fashion.* Routledge: London

Miles, M. B., & Huberman, A. M. (1984). Drawing valid meaning from qualitative data: Toward a shared craft. *Educational Researcher*, *13*(5), 20-30. Retrieved from http://journals.sagepub.com/doi/abs/10.3102/0013189X013005020

Miller, W. L., & Crabtree, B. F. (1992). Primary care research: A multimethod typology and qualitative road map. In B. F. Crabtree & W. L. Miller (Eds.), *Doing qualitative research* (pp. 3-28). Thousand Oaks, CA: Sage.

Moggridge, B., & Atkinson, B. (2007). *Designing interactions*. Cambridge, MA: MIT Press.

Mont, O. (2002). Drivers and barriers for shifting towards more service-oriented businesses: Analysis of the PSS field and contributions from Sweden. *The Journal of Sustainable Product Design*, *2*(3-4), 89-103. doi: 10.1023/B:JSPD.0000031027.49545.2b

Moustakas, C. (1994). *Phenomenological research methods*. Thousand Oaks, CA: Sage.

MUD Jeans. (n.d.). Sustainability - Did you know that fashion is the second most polluting industry in the world?. Retrieved from http://www.mudjeans.eu/about-mud-jeans/sustainability/.

Oliver. (2015, June 16) The architecture of the Fairphone 2: Designing a competitive device that embodies our values. Retrieved from https://www.fairphone.com/en/2015/06/16/the-architecture-of-the-fairphone-2-designing-a-competitive-device-that-embodies-our-values/

Ongondo, F. O., Williams, I. D., & Cherrett, T. J. (2011). How are WEEE doing? A global review of the management of electrical and electronic wastes. *Waste management*, *31*(4), 714-730.

Orr, J. E. (1996). *Talking about machines: An ethnography of a modern job*. New York: Cornell University Press.

Packard, V. (2013). *The waste makers.* New York: Van Rees Press. (Original work published 1960)

Papanek, V. J. (1985). *Design for the real world: Human ecology and social change*. Chicago: Academy Chicago. (Original work published 1971)

Patagonia. (n.d.). Patagonia Clothing Company [Online image]. Retrieved on from http://eu.patagonia.com/enGB/home.

Philips. (2014). Sustainability. Retrieved from http://www.philips.co.uk/about/sustainability/index.page

Phillips, E., & Pugh, D. (2010). *How to get a PhD: A handbook for students and their supervisors* (4th ed.). Maidenhead: McGraw-Hill Education. (Original work published 1987)

Phillips. (2012). Pay Per Lux, an intelligent lighting system designed to fit the requirements of the office environment [Online image]. Retrieved from http://www.innovationservices.philips.com/news/philips-transition-linear-circular-economy.

Philips Lighting. (2012). Case study: RAU Architects. Retrieved from http://faculty.som.yale.edu/florianederer/behavioral/Pay-per-Lux.pdf

Pitt, J., & Heinemeyer, C. (2015). Introducing ideas of a circular economy. In K. Stables & S. Keirl (Eds.), *Environment, Ethics and Cultures*. Rotterdam: Sense Publishers (pp. 245-260). doi: 10.1007/978-94-6209-938-8_16

Planned Obsolescence. (2006, June). In *www.oxfordenglishdictionary.com*. Retrieved from http://www.oed.com/view/Entry/145131?redirectedFrom=planned+obsolescence#eid29997289.

Prendeville, S., Hartung, G., Purvis, E., Brass, C., & Hall, A. (2016). Makespaces: From redistributed manufacturing to a circular economy. In R. Setchi, R. J. Howlett, Y. Liu, & P. Theobald (Eds.), *Sustainable design and manufacturing 2016* (pp. 577-588). New York: Springer

Prendeville, S., Sanders, C., Sherry, J., & Costa, F. (2014). Circular Economy: Is it enough?. Wales: EcoDesign Centre. Retrieved from https://www.researchgate.net/profile/Sharon_Prendeville/publication/301779162_Circular_Economy_Is_it_Enough/links/5727a2be08aef9c00b8b4ddd.pdf

Preston, F. (2012). A global redesign? Shaping the circular economy. *Energy, Environment and Resource Governance*, *2*, 1-20.Retrieved from http://s3.amazonaws.com/academia.edu.documents/32547802/A_global_redesign_-_shaping_the_circular_economy.pdf?AWSAccessKeyId=AKIAIWOWYYGZ2Y53UL3A&Expires=1489482906&Signature=ZG9QItG8y0UO2O2mNk3OrzEVlXU%3D&response-content-disposition=inline%3B%20filename%3Dbriefing_paper_A_Global_Redesign_Shaping.pdf

Ramakers, R. (2002). *Less+more: Droog design in context*. Rotterdam: 010 Publishers.

RAU Architects. (n.d.). RAU. Retrieved from http://www.rau.eu/sample-page/

Reeve, J. (2008). *Understanding motivation and emotion* (5th ed.). Hoboken, NJ: Wiley.

Repair. (2009, December). In *www.oxfordenglishdictionary.com*. Retrieved from http://www.oed.com/view/Entry/162631?rskey=fg2akU&result=4#eid.

Repair Café Foundation. (n.d.). A Repair Cafe in Germany. Volunteers are teaching people how to fix broken household items [Online image]. Retrieved from http://repaircafe.org/.

Riva 1920. (n.d.). Riva 1920's Piano bookshelf is designed in a way to allow easy replacement and upgrading of the components [Online image]. Retrieved from http://www.riva1920.it/en/prodotti/bookshelves/piano-design/.

Riva 1920. (n.d.). The maintenance set that comes with Riva 1920's Piano bookshelves [Online image]. Retrieved from http://www.riva1920.it/en/prodotti/bookshelves/piano-design/.

Rivera, J. L., & Lallmahomed, A. (2016). Environmental implications of planned obsolescence and product lifetime: A literature review. *International Journal of Sustainable Engineering*, *9*(2), 119-129. http://dx.doi.org/10.1080/19397038.2015.1099757

Robson, C. (1993). Real world research: A resource for social scientists and practitioner researchers. Oxford: Blackwell.

Rosner, D. K., & Ames, M. (2014, February). Designing for repair?: Infrastructures and materialities of breakdown. In *Proceedings of the 17th ACM Conference on Computer Supported Cooperative Work & Social Computing* (pp. 319-331). New York: ACM.

Rosner, D. K., Jackson, S. J., Hertz, G., Houston, L., & Rangaswamy, N. (2013). Reclaiming repair: Maintenance and mending as methods for design. In *CHI'13 Extended Abstracts on Human Factors in Computing Systems* (pp. 3311-3314) New York: ACM. doi:10.1145/2468356.2479674

Rust, C. (2007). Unstated Contributions: How artistic inquiry can inform interdisciplinary research. *International Journal of Design*, *1*(3), 69-76.

Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist*, *55*(1), 68.

Ryan, R. M., & Deci, E. L. (2008). A self-determination theory approach to psychotherapy: The motivational basis for effective change. *Canadian Psychology/Psychologie Canadienne*, *49*(3), 186.

Salvia, G., & Cooper, T. (2016). The role of design as a catalyst for sustainable DIY. In A. Genus (Ed.), *Sustainable consumption - Design, innovation and practice* (pp. 15-34). New York: Springer.

Schenkel, M., Caniëls, M. C., Krikke, H., & van der Laan, E. (2015). Understanding value creation in closed loop supply chains–Past findings and future directions. *Journal of Manufacturing Systems*, *37*, 729-745.

Schifferstein, H. N., & Hekkert, P. (Eds.). (2011). *Product experience*. London: Elsevier Science. (Original work published 2008)

Scott, K. A., & Weaver, S. T. (2014). To repair or not to repair: What is the motivation? *Journal of Research for Consumers*, 26, 1.

Shah, V., (2014). The Circular Economy's Trillion-dollar Opportunity. Retrieved from http://www.eco-business.com/news/circular-economys-trillion-dollar-opportunity/

Slade, G. (2006). *Made to break: Technology and obsolescence in America.* Cambridge, MA: Harvard University Press.

Smith, D. W., & McIntyre, R. (1982). *Husserl and intentionality: A study of mind, meaning, and language*. Dordrecht: D.Reidel.

Smith, D. W., & Thomasson, A. (2010). *Phenomenology and philosophy of mind*. Oxford: Oxford University Press.

Solomon, M. R., Bamossy, G.,Askegaard, S., & Hogg, M. K. (2006). *Consumer behaviour: A European perspective* (3rd ed.). Milan: Rotolito Lombarda. (Original work published 1999)

Sokolowski, R. (2000). *Introduction to phenomenology*. Cambridge: Cambridge University Press.

Souza, G. C. (2013). Closed-loop supply chains: A critical review, and future research. *Decision Sciences*, *44*(1), 7-38.

Spelman, E. V. (2003). *Repair: The impulse to restore in a fragile world.* Boston: Beacon Press.

Stahel, W. R. (1994). The utilization focused service economy: Resource efficiency. In B. R. Allenby & D. J. Richards (Eds.), *The greening of industrial ecosystems* (pp. 178–190). Washington: National Academy Press.

Stahel, W. R. (1997). The service economy: 'Wealth without resource consumption?'. *Philosophical Transactions of the Royal Society of London A: Mathematical, Physical and Engineering Sciences*, *355*(1728), 1309-1319. doi: 10.1098/rsta.1997.0058

Stahel, W. R. (2008). The performance economy: Business models for the functional service economy. In *Handbook of performability engineering* (pp. 127-138). London: Springer.

Stahel, W. R., (2010). *The performance economy*. Basingstoke: Palgrave Macmillan.

Stahel, W. R. (2013). The business angle of a circular economy: Higher competitiveness, higher resource security and material efficiency. In K. Webster, J. Bleriot, & C. Johnson (Eds.), *A new dynamic: Effective business in a circular economy* (pp. 45-60). Cowes: Ellen MacArthur Foundation.

Su, B., Heshmati, A., Geng, Y., & Yu, X. (2013). A review of the circular economy in China: moving from rhetoric to implementation. *Journal of Cleaner Production*, *42*, 215-227.

Suchman, L. A. (1987). *Plans and situated actions: The problem of human-machine communication*. Cambridge: Cambridge University Press.

Sugru. (n.d.). Sugru's amazing properties. Retrieved from https://sugru.com/about

Taylor, A. S., & Swan, L. (2005, April). Artful systems in the home. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 641-650). New York: ACM.

Thackara, J. (2015). *How to thrive in the next economy: Designing tomorrow's world today*. New York: Thames & Hudson.

Thomas, V. M. (1997). Industrial ecology: Towards closing the materials cycle. *Journal of Industrial Ecology*, *1*(2), 149-151.

Thorpe, A. (2008). Design as activism: A conceptual tool. In C. Cipolla & P. P. Peruccio (Eds.), Proceedings of the *Changing the Change Conference* (pp. 1523-1535). Turin: Allemandi. Retrieved from http://www.allemandi.com/university/ctc.pdf

Dannoritzer, C. (Director), Ubeda, J. & Barrat, P. (Producer), & Thackara J. (Performer). (2010). Pyramids of waste [Motion Picture]. Spain: Articles Media 3.14.

United Nations Environment Programme. (2011). UNEP annual report 2011. Retrieved from http://apps.unep.org/repository/publication-type/annual-report?page=4

Van den Berg, M. R., & Bakker, C. A. (2015). A product design framework for a circular economy. In T. Cooper, N. Braithwaite, M. Moreno, & G. Salvia (Eds.) Proceedings of the *Product Lifetimes and the Environment Conference* (pp. 365-379). Retrieved from http://www.plateconference.org/product-design-framework-circular-economy/

Vezzoli, C., & Manzini, E. (2008). *Design for environmental sustainability*. London: Springer.

Wada, Y. I. (2004). Boro no Bi: Beauty in humility—Repaired cotton rags of old Japan. In *Proceedings of the Textile Society of America 9th Biennial Symposium.* Retrieved from http://digitalcommons.unl.edu/tsaconf/458/?utm_source=digitalcommons.unl.edu%2Ftsaconf%2F458&utm_medium=PDF&utm_campaign=PDFCoverPages

Wainwright, O. (2013). Astley Castle was converted into a holiday home, blending old and new, by the Landmark Trust in 2012 [Online image]. Retrieved from https://www.landmarktrust.org.uk/search-and-book/properties/astley-castle-4806.

Wainwright, O. (2013). Astley Castle restoration project wins Stirling Prize. Retrieved from https://www.theguardian.com/artanddesign/architecture-design-blog/2016/mar/10/spain-concrete-castle-restoration-matrera-cadiz-accidental-genius

Wallace, J., McCarthy, J., Wright, P. C., & Olivier, P. (2013). Making design probes work. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 3441-3450). doi:10.1145/2470654.2466473

Warnier, C., Verbruggen, D., Ehmann, S., & Klanten, R. (Eds.). (2014). *Printing things: Visions and essentials for 3D printing*. Berlin: Gestalten.

Webster, K. (2013) A concise guide to circular economy: Knowing the territory, surviving and thriving. In Ellen MacArthur Foundation (Ed.) *A new dynamic effective business in a circular economy* (pp. 20-28). Cowes: Ellen MacArthur Foundation Publishing.

White, R. W. (1959) Motivation reconsidered: The concept of competence. *Psychology Review*, *66*, 297-333.

Wiens, K. (2015). The right to repair. *IEEE Consumer Electronics Magazine*, *4*(4), 123-135. doi**:** 10.1109/MCE.2015.2463411

World Business Council for Sustainable Development (WBCSD). (2016). WBCSD climate business solutions update. Retrieved from http://wbcsdpublications.org/project/3566/

WRAP. (n.d.). Innovative business model map [Online image]. Retrieved from http://www.wrap.org.uk/content/innovative-business-models-1

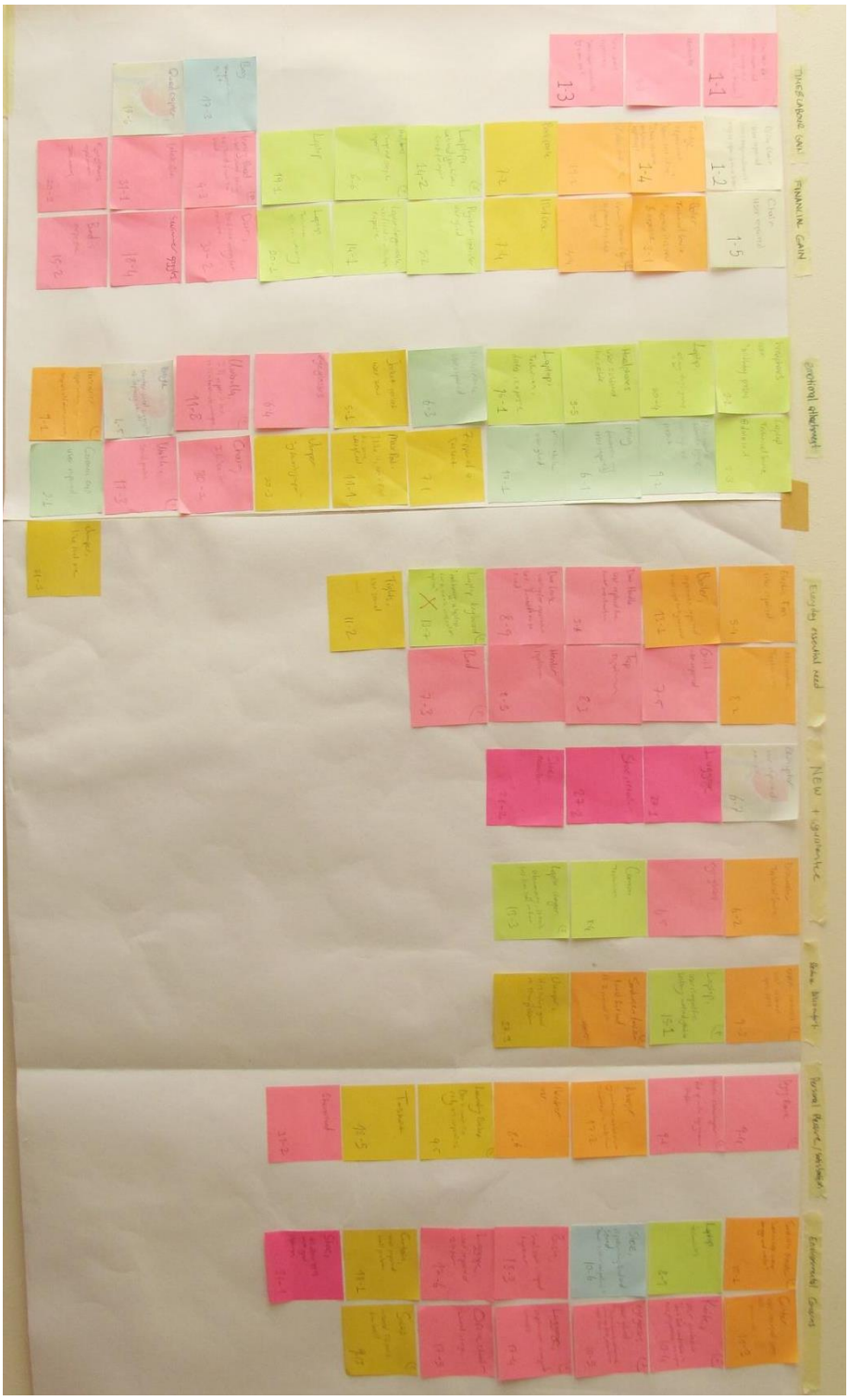
WRAP. (2009). Lifetime optimisation tool. Retrieved from http://www.wrap.org.uk/category/subject/product-optimisation

WRAP. (2014). Innovative business models. Retrieved from http://www.wrap.org.uk/content/innovative-business-models-1

WRAP. (2015). Economic growth potential of more circular economies. Retrieved from http://www.wrap.org.uk/sites/files/wrap/Economic%20growth%20potential%20of_more%20circular%20economies.pdf

APPENDIX A (1)

The Cultural Probes Research Motivations Categories Affinity Diagrams

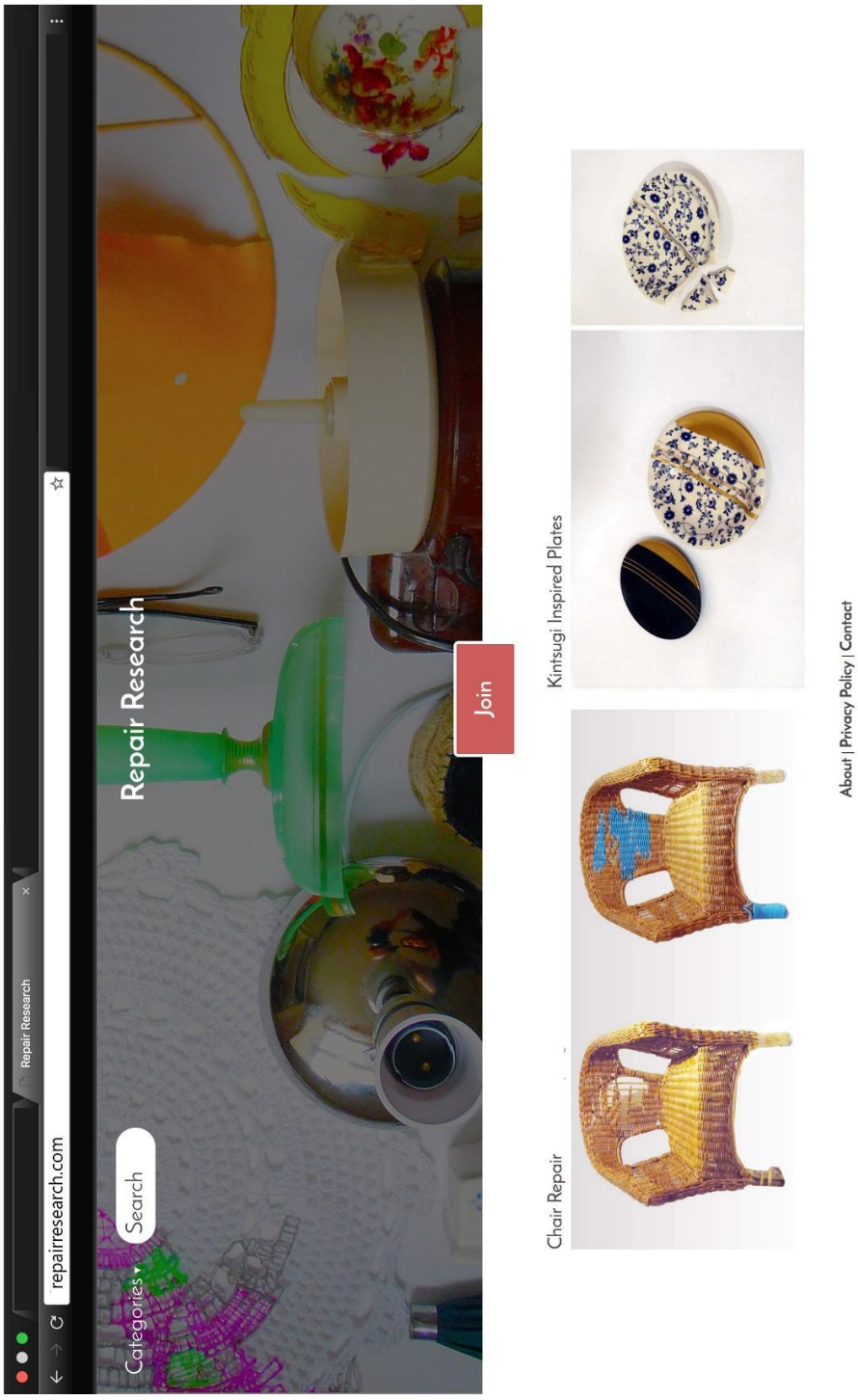


APPENDIX A (2)

The Cultural Probes Research Barriers Categories Affinity Diagrams

APPENDIX B

Repairresearch.com: Online Social Repair Platform



APPENDIX C

Workshop Poster

Hyperfix: Repair Workshop

24th February Wednesday 13:00
Booking essential - RCA Darwin Building - Free
To book, email hyperfix.workshop@gmail.com

- **You will learn how to visibly fix physically damaged products.**
- **You can bring your physically damaged product or work on the ones available.**
- **More methods and materials are available depending on the type of damage.**
- **Textiles, shoes, leather goods, luggage, ceramic products, watch strap, baskets, physically damaged electricals and electronics... are suitable for this workshop.**

APPENDIX D

Workshop Worksheet

HyperFix Workshop

Task1-Discover
What is your product? Can you explain the features of it? Can you explain the broken part?

Task2-Ideation: Work on your design, do some sketches before you implement your idea. Visualize your design and the process by using tools and materials provided.

Task 3-Feedback: Swap seats and give feedback to other projects.

Task 4-Implementation: Implement the ideas and concepts from task 2 and 3.

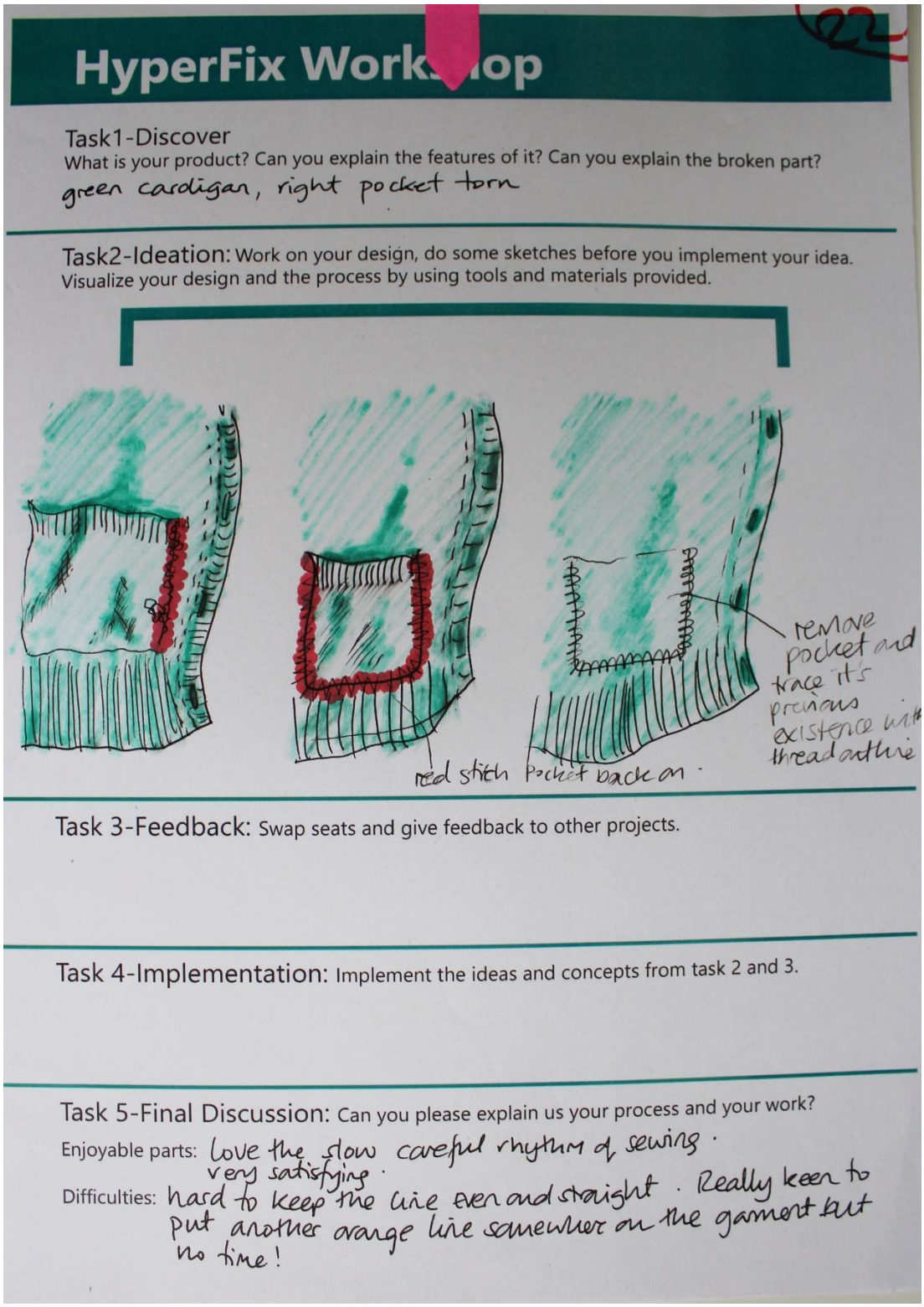
Task 5-Final Discussion: Can you please explain us your process and your work?

Enjoyable parts:

Difficulties:

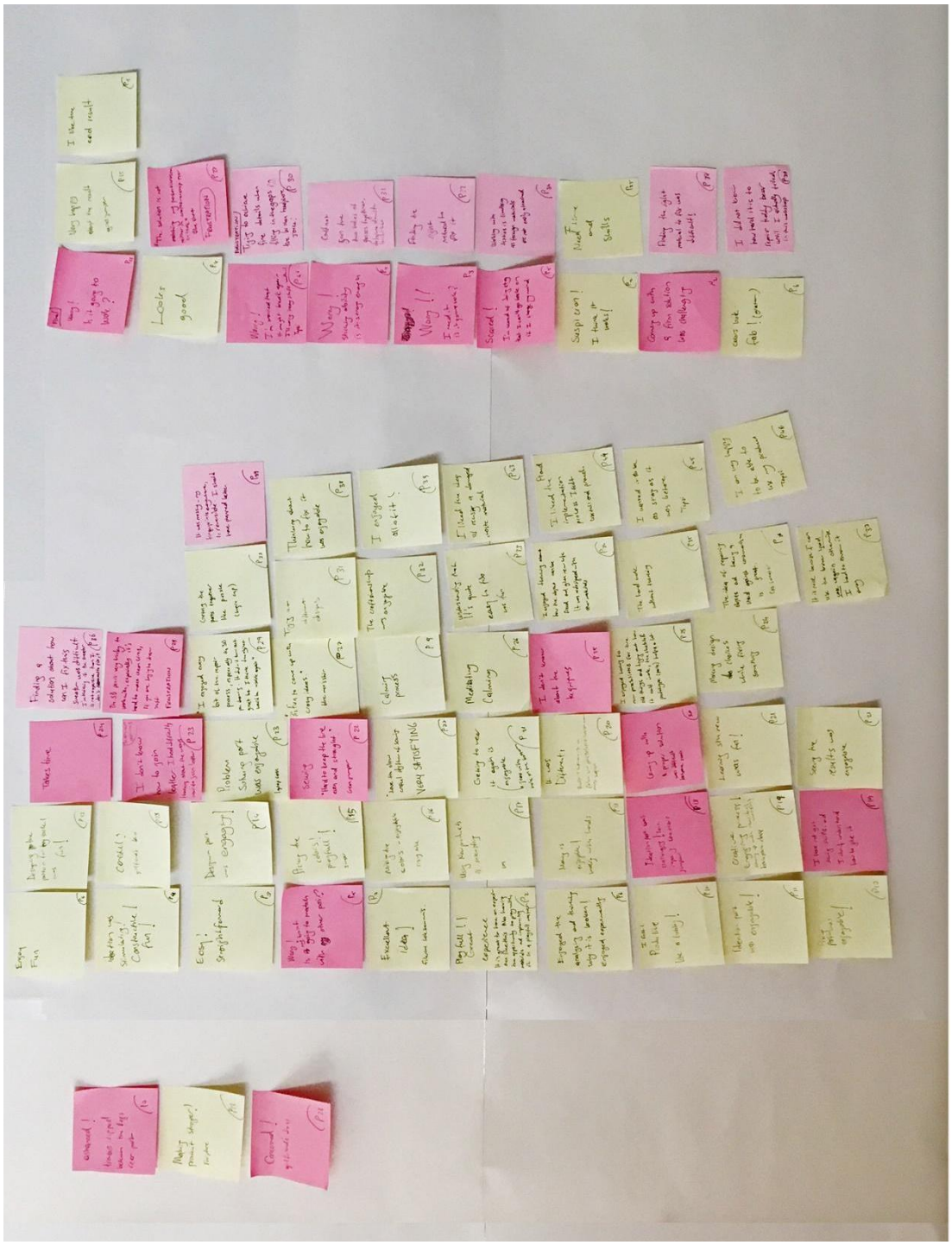
APPENDIX E

An Example Worksheet from the Second Workshop



APPENDIX F

Participants Answers from the Workshops



APPENDIX G

RCA Work in Progress Show Exhibition

VIVA VOCE EXAMINATION

4th May 2017, 09.30

Thanks to my PhD examiners, Prof Conny Bakker and Prof Jonathan Chapman; Chair, Dr Catherine Dormor and Prof Ashley Hall.