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A Service and Interaction Design case study towards Sustainable Transitions in Fashion

Dissertation in the context of the Master in Informatics Engineering, specialization in Design and Multimedia, advised by Professor Licínio Roque and by Professor Tiago Martins and presented to the Department of Informatics Engineering of the Faculty of Sciences and Technology of the University of Coimbra.

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A Service And Interaction Design Case Study Towards Sustainable Transitions In Fashion

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ABSTRACT

Through the lenses of the Transition Design discipline, Fashion and Textile Sustainability is a well-identified 'wicked problem' – a complex system of intertwined issues with overwhelming environmental and social consequences which are urgent to address. Despite its increasing acknowledgement and awareness with known identified approaches, they seem hard to implement or are overall ineffective. In fact, the integration of sustainability concept into the design practices is still scarce and the role of the designer, as well as the importance of user's behaviour, is still neglected.

Therefore, as investigated in this dissertation, a holistic change in user-garments relationship, and the formulation of a new paradigm for fashion and textile design is needed. Arguably, those radical and necessary changes only can occur in the use stage of the lifecycle of the product – more than projecting the end-of-life of clothing, is in this phase where design and designers can play a crucial role in effectively extending the clothing lifespan (with co-design, new pattern construction systems, modular clothing and user engagement) towards social change in our relation with fashion.

Hence, the objective of this dissertation is to conceptualise, develop and evaluate a digital interface through which a service is accessed. This service enables users to co-create modular garments and to discover new insights about their garment options at the early phase of the fashion design process. The aim is to increase the length of clothing lifespan hence, decreasing its environmental and social impact in a context of a circular economy system.

This dissertation explores the challenges, barriers, and opportunities in early attempts of implementing sustainable co-creation systems, understanding the user-garments dynamics and investigating the adaptation of alternative garment construction techniques into modular

garments through the lenses of Service Design, Interaction design and UI/UX disciplines.

Moreover, it is studied how Service design, modular design and co-creation combined can constitute a societal generative system and promote a system-scale behaviour change –the holistic paradigm shift- from both organisations and consumers over time towards Fashion Sustainability.

KEYWORDS

Fashion Sustainability . Service Design . Interaction design . Transition Design . Modular design . Co-creation

RESUMO

Através da perspetiva da disciplina de Design de Transição, a Sustentabilidade da Moda e Têxtil é considerada um problema 'perverso' bem identificado – um sistema complexo de questões interconectadas e de consequências ambientais e sociais esmagadoras e urgentes de resolver. Apesar da crescente consciencialização e reconhecimento, com propostas identificadas, a sua implementação parece difícil ou, em geral, mostram-se ineficazes. De facto, a integração do conceito de sustentabilidade na prática do design ainda é escassa e o papel do designer, assim como a importância do comportamento do utilizador final é ainda negligenciado.

Assim sendo, conforme estudado nesta dissertação, é necessária uma mudança holística na relação usuário-vestuário assim como, a formulação de um novo paradigma para o design de moda e têxtil. Indiscutivelmente, essas mudanças radicais e necessárias só podem ocorrer na fase de uso do ciclo de vida do produto – mais do que projetar o fim de vida útil da roupa, é nessa fase que o design e os designers podem desempenhar um papel crucial na extensão da vida útil do vestuário (através do co-design, novos sistemas de construção de moldes de vestuário, vestuário modular e engagement do utilizador)rumo à mudança social na nossa relação com a moda.

O objetivo desta dissertação é conceptualizar, desenvolver e avaliar um serviço acedido através de uma interface digital que permite aos utilizadores co-criar peças de vestuário modulares e de descobrir novas perspetivas sobre as suas opções de vestuário na fase inicial do processo de design de moda.

O objetivo é aumentar a vida útil das roupas, e assim diminuir o seu impacto nefasto ao nível ambiental e social, de acordo com um sistema de economia circular.

Esta dissertação explora os desafios, barreiras e oportunidades nas primeiras tentativas

de implementação de sistemas sustentáveis de co-criação, entendendo a dinâmica utilizador-vestuário e explorando a adaptação de técnicas alternativas de construção de moldes de vestuário modular utilizando o Design de Serviços, Design de Interação e as disciplinas UI/UX.

Além disso, é explorado como é que o Design de Serviços, o design modular e a co-criação combinados podem constituir um sistema generativo da sociedade de modo a promover uma mudança de comportamento sistémica – a mudança holística de paradigma – necessária para a sustentabilidade de moda feita por organizações e consumidores ao longo do tempo.

PALAVRAS-CHAVE

Sustentabilidade da Moda . Design de Serviços . Design de Interação . Design de Transição . Design modular . Co-criação

ACKNOWLEDGEMENTS

Dedicated to the memory of my beloved friend Inês, whose inspiration made this journey possible.

To my son.

Thank you to my family, especially to my mother for her unconditional love and support.

I would like to thank Professor Mariana Seiça for her enormous generosity.

I would like to offer special thanks to my advisors, Professors Licínio Roque and Tiago Martins for their precious advice and guidance.

CONTENTS

"Mr. Cleg?
How many shirts are you wearing?
One, two, three... four?!
Now really is this absolutely necessary?
Oh... indeed it is madam.
clothes maketh the man...
the less there is of the man, the more the need for clothes."

- DAVID CRONENBERG's Spider film script (2002).

1. INTRODUCTION

1.1 RESEARCHER'S BACKGROUND AND STANCE

The primary motivation for undertaking this project comes from my personal background in the fashion field as a women's wear designer and my aim to contribute to a more sustainable fashion system whilst unfolding the fashion sustainability issues.

At an early age, I followed my passion and started to study fashion design in 2003. In 2005 I graduated and started to work as a woman´s wear designer. In 2010 I embarked on a BA in Fashion & Textile Design and graduated in 2012. Since then, I´ve had different roles in the fashion industry. I've worked as a fashion designer, brand ambassador, personal stylist, visual merchandiser, and several managerial roles. This background informed and supported my dissertation with access to this industry.

Over the past ten years, I've been watching my own disengagement from my passion as I am increasingly more aware of its negative environmental and social consequences and the numbness of the whole industry perpetuated by the unconscious user's purchase behaviour.

Personally, the expectation of this dissertation is to increase my knowledge and practical competencies, ultimately leading to the development of strong theoretical and practical skills in the field of Fashion Sustainability, Transition Design, Service Design, Interaction Design, User Interface Design / User Experience Design, which can widen the scope of a professional future.

1.2 RESEARCH AIMS AND OBJECTIVES

The research aim conducted the State of Art, in order to :

- To understand the scope of sustainability within the fashion industry;
- To identify existing sustainable fashion methods;
- To understand alternative pattern cutting techniques and their sustainability potential;
- To understand the advantages of modular fashion garments and their application in a fashion service;
- Understanding the user-garment dynamics, consumer behaviour and co-creation;
- To understand the role of both designer and end-users as active contributors to a sustainable fashion future;
- Understand the role of Service Design and Interaction design in the context of the project at hand;
- To understand how IxD, UI, UX fields can enable the co-creation of modular fashion garments;
- Acquire knowledge about the design process in developing a digital solution in an experimental and innovative context;
- Deliver a proposal for a solution/working prototype of fashion as a service.

The overarching research objective is to:
Design, develop and evaluate a service model for modular apparel co-creation to extend the clothing lifespan, hence generating positive behavioural changes leading to a system-level transition within the fashion industry.

1.3 METHODOLOGY

The methodology has been traced having in mind the objectives of the dissertation itself, therefore it had the flowing goals:

- Understanding the complexity of the fashion system by contextualising fashion sustainability imperative as a Transition Design 'wicked problem';
- To acquire comprehensive knowledge regarding the processes of change, in the context of fashion sustainability;
- To identify 'leverage points' through which action can take place and its paths of change to contribute to more sustainable fashion industry;
- Understanding and conceptualising a non-digital service in a digital form;
- Focus on Service Design by understanding the parallel experience and the relation between physical and digital touchpoints;

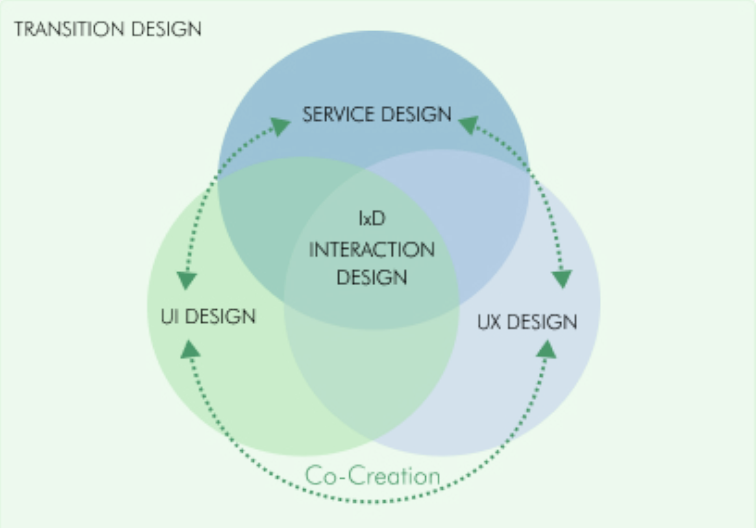

Figure 1 - Applied methodology

- Focus on UX design within a Service Design project by understanding the relationship between them, Interaction Design, and its synergistic dimension;

Due to the level of complexity of the issue at hand – The Fashion Sustainability 'wicked problem' –the methodology approach is presented in figure 1. Firstly, the contextualization within the Transition Design discipline. The research involved informed which path this investigation would take. Along this process, it has been made clear the importance of co-creation in the design of modular women's wear clothing garments that aligned with additional services defined by Service Design methodology could increase the length of clothing lifespan. To access this system, a digital interface proposal is made which is achieved with the resources of interactive design and its intertwined disciplines – UX (User Experience design) and UI (User interface design).

1.4 WORKPLAN

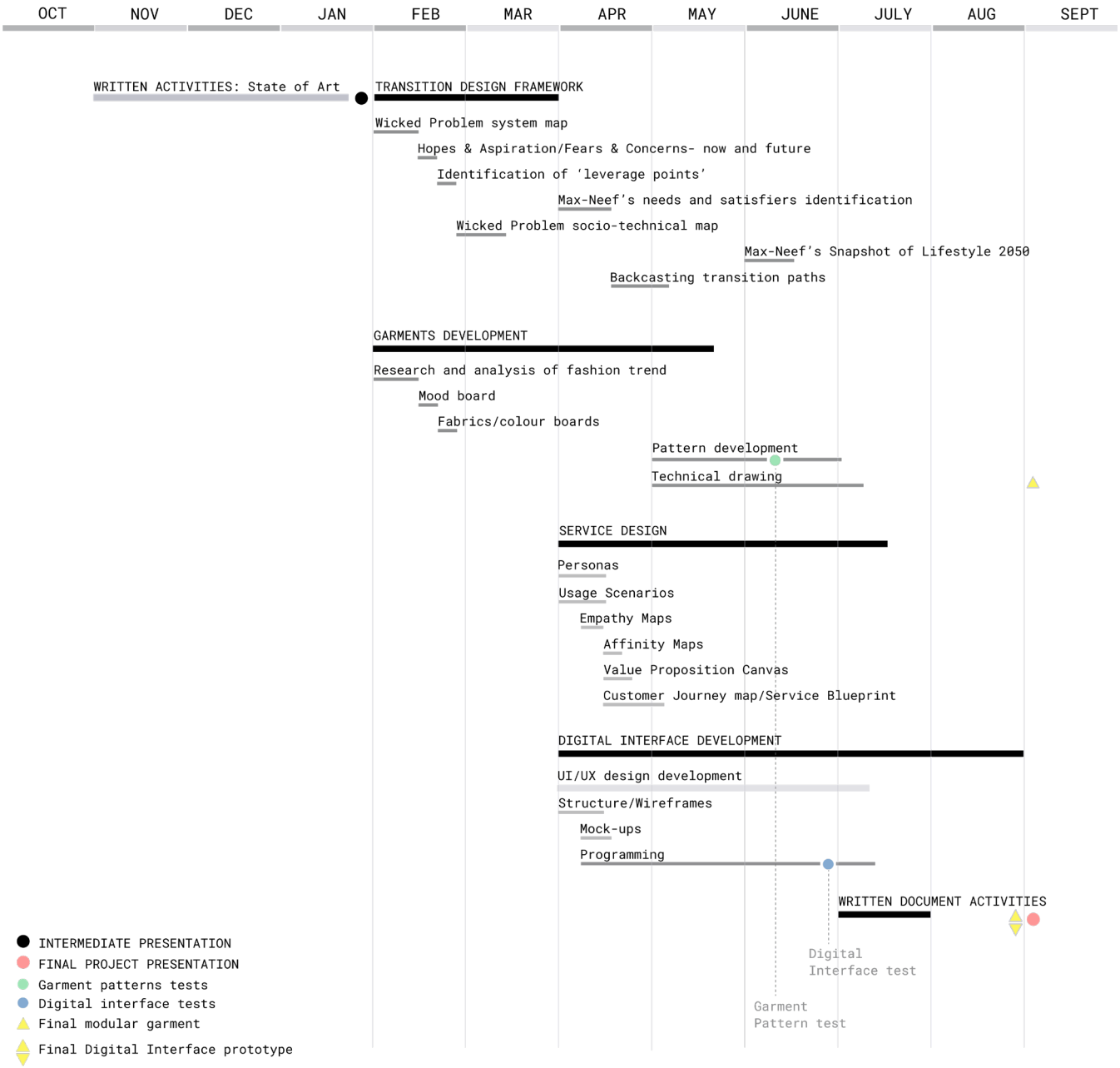

Figure 2 - Work Plan

1.5 CHAPTERS SUMMARY

Chapter 2 is where the State of Art is documented. Considering the enormous complexity of the Fashion Sustainability field, it is imperative to achieve a considerable high level of knowledge regarding the subject, its implications, and the correlation of subjects. In this chapter, the garment life is divided into its three stages: Pre-user stage; User-Stage and Post-user stages where sustainability processes are explored. Moreover, other factors like the User-Garments dynamics and co-creation are targets of the research. This chapter shapes the mindset towards understanding the end user moulding the development of the digital solution.

Chapter 3, describes the Design Proposal, its development and consequently the design process. Here, Fashion Sustainability was faced as a 'wicked problem' hence susceptible to be explored through the lenses of the Transition Design methodology. This approach inevitably shapes and models the processes that followed such as Service Design, Interaction Design, User Experience Design and User Interface Design. The discussion of uncertainties takes place before testing and results analysis.

In Chapter 4, the final chapter, the research limitations are discussed as well as the directions for future research. Here the contributions made in the scope of this dissertation are summarised and conclusions are drawn.

2. STATE OF ART

2.1 SUSTAINABLE FASHION CONTEXT

2.1.1 Climate emergency context

"A code red for humanity."

The UN Secretary-General, ANTÓNIO GUTERRES (2021,AUGUST 9)
(retrieved on https://unric.org/en/guterres-the-ipcc-report-is-a-code-red-for-humanity/)

As stated by The UN Secretary-General António Guterres "the alarm bells are deafening, and the evidence is irrefutable: greenhouse gas emissions from fossil fuel burning and deforestation are choking our planet and putting billions of people at immediate risk".

In their *Underestimating the Challenges of Avoiding a Ghastly Future - a Frontiers in Conservation Science's Report* which, references more than 150 studies detailing the world's major environmental challenges, international scientists and experts alert for the fast loss of biodiversity as cause of human activity (BRADSHAW ET AL., 2021). According to them, the planet is upon a "ghastly future of mass extinction, declining health and climate-disruption upheavals".

Unfortunately, general society lacks of comprehension of the critical links between environmental degradation and human well-being (SHANLEY AND LÓPEZ, 2009), despite of continuous degradation of human civilization (CEBALLOS ET AL. ,2015; IPBES, 2019; CONVENTION ON BIOLOGICAL DIVERSITY, 2020; WWF, 2020 cited by BRADSHAW ET AL., 2021). Actually, widespread ignorance of human behaviour (VAN BAVEL ET AL. , 2020, cited by BRADSHAW ET AL., 2021) and the socio-political nature of planning and implementing solutions contribute to a further action delay (SHANLEY AND LÓPEZ, 2009).

As stated by Dr. Guenther Dobrauz (PwC Switzerland) and Thomas Vellacott (CEO

WWF Switzerland) on *Nature is too big to fail*, "never in human history has biodiversity declined as fast as it does today. "(WWF[37]-PWC REPORT, 2020, P. 3). In fact, this "biological annihilation" underlines the seriousness for humanity of Earth's ongoing sixth mass extinction event and witnessing up to 1 million species being wiped out by the end of the century."(CEBALLOS, EHRLICH & DIRZO, 2017, P. 1).

Overexploitation, ocean acidification, land and air pollution have several harmful consequences as listed by NASA (National Aeronautics and Space Administration) "increased heat, drought and insect outbreaks, increased wildfires, declining water supplies, reduced agricultural yields, health impacts in cities due to heat, flooding and erosion in coastal areas" (NASA, 2020; WWF-PWC, 2020; PWC MEGATRENDS, 2020 cited in STAHEL ET AL., 2021, P. 8) and many more. Those symptoms are a "code red for humanity" (GUTERRES, 2021, AUGUST 9).

To all intents and purposes, humankind only has few years to make significant systemic and social changes to all facets of human activity under the threat of catastrophic climate change, leading to ecosystem, financial and social collapse (MCQUILLAN, 2019, P. 11)

The heart of the matter is definitely human consumption and population growth (BRADSHAW ET AL., 2021). In fact, the nocive effects of the impact of human activity characterised by linear resource-extraction-to waste behaviours are so prominent that scientists and researchers no longer call this living time the Holocene - the environment within which human societies were developed - we are now on the Anthropocene (STEFFEN ET AL., 2011, PP. 740-741; RAWORTH, 2017).

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37 WWF - World Wild Fund for Nature (previously named World Wildlife Fund) is an international non-governmental organisation created in 1961 that works towards wildlife preservation and reductions of human's environmental footprint.

2.1.2 Urgency in Fashion Sustainability

The Fashion and Textile industry is contributing to the environmental and social crises on an unprecedented and increasing scale being described as the second most polluting industry in the world (UN CONFERENCE ON TRADE AND DEVELOPMENT - UNCTAD, 2019 as cited in STAHEL ET AL., 2021).

Currently, the Fashion system is linear and wasteful with low rates of utilisation (feeding the cycle of false "need of new products") and low levels of recycling with negative environmental and societal impacts (KOUMBARAKIS ET AL., 2021).

In A new textiles economy: Redesigning fashion's future (ELLEN MACARTHUR FOUNDATION, 2017, PP. 38-39) describes how the current Fashion system launches over exploitation of nature with large quantities of non-renewable resources and fossil energy being overused in the production through all stages of the value chain. An estimated 342 million barrels of oil are used every year[38] in the production of plastic-based textile fibres (e.g: polyester). Moreover, textile production uses significant volumes of water often in water-scarce areas (most of key cotton-production countries such as China, India, the US, Pakistan, and Turkey[39]).

Textile production (including cotton farming) uses around 93 billion cubic metres of water annually, representing 4% of global freshwater withdrawal[40] and even after production, during the use-fase, the wash of clothing in household washing machines requires an additional 20 billion cubic metres of water per year globally[41]. Despite the existence of "no wash" garments, designed to be disposable after use skipping laundering (e.g. underwear or items bought for a one-off occasion), other disposability impacts like cost of production and consumerism are on the table (FLETCHER, 2014).

Greenhouse gas (GHG) emissions from textiles production is another huge concern. The production of 1 tonne of textiles generates 17 tonnes of CO2 equivalent (compared to 3.5 tonnes for plastic and less than 1 tonne for paper). In fact, washing and drying clothing alone are estimated to account for 120 million tonnes of CO2 equivalent[42].

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38 In 2015, 33 billion barrels of oil were produced, 4% of total oil production is used to produce plastics, of which 25% becomes textiles (see Nordic Fashion Association, Polyester and synthetics; Statista, Global oil production from 1998 to 2015 (2017), https://www.statista.com/statistics/265203/ global-oil-production-since-in-barrels-per-day/). Figure averaged with other sources: Muthu, S., Roadmap to Sustainable Textiles and Clothing: Eco-friendly Raw Materials, Technologies and Processing Methods (2014); Gervet, B.,The use of crude oil in plastic making contributes to global warming (2007) .

39 Gassert, F., et al.,Water stress by country, WRI Aqueduct (2013).

40 World Bank, AQUASTAT, and FAO, Dataset: Annual freshwater withdrawals, total (2014).

41 Calculation based on Circular Fibres Initiative analysis and following sources: Pakula, C., Stamminger, R., Electricity and water consumption for laundry washing by washing machine worldwide (2009).

42 Calculation based on Circular Fibres Initiative analysis and following sources: Pakula, C., Stamminger, R., Electricity

Furthermore, both cotton and wool-related agriculture competes for available arable land (food production) and freshwater resources with the world's growing global population[43]. In fact, wool has a higher land impact compared to cotton (278 hectares per tonne of fibres against just over 1 hectare per tonne for cotton- estimation by DEFRA[44]). Due to this fact, production of cellulose – and protein-based fibres may face scarcity in the near future[45].

Also water resources suffer from cotton agriculture. This industrial farming activity uses "high volumes of fertilisers and pesticides (unless farmed using regenerative agriculture) which are directly or indirectly (penetrating the soil and contaminating water resources) – estimated to use 200,000 tonnes of pesticides and 8 million tonnes of fertilisers annually[46]". In addition, both production and after-use stages contribute to the increase of oceans' pollution levels and contamination of water resources. Chemicals products such as "dyes or finishing treatments used in textile production, release around 43 million tonnes in total per year[47]" whilst "the release of plastic microfibers from the washing of plastic-based textiles, such as polyester, nylon, and acrylic, have been identified as a major contributor" to this issue[48].

Despite benefiting from employment in the industry, local communities are directly affected by poor environmental practices as some factories discharge untreated wastewater production, polluting local rivers used for fishing, drinking, or bathing. At this point, it is also important to stress the fact that not only the health of textile workers but also the health of wearers are affected by those hazardous substances - for instance, commonly called "non-iron" garments are achieved by treating the textile surface with formaldehyde – a carcinogenic substance according to the International Agency for Research on Cancer which is also linked

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and water consumption for laundry washing by washing machine worldwide (2009); Dupont, Consumer Laundry Study (2013).

43 Maxwell, D., et al., State of the apparel sector report: Water, GLASA (2015), p.23; Rodale Institute, Dig deeper: Chemical cotton (4 February 2014), http://rodaleinstitute.org/ chemical-cotton

44 Department for Environment, Food and Rural Affairs, The role and business case for existing and emerging fibres in sustainable clothing (2007), p.75.

45 Maxwell, D., et al., State of the apparel sector report: Water, GLASA (2015), p.14.

46 Globally, around 2 million tonnes of pesticides are consumed, of which 11% are used for cotton farming. (De, A., et al., World pesticide use (2013); WWF, The impact of cotton on freshwater resources and ecosystems

(1999); FAOSTAT, Composition of agricultural area dataset (2016)); average fertiliser application rates per hectare of cotton weighted by main producing countries, multiplied by hectares of world arable land times cotton share of arable land (see Rosas, F., Fertiliser use by crop at the country level (1990–2010) (2012)).

47 For every kilogram of fabric, an estimated 0.58kg of various chemicals are used. For example, 0.35–1.5kg of chemicals goes into the production of 1kg of cotton textiles (see Bluesign, Environmental Health & Safety (EHS) guidelines for brands and retailers (2011).

48 International Union for Conservation of Nature, Primary microplastics in the oceans: A global evaluation of sources (2017).

to allergic contact dermatitis[49]. In reality, Fashion and Textile industry has multiple negative societal dreadful consequences, caused by poor working conditions with long hours and low pay[50] – a consequence of the "fast fashion" linear system that generates increasing pressure on manufacturers and subsequently on workers to deliver low quality items with lower pricing in fast-pace. Cases of modern slavery and in some cases child labour are reported[51] (ELLEN MACARTHUR FOUNDATION, 2017, PP. 38-39).

Briefly to add to common understanding, management of textile waste would become increasingly challenging to the point of being unmanageable.The truth is that less than 1% of new clothing is produced by recycled materials (KOUMBARAKIS ET AL., 2021) leaving a largely part unfit for a circular system (case of multi-fibre materials), often impossible to be recycled and with a short lifespan (half of it is disposed of in a year[52]), after which, most of it is incinerated or thrown away into landfills.

Even though the Fashion and Textile Industry is massive, globalised and complex (MCQUILLAN, 2019, P.10) there is hope. At COP24 (KATOWICE, 2018), several industry's stakeholders (fashion brands, retailers, suppliers and shipping companies) chartered to make significant systemic and social changes by agreeing to address the climate impact of the fashion industry. In doing so, signatories pledged to align their operations with the Paris Agreement goals, securing 100% of electricity from renewable sources with minimal other environmental or social impacts; pursuing the reduction of greenhouse gas emissions by 30 per cent by 2030; phasing out and eliminating coal-fired boilers; sourcing 100% of priority materials that are both preferred and low climate impact by 2030; pursuing a transition to zero air, sea and road emissions (IPCC, 2018; FASHION INDUSTRY CHARTER FOR CLIMATE ACTION, 2018[53]). In order to acknowledge the contribution of the sector to climate change and take the responsibility to endeavour towards climate neutrality, among 43 industry leaders, companies such as Adidas, Burberry, Gap.Inc, Hugo

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49 Piccinini, P., et al.,European survey on the release of formaldehyde from textiles (2007) .

50 Greenpeace, Time out for fast fashion (2016); Doane, D., Living in the background: Home-based women workers and poverty persistence (2007).

51 Bureau of International Labor Affairs, Findings on the worst forms of child labor (2013), pp.10, 30, 31, 56, 59, 110, 146, 171, 368, 369, 561, 775, 776; Moulds, J., Child labour in the fashion supply chain, The Guardian; Verité, Help wanted (2010), p.5; Anti-Slavery International, Slavery on the high street (2012); http://www.safia-minney.com/slave-to-fashion.html

52 McKinsey, Style that's sustainable: A new fast-fashion formula (2016),as cited in Ellen MacArthur Foundation (2017),p.36.

53 The Fashion Industry Charter was launched at COP24 in Katowice, Poland, in December 2018. Under the auspices of UN Climate Change, fashion stakeholders identified and defined paths of change within the textile and fashion industry towards a holistic commitment to climate action which culminated in the Fashion Industry Charter for Climate Action which contains the vision to achieve net-zero emissions by 2050.

Boss, H&M Group, Inditex, Kering, Puma SE, Levi's Strauss & Co, Target and Maersk (one of the world's biggest shipping companies) reiterated their commitment to the Fashion Industry Charter for Climate Action.

LUXURY FASHION

As mentioned by Pencarelli et al. (2020) "luxury" is aligned with pre-defined notions of exclusivity and "perceived excellent quality". The luxury sector is "inherently sustainable" (ARRIGO, 2020[54], as cited in PENCARELLI ET AL., 2020, P.8) due to its characteristics: uniqueness (luxury goods are not mass-manufactured due to its unique components and materials, design and skilled production processes, crafted, handmade and requiring savoir faire which a lot of times are associated with brand's heritage); exclusivity (scarce and/or slightly difficult to acquire); aesthetics (often their beauty is a reflection of being likely innovative); durability (the quality of materials allow their endurance, likely to be an investment or/and handed down from generation to generation) and definitely a higher price (this perception is established through contrast with other products).

Broadly, in the last decades, consumers have become better informed and aware of the consequences of their choices, therefore more selective when choosing a clothing brand or company. Worldwide, companies felt the need within their organisations to develop corporate social responsibility (CSR) activities.

Although, regarding the Luxury sector, CSR arguably is not a factor of decision making for fashion consumers .Arguably, "luxury fashion consumers are already willing to pay high prices, it is unlikely that any reasonable 'eco' or 'social' mark-up on their favourite luxury brands will act as a purchase dissuader[55]" (CARRIGAN ET AL., 2013, P. 26 as cited in PENCARELLI ET AL, 2020, P. 8). Furthermore, it seems that self-enhancement fulfilment (i.e status) is a better justification to select a luxury brand or product rather than ethical-behaviour.

Despite being keen on sustainability , the luxury fashion sector could be more sustainable. In order to achieve it, three scenarios are emphasised: "(1) institutional change through *slow luxury fashion* (e.g., modifying the current concept of seasonality and replacing it with

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54 Arrigo, E. Corporate Sustainability in Fashion and Luxury Companies. Symph. Emerg. Issues Manag. 2015, 4, 9–23.

55 Carrigan, M.; Moraes, C.; McEachern, M. From conspicuous to considered fashion: A harm-chain approach to the responsibilities of luxury-fashion businesses. J. Mark. Manag. 2013, 29, 1277–1307.

slower cycles), (2) *innovative luxury fashion* (e.g. using eco-fabrics, reduce waste in every stage of the production process, and/or increase recycling of discarded clothes), (3) *upgrading luxury fashion* through regulation (e.g. regulations of the state or the industry; GODART & SEONG, 2014[56], as cited in PENCARELLI ET AL., 2020, P. 8)".

FAST FASHION

Fed by high street fashion brands and retailers chains, *fast fashion* ("fast changing fashion") as suggested by its name, implies speed in every step of its production stage. It is *fast sourced and produced* - increasingly inexpensive, unsustainably sourced materials and construction quality often neglected, *fast shipped and displayed* - easily accessible, *fast consumed* - cheaper to acquire and *fast discharged* - perceived as low value goods worthless (regarding time and money) of giving a second chance: if damaged clothes are not repaired or mending or if old fashioned clothes are not re-styled, as example (FERREIRA & NETO, 2020).

In fact, clothing today is more economically accessible than ever before, at least in developed nations (ALLWOOD ET AL., 2006, PP. 11–12, as cited in RISSANEN & GWILT, 2013) which makes it easily disposable as its perceived value is low.

Despite fast fashion being a root cause of the sector's lack of sustainability (FLETCHER, 2014), arguably, one potential solution could be to design short lifespan items to be potential "good" waste using materials that are easy to recycle or compost, and not even necessarily made of textile (NIINIMÄKI, 2009, as cited in LAITALA, BOKS & KLEPP, 2015, PP. 103-104).

SLOW FASHION

Conceivable, at first glance, as a desirable sustainable response to fast fashion would be slow fashion. *Slow fashion* thoroughly suggests three stages: *design* - using sustainable sources, ecological and ethical practice; *production* - quality and craftsmanship; *consumption* - longevity and sustainable commitment (NETO & FERREIRA, 2020). The whole life cycle of the product is reconsidered, from creation (with durable or/and organic resourced materials and quality features as *timeless* design[57]) to its end: its recycling, reuse and upcycling, which is done keeping in mind

56 *Godart, F.; Seong, S. Is sustainable luxury fashion possible? In Sustainable Luxury: Managing Social and Environmental Performance in Iconic Brands; Routledge: Abingdon-on-Thames, UK, 2014.*

sustainability and ecology.

Slow fashion provides to end users information regarding the source of raw materials, its environmental footprint, and ethical concerns (animal cruelty and labour source- who made the clothes, how it is priced and whether fair paid labour was accomplished). It is a philosophy through which the consumer is questioned on *why* he/she/ze wears and buys and how he wears, buys and cares for his clothes - a sense of belongingness to wearers is proclaimed by this movement.

Commonly, slow fashion consumers show high levels of consciousness as they are better informed, hence they have better awareness and think twice before they buy. However, consumers' sustainable behaviour depends significantly more on their habits rather than on their knowledge of sustainable business practices (PENCARELLI ET AL., 2020).

Another relevant issue is that the price point of slow fashion products, usually more expensive than fast fashion ones, discourages many consumers from adopting them (YANG, SONG & TONG, 2017[58], AS CITED IN PENCARELLI ET AL., 2020, P.8) assuming that low quality – low price relation of fast fashion items is in a short-term comparison, more convenient.

57 *i.e., commonly named "classic"- both stylish and wearable over multiple seasons.*

58 *Yang, S.; Song, Y.; Tong, S. Sustainable Retailing in the Fashion Industry: A Systematic Literature Review. Sustainability 2017, 9, 1266.*

2.1.3 Circular economy

As previously defined in 1948, the international Human Rights norms and laws established that every human being despite their financial/social condition has the right of several basics such as: sufficient food; clean water and decent sanitation; access to energy and clean cooking facilities; access to education and to healthcare; decent housing; a minimum income and decent work; and access to networks of information and to networks of social support. All those are conceptualised as the "social foundation". Moreover, it calls for achieving these with gender equality, social equity, political voice, and peace and justice.

The Fashion and Textile Industry has a large and increasing responsibility by the way clothing is produced and distributed, and how collective fashion production and consumption patterns are developed. Its linear system creates significant negative environmental, financial and societal impacts at local, regional, and global scales. As previously argued, the economic growth proclaimed by a linear economy is definitely inconsistent with the concept of long-term ecological effectiveness, hence the urgency of a paradigm shift (KOUMBARAKIS ET AL., 2021, P.4).

In her book, *Doughnut Economics*, Kate Raworth (2017) argues that "successful human existence" functions between a "social foundation" and an "ecological ceiling" and reveals how the obsession with economic growth within a linear economy has led society and industry to transgress both.

The "ecological ceiling" - the limits beyond which we should put no further pressure on the planet-is defined by the "nine planetary boundaries" (such as: limiting land conversion, concentration of carbon dioxide and use of chemical fertilisers), summarised in 2009 by an international group of Earth-system scientists, led by Johan Rockström and Will Steffen, in order to drastically disrupt the ongoing environmental catastrophe. The origins of this line of thought, both historical and philosophical echoe from the Industrialization after World War II in the advent of computer-based studies of nonlinear systems that exposed the complexity and intertwined nature of the world.

The *Circular Economy model* (CE) synthesises several major schools of thought, most of them inspired by Nature. They include the functional service economy (performance economy) of Walter Stahel; the Cradle to Cradle design philosophy of William McDonough and Michael Braungart (BRAUNGART & MCDONOUGH, 2009); biomimicry as articulated by Janine Benyus (BENYUS, 1997); the industrial ecology of Reid Lifset and Thomas Graedel (LIFSET & GRAEDEL, 2002); natural capitalism by Amory and Hunter Lovins and Paul Hawken (HAWKEN ET AL., 2013) ; and the blue economy systems approach described by Gunter Pauli (PAULI, 2010).

It is clear that in a CE the resource consumption over time is the most important thing

rather than waste management. In such a system, clothes, textiles and fibres are kept at their highest value during use and re-enter the economy after use, never ending up as waste.

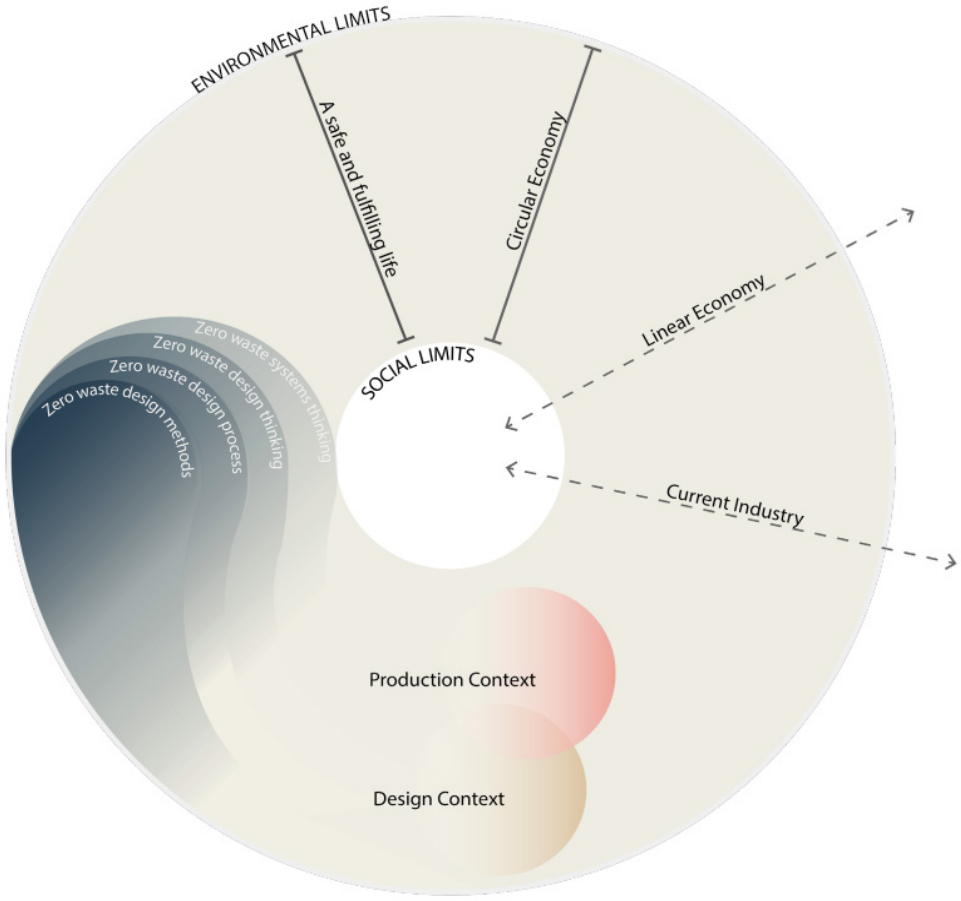

Figure 3 - Developed from Kate Raworth's Doughnut Economic model, the model shown explores the relationship between the broader social and environmental contexts of industry. All design and economic models need to be bound by the limits placed on them by social foundations and the environmental ceiling. As shown our current industry and linear economy overshoots both these boundaries in a variety of ways. From the space between the social and environmental limits comes the design and production context which informs and is informed by the theoretical zero waste design model (MCQUILLAN, 2019).

On the contrary of the linear industrial economy, the *Circular Economy* (CE) approach is not based on the incessant production and consumption of "new objects for sale" which has an irrefutable negative impact on the overall wellbeing. The Fashion and Textile industry

requires fundamental changes transversal to the whole life cycle of textile products, based on three principles, driven by design:

- New business models that enhance clothing use (e.g. services that provide usership rather than ownership).
- Safe and renewable inputs used efficiently (sufficiency-based approaches as solutions that actively reduce consumption and production).
- Solutions to keep raw materials in the cycle (eliminate the concept of waste and by turning waste streams into useful and valuable inputs for other processes).

2.1.4 Circular Economy debunked

Whilst *Circular Economy* applied to the fashion sector should be restorative and regenerative by design and provide benefits for business, society and the environment we need to remain critical regarding CE particularly how it has been applied, never forgetting that is firstly "to meet human needs while minimising the associated environmental impact[37]" (KOUMBARAKIS ET AL., 2021).

CE is defined as a "regenerative system in which resource input and waste, emission, and energy leakage are minimised by slowing, closing, and narrowing material and energy loops[38]". This definition implies that minimising material and energy inputs and outputs is "enough" for a regenerative system. However, the allegedly "circular" business neglects the behaviour of consumers and massively fails to develop strategies to address the "growth-centric" business models.

Even if brands and companies assume environmental commitments , consumers fail to align with their own consumption behaviour (the so-called "sustainable fashion paradox" – commonly justified by Heider's balance theory [1958[39]]).

Another perceived issue for both companies and consumers is the preconception that by using eco-fabrics/recycled materials environmental collapse is prevented. In truth, recy-

37 Allwood, J. M. 2014. Squaring the circular economy: The role of recycling within a hierarchy of material management strategies. In Handbook of recycling: State-of-the-art for practitioners, analysts, and scientists, edited by E. Worrell and M. Reuter. Waltham, MA, USA: Elsevier, p.446 ,as cited in Zink & Geyer, 2017, p.2

38 Geissdoerfer, M. et al., 2017. The Circular Economy–A new sustainability paradigm?', Journal of Cleaner Production. Elsevier, 143, pp. 757–768, as cited in McQuillan,2019,p.24

39 Han, J.; Seo, Y.; Ko, E. Staging luxury experiences for understanding sustainable fashion consumption: A balance theory application. J. Bus. Res. 2017, 74, 162–167, as cited in Pencarelli et al.,2020, p.5

cling would only generate a 1.6% reduction in GHG emissions. Moreover, raw materials saved through the recycling process can eventually become drivers for growth as a 'rebound effect' (MCQUILLAN, 2020, P. 25).

To diverge 'rebound effect', companies must draw people away from primary goods production (avoiding resource extraction in the first place) and enhancing the use of 'secondary goods[40]'.

Otherwise, if primary production is not reduced the lifecycle of the products is merely delayed being circular economy ineffective, summing up primary and secondary products production and waste (ZINK & GEYER, 2017, P. 2). An evidence of the 'rebound effect' is the increasing volume of consumption which, has crumbled any possible achievements: around 120 billion new garments are produced every year (FLETCHER & TOTH-FEJEL, 2014 as cited in MCQUILLAN, 2019).

Ironically, because it is viewed through an anthropocentric perspective, the circular economy has been failing - according to the Circularity Gap (DE WIT ET AL., 2019 as cited in MCQUILLAN, 2019) only 9% of the economy is circular. In effect, " fundamentally changing consumption patterns represents a threat to one of the logics that underpins capitalism" – grow or perish."(MCQUILLAN, 2020). In addition, Brooks et al. (2017) cited in McQuillan (2020) argues that circular economy models "privilege the status quo and technological change" by focussing on closed-loop recycling.

In fact, there is much left to be done in order to create a political framework which promotes full environmental liability of producers/retailers, as well as, circularity for immaterial loops within ethical and sustainable resources (KOUMBARAKIS ET AL., 2021).

2.1.5 Greenwashed Industry

We are witnessing an increasing fashion trend of "green" products being offered by fashion brands across the entire spectrum of the market due to its favourable consumers' response. In fact, it seems that responsable environmental designs have a higher appeal that non-environmental ones as the customer then feels better about their purchase and themselves (HO, 2003 CITED IN RUMSEY, 2008, P. 9).

However, despite sustainability claims, there's lack of information regarding the eco-ef-

40 'Secondary goods' refer to products made from three core circular economy activities: "repaired" or "refurbished"(reuse at the product level;"remanufactured" (reuse at the component level); and "recycled" (reuse at the material level).

fectiveness of garments which limits the consumers' ability to make an informed and true conscious choice. In fact, products being deliberately presented as sustainable without any information to support the claim are called "greenwashed" (HO, 2003 cited in RUMSEY, 2008, P.9). A lot of products" claim environmental responsibility without the information to back it up" (HO, 2003). For instance, cotton/elastane blends are still a big issue regarding the end-of-life of the product as it makes it really hard to recycle.

Even if not yet worldwide spread, it is important to note that considerable efforts are being made around the world to find ways to recycle blended fabrics. Nowadays, a process called Blend Re:wind, a Swedish process for the recycling of polycotton blended textiles, developed by Mistra Future Fashion(DE LA MOTTE & PALME, 2018; PALME ET AL., 2017 cited in SANDIN ET AL., 2019) allows the polyester/cotton blends to be transformed into three outgoing product streams. Through an alkaline base product, the cotton is turned into new high quality viscose filaments and the polyester into two pure new monomers.

Because this technology is still in development and not widely spread instigating a non-blend fibre consumption is a must but what often happens is that blended fibres are labelled as "green". This situation frequently occurs in the fashion and textile industry with the emergence of strategies built on sustainable and green messages. As a matter of fact, deliberately misleading marketing messages with proper green-related lexicon terms are being used to label fashion products making brands profit from the gap between consumer expectations and information that companies share (KANER, 2021). Whilst "greenwashed" consumers think they are making environmentally responsible purchases and the product fails to live up to sustainable expectations (HO, 2003). Transparency regarding every stage of green businesses should be communicated to customers (KANER, 2021).

2.2. SUSTAINABLE FASHION METHODS

2.2.1 Cradle-to-Cradle (C2C)

In 2002, the architect William McDonough and the chemist Michael Braungart presented one of the most widely acknowledged important environmental manifestos of our time - the *Cradle-to-Cradle* (C2C). It is a design framework with the goal of analysing and preparing the lifespan of a product, focusing on the manufacturing, use and disposal of the item.

This design concept model prioritises the use of "clean" energy sources such as solar, wind and geothermal as well as the elimination of pollutants and harmful processes. Within the *Cradle-to-Cradle* model "everything is a resource for something else", utilising all resources like nutrients and resulting in creating a closed nutrient loop. A closed nutrient loop is possible when an item's "waste/excess" is used as "food/fuel" for a product.

All nutrients are considered either biological or technical (MCDONOUGH & BRAUNGART, 2002). Biological nutrients are nature sourced substances, therefore at the end of their use they are returnable to the earth composted to the ground without harmful effects and closing their biological loop (MCDONOUGH & BRAUNGART, 2002)or they can be ground up and processed into new fabric.

Technical nutrients are synthetic nutrients (man-made fibre produced entirely from chemical substances such as acrylic, nylon and polyester) that must remain separate to ensure a closed lifespan loop. They cannot be mixed with biological nutrients or even different technical nutrients. Technical nutrients are manufactured nutrients able to be recycled into new products of the same quality as the original (MCDONOUGH & BRAUNGART, 2002). The recycling process allows the product at the end of its usage to be reused infinitely rather than going to a landfill

(MCDONOUGH & BRAUNGART, 2002). Using the "waste/excess" of an item to provide nutrients for another is a simple, yet challenging concept.

2.2.2 Zero Waste Fashion Thinking

'Zero Waste Fashion Thinking' (ZWF) is a theoretical framework (figure 5) that interconnects and co-relates three theories: transition design; post-anthropocentric design; and design as future-making for aesthetic and technical development of systems and methods – a new understanding of the relationship between designer and system, textile and form.

Broadly throughout the Fashion Industry circle, waste is faced as a problem to manage rather than to avoid, and certainly not treated as a design problem (MCQUILLAN, 2019; MCQUILLAN, 2020).

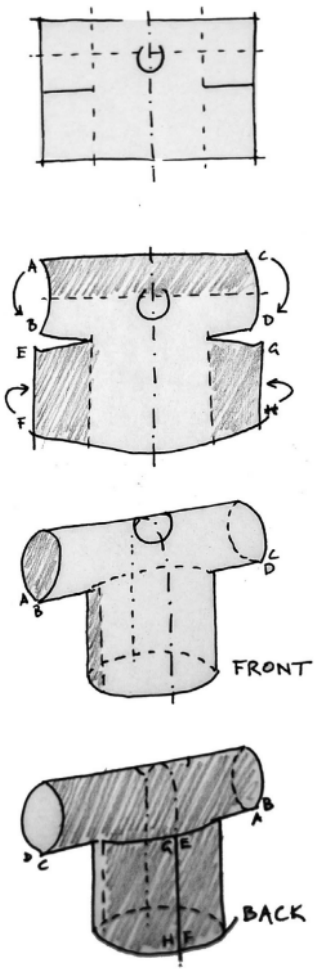

Figure 4 - By making three simple cuts, two from either side of the fabric and one cut for the desired neckline the basic T-shirt form is able to be created. Illustration by Jen Archer-Martin (MCQUILLAN ET AL., 2018).

As opposed to the majority of fashion design, zero waste fashion design could be seen as a practice concerned with solving a problem - design without making waste, rather than having the goal to merely introduce difference (HALLNÄS, 2009, AS CITED IN MCQUILLAN, 2019). Its potential rests in material waste elimination and also in the reduction of the yield (volume of resources required – length of the fabric roll) .

Distinct from the usual way of working with textiles in fashion where the textile is selected before the garment design ascertained, ZWF evolved from the perspective of a zero waste pattern and proposes the development of a surface pattern and subsequent form where the surface pattern is' engineered' (shaped) to respond to the form and the textile is selected afterwards (MCQUILLAN, 2020).

Under the umbrella of Zero Waste Fashion Thinking, one of the most promising projects is *Make/Use* (figure 4), developed by McQuillan et al.(2018). It is a multi-disciplinary research project where the ground-zero for pattern development is the whole rectangle fabric (2D) which, is cut and wrapped around the body into a garment form without subtracting and removing any of the cloth. It

uses a flexible parametric grid – the zero waste matrix – a ZWF garment block that reflects the relationship between body measurements and two-dimensional pattern.

Using the zero waste matrix as a foundation, it is possible to generate an infinite array of zero waste garment designs. The matrix helps the maker/user to rapidly grasp the underlying geometry and sequence of construction moves needed to transform flat (2D) to form (3D).

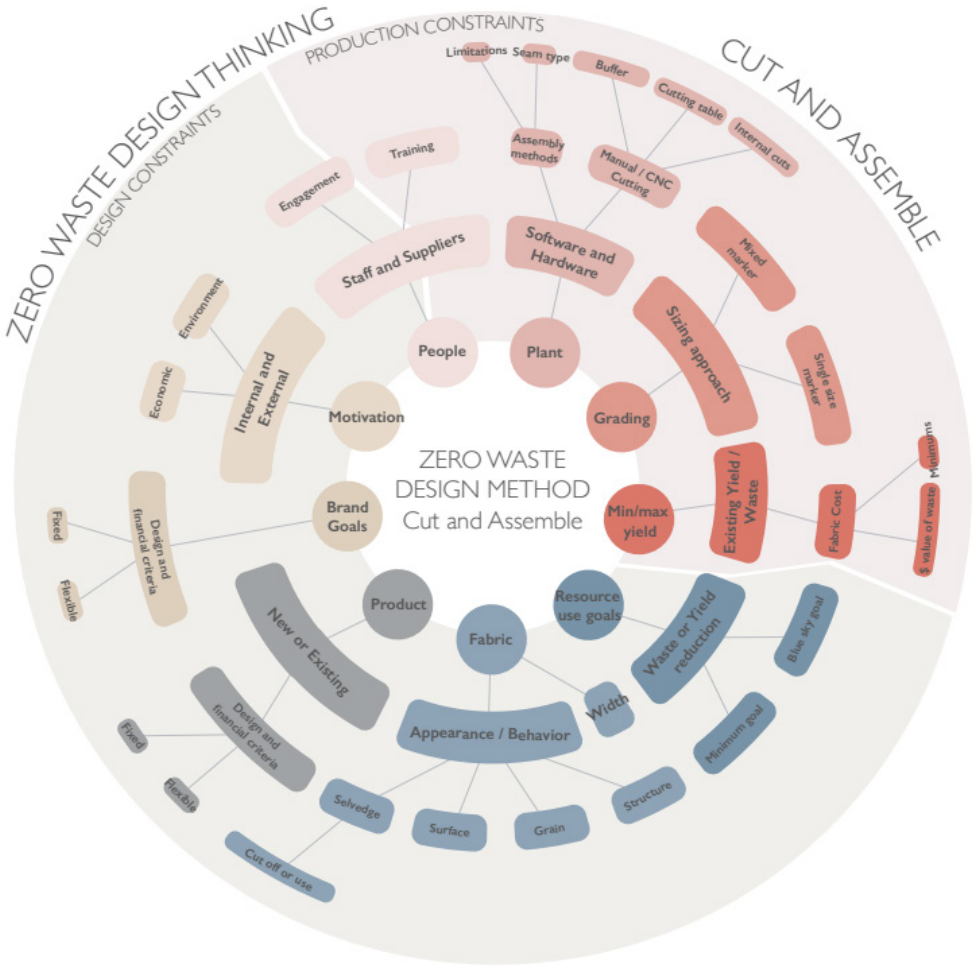

Figure 5 - Zero-Waste Design Thinking Framework (MCQUILLAN ET AL., 2018).

Moreover, in the projects digital textile print is used on the garment matrix to facilitate the cognitive and creative processes involved in the transformation from two-dimensional to three-dimensional form (MCQUILLAN ET AL., 2018).

The relevance of ZWF to sustainability goals are undoubtedly timelessness and waste elimination (in both production and use) but also, co-creation (RISSANEN, 2005; MCQUILLAN, RISSANEN & ROBERTS, 2013; NIINIMAKI, 2013) – by enhancing the garment-user connection through processes of making and modifying, it is hypothesised, once again that the lifespan of garments could be lengthened.

Suitable for the research at hand, is the fact that in the *Make/Use* project, the fabric is retained, forcing the garment pattern to be open, making it prone to upcycling .In fact, the process promotes user's emotional investment and connection, enhancing extending its functional lifespan.

2.2.3 Sustainable Fashion Bridges

Another example is a co-design toolkit for sustainable fashion design and consumption platform that facilitates positive behaviour (HUR, BEVERLEY, & CASSIDY, 2013). It includes six design and use patterns with several examples of each.

1. Choice: e.g., choice of use of resources in production and ways of use (wear, care, dispose).

2. Optimisation: e.g., cradle-to-cradle thinking, zero-waste and rethinking alternatives such as swap and share services.

3. Empowerment: propose solutions that satisfy psychological and social needs, such as personalisation.

4. Persuasion: ways to motivate people, e.g., providing information or rewards.

5. Interaction: patterns in user-product relationships, such as behaviour feedback and sensory effects.

6. Social conversation: enables changes through social learning, use of open-source, creative communities and ways of living.

2.2.4 TED´S tens

TED'S Tens, developed by the Textiles Environment Design (TED) research group at the Chelsea College of Arts, under the guidance of Becky Earley and Kay Politowicz. It consists in ten sustainable design strategies for textile and fashion designers proposed as follows:

1. Design to Minimise Waste	6. Design that Looks at Models from Nature & History
Assess the potential forward impact of design choices /decisions, on production, use and eventual disposal of textile products. Create a design narrative in response to the life-cycle analysis of the product. Examples: slow design; design for long-life and short-life applications; zero waste cutting; design with enhanced aesthetic value.	Seek design inspiration, information and solutions from studying the textiles, habits and societies of the past and from nature including biomimicry. Examples: shape-memory polymers to mimic natural movement; 'lotus effect' nano-coatings; Velcro; austerity repair; make-do-and-mend; D.I. Y/punk customization; modern nomads; historic dyeing /printing techniques
2. Design for Recycling / Upcycling	**7. Design for Ethical Production**
The initial design process anticipates the potential for eventual recycling and repurposing of the textile product. Also existing garments or products considered as 'raw materials', ready for added value to be applied. Examples: this strategy includes design for recycling, upcycling, design for mono materiality and design for disassembly for the closed-loop systems of the future. Think reusable/non-invasive installation or renewal.	Designers can engage with communities, either in the supply chain or for local needs. Examples: sourcing fair trade materials; engaging suppliers who abide by codes of conduct; vertical supply chains; consideration of local resources; designers acting as facilitators of sustainable enterprise in communities.
3. Design to Reduce Chemical Impacts	**8. Design to Replace the Need to Consume**
Select the most appropriate material and processes for any product to minimise environmental impacts. Examples: seek organically produced materials; use mechanical technology to create non-chemical decorative surface patterns; create effects to replace materials and processes known to be harmful.	Textile products can be designed and produced to adapt and improve with age. Encourage replacement of shopping with creative social experiences; the customisation of clothing and textiles; the DIY culture. Examples: emotionally durable design; slow design; consumer participation in co-design and collaborative consumption, crowdsourcing and social networks; apps for bespoke information.
4. Design to Reduce Energy and Water Use	**9. Design to Dematerialise and Develop Systems & Services**
Evaluate the ways water and energy are consumed in the processing of textiles. Assess the carbon footprint, particularly in consumer laundry. Examples: In the production phase: exhaust printing and dyeing; dry patterning systems; air-dyeing; distributed manufacture. In the use phase: design for no/low launder; 'short life' textiles; technical coatings to reduce washing; innovative and informative labelling; localisation; natural energy systems.	Employ a design strategy for multi-functional products and materials conservation via temporary and non-invasive installations. Encourage repair. Facilitate on-line/local communities of producer-consumers.Examples: lease; share; repair; experience design; user centred methods to design services; collaborative online/ local communities; transition-towns.
5. Design that Explores Clean / Better Technologies	**10. Design Activism: leave behind the product and work creatively with the consumers and society at large**
Design for new technologies to save energy and materials. Reduce environmental damage in the production of yarn and fibre, the construction of fabrics, dyeing and finishing of products. Examples: bio-based materials and processes; 3-D printing; laser; water-jet; sonic cutting; sonic welding; digital printing, 'resurfacing' of polyester; novel dyeing techniques; digital finishing; tagging.	The textile designer becomes a 'social Innovator' using design skills to meet social needs. It includes designing events and communication strategies to increase consumer and designer knowledge about the environmental and social impacts of textile products. Examples: publications; blogs; open-source networks; exhibitions; conferences; festivals; social media; manifestos.

Table 1 - TED's Tens (source: http://mistrafuturefashion.com/output/teds-ten/)

2.3 SUSTAINABLE FASHION PROCESSES

Deeply intertwined with the environmental movement, Fashion Sustainability or Eco-Fashion is a part of the growing philosophy and design approach whose overarching goal is to create a fashion system that constrains the impact of human activity within the environmental and social responsibility limits.

Over the past two decades different design strategies to address sustainability of fashion products were developed with varying degrees of success. As seen in the table 2, next page *Summary of Design for Sustainable Strategies* (FLETCHER, 2017), those strategies are applied in three different stages of the product's lifecycle: the *Pre-User* stage- when the materials are selected , production and distributions are made (i.e garments which make use of eco-fabrics, resource-efficient and ethical production chains, zero waste pattern cutting); the *User* stage - when low impact use is achieved (i.e. fashion system-services, home laundering practices which use less energy and water and extended life-span methods such as kinetic pattern construction, modular garments and upcycling) and the *Post-User* stage (recycling and donation to optimise the "end of life"). In this dissertation a reflection about their pros and cons is made in order to explore new possibilities of implementation through complementary processes and techniques.

For the purpose of this dissertation, despite slightly delving into each stage of the clothing lifecycle, the main focus will be on the *User* stage – where garment-clothes relationship is forged and positively influencing consumer's behaviour and the clothes' lifespan.

Lifecycle phase	goal	strategy
materials selection	choose low-impact materials	• avoid materials that damage human health,ecological health or deplete resources • use minimal resources • use renewable resources • use waste by-products • use recycled or reused materials
production	optimize manufacturing	• minimize manufacturing waste • minimize energy in production • minimize number of production methods and operations • minimize number of components/ materials
distribution	efficient distribution	• reduce product and packaging weight • use reusable or recyclable packaging • use an efficient transport system • use local production and assembly
use	low-impact use	• reduce energy inefficiencies • reduce water use inefficiencies • reduce material use inefficiencies
	optimize product lifetime	• build in user's desire to care for product long term • design for take-back programmes • build in durability • design for maintenance and easy repair • design for upgrades • design for second life with a different function
end of life	optimize end of life	• integrate methods for product collection • provide for ease disassembly • design reuse or 'next life of product' • provide for reuse of components • provide ability to biodegrade • provide for sale disposal

Table 2 - Summary of design for sustainability strategies (FLETCHER, 2017).

2.3.1 Pre-User stage

SUSTAINABLE MATERIALS AND RESOURCES

Firstly and foremost, as stated by the waste hierarchy, developed by Lansiks Ladder (1978), creation of waste must be prevented (even before stages of reuse, recycling and before landfill or incineration). However, expecting a non-material/ total zero-waste industry might be arguably utopian as by definition fashion and textile industry's product is material 'stuff' – fibre, fabric, textile product and garment (FLETCHER, 2013).

In his book *Designing for the Circular Economy* (2018), Martin Charter argues that a deep holistic transformation is required in a two-paths approach: "focus on 'zero waste' and maximising value in the system over time – "we need to design and implement new systems that focus on maximising materials value in the system for the longest time period, where waste is 'designed out' from the beginning" (CHARTER, 2018 as cited in MCQUILLAN, 2019).

Casting materials and resources play a major role towards sustainability as more often than not, represent a ground-zero for change.Historically, important shifts were made. In the early 1990's, natural and recycled fibres dominated whereas, from the mid part of the 2000's organic, "Fair Trade" and renewable fibres started to lead, a situation that persists nowadays.

Sourcing materials demand amplification of satisfying practices in the use – a bond between material and the user; linking industry and ecology with cultural systems, connecting innovative wardrobe practises to the infrastructure and technological changes lower levels of consumerism (FLETCHER, 2013).

A product's fibre main fibre may be of "organic" but the dyes, fabric treatments, and other elements such as trims and closures may fail to be sustainable (MCDONOUGH & BRAUNGART, 2002). However, inappropriate dye usage can lower the quality of the eco-friendly product, leading to problems such as colour shifting, and crocking (KADOLPH, 2007).

Details such as the type of thread used to sew the garment can take an otherwise eco-effective garment and ruin its ability to recycle (MCDONOUGH & BRAUNGART, 2002).

The closures used on apparel products can easily destroy the sustainability of a garment. Apparel products often utilise adhesive and interfacings to create the desired support, or structure of the design. These underlying components contain many problematic chemicals. The need for development in sustainable components is necessary to achieve truly sustainable apparel to exist in the marketplace.

ECO-FABRICS

In order to reach the desirable sustainable fashion system, the use of eco-fabrics needs to be maximised and subsequently increased (KOUMBARAKIS ET AL., 2021). Therefore, the use of recycled fibres and often biodegradable materials (which minimises environmental impact) is made,shifting away from mixed fibres (e.g. polycotton) and predominantly using mono-fibres (e.g.pure cotton; GOLDSWORTHY, 2012).

Fostering sustainability also means that harmful chemicals (i.e. persistent, bio-accumulative, endocrine-disrupting or carcinogenic substances) must be phased out and alternatives for dying textiles, and making them biodegradable must be pursued.

Actually, an increasing number of fibre and fabric producers are currently narrowing and regenerating resource loops as an important part of their business model (e.g. Austrian fibre producer Lenzing has implement - ed closed-loop chemical cycles in its *Tencel Lyocell* production process which can recover up to 99.5% of the solvent and reuse it (KOUMBARAKIS ET AL., 2021). Examples of successful innovation in production processes include the improved production of cellulose based fibres.

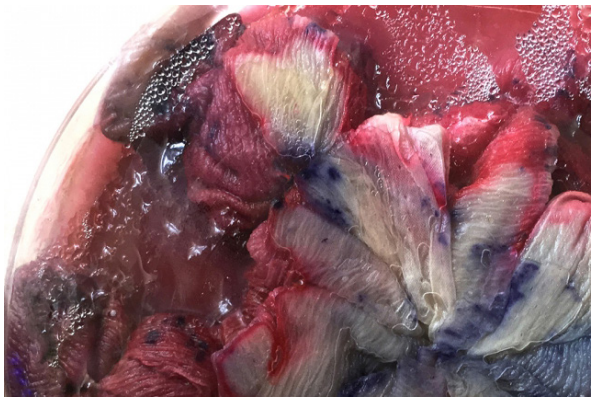

Figure 6 - Bacteria Textile Dyes

(source: http://fabtextiles.org/tag/adriana-cabrera/)

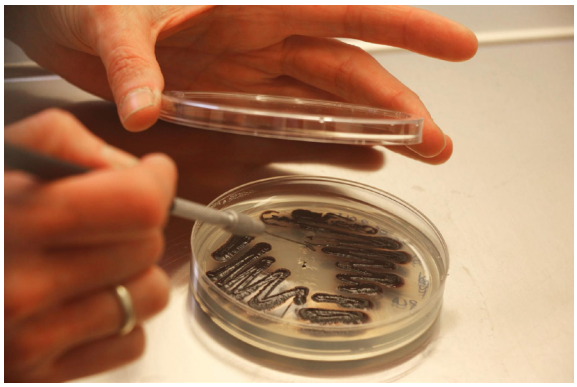

Figure 7 - Growing bacteria, dying textiles

(source: http://fabtextiles.org/tag/adriana-cabrera/)

Cellulose-based fibres refers to those obtained from plant-based material. This material can be either directly captured from plants, such as cotton, or treated chemically to extract and process cellulose. Cellulose-based fibres account for one-third of all fibres used for textiles, 27% of which is cotton alone. If produced without using or retaining any substances of concern, cellulose-based fibres as well as protein-base fibres can be safely biodegraded. Bast fibres (include flax, hemp, and jute) are also decomposable.

Protein-based fibres refer to those from animal sources, such as wool and silk. They account for less than 2% of all fibres used, the vast majority of this being wool. If produced

without using, or retaining any substances of concern, protein based fibres can be safely biodegraded.

Whilst leakage of chemicals is significantly reduced, water-saving practices can also be achieved. For instance, for cotton, *ColorZen* offers pre-treatment that modifies the chemical structure of cotton to make it more receptive to dye claiming water reduction by 95%, and energy use by 75%, compared to conventional cotton treatment. *DyeCoo* has developed a disruptive technology called *Drydye* that does not use any water and significantly reduces solvent use in the dyeing process, by using compressed carbon dioxide as a solvent in a closed-loop system. Using this *Drydye* technique, 95% of the carbon dioxide can be recovered and reused, and while the capital investment in the equipment is higher than for conventional dyeing, it can reduce operating costs by 45%, due to energy savings of 50%. Currently, the *Drydye* technology can only be used on plastic-based fibres and dyes suitable for cotton are currently being investigated. Unfortunately, the high cost of those processes and technologies represent a barrier for its widespread use (ELLEN MACARTHUR FOUNDATION, 2017, P. 117).

Figure 8 - Combination of bioplastics with fabric and pigments applied on a thin surface to create flexible sheets of bioplastic (source: http://fabtextiles.org/tag/adriana-cabrera/)

As a solution for sustainable textiles innovative materials have been developed such as bio-plastics (based on glycerin and glycerol) as seen in figure 8, bio-couture, as seen in figure 9, and bio-dyes, as seen in figures 6 and 8, (natural dyes and bacterial dyes). Because of their different molecular structure, cellulose (cotton, linen, hemp, ramie, bamboo, rayon) and protein fibres (wool, angora, mohair, cashmere, silk, soy, leather, suede) require different mordant treatments to prepare them for natural dyes.

Figure 9 - Kombucha skin of 1m x 1m grown for 2 months using the biocouture recipe of Susan Lee for growing your own cellulose fabric garment prototype. (source: http://fabtextiles.org/tag/adriana-cabrera/)

Cellulose fibres have a lower affinity for natural dyes than do protein fibres. The most common method for preparing cellulose

fibres is to use a tannin first (tannins have high affinity for both protein and cellulose fibres), then use an aluminium metal salt. The most common method for preparing protein fibres is to use alumInium. However, the historic record contains many hundreds of different mordanting methods for both protein and cellulose fibres.

The types of natural dyes currently popular with craft dyers and the global fashion industry include: *animal-derived dyes* (such as Murex snail -purple, indigo blue; Octopus/Cuttlefish - sepia brown; Lac insect -red, violet; etc.) and *plant-derived dyes* plan-derived dyes (such as Gamboge tree resin -dark mustard yellow; Himalayan rhubarb root - bronze; Chestnut hulls- peach to brown - Indigofera leaves (blue).

Moreover, developed through a collaboration with AFML Lab + Botany Lab at The University of British Columbia (Vancouver, Canada) a "live" textile was developed. Named *Biogarmentry* it is a biotextile that lives through photosynthesis - a breathing material whose cellular respiration converts carbon dioxide into oxygen. It is 100% natural therefore biodegradable and because it is a living material, its lifespan directly depends on how it is taken care of, encouraging

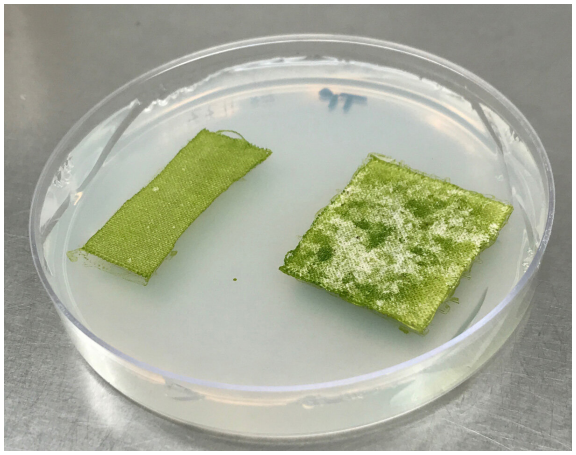

Figure 10 - Biogarmentry project- biotextile (source: https://www.materialincubator.com/biogarmentry).

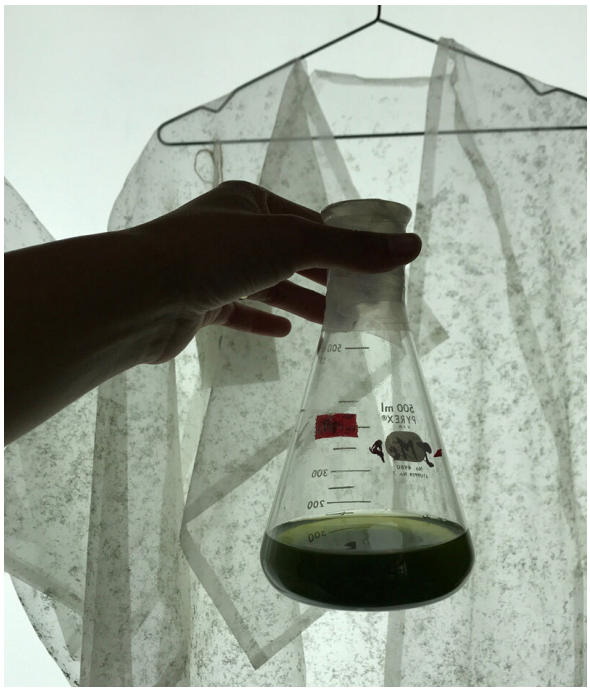

Figure 11 - Biogarmentry project - garment (source: https://www.materialincubator.com/biogarmentry).

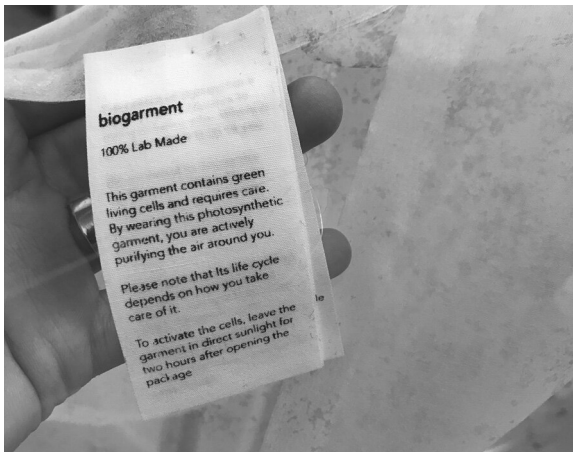

Figure 12 - Biogarmentry project - garment label (source: https://www.materialincubator.com/biogarmentry).

users to actively embrace habits that support its health and growth. In fact, the *Biogarmentry* fundamentally challenges users-garment relationships towards a more holistic idea of changing both individual and collective consumption habits ,as well as, our core values.

PATTERN CUTTING TECHNIQUES

Primarily, the shape of garment patterns has two origins, either is adhered to the form of the animal skin, or "dependent on the rectilinear form of loom-woven cloth" (MCQUILLAN, 2020, P. 31). Pattern cutting for contemporary cut and assembly methods is driven primarily by an anthropocentric, production perspective that over time sought to simplify the stitching as much as possible to reduce labour costs with little care for the broader environmental impacts.

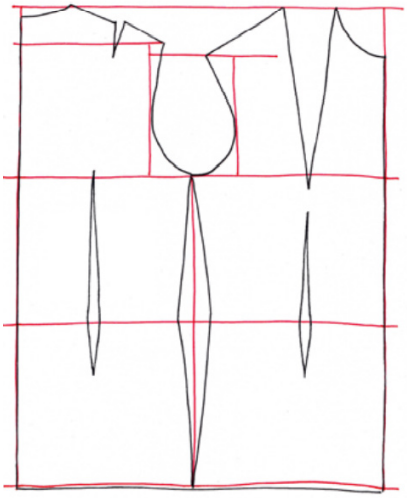

Figure 13 - Horizontal and vertical guidelines based on measurements of the torso as drafted in a flat tailoring matrix with basic body blocks for women drafted within the matrix (LINDQVIST, 2015).

The environmental crisis increasingly demands the development of new relationships with the material world. Innovative responses are required that build on the kind of holistic relationships between textiles, the forms and bodies which have existed ever since.

ZERO WASTE PATTERN CUTTING

The current "tailor matrix" (figupattern-making technique, broadly used by the fashion industry has its main limitation the size of the loom where the textile is woven. In order to avoid additional costs the process of creating and puzzling together its 2D

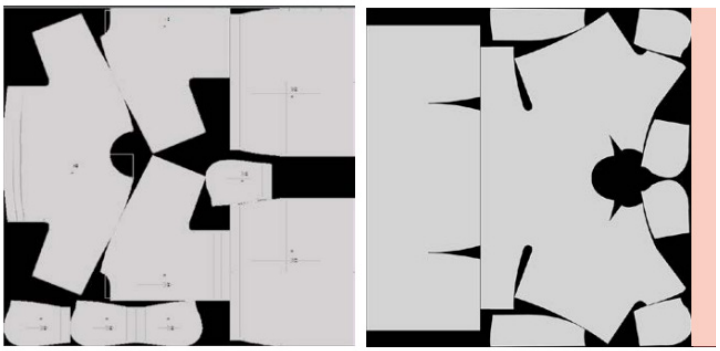

Figure 14- Left - original pattern for Experimental Field Test 1 (MCQUILLAN, 2020, P.55). Right - minimal waste version with reduced yield of about 10% (pink section) (MCQUILLAN, 2020, P.55).

complex pattern shapes (markers making) performed before fabric cutting is the main focus.

In order to generate the ambitious 'high efficiency' marker (92%) rather than the usual (80-85%) when developing the marker's layout plan (figure 14), two different lines of thought

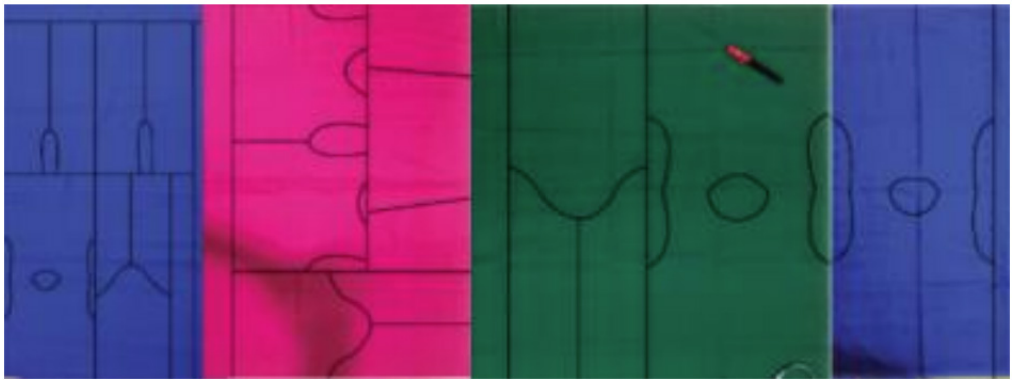

Figure 15 - Zero-waste pattern cutting for childrens wear (SHAHARUDDIN & JALIL, 2021)

are applied. The first one, as seen in figure 15, is the total geometrization of the clothing patterns that seriously compromise the shape of the garments, fitting and aesthetic. For practical reasons, the geometrization of patterns approach has a better acceptance within children's wear (SHAHARUDDIN & JALIL, 2021).

The second one, without change of silhouette or critical details, involves seam *Transferral* (eliminating a seam in one location by moving it to another), as seen in figure 16, below, to balance the modification of pattern for efficiency the alternative seam placements, without changing the silhouette or adding to the overall seam numbers. As a consequence, it often means that the three-dimensional form is difficult to forecast. As stressed by McQuillan "zero-waste design is design practice that embraces uncertainty" (GWILT & RISSANEN, 2011).

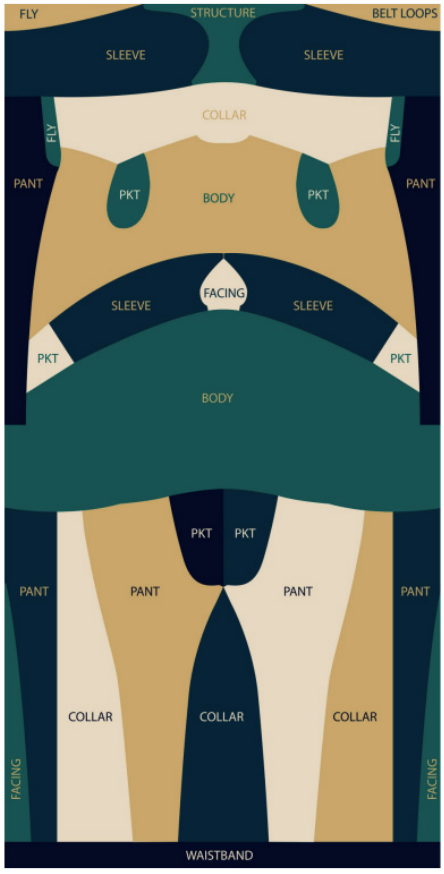

Figure 16 - Zero-waste pattern layout by Holly McQuillian utilising transformed block patterns as the tools for achieving zero-waste (MCQUILLAN, 2019)

Moreover, by not allowing a "no-space" between the pattern pieces, size grading is indeed a challenge. The limitations and constraints of these two methods uncovers a third path vested in a compromise between both of them and comprising the Zero Waste Fashion Design Thinking – the minimal waste pattern cutting.

Even though, evidently beneficial because material is saved in the material yield, that could be outweighed by the extra cost of additional sewing seams or gathering operations as the used material is extremely inexpensive in a fast fashion context (MCQUILLAN, 2020).

PRINT-ENCODING GARMENT CONSTRUCTION

Digital print is used as "an embedded navigation system" enabling users to smooth the cognitive process in interpreting the two-dimensional (2D) garment pattern and assemble it into a three-dimensional (3D) garment form. Ultimately, the garment construction and manipulation depends on the functional understanding of the form and construction (MCQUILLAN ET AL., 2018).

Relevant to this dissertation is the awareness of digital print limitations as a facilitator of garment construction. As experienced by McQuillan et al. (2018) in the *Make/Use* project, additional instructions needed to be provided for unassisted non-expert users in order to achieve satisfactory results – a well-constructed garment (MCQUILLAN ET AL., 2018).

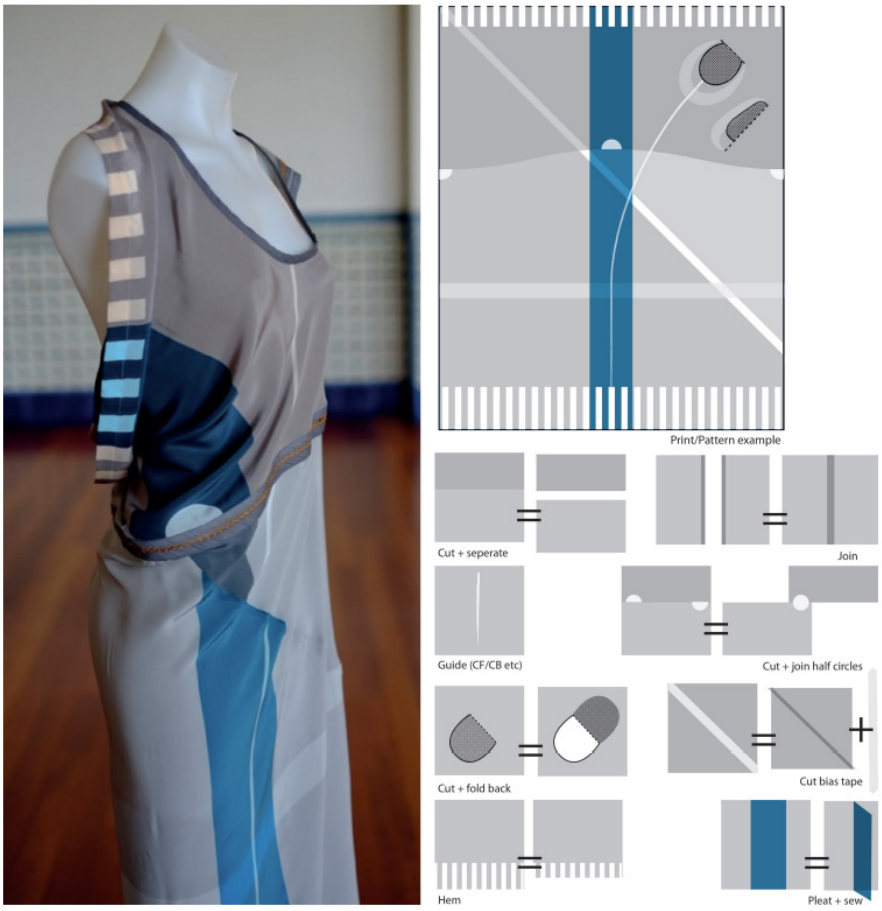

Figure 17 - "Make/Use"v1 Tube Dress design with key demonstrates early instructional/ wayshowing print experimentation. Photograph and illustration by Holly McQuillan (MCQUILLAN ET.AL., 2018).

ONE-PIECE PATTERN CUTTING

The French designer Geneviève Sevin-Doering has been developing, since the 1970's, one-piece garment pattern designated as '*coupe en un seul morceau*' ('all in one piece') in which, the cloth is sculpted around the body having in consideration its volumetry and movement.

Inspired by pre-tailoring garment pattern cutting techniques from European Middle Ages and in worldwide ethnic/traditional costumes that were executed before the introduction of

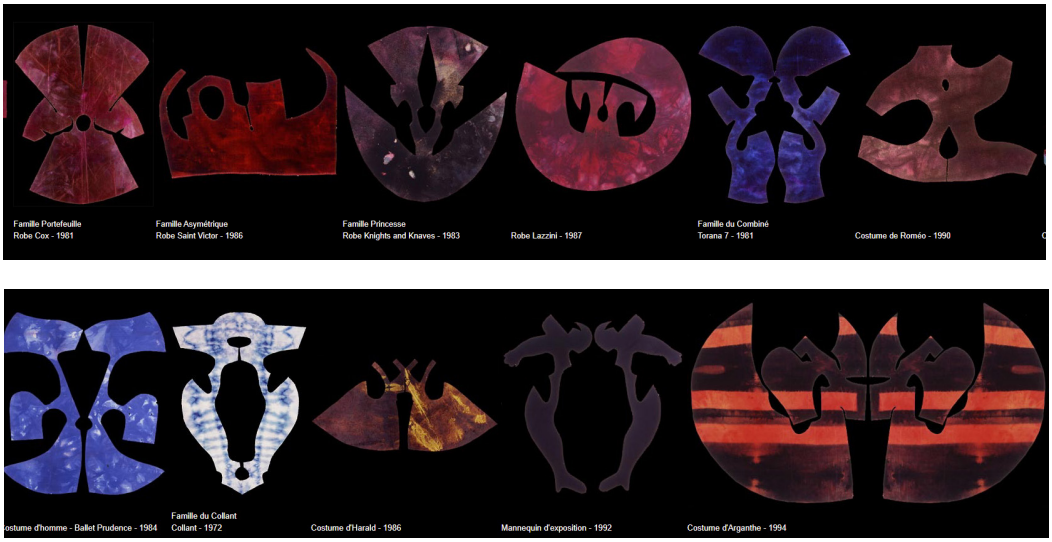

Figure 18 - 'Coupe en un seul morceau' by Geneviève Sevin-Doering (source: http://sevindoering.free.fr/fr/fraccueil/cadreaccueil.htm).

templates, drafting systems and mannequins (SEVIN-DOERING, 2004).

In fact, cutting cloth driven by the textile itself, often wrapped around the body, allows greater freedom of bodily movement (e.g. Roman Chiton and Greek himation, India's sari, the Scottish kilt).

The focus of this technique is

> *"all about the body, not about the dress or the pattern. What we are interested in is what the dress does with the body".*
>
> - LINDQVIST (2015).

The conventional tailor's matrix is a merely theoretical approximation of the non-moving body that is derived from horizontal and vertical measurements in an upright position. It is a drafting system from which the unwanted parts of material (in the form of darts and vertical seams) are removed and more fabric in certain areas is added (in the form of pleats and folds). According to Geneviève, the tailor's matrix "works from outside towards the body" (LINDQVIST, 2015).

KINETIC GARMENT CONSTRUCTION

From the Greek 'kinein', kinetic means 'movement' or 'to move' (MERRIAM-WEBSTER, 2014B as cited in LINDQVIST, 2015) and refers to the biomechanical functions of the body. The kinetic perspective takes into consideration the relation between the fabric that falls draped over the body (with the gravity pulling it down) and the body movement and its linear (transversal) and angular (rotation) intrinsic dynamics.

Developed by Rickard Lindqvist's PhD (2015), *Kinetic Garment Construction* has its roots in the ancient ways of dressing and combines Geneviève Sevin-Doering's design methods with a reverse engineering approach, wrapping the cloth around the body in almost unrecognisable patterns (LINDQVIST, 2015).

Whilst wrapping the body, the fabric falls and the places where it 'breaks' or folds highlights specific points (Figure 19). Those lines and those points are the base from which an alternative garment construction grid is built, towards a more dynamic approximation of the body, therefore defying the traditional tailor's matrix.

In order to achieve not only functionality but also aesthetic and expression qualities which are relevant for the user-garment engagement, the kinetic approach, as seen in figure 20, explores alternatives to utilisations of the direction of fabric grain beyond the traditional varies

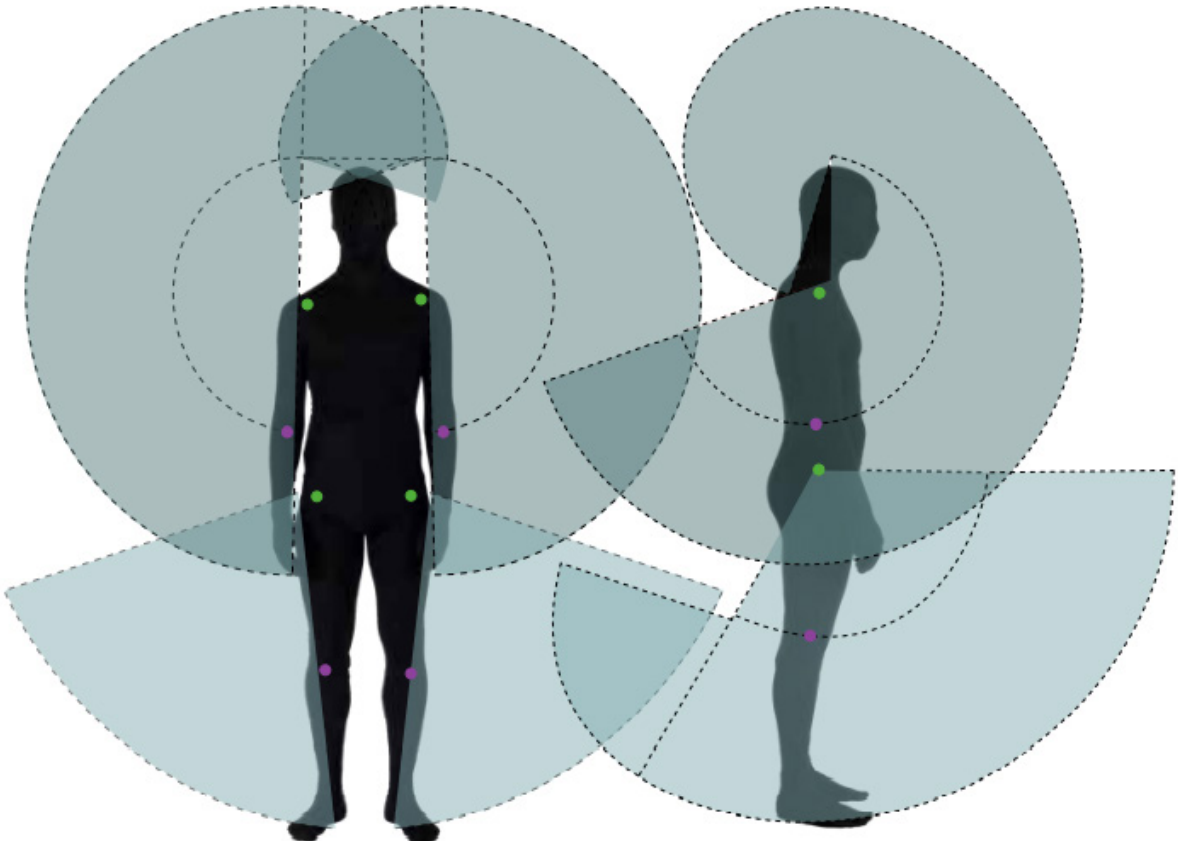

Figure 19 - Scheme of possible movement of arms and legs and key points of rotation (LINDQVIST, 2015).

(straight and 45°bias) exploring the expression qualities of the commonly "unwanted" asymmetrical distortions. This is particularly relevant because woven fabrics often have anisotropic qualities- "different in different directions" (GORDON, 1981, P. 251, as cited in LINDQVIST, 2015).

As argued by Lindqvist (2015), the importance of grain direction is possibly connected of Langer's lines (LANGER, 1861; LI, 2006, P. 113 as cited in LINDQVIST, 2015) – figure 21, below, which, lies on biomechanical properties of the human anisotropic skin (CF. WILKES ET AL. 1973, as cited in LINDQVIST, 2015) and the notion that the body posture as well as gravity influences the skin (NIZET ET AL., 2001, as cited in LINDQVIST, 2015).

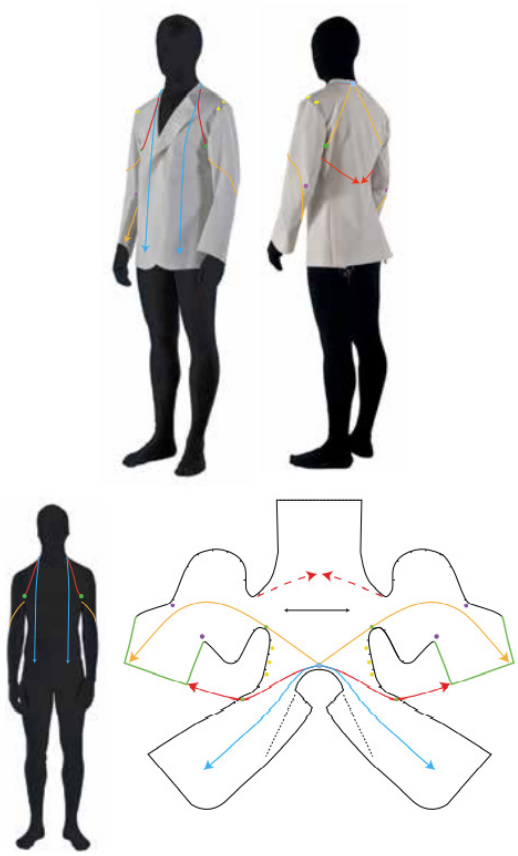

Figure 20 - Kinetic garment construction pattern (LINDQVIST, 2015).

In addition, Lindqvist's work is open to the introduction of new possibilities and further applications to its system to present alternative theories that may lead to new manufacturing /assembling methods as well as, positive user-garment relation leading to new consumerism behaviour.

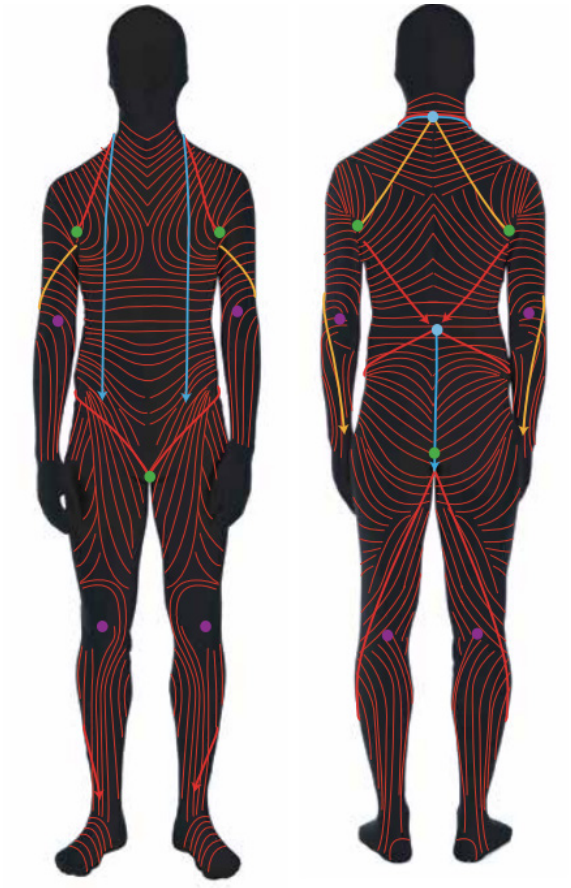

Figure 21 - Langer lines and fundamental directions and points for the kinetic garment construction theory, visualised on the human body. The blue points indicate starting points, and green points indicate fundamental (structural) points (LINDQVIST, 2015).

With the aim to further creatively develop the approach of kinetic pattern cutting and Lindquist´s work, as seen in figure 22, below, Quiannan Shi developed further explorations regarding the fabric's grain direction leading to new both functional and aesthetic approaches for women's wear (SHI, QUIANNAN, ND).

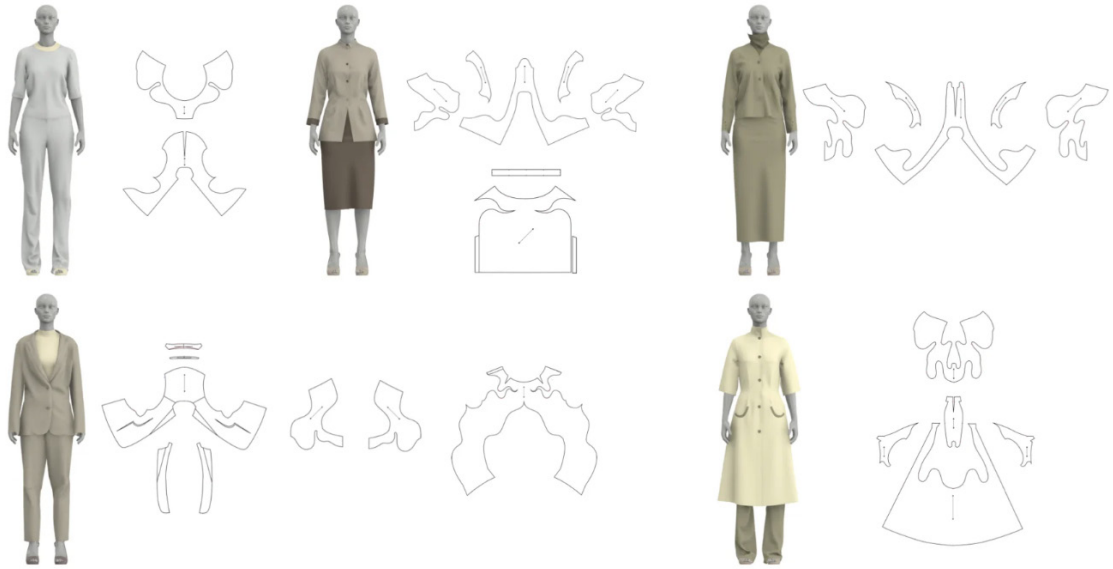

Figure 22 - Shi, Quiannan, ND, "Garment Reconstruction For the Dynamic Human Body", nd.(source: https://graduate-showcase.arts.ac.uk/project/316978/cover)

Like Lindqvist, also the designer Aitor Throup takes into consideration the body dynamics and movement-well represented in his "Legs"work (figures 23 and 24), a retrospective trousers collection between 2004 and 2010 – when developing his own construction pattern blocks. Itself a dynamic process that evolves and he perfects over time. In fact, for Throup each piece is

Figure 23 & 24 - Trousers from When Football Hooligans Become Hindu Gods (2006) (image: Neil Bedford, © Aitor Throup)at Galerie Jean-Luc & Takako Richard in the Marais district (source:https://www.iconeye.com/design/news/aitor-throup-s-trouser-collection).

a prototype.

Relevant for this dissertation is the fact that not only his method refuses the commonly used tailor's matrix but also his creative fashion design approach.

In fact, Aitor Throup designs are developed under the "Justify Design "system dynamics which gives equal importance to each element designed, for instance he defends a "conceptual functionalism" in which all function elements such as zips, pockets, folds, pleats, etc are justified and the design elements are established through "algorithmical construction"- a system of embedded parameters through a collection to determine which design elements are going to be used.

Undoubtedly, the kinetic garments construction is applicable to any type of human body, specific or general, is adaptable to both sizing systems and individual bodies and contributes to new notions of fit.

Eventually, the zero waste thinking design practice of its project seems to only rely on how it enhances the user-garment relationship leading to an extension of the clothing lifespan rather than towards a zero waste pattern cutting method that avoids material waste. However, as mentioned in his thesis "the theory and methodology suggested in this thesis cannot be dismissed because of any hypothetical fears of increased fabric consumption" (LINDQVIST, 2015). He defends that by splitting the pattern into different forms could provide a solution for fabric consumption as well as to technical restrictions and constraints (e.g, the fabric length).

New pattern construction approaches like the kinetic one are with great relevance as it explores new possibilities to achieve flexibility of movements when dressing up the body - a possible path to further detach the fashion industry of the use of fabric blends in particularly the mixed of elastane with natural fibre that makes them not composable nor recycled. The structure of the fabric itself could improve fabric expansion (such as knitted ribs).

TRANSFORMATIONAL RECONSTRUCTIVE PATTERN CUTTING

The Japanese designer Shingo Sato has been developing a pattern cutting technique called ***Transformational Reconstructive Pattern Construction*** (TR) which consists in reconstruct the traditional garment seams derived from the taylor's matrix by displace them and passing them on key points (similarly to kinetic garment construction), origami techniques, as well as, darts manipulation, as seen in figure 25, below.

Previously explored by the 'Anatomisk tilksæring' ('Anatomical cutting') by Preben Hartman ([1985]cited in LINDQVIST, 2015), TR is presented as hybrid methodology using pre-prepared block patterns combined with draping/moulage on live bodies techniques.

This technique is relevant as an exploratory field for possible solutions regarding seam displacement (figures 25 and 26) which, is one of the core aspects of the kinetic garment construction that will be further developed in the present dissertation.

Figure 25 - Designing seam lines directly on the body in order to eliminate the traditional shoulder seam. At the end of it, no real armhole is visible (TR-Transformational Reconstructive Pattern Technique by Shingo Sato; source: https://www.muellerundsohn.com/en/allgemein/pattern-cutting-master-shingo-sato/).

Figure 26 - Jacket's TR new pattern blocks (TR-Transformational Reconstructive Pattern Technique by Shingo Sato; source: https://www.muellerundsohn.com/en/allgemein/pattern-cutting-master-shingo-sato/).

SUBTRACTION PATTERN CUTTING

Subtraction pattern cutting is a method of pattern cutting developed by Julian Roberts; fashion designer, filmmaker and a teacher (Royal College of Art, n.d.). Julian Roberts (2013) suggests it is possible to design from multiple axes simultaneously in his *Subtraction* Cutting method - best described through his *Absolute Basics'* diagram (figure 26) which shows the perspective of a complete house form unfolded like a box.

In his book *Free Cutting*(2013), Roberts explains his pattern cutting technique which is predicated on a the basic principle: the shapes on the garment are created by subtracting material rather than adding it. While not zero waste, his *Subtraction* pattern cutting approach considers the rectangularity of textiles and works with it to generate form (MCQUILLAN, 2014; MCQUILLAN ET AL., 2018).

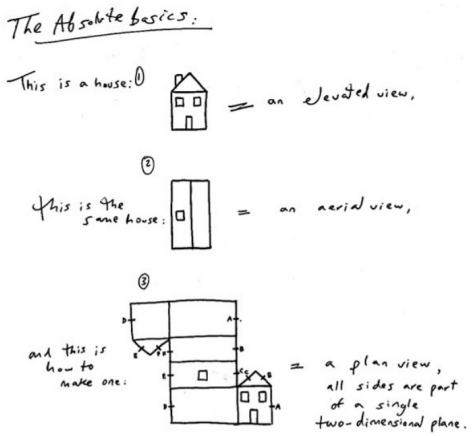

Figure 27 - "The Absolute Basics" (ROBERTS, 2013).

This subtraction challenges the conventional pattern cutting methods by generating a more organic approach of shape creation: negative spaces created by the subtraction allowing the body to go through and the shape emerges when the garment is worn. (ROBERTS, 2013, P. 14)

Considering that both body and fabric are not static, traditional measurements and sizing scales are ignored (ROBERTS, 2013, P.12). This represents an opportunity to discover new shapes and forms as creation expressions (ROBERTS, 2013, P. 31, P. 27).

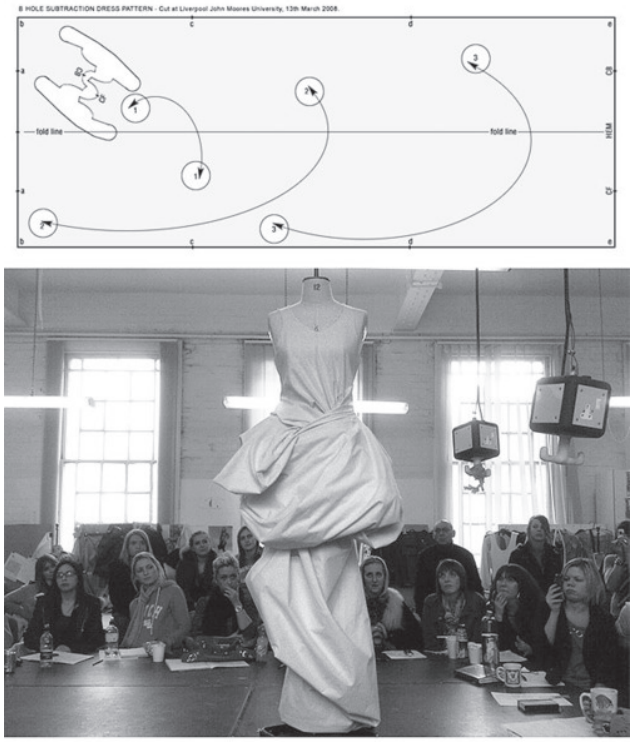

Figure 28 - "Subtraction Pattern" (ROBERTS, 2013).

"This is a subtraction method of cutting, because the resulting shape is created by the removal of fabric, not the addition of fabric. This removal creates space for the body, but also controls how the fabric falls around the body."

- JULIAN ROBERTS (2013).

With these non-conventional techniques it is usually hard to know what the final outcome is (ROBERTS, 2013, P. 15) and hard to previously envision what the final form will look like hence the designer encourages to embrace the risk in it by learning through experimentation.

Within the *Subtraction* pattern cutting method, several approaches are developed such as: the *tunnel technique*, the *plug technique* and *displacement technique*.

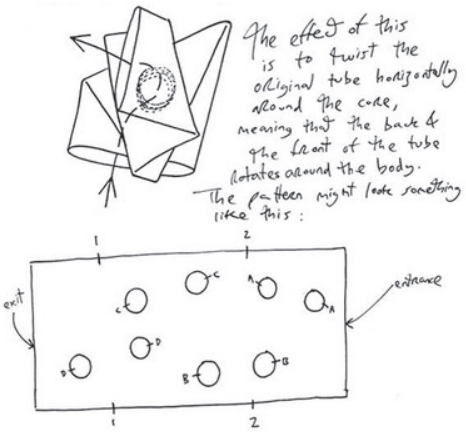

Figure 29 - "Tunnel Technique" (ROBERTS, 2013).

THE TUNNEL TECHNIQUE

This technique allows the body to pass through the surface of a pattern many times over, through the openings (holes) of the fabric. It is "a cross between a simple tube pattern and a one-second tube with volume at its openings. The holes are sewn together internally to create a single hole through which the body travels" (ROBERTS, 2013).

THE PLUG TECHNIQUE

The plug technique, developed by Julian Roberts, is based on the idea of creating mismatching shapes, a cut out and a separate shape which are sewn together. One shape is cut out (on the pattern piece) and another one is then sewn on the place of the cut out.

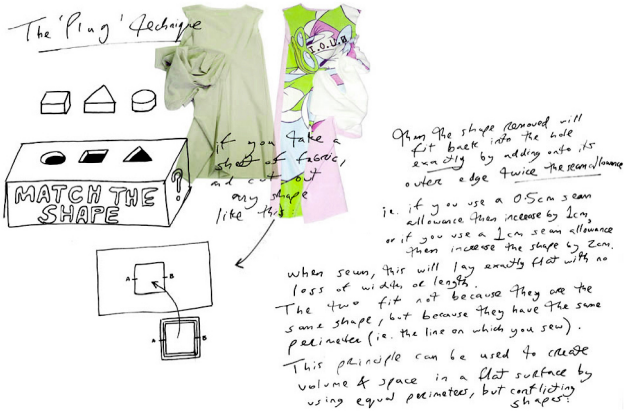

Figure 30 - "Plug Technique" (ROBERTS, 2013).

Conflicting shapes being forced to be combined (ROBERTS, 2013, PP. 52-54) creates dimensional volumes: the shape is cut on one fabric and a contrasting shape is sewn along the cut line with the same circumference (ROBERTS, 2013).

THE DISPLACEMENT TECHNIQUE

The displacement technique uses separate front and back pieces that are sewn on a form with a shape cut out, for example a circle with a smaller circle cut out. The other pattern piece has to then travel through the shape within the shape in order to be sewn to the other pattern

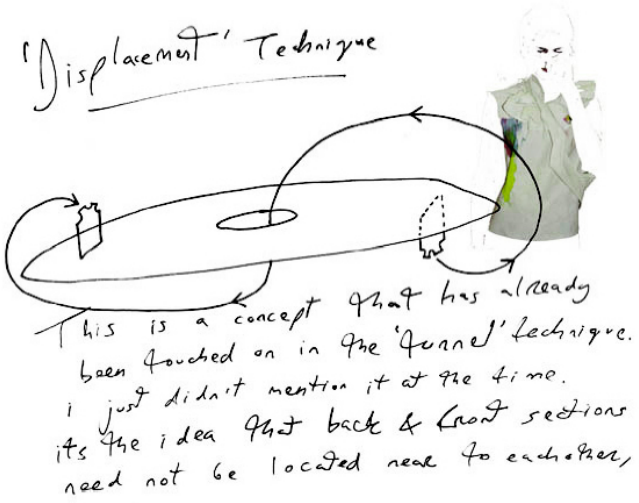

Figure 31 - "Plug Technique" (ROBERTS, 2013).

piece (ROBERTS, 2013, P. 66-67).

Both techniques are relevant as they provide an exploratory field to better understand the potential of multi-techniques in the placement/swap of modular garment pieces.

2.3.2 Use Stage

The *Use Stage* of the product is when the garments are worn by people. Is in this stage that care activities occur (washing, cleaning, ironing) as well as, maintenance activities (repair) to build garment's durability.

In order to reduce negative environmental impacts in the use stage, two simultaneous approaches are in need: 1) to diminish the quantity of textile materials in circulation through a) expanding the life of the existing textiles and b) re-using the products (COOPER ET AL., 2013; FLETCHER, 2012; JØRGENSEN ET AL., 2006; MADSEN, HARTLIN, PERUMALPILLAI, SELBY & AUMÔNIER, 2007, as cited IN LAITALA,BOKS & KLEPP, 2015) and 2) to reduce the consumption of energy, water, and chemicals

during the use including laundering and drying of clothes within households (BAIN ET AL., 2009; LAITALA, BOKS, & KLEPP, 2011; PAKULA & STAMMINGER, 2010; LAITALA,BOKS & KLEPP, 2015).

EXTENDED LIFESPAN

The lifespan of garments can be lengthened by enhancing the garment-user connection through processes of making and modifying. As hypothesised by various authors and researchers (FLETCHER, 2014; RISSANEN, 2013; MCQUILLAN, 2019) the digital artefact that is proposed in this dissertation enables the user to engage and participate in their wardrobe creation by selecting the components/modules of each garment and by exploring the capacity of transformation of a piece into another piece with different use.

Moreover, in an attempt to engage the user with the proposed system, information about each garment (e.g. expected lifespan, CO2 emission, water resources, material waste, materials provenience and labour source) is provided in a perspective that this would help consumers to make better informed choices. In fact, a lot of strategies to increase the physical durability of garments have been developed and executed within cost and labour limitation, such as: designing seasonless styles; designing multifunctional garments and other systems that allow clothes to adapt to user's change of needs (fit, size or style) over time (NETO & FERREIRA, 2020).

However, a lot of the existing approaches still fail to avoid clothing waste and early replacement because ultimately, it is the user engagement with clothes beyond the point of purchase that determines their durability. The truth is that clothing is massively underutilised worldwide - while many users living in developing countries have higher clothing utilisation rate, the opposite happens in first world countries. Actually, a lot of users are acknowledging this as a problem, with, for example, 60% of German and Chinese citizens admitting to owning more clothes than they need (ELLEN MACARTHUR FOUNDATION, 2017).

For the purpose of this dissertation, we will not delve into each stage of the clothing lifecycle, and will instead focus on the use phase: its influence in the lifespan of clothes and further resource throughput and waste has led the European Clothing Action Plan to address Design for Longevity as one of their key action areas (NETO & FERREIRA,2020).

It is also important to note that each of the consumption stages influences the other stages. For example, the amount of clothing a person acquires influences how much each garment is used, and if garments are not properly taken care of, they can end up sooner in the disposal phase (LAITALA, BOKS & KLEPP, 2015).

A deceived concept that durability of materials alone is a solution that extends product

lifespan, hence, sustainability is common, yet wrong. Perception of materials quality, often associated with their durability (long-lasting properties and endurance performance) is not a factor that stops consumerism culture (FLETCHER, 2017). Actually, durability, while facilitated by materials, design, and construction, is determined by an ideology of use (FLETCHER, 2010, P.222-223) deeply connected with obsolescence perception and emotional aspects.

2.3.3 Post User-Stage

RECYCLING

A vital pillar of the circular economy is *recycling* which represents an opportunity for the industry to capture some of the value in more than USD 100 billion worth of materials lost from the system every year, as well as to reduce the negative impacts of their disposal (ELLEN MACARTHUR FOUNDATION, 2017). Currently, clothing design and production typically do not consider what will happen when clothes cannot be used anymore. Converging towards a range of materials (including blends where those are needed for functionality), and developing efficient recycling processes for these, is a crucial step in scaling up recycling, as is the development of new materials.

A key point for the success is to align the fashion industry with recycling by including the product's *end of life* as part of the design process . In addition, the pursuit of technological innovation to output quality to capture the full value of the materials as well as, development of new materials, where current ones do not provide the desired functionality and recyclability. Furthermore, implementing clothing collection at scale and development of improved sorting technologies would increase the quantity and quality of recycled materials providing better matching supply and demand. On top of that, clear policy and commitments through transparency and communication, in order to increase recycled input has the potential to accelerate the uptake of clothing recycling.

UPCYCLING

The *upcycled fashion design* and production supply chain are similar to the standard fashion design and production supply chain, with stages of manufacture, distribution, wholesale, retail, and purchase by consumers. Whilst the main difference is the extension of the item's lifespan, that benefit is felt only if the material' end of life is previously designed. The greatest

difference is that upcycling design is directly informed by the available source materials as they are sourced in the post-consumer phase therefore, it has its own limitations.

They go through a triage process in which they separate wearable from un-wearable according to a textile grade. The wearable garments and accessories are conducted to second-hand use and often donated with different destinations according to its grade of deterioration (the lower quality ones to Eastern Europe and Sub-Saharan Africa whereas the higher quality ones are resold in Western Countries. The least good ones have recycling, incineration or the landfill as a destination (HAN ET AL., 2017).

Classified as wearable items, upcycled items have their intrinsic value recovered through repairing, recycling, recutting, refashioning (modified and adorned) closing the loop of the remanufacturing system (DUNN 2008, P. 6; FRASER 2009, P. 16; AUS 2011, P. 41; DADIGAMUWAGE 2012, P. 58).

The benefits of upcycling include using waste as a source material, post-industrial (or pre-consumer) waste, diverting it from landfill, and in doing so reducing carbon emissions and other negative environmental impacts. Moreover, often, and preferably utilises local wisdom (FLETCHER, 2014) – locally sourced materials, workforce and craftsmanship is a key factor in the development of local communities.

For all that, sustainable consumption is deep-rooted in it (HUR, BEVERLEY & CASSIDY, 2013) and upcycled fashion brands often demonstrate highly engaged consumer relationships, associated with understanding of its products. Upcycling is increasingly associated with the "value added" concept, as reflection of public consciousness and perceived uniqueness.

Key design insights in the upcycling process include: the technique of 'patchwork' pattern cutting, which enables the best use of set quantities of fabric; "visible mending" where mending is assumed by using contrasting colours and/or materials – a concept based on the ancient Japanese technique "Kintsugi" where instead of camouflaging the pottery repair, a gold, silver, or platinum. lacquer was used, print or reprint and ultimately and assertive the use of modular pieces.'

Production challenges are presented in manufacturing standardised upcycled designs with consideration for flexible fabric options. In more traditional production line and factory methods, operatives use one machine to complete a singular part of the production, before passing items on to the next operative.

MODULAR GARMENTS

TYPOLOGIES OF MODULAR DESIGN

Definitely, the adaptations of the garment construction patterns into smaller pattern pieces, making up standardised designs, allow for greater flexibility in fabric and colour combinations and substitutions. This method has a direct impact on aesthetics and also the functionality of the garment. In fact, by enabling assemblage/disassemblage of the garment into small flat pieces, allows the use of over-printing and upcycling technology (RISSANEN, GROSE & RIISBERG, 2019).

According to *Modular Design in Fashion Industry*'article (CHEN, LI, & WANG, 2018), depending on its assembly/disassembly form, modular design can be categorised in three different forms: component modular design, geometric modular design and compounded modular design.

The component modular design, as its name reveals, retains the basic form of the garment and only few strategic parts (such as collars, cuffs, pockets, etc.), due to its use features, are susceptible to be disassembled, replaced, or altered or even restored back the original overall shape of the clothing piece.

Depending on their function, component modules can be classified as: single function modules- one single function- (e.g. *Lemaire*) or multi-function module- the module has two or more functions (e.g. *DePloy* London).

Figure 32 - Zola Teixeira's "Modular" (source: https://cargocollective.com/zolateixeiradesign/Modular-Garments)

Multi-function modules can have two different assemblage approaches: *Assimilation method* and *Role Conversation method*. In the first one, measurements of different parts of the garment are made equal (e.g. the cuff opening is the same as the leg opening so that a decoration module of the cuff could be transferred to the leg opening). The second one, changes the original role of the garment (e.g. if the armhole depth of a style is enlarged and assimilated to the thigh leg opening, a sweater could be transformed into trousers).

A good example is the work of Zola Teixeira (nd.), in figure 32 , or in the work of Wei Hung Chen, in figure 35, where the original modules can be dismantled and gathered in a completely different piece. The geometric modular design is a "Lego" approach to clothing. Small

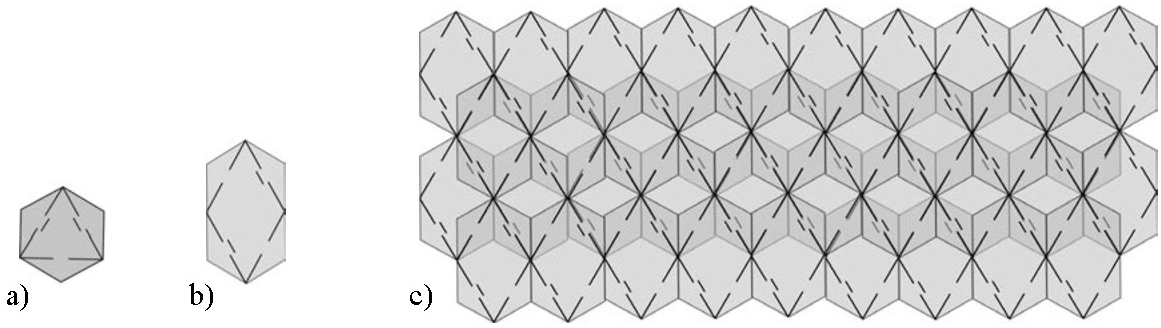

Figure 33 - Development of the modular series showing a) the initial triangular module b) the derivative larger module and c) a tessellation incorporating the two sizes of module (HUR & THOMAS, 2011).

geometric modules can be assembled/disassembled to create shapes of clothing. A recognizable example was explored by Eunsuk Hur in her 2009's *Modular Textile Design* (HUR & THOMAS, 2011).

Hur started the development of a modular system based on interconnection of several

Figure 34 - Eunsuk Hur, "Transformative Modular Textile Design", 2009 (HUR & THOMAS, 2011).

circular fabric pieces where equilateral triangles were inscribed (figure 33). By partially overlapping them it was possible to interlock their tabs – a repeated process until the desirable rich surface texture is achieved.

Compounded modular design is the most complex type but often the one that enriches its realm of possibilities. Often combines geometric modular design with component modular

Figure 35 - Wei Hung Chen' "Modular Cycle" (source: https://www.notjustalabel.com/wei-hung-chen)

THE INNOVATIVE VALUE OF MODULAR DESIGN

Modular design enables the creation of products with a second "life" through its capacity to reinvent and reconfigure a product through use of a flexible core with adaptable and removable sections, which allow growth and change over time. Therefore, in order to facilitate modularity in design, a mathematical appreciation of geometric structure and form is essential.

The value of modular design is embodied in its inherent potential to enhance sustainability and deep-rooted in its own features: diversity, interaction, flexibility and continuity.

- *Diversity*- by choosing a module and assembling it, changing the style of the garment is a process that increases the wearer's interest in the design, maximising user-clothing relationship.
- *Interaction* - by letting the wearer be involved and actively participate in it, the design process transitions from one-way to two-ways output in the final garment piece. Interaction may contribute to feelings of well-being as they help satisfy inherent psychological needs for competence, relatedness and autonomy (FLETCHER, 2017).
- *Flexibility* - modules can be produced and sold according to market demand and users can swap/abandon the modules they don´t want and the useful parts.
- *Continuity* - modular design can be used only in one garment but also be used in a range of products, or a series of products. When modular standards are comprised in a series of long-term products, modular design can provide the continuity of use. For instance, one item bought this season and if not suitable for the next season, can be reinvented or even acquire new functionalities by swapping the modules and transform it into another different use garment.

Moreover, modular design can lead to less laundry and water use reduction as the soiled parts can be easily detachable from the main body and washed separately (FLETCHER, 2013). If efficiently resourced, and due to its small dimensions and proposedly lack of sewing operations to assemble, modular garments are low energy consumption and low-carbon environment (CHEN, LI & WANG, 2018).

MODULAR CONSTRUCTION/DECONSTRUCTION METHODS

The splicing techniques adhered to the modularity of garments can have two kinds of expressions: recessive and explicit. Recessive is to try to use the same colour, reduce the quantity and volume of splicing tools to reduce the sense of presence,whereas the explicit prefers to not use the colour matching assuming its presence and even emphasise them , making it part of the garment aesthetic.

Common techniques are: buttons/snap fasteners, hook and eyes, zippers, knots, velcro tapes,embedded or interlock and magnets. The suitability of these methods depends on factors such as price, recyclability/reuse capability, time taken to assemble/disassemble and the fabrics weight (e.g. interlock techniques are not able to be effectively applied on low weight fabrics).

BEYOND UPCYCLING, MODULAR AND DIGITAL

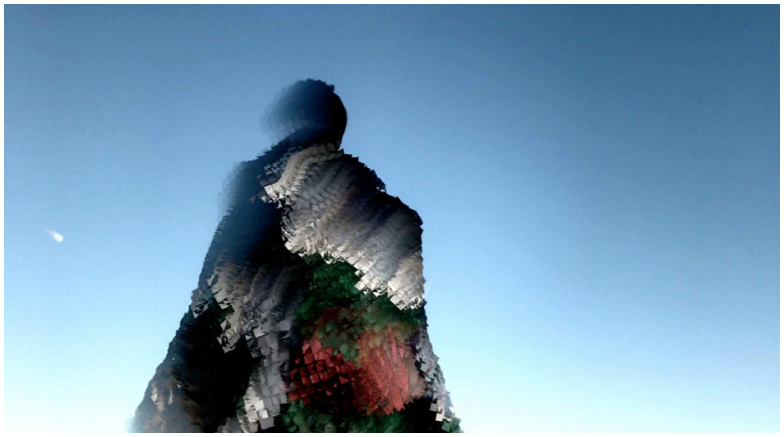

Figure 36 - "Modular Augmented Capsule", Mathilde Rougier, 2020 (source: https://www.mullenlowenova.com/artist/mathilde-rougier/)

A great example of the combination of modular fashion design and digital design is Mathilde Rougier's upcycling project *Modular Augmented Capsule* (2020). She created clothes from ripped or stained cotton hotel sheeting and small tiles from offcuts and sample books - recycling A5 sized sheets of leather used by designers as reference.

Particularly relevant fact for the aim of this dissertation is that those modules work like "Lego", the pieces can be rearranged and assembled in a different way "they are slotted together, you can take them apart, put them back together differently."- the garment is dynamic and evolves.

The collection is partly physical and part augmented. After, the laser cut small pieces (to maximise the quantity of material used) work as 'pixels' , and are 3D scanned and a Convolutional Neural Network algorithm to estimate the amount of material. Sequentially, 3D models are imported to Spark AR (augmented reality software) adding on it a layer of AR imaginarium

altering the outfits' shape.

Collection accessories are materialised re-melting single-use plastic packaging. Neither of these processes involve sewing, meaning the garments are built for disassembly and recyclable, as material unity is conserved. The third process is based around upcycling.

2.3.4.User-garment dynamics

USER-GARMENT RELATIONSHIP

The way people relate with their clothes , which are depending on their culture (and its implicit societal norms) and idea of fashion, has direct reflection on consumer/usage behaviour (usage and maintenance) and purchase loops therefore intertwined with Fashion and Textile industry's impact on Nature. On that account, user-garment dynamics are linked to the social and environmental issues that arise from growing rates of production and consumption of clothing (NETO & FERREIRA, 2020).

WEARER´S ATTACHMENT TO CLOTHES

Emotional durability of clothing and person–clothing relationships are growing topics of the research community. In Russo[37] showed that the relationships between person and object change and develop over time and depend on continual interaction, as recognised by other authors on *product attachment*[38] and specifically on wearer– *clothing relationships*[39]. On a superficial level, we can understand that these changes in the relationship result from changes in

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37 Russo, B. Shoes, Cars and Other Love Stories: Investigating the Experience of Love for Products. Ph.D. Thesis, Delft University of Technology, Delft, The Netherlands, 2010.

38 Chapman, J. Emotionally Durable Design: Objects, Experiences and Empathy, 2nd ed.; Routledge: Abingdon, UK; New York, NY, USA, 2015.

Norman, D.A. Emotional Design. Why We Love (or Hate) Everyday Things; Basic Books: New York, NY, USA, 2004.

39 Valle-Noronha, J. Becoming with Clothes: Activating Wearer-Worn Engagements Through Design. Ph.D. Thesis, Aalto University School of Arts, Design and Architecture, Aalto, Finland, 2019.

Niinimäki, K. Forming Sustainable Attachments to Clothes. In Proceedings of the 7th International Conference on Design & Emotion, IIT, Chicago, IL, USA, 4–7 October 2010.

the item, *changes in the owner*, or *changes in the context*[40].

In his book, *Emotionally Durable Design*[41], Jonathan Chapman claims that products are thrown away when they fail to provide meaning and that we can disrupt our consumption needs by creating an emotional/ experiential connection between person and product (CHAPMAN, 2015). Chapman points out specifying points of intervention and pathways to shift the focus from things to social relations and interactions:

1.**Narrative:** Users share a unique personal history with the product.
2. **Detachment:** Users feel no emotional connection to the product, have low expectations of it and thus view it favourably because it makes few demands.
3. **Surface:** The product ages well physically and develops a tangible character through this process.
4. **Attachment:** Users feel a strong emotional connection to the product.
5. **Enchantment:** Users are delighted by a product and the process of discovery of it.
6. **Consciousness:** The product is perceived to have free will. It is temperamental and users need to acquire skills to interact with it fully.

Table 3 - Intervention and pathways points to shift the focus from things to social relations and interaction (CHAPMAN, 2009 AS CITED IN FLETCHER, 2012B, P. 197; 2017).

Even if it is a facilitator of behaviour change by prolonging the clothing lifespans. the user's attachment to clothes, however, does make the user less likely to purchase new items . In fact, it can induce accumulation and storage. Chapman himself recognises the limitations of designing for attachment and engagement:

40 *Mugge, R. Product Attachment. Ph.D. Thesis, Delft University of Technology, Delft, The Netherlands, 2007.*

41 *Chapman, J. (2009), Design for (Emotional) Durability, Design Issues, 24(4), p33*

"Although a designer can certainly elicit within users an emotional response to a given object, the explicit nature of the response is beyond the designer's control; the unique assemblage of past experiences that is particular to each user, their cultural background and life journey determines this. Designers cannot craft an experience but only the conditions or levers that might lead to an intended experience. What those required conditions are, however, is still unclear to design".

- CHAPMAN (2015).

Echoed by several authors (Burcikova, Woodward and Niinimäki) product attachment is a dynamic state that evolves and can develop over increasing experience, conferring users more confidence and willingness to undertake new explorations. It is influenced by four distinctive areas:

"(1) sensory experiences, related to the perception wearer have of their clothes through multiple senses; (2) enablers, related to the way clothes enables use ,concerning practicality and appropriateness; (3) longing and belonging, related to the personal histories, memories and family ties that often influence choices; (4) layering, highlighting that clothes do not have a linear lifespan, and instead have ups and downs in different phases of the wearer's lives".(NETO & FERREIRA, 2020).

DURABILITY

Favourite items are related to satisfaction of use, which can have different levels or degrees of engagement during their lifecycle, often decreasing after being owned for a long period. More attached to clothes , less likely we are motivated to dispose of them (NIINIMÄKI, 2010).

The level of attachment is connected to memories and enjoyment (SCHIFFERSTEIN & ZWARTKRUIS-PELGRIM, 2008, AS CITED IN LAITALA, BOKS & KLEPP, 2015, P. 103).

The concept of durability is often wrongly connected with physical durability of the product. Hypothetically this could result in a lesser need for new clothes (RISSANEN & GWILT, 2013) However, things last and continue to be used when people want them to (FLETCHER, 2016) and durability is defined by "immaterial reasons" (e.g. reasons that make users have the perception

that is worth to mend/repair clothes, or be careful with laundering practises).

Another identified problem to tackle is the lack of information which prevents the capture of an item's full value. Valle-Noronha stated that information and knowledge is passed to the user on two levels during user-clothes engagement (i.e. wear and care phases): 1. *physical level* - how the garment is constructed and 2. *perception level* - how important and relevant the garment has in the wear's life (LAITALA, BOKS & KLEPP, 2015).

However, even if the lack of durability is a source of dissatisfaction, as knowledge and evidence suggests, the existence of high-quality/ durable clothes has a nonlinear relationship with user satisfaction-durable items are thrown away as well.

NOVELTY

Another factor that drives high usage rates is the sense of novelty. In this area, design in particular modular design plays a crucial role as it can provide different combinations in the same garment giving a sense of innovation in every outfit.

REASONS FOR CLOTHING DISPOSAL

According to research stated in *Making Clothing Last: A Design Approach for Reducing the Environmental Impacts* (LAITALA, BOKS & KLEPP, 2015) the main motive for clothing disposal is "changes in garments" (40%). In fact, Changes in garments are reiterated as the main disposal reason in three other studies, as they also had wear and tear as the most important category (COLLETT ET AL., 2013; KLEPP, 2001; UNGERTH & CARLSSON, 2011, as cited in LAITALA, BOKS & KLEPP, 2015).

"Changes in garments" category include several reasons: the user "had grown out of the garment" (18%); "holes and tears" (13%); "having similar or better garments" (6%). Those reasons are followed by "dislike of design or shape" (4%), "stains "(4%) - especially for children's clothing - (BUTLER, 2011, AS CITED IN LAITALA, BOKS & KLEPP, 2015), and "worn out look "(3%). Undoubtedly, size and fit, either that the owners had grown out of their clothing, or that the clothing never fitted well to start with is the main reason within "changes in garments".

Only for young females (CHUN, 1987, AS CITED IN LAITALA, BOKS & KLEPP, 2015) the fact that the item is considered outdated (out of fashion) is a main reason to dispose of clothes, otherwise seems irrelevant (4%). Based on the style of clothing and the location on which clothing pilling or fuzzing appears (present in 40% of the clothes), it is accepted to some degree - actually, be-

ing worn out is a socially dependent matter (LAITALA, BOKS & KLEPP, 2015, FLETCHER, 2013, 2016, FLETCHER & TOTH-FEJEL, 2014).

2.3.4 Reformulation of the Fashion Life Cycle

After clothing is used, almost all the value in the materials they are made from is lost. In fact, less than 1% of material used to produce clothing is recycled into new clothing. This includes recycling clothing after use, as well as the recycling of factory offcuts.

For recycling after-use clothing, expert interviews and some reporting suggest that the figure could be below 0.1%. Only 13% of the total material input is in some way recycled after clothing use (ELLEN MACARTHUR FOUNDATION, 2017) and the majority of it cascading into lower-value applications such as insulation material, wiping cloths, and mattress stuffing. And after that, the materials are difficult to recapture and therefore are usually discarded.

At the same time that a circular economy needs to be implemented worldwide, increasing efforts to increase clothing use/reuse is imperative.

2.5 DIGITAL DESIGN TOOLS/SYSTEMS FOR FASHION SUSTAINABILITY

Digital technology can enhance virtualization and dematerialization providing transparency and as feedback-driven intelligence as the potential to support the transition to a circular economy. Actually, the Fashion and Textiles industry is an increasingly hybrid design practice. Companies such as Lectra (Modaris), Gerber (AccuMark), CLO3D, Browzwear, Optitext, provide 3D modelling software. It is used for pattern making, maximising cutting plans, fashion and textile collections design, enabling real time 2D and 3D forms aligned with zero waste fashion design thinking.

In fact, rather than having to undergo a time-intensive physical iterative process of drawing/alteration/ sampling/ alteration/ sample,design and model production occurs rapidly, in real time and entirely digitally. Despite not reflecting the full potential of a real model/prototype and its design qualities, the advantages are undoubtedly clear-no fabric is used in a prototype phase hence less expensive, avoids paper maquettes to do this initial testing, and is "clean", significantly reducing the need to cut fabric for prototypes elaboration as well as its worldwide shipment (a common practice in the last decades). Early exploration of the use of these tools began by testing known patterns in the digital space and revealed it was possible to rapidly generate new design variations – a process that in the past, may have taken many days, can be completed within minutes (MCQUILLAN, 2020).

Arguably few downsides are percepted: these digital tools need user's mastering and its potential benefits are only available for industry people and not applied as a tool to inform, educate and promote behaviour shifts from the general public.This uncovers the exploration of new solutions in the context of the proposed work.

2.6 CO-CREATION

Co-creation, the practice of developing systems, products/services by means of collaboration between different stakeholders (RAMASWAMY & GOUILLART, 2010) is not new. In fact, co-creation can be situated within the wider area of Participatory Action Research (PAR) that started to be implemented in 1940's (IND & COATES, 2013). Those participatory methods invite "users to actively participate and shape knowledge" (CHEVALIER & BUCKLES, 2013) and rely on three pillars: to life in society (participation), engagement with experience (action) and sound reasoning (research).

However, the roots of co-creation are diverse through the 20th Century. In the 1970's, in the Scandinavian countries under the name of "participatory design", the first research projects saw the light of day. It was in Norway, Sweden, and Denmark that the *Collective Resource Approach* was implemented with the objective of increasing the value of industrial production by involving the workers in the generation of new workplace systems. This process aligned the expertise of the systems designers / researchers and the situated expertise of the workers whose work was to be impacted by the change. This was accomplished by providing the resources to the workers to make them able to act on the task and use their own experience. (BØDKER, 1996 , cited in SANDERS, 2008).

Moreover, back in September of 1971, in England, the "Design Participation" conference sponsored by the Design Research Society (Manchester) took place from where overlapping ideas from different contributors were exposed and compressed in a book a year later. In the preface, Nigel Cross wrote:

"(…) There is certainly a need for new approaches to design if we are to arrest the escalating problems of the man-made world and citizen participation in decision making could possibly provide a necessary reorientation. Hence this conference theme of 'user participation in design'."

- CROSS (1972, p. 11).

More recently, participatory design is often referred to as co-creation and co-design. Those terms are often confused and/or addressed at the same time as a wide range of opinions about who should be involved in these activities and at which level differ (SANDERS, 2008).

In fact, the spectrum of forms of co-creation and the influence of its inherent democratising principle go from the "Fuzzy front-end "phase of the design process (SANDERS, 2008) through the development of design thinking (BROWN, 2008, cited in IND & COATES, 2013) until the emergence of the open source movement (Raymond, 1999 cited in Ind & Coates, 2013).

For some authors, co-design refers specifically to the collective cooperation and creation between designers. Consequently, co-design is a specific instance of co-creation. However, in the context of this dissertation it is used co-design as a wider landscape in reference to the creation activities and design process that imply the collaboration between designers and "non-designers" (people who are not design trained).

Co-creation has emerged due to the coincidence of several developments: the orientation towards services and experiences, a more open approach to innovation and the growth of social, collaboration and customisation technologies have led to the further development and adoption of co-creation (IND & COATES, 2013).

The mainstream adoption digital technologies and the internet – the platform for co-creation (CHEPURNA & CRIADO, 2018) that enables an open exchange and collaboration between consumers/ users and the organisation with participants across whole globe and with different cultural backgrounds (BENSON ET AL., 2021).

2.6.1 Co-creation of value

The role of the consumer in the industrial system has been changing in the past decades, from isolated to connected, from unaware to informed, from passive to active (PRAHALAD & RAMASWAMY, 2004). Consumers are now informed, networked, and empowered (HOHER ET AL., 2010). This means that consumers have now a more participative and collaborative role in the creation process and are being placed alongside organisations (BENSON ET AL., 2021). Together they are generating and developing meaning (IND & COATES, 2013).

Usually the value contained in products/services is exchanged in the markets from the producers to the consumers (PRAHALAD & RAMASWAMY, 2004). Nevertheless, with co-creation, the centre of value creation is the interaction between the company and the consumer (PRAHALAD & RAMASWAMY, 2004).

The creation of value is transitioning from a product and firm-centric view, "the co-produced value (supply chains)" to individual-centric view, "the co-created value (value networks, constellations, business ecosystems)" (GALATEANU AND AVASILCAI, cited in BUJOR ET AL., 2017) culminating in personalised consumer experiences. Hence, the co-creation value concept (the process of value creation) results from the interaction between consumers/users and organisations/companies (GRÖNROOS & VOIMA, 2013; HIDAYANTI, HERMAN & FARIDA, 2018 cited in MARTINS ET AL., 2020) and relies on an exchange between both parties.

On one hand, consumers assume a double role - they are both developers and evaluators being able to give to the company precious feedback reducing the risk of launching new products. On the other hand, the company offers an experience instead of just a product/service (MARTINS ET AL., 2020). Actually the co-creation experience of the consumer itself becomes the very basis of value (PRAHALAD & RAMASWAMY, 2004).

To apply co-creation to the fashion industry with a positive outcome increasing consumers' loyalty and longer-term relationships, it is needed to look for individual rather than universal needs, changing from a product and firm centric view to personalised consumer experiences (PRAHALAD & RAMASWAMY, 2004). The meaning of value and the process of value creation is changing from focusing on micro instead of macro level consumer segments (MALTZAHN, 2016).

Co-creation is only possible by incorporating key consumer values into retail concepts and marketing strategies as a way of connection between companies and consumers (MALTZAHN, 2016; HIDAYANTI, HERMAN & FARIDA, 2018 cited in MARTINS ET AL., 2020). For that reason, several aspects are involved in the process of co-creation being the most important ones: dialogue, access, risk-return, and transparency (MALTZAHN, 2016; PRAHALAD & RAMASWAMY, 2004).

Nowadays, with transparency and access to unprecedented amounts of information,

knowledgeable consumers can make more informed decisions by accessing data on its manufacturing processes, design, production as well as quality processes. Moreover, consumers can access what other consumers's actions/reactions are allowing a broader scrutiny. With more widely disseminated information concerning the risks associated in using a product/service, consumers can make a risk assessment and that when combined with transparency enhances the ability to co-develop trust (PRAHALAD & RAMASWAMY, 2004).

2.6.2 Fashion and co-creation

The pandemic of *Covid-19* shaped the current social and economic crises, due to governmental mandatory physical-distancing and lockdowns with the temporary closure of several businesses and disruption of supply chains. Although this conjuncture increased the level of awareness of the environmental, social, and economic sustainability issues consumers were already getting aware of lack of fashion sustainability, the excess buying of cheap and impersonalized products. Fortunately, it is possible to witness changes in the buying behaviour, the exponential growth of brands using co-creation and in the use of online platforms (ACHILLE AND ZIPSER, 2020 cited in MARTINS ET AL., 2020).

The relationship between brands and consumers/users has been evolving towards an increase of users' input in the designing and development process of products and services (PRAHALAD & RAMASWAMY, 2004). In fact, brand - consumer interactions enhance the value for the consumer and the brand value (GENTILE, SPILLER & NOCI, 2007 cited in MARTINS ET AL., 2020) since co-creation allows insights about motivations that led consumers or communities to purchase acts and what are the most value connections are during that engagement (MALTZAHN, 2016). Therefore, the consumer/user needs are better understood and fulfilled (PRAHALAD & RAMASWAMY, 2004; HOHER ET AL., 2010) and their contribution of ideas allows companies to forecast the level of success of products/services.

2.6.3 Motivators in co-creation

For the co-creation design processes to become possible, individuals need to have access to expertise, creative thinking skills and motivation (FERNANDES & REMELHE, 2016). As previously mentioned, the co-creation value depends on individuals and their personalised interaction with

the product/service. In fact, it is their own uniqueness that affects their creation (PRAHALAD & RAMASWAMY, 2004) process and the creation not only of things of meaning (IND & COATES, 2013).

The core focus of co-creation is the intrinsic need for self-expression (HOYER ET AL., 2010) which is exponential in sectors such as the fashion industry (MARTINS ET AL., 2020).

Co-creation also has monetary and non-monetary costs for the consumers, and only if the balance between the two of them is positive there's co-creation engagement (HOYER ET AL., 2010; FÜLLER, 2010). Users and consumers only develop rewarding and cognitive stimulating activities (FÜLLER ET AL., 2012, CITED IN FERNANDES & REMELHE, 2016) according to their expectations (NAMBISAN & BARON, 2009; VIVEK ET AL., 2012 cited in MARTINS ET AL., 2020).

Literature points outs several motivations for engagement in co-creation: intrinsic motivations (FERNANDES & REMELHE, 2016) such as fun and pure enjoyment of contributing in terms of creativity (HOHER ET AL., 2010) without external incentives, internalised extrinsic motives such as knowledge acquisition and reputation and lastly, entirely extrinsic motives - monetary compensation, career prospects and recognition (FULLER, 2010; HARS & OU, 2002, cited in FERNANDES & REMELHE, 2016).

Human beings are intrinsically social beings therefore the intellectual, social, and hedonic benefits of sharing with others are major benefits in co-creation (NAMBISAN & BARON, 2009; IND & COATES, 2013). Even though some studies emphasised reciprocity as the main motivator (NAMBISAN & BARON, 2009) most of them show that most users are often willing to help others in a volunteer way for the intellectual, social, and hedonic benefits of sharing (NAMBISAN & BARON, 2009; IND & COATES, 2013).

Moreover, co-creation has a "powerful democratising element that involves users as citizens that can use their influential groups in co-creating in different areas such as social innovation and governmentality (IND ET AL., 2012, cited in IND & COATES, 2013), public services (RAMASWAMY & GOUILLART, 2010) and healthcare and education" (LEADBEATER 2009, cited in IND & COATES, 2013).

From the service provider, organisation and brand perspective, co-creation enables cost reduction in production and overstock. At the same time, consumer needs and trends can be forecasted (BUJOR ET AL., 2017; MARTINS ET AL., 2020).

Considering the goal of the present dissertation, the use of co-creation in this context is meant to be "a collaborative new product development (New Product Development) activity in which consumers actively contribute and select various elements of a new product offering" (O'HERN & RINDFLEISCH 2009, P. 4 cited in HOHER ET AL., 2010).

3. A TRANSITION DESIGN PROPOSAL

3.1 TRANSITION DESIGN METHODOLOGY

3.1.1 Transitioning away from an Anthropocentric view of Design

Design is an inherent anthropocentric activity whose impact is verified beyond function and aesthetics. It is inextricably intertwined with all aspects of human life such as environmental sustainability, social justice, self-care and economic equality (WENDT, 2017, cited in MCQUILLAN, 2020, P. 28). Therefore, Design "needs to step outside of the merely human"(MCQUILLAN, 2020, P. 28) - a post-humanist theoretical direction could contribute to a holistic approach to design.

In her article Posthumanism and design, Laura Forlano (2017, P. 17) writes that the decentering of human "greatly expands our understandings of the multiple agencies, dependencies, entanglements, and relations that make up our world".

3.1.2 Transition Design and Design for Sustainability

The fashion industry has been conceptualised as "a series of interconnected problems, with an enormous economic and environmental burden" (RITTEL ET AL.,1973; BUCHANAN, 1992, cited in MCQUILLAN, 2019, P. 44) – a "wicked problem" which is addressed through the lens of Transition Design.

The world's zeitgeist obliges that we "confront an unavoidable choice: we either support the status quo or we choose a path of change" (FRY, 2010, P. 1, as cited IN MCQUILLAN, 2019, P. 44).

Over the past few decades, Transition design (TD, also referred to as design for sustainable transitions - DfST) adopted several theories and developed practices with the aim to transform socio-technical systems (STS) with the overarching goal of sustainability. Deeply interconnected with social, economic, political and natural systems, TD addresses complex problems at all scale levels, recognises its complexity projecting design strategies in a significant period of time (i.e, systemic changes at societal level ; GAZIULUSOY & ÖZTEKIN, 2019).

There are many frameworks within Transition Design (circular economy, sustainable design, permaculture design, elimination design, speculative design (MCQUILLAN, 2020, P. 582) regenerative cultures and so on) however, there is still a gap between lines of thought and reality - an opportunity to explore.

Brezet's *Dynamics in Ecodesign Practice* (BREZET, 1997[37], cited in GAZIULUSOY & ÖZTEKIN, 2019, P.6)is the oldest literature that considers socio-technical system innovations, referring to one socio-technical system transitioning into another. Brezet developed scenarios and back-casting methods to "develop a vision for sustainable function fulfilment by systems in the year 2040" (BREZET, 1997, P.23, AS CITED IN GAZIULUSOY & ÖZTEKIN, 2019, P.6). *Backcasting* (ROBINSON, 1982; DREBORG, 1996, cited in IRWIN,2015) is used to define a path towards a desirable future, backcasting them to the present to enlighten a "transition pathway".

In 2008, Ryan (2008[38]) presented his designing-visioning concept and Vezzoli, Ceschin & Kemp (2008[39]) established links between design and transition management by defending an "evolutionary co-design while they put sustainable (product-service) system innovations in focus"(GAZIULUSOY & ÖZTEKIN, 2019, P. 6). Gaziulusoy (2010) has developed a scenario method which integrates backcasting approaches and exploratory bridging present decisions with future visions.

However, Joore (2010[40]) developed a model that clarifies the contemporary dependencies of stakeholders and their expectations, exploring the mutual influence of new products/ society within industrial design engineering. (GAZIULUSOY, 2010[41], cited in GAZIULUSOY & ÖZTEKIN, 2019, P. 6)

37 *Brezet, H. Dynamics in ecodesign practice. Ind. Environ. 1997, 20, 21–24.*

38 *Ryan, C. The Melbourne 2032 project: Design visions as a mechanism for (sustainable) paradigm change. In Proceedings of the Changing the Change Conference, Turin, Italy, 10–12 July 2008b.*

39 *Vezzoli, c.; Ceschin, f.; Kemp, r. Designing transition paths for the diffusion of sustainable system innovations: a new potential role for design in transition management? Presented at the changing the change: design visions, proposals and tools, an international conference on the role and potential of design research in the transition towards sustainability, turin, italy, 10–12 july 2008; available online: https://bura.Brunel.Ac.Uk/bitstream/2438/6712/2/fulltext.Pdf (accessed on 28 june 2019).*

40 *Joore, P. New to Improve, the Mutual Influence between New Products and Societal Change Processes. Ph.D. Thesis, Technical University of Delft, Delft, Netherlands, 2010.*

41 *Gaziulusoy, A.I. System Innovation for Sustainability: A Scenario Method and a Workshop Process for Product Development Teams. Ph.D. Thesis, University of Auckland, Auckland, New Zealand, 2010.*

Also, Yelavich and Adams (2014) propose that design can facilitate a process of "Future-Making"- a process that would be inherently social and profoundly political changes.

Kossoff (2011[42])proposes a re-design of transition arenas by using a co-design perspective. He argues that design should be everyone's activity and "constitute facilitating emergence of nested domains of everyday life and make them whole" towards sustainability (GAZIULUSOY & ÖZTEKIN, 2019, P. 6).

Transition Design (2015) as conceptualised by Irwin, Kossoff and Tonkinwise consists of an accepted body of transdisciplinary knowledge about the anatomy and dynamics of change within complex systems (TONKINWISE, 2014, cited in IRWIN, 2015) supporting theories of change.

From notes on *Transition Design* by Tonkinwise, School of Design, Carnegie Mellon University (2014) "theories of change is a model of the system in which design interventions are taking place", a four parts stages of transition from what we have to where we need to

Figure 37 - From Terry Irwin, Cameron Tonkinwise, and Gideon Kossoff, "Transition Design: Re-conceptualizing Whole Lifestyles." Head, Heart, Hand: AIGA Design Conference, October 12, 2013, Minneapolis (source: http://www.aiga.org/ video-HHH-2013-irwin-kossoff-tonkinwise).

42 *Kossoff, G. Holism and the Reconstitution of Everyday Life: A Framework for Transition to a Sustainable Society. Ph.D. Thesis, University of Dundee, Dundee, UK, 2011*

be - a clear intent and purpose for design in the future: *vision*, *theories of change*, *mindset/ posture*, and *new ways of designing* (MCQUILLAN ET AL., 2018).

VISIONS FOR TRANSITION

In *The Rise of Global Left: The World Social Forum and Beyond* (2006), Boaventura de Sousa Santos in his "sociology of emergences" concept, identified the signs of possible future experiences that reveal themselves as tendencies and latencies that often go ignored (SANTOS, 2006 AS CITED IN IRWIN, 2005, P. 239). Moreover, in *The Principle of Hope* (1995), Ernst Bloch introduced the concepts of "*Noch Nich*" (The Not Yet) and "*The Possible*" which explores the idea that "the tendencies of the future in the latency of the present." In other words, the clues for solutions for sustainable futures exist in the present therefore they can be anticipated over time (BLOCK, 1995, P. 241, cited in IRWIN, 2015, P. 239).

For that manner, it is relevant as line of thought the concept of *living systems theory* that explains the dynamics "of self-organisation, emergence, symbiosis, holarchy and interdependence", among others, can serve as *leverage points* for initiating and conduct change within complex systems (IRWIN 2011B; BRIGGS & PEAT, 1990; PRIGOGINE & STENGERS, 1994; WHEATLEY & KELLNER-ROGERS, 1996; CAPRA, 1997; WHEATLEY, 2006; MEADOWS, 2008; CAPRA & LUISI, 2014, cited in IRWIN, 2015).

In order to map the dynamics between organisms and the relationship with its environments, a Fashion Sustainability systems map is proposed at the very first glimpse of this project. Focused on the use stage of clothing, one might preliminarily identify four main *leverage points*: *durability; upcycling; consumer's behaviour; fashion as fashion-system*.

However the system's map is not enough because it doesn't take into consideration the stakeholder concerns, fears, hopes and desires which is an obstacle in finding a resolution. For that, it is proposed the use of Max-Neef's 'Needs and Satisfiers' (MAX-NEEF, 1991) which catalogues the different stakeholders' needs and how they are met - satisfiers. Max argues that needs are finite and universal, but the ways they are met vary and are substantially different (depending, among others, on their time, culture, age and mindset.)

A deep understanding of the "interconnectedness of social, economic, and natural systems" (IRWIN, 2015, 2018; IRWIN, KOSSOFF & TONKINWISE, 2015) is also needed to elaborate a Fashion Sustainability socio-technical wicked problem scope.

According to the Socio-technical Regime theory (BERKHOUT ET AL., 2004; GEELS, 2010) transformation in socio-technical regimes (patterns of artefacts, institutions, rules, and norms) commonly happens in patterns, starting from existing in "niche" and can evolve over time to be

widely adopted.

Informed by these previous works, futuring scenarios and *visioning-back-casting* can be developed and used to identify paths for transition. In terms of *futuring scenarios*, radical approaches can be taken into consideration (even science fiction). Using "Snapshots of Lifestyle" technique, desirable futures can be envisioned through storytelling and speculative narratives enabling critical design thinking. Visions of long-term, lifestyle-based futures in which the problem has been resolved and many stakeholder fears and concerns are addressed and hopes and desires accomplished (IRWIN, 2015).

A relevant aspect to refer to is the importance of the *everyday life discourse*, as it is the primordial context where design's human-scale artefact-interaction focus to the transformation of everyday practises (LEFEBVRE 1984, 1991; HIGHMORE, 2002; GARDINER, 2000, cited in IRWIN, 2015) and where user's behavioural changes and transitions towards sustainability can occur (TONKINWISE, 2015).

THEORIES OF CHANGE

Upon multiple streams of thought from several fields and disciplines, *Theories of Change* have been proposed to be explored in the context of Transition Design (TD) (IRWIN, 2015).

Developed by Thomas Kuhn in *The Structure of Scientific Revolutions* (2012), the concept of *Paradigm Shift*, argues that new paradigms rooted in new knowledge and discoveries, interrupt the continuity periods of scientific "accumulated" progress.

In fact, "paradigm" designates what the people in a community context commonly hold: techniques, patents, knowledge, and values. Therefore, *Paradigm Shifts* can guide the investigation/ design also in the absence of rules as they describe profound changes in a fundamental model or perception of events hence defining and guiding the dynamics of change within complex systems.

Also, at the *International Design Conference* in Aspen, Colorado, 1958, the sociologist C. Wright Mills emphasised that the design practice is grounded in core values such as: dialogue across disciplines, the significance of social collaboration and its relevant craftsmanship in shaping the physical frame of both public and private life. That being said, designers should remain critical and perceive their role as agents of change (YELAVICH & ADAMS, 2014, P. 182). This requires holistic ways of thinking and holistic methods of designing (MCQUILLAN, 2020, P. 29).

Another line of thought necessary for the paradigm shift is *Alternative Economics*

(SCHUMACHER, 1973; MAX-NEEF, 1992; HAWKEN ET AL., 1999; KORTEN, 1999; RITZER, 2011, cited in IRWIN, 2015), which claims that the current dominant economic model (linear, liberal and capitalist economy) is one of the root causes of the complex problems lived nowadays. As an alternative, Circular Economy, as previously mentioned, is pointed out as a possible solution. In the specific context of the fashion and textile industries, (MATILDA THAM AND KATE FLETCHER IN EARTH LOGIC, 2019, AS CITED IN MCQUILLAN, 2020, P. 28) have argued that fashion needs to "not growth" using "holistic 'landscapes': *Less* (the rejection of the logic of growth, and the centring of Earth); *Local* (de-centralising production and economic systems); *Plural* (rejection of an Anthropocentric view of the industry); and *Governance* (cultural level changes promoting diversity and resilience)."

COSMOPOLITAN LOCALISM

Ezio Manzini (design strategist and coordinator of DESIS[43]- Design for Social Innovation toward Sustainability defends that design should be small, local, open in order to avoid normative system's failures by activating cooperation on building alternative scenarios (YELAVICH & ADAMS, 2014, P. 182). In fact, localism is a resilient and independent way of bridging the satisfaction of sustainability needs (DOUTHWAITE, 1996; SHUMAN, 2000, AS CITED IN IRWIN, 2015, P. 239): local economy is prioritised and empowered; relationship bonds are strengthened as it generates new relationships and practises by fostering the community to action which affects consumption and therefore carbon-emissions and waste reduction.

USERS AS MAKERS, DESIGNERS AS FACILITATORS

> *"a text's unity lies not in its origin but in its destination…to give writing its future, it is necessary to overthrow the myth: the birth of the reader must be at the cost of the death of the author".*
>
> - ROLAND BARTHES in "La Mort de l'auteur" (BARTHES, 1968).

Bearing in mind that design is a basic human activity, a less designer-informed and more group-driven design processes that meets bottom-up[44] transitions is defended (ERDOĞAN ÖZTEKIN

43 DESIS is an "international network of design labs, which emphasises scenario building to promote social and environmental sustainability"(Yelavich & Adams, 2014, p.182).

44 Bottom-up processing is an explanation for perceptions that begins with an incoming stimulus from our environment (sensorial information) and works upwards until a representation of the object is formed in our minds.(Gibson ,1966). 23 December,2021, retrieved on https://www.verywellmind.com/bottom-up-process-

& GAZIULUSOY, 2019[45], cited in GAZIULUSOY & ÖZTEKIN, 2019, P. 9).

In the realm of Fashion Design practises (Zero Waste Fashion – ZWF – literature), Kate Fletcher proposes the shift from the design expertise from the designer to the everyday clothing user reframing design practice as design behaviour (MCQUILLAN ET AL., 2018). This subsequently throws into systemic change in "the systems in which the wearing and using occurs"(RISSANEN, 2013, P. 160, cited in MCQUILLAN ET AL., 2018) shifting designer's role from the creation of products to the facilitation of social and political change.

DEMOCRATISING THE DESIGN PROCESS

In his 1990's book *Technocracy and the Politics of Expertise* , Frank Fischer describes "...the ways in which expert knowledge and technocratic practises have become key political resources sustaining increasingly undemocratic forms of decision-making" ("Review: Technocracy and the Politics of Expertise", 1992).

In order to move from a technocratic to a democratic model of design, transforming the passive consumer into an active participant in the design process, designers need to work as facilitators, providing appropriate tools for self-expression (SANDERS & STAPPERS, 2008, PP. 13-14) and the notion of creativity must be explored from the perspective of the user (FLETCHER, 2012).

POSTURE & MINDSET

Transition Design is based on the relationship between internal and external factors that mutually influence each other. The internal factors that call for self-reflection and new mindsets (beliefs, values, assumptions, and expectations) affect the external factors - our posture towards others and the world - it calls for a new way of "being" (IRWIN, 2015).

Mindset (or worldview) is viewed as a powerful *leverage point* for change (MEADOWS, 2008) because mutually influences each other positively or/and negatively and those synergies inform design and its solutions. that are formed by our individual experiences, cultural norms, religious/spiritual beliefs, and the socioeconomic and political paradigms to which we subscribe (CAPRA, 1983, 1997; KEARNEY, 1984; CLARKE, 2002, cited in IRWIN, 2015).

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ing-and-perception-4584296

45 Erdo ˘ganÖztekin, E.; Gaziulusoy, A. ˙I. Designing Transitions Bottom-up: The agency of design in formation and proliferation of niche practises. Des. J. 2019, 22, 1659–1674.

USERSHIP

In fact, changing the mindset of ownership to usership could become a key factor that contributes to the achievement of Fashion Sustainability. Arguably, even if alone durability might not lead to increase the length of product's life, Walter Stahel suggests that by promoting competences and freely choosing practises, usership can be viewed as an expansion factor of product's durability and therefore actively contributes to the reduction of material's demand (FLETCHER, 2017).

THE BEHAVIOUR DESIGN

As advanced by Social psychology (KASSER, 2011; HARGREAVES ET AL., 2012, cited in IRWIN, 2015) user's information and awareness, values and behaviours are linked to their attitudes towards the environment. Therefore, the value of designs lies in the new habits they create. "Design not only gets users to "attend-away-from" (in Michael Polanyi's sense) the "present-at-hand" (in Martin Heidegger's sense) features of the thing that has been created" (TONKINWISE, 2014). "Designers (as opposed to artists) create "artefacts-as-means"rather than "artefacts-as-ends-un-to-themselves" - the essence of design ethics" (FRY, 2010 cited in YELAVICH & ADAMS, 2014). The effectiveness of design is deeply linked with the value of design (shape, forms, function) depends on its resulting affordances (LANIER, 2010[46], cited in YELAVICH & ADAMS, 2014, P. 182).

In its 1994's work Design, Environment and Social Quality, Manzini questions the role of both design and designer and user relationships inventorying a transition from "existenzminimum" to "quality maximum," through three scenarios: "Care", "Utilisation of Service," and "Non-Consumption"(MCQUILLAN ET AL., 2018, PP. 5-6).

Despite having a smaller-scale impact on positive outcome, changes to products/processes are prioritised over cultural shifts regarding consumers habits. The first is faster to introduce whereas the later is hard to achieve. In fact, consumer consciousness is hard to attain and even more difficult is to align consumer consciousness with consumption behaviour.

In order to accomplish satisfactory results, the development of skills and knowledge of garment-use practice must be considered. The design process involves the interaction with users over time (broader social and cultural contexts), far beyond the sale stage (FLETCHER, 2014).

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46 *Jaron Lanier, You Are Not a Gadget: A Manifesto ,New York: Vintage, 2010*

NEW WAYS OF DESIGNING

NEW AESTHETIC

Laying out the flaws of and opportunities for the design world, Victor Papanek (1972), pointed out a blueprint of ways of achieving sustainability by using materials that can be recycled and reused, thinking about how products make us feel enhancing our senses, be inspired by nature, working at a smaller scale, thinking before we buy and ultimately, rejecting aesthetics for their own sake (PAPANEK, 1995).

In fact, half a century later, we are urged to implement Papanek's ideias urged by climate change. Being sustainability an overarching goal of the fashion sector, those radical ways of living and its design approaches make new aesthetics possible. In truth, design is a material reflection (literally and conceptualised) of the word (MCQUILLAN, 2020). In fact, for Lars Hallnäs, sustainability is a technical issue, from which emerges new aesthetics - "the expression of change in a way of living."(HALLNÄS, 2019[47], cited in MCQUILLAN, 2020, P. 29).

Moreover, research developed by Timo Rissanen, Lynda Grose and Vibeke Riisberg (2018) highlight that garments necessarily have evolving aesthetics. For instance, methods of design that allow garments to be flatten after use to facilitate upcycling (over-print, repair or replacement as a fashion system service) affect forms and aesthetics (MCQUILLAN, 2020).

3.1.3 Fashion Design as a service system, not a product

However, often in the context of "collaborative consumption" or "product-service systems," the concept of elimination design urges. Elimination design implies the notion of functional equivalency (e.g."you don't need a car, you need mobility"). It is a relatively new practice of "service design" through which we eliminate (the need for) ownership of a product. However, it often requires a modification of expectations and not to be held as disadvantage compared to the benefits provided by an owned product (YELAVICH & ADAMS, 2014, PP. 212-213).

In fact, service-based business models emphasise access over ownership to prolong use phase. Regarding the Fashion and Textile Industry, designers and brands would be required to

47 *Hallnäs, L. (2019). Introduction. In Dumitrescu, D., Hallnäs, L., Hermansson, M., Nordlund Andersson, A., & Thornquist, C. (Eds.), ArcInTex ETN (pp.8-16). Borås, Sweden: Högskolan i Borås.*

shift away from mere sales of goods towards service-based business models (RISSANEN, 2011), in order to slow the resource loops and extend clothing lifespan (making it more durable and less disposable). Fashion design as a service-system may include: renting of garments to consumers or leasing services for which consumers pay a monthly fee in exchange for access to a garment; offering repair services; reselling used products. For customers desiring frequent outfit changes, subscription-based models can offer an attractive alternative to frequently buying new clothes.

3.2 TRANSITION DESIGN PROCESS

SYSTEMS THINKING

With regards to Transition Design's context and using Donella Meadows the Systems Thinking model (MEADOWS, 1999) identification of 'leverage points' has been made as a key approach to "effective roadmap integration and action" (STEELE, ND).

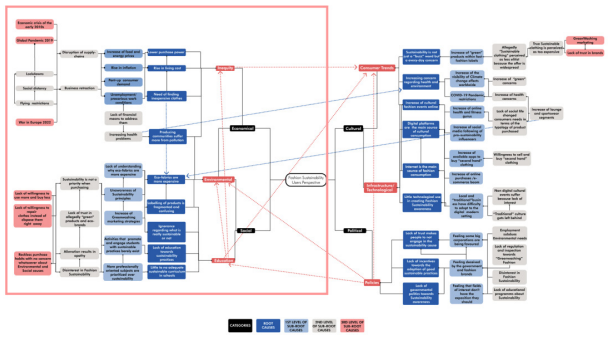
The interconnections and dependent relationships between various elements were established. After, it was identified how the parts affect each other and how persistent over time those affections are and if they happen despite the environment. Lastly, the 'leverage points' were identified, as seen in figure 37, below.

According to Donella Meadows the leverage points are places in a system where "a small shift in one thing can produce big changes in everything." Actually, leverage points are" like acupuncture points — places where finely tuned, strategic intervention can create lasting change, creating positive"(MEADOWS, 1999).

Figure 38 - Fashion Sustainability - Systems Thinking (at conceptual level).

WICKED PROBLEM SYSTEMS MAP

At the same time, and as a parallel activity, it was made the Fashion Sustainability Wicked problem mapping. This process was made through both research and living experience. To help this task the subject was divided into subtopics – a guiding framework that helped ensure a comprehensive and balanced approach to the 'wicked problem' at hand. Hence, according to the two main stakeholders' views - Users (figures 39 -40) and Brands & Retailers (figures 41-42), the division in subtopics was made as follows: the Economic perspective; the Social perspective; the Cultural Perspective; Infrastructure/Technological and Political perspectives.



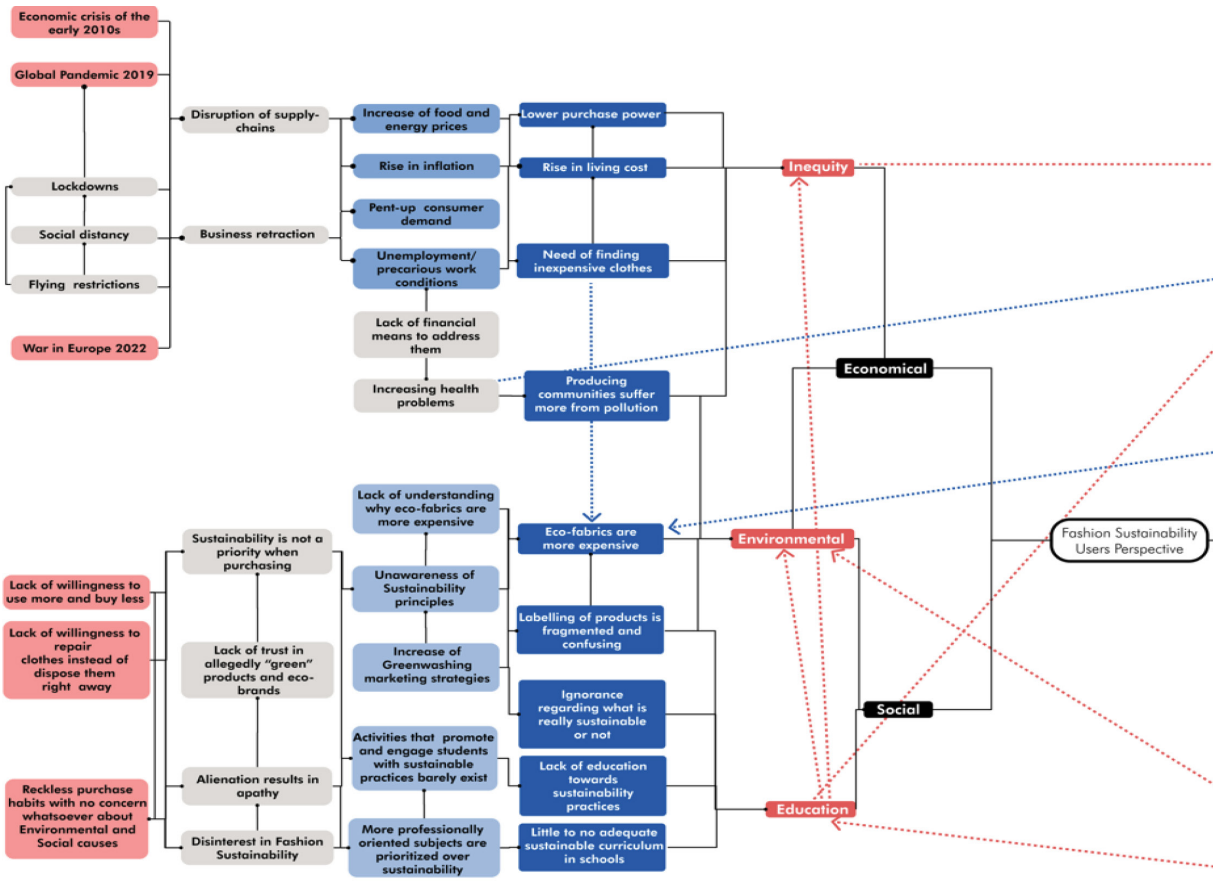
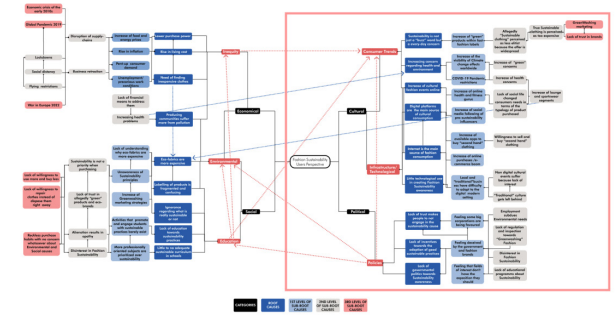
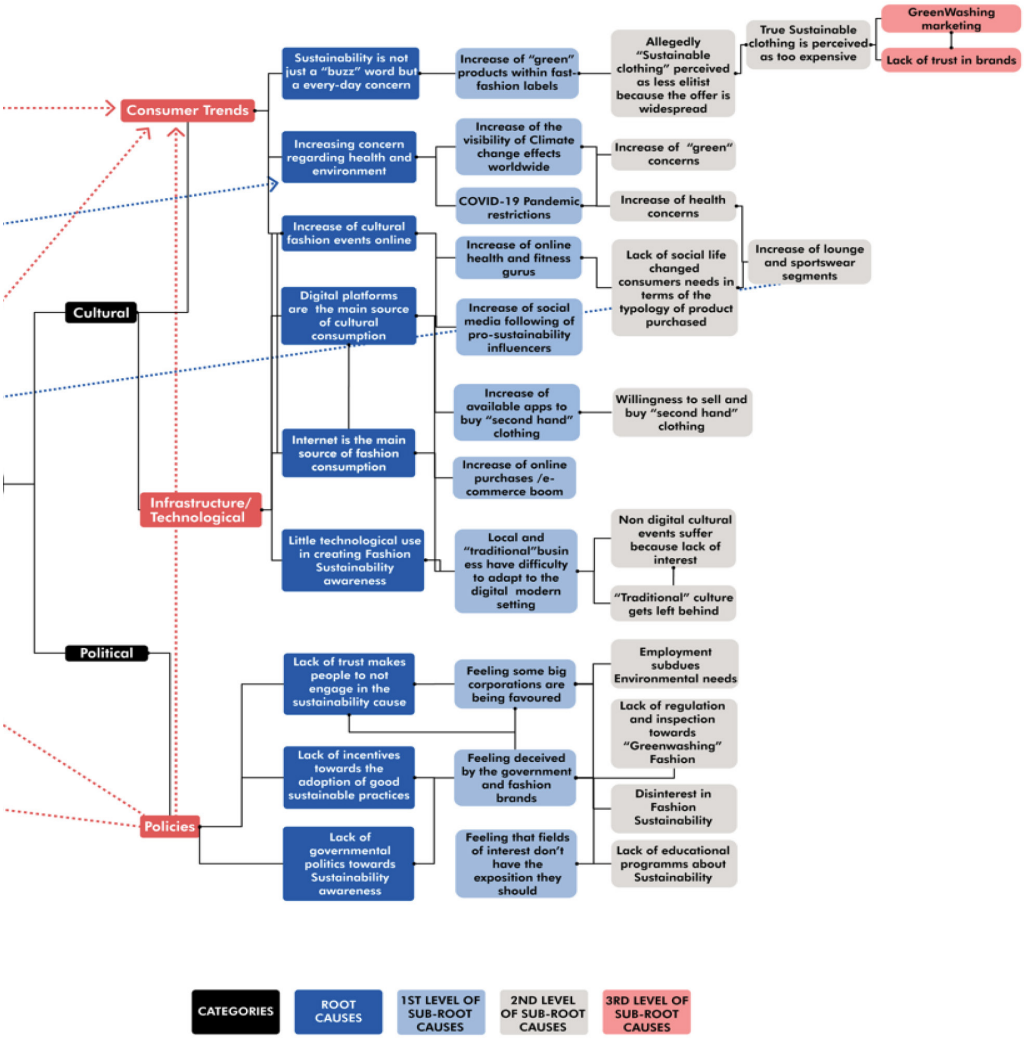


Figure 39 - Wicked Problem Systems Map - Users Perspective - 1/2

Figure 40 - Wicked Problem Systems Map - Users Perspective - 2/2





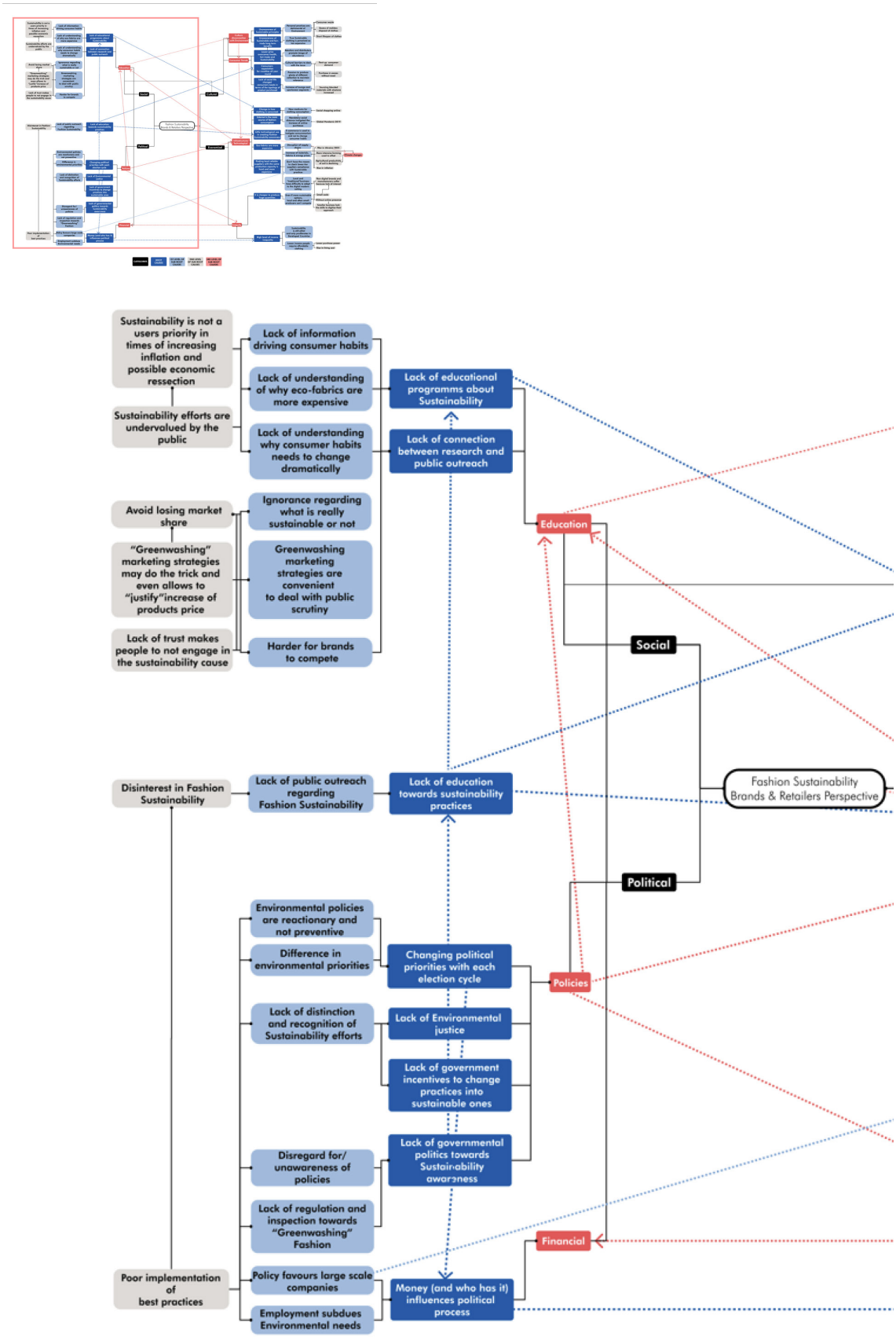
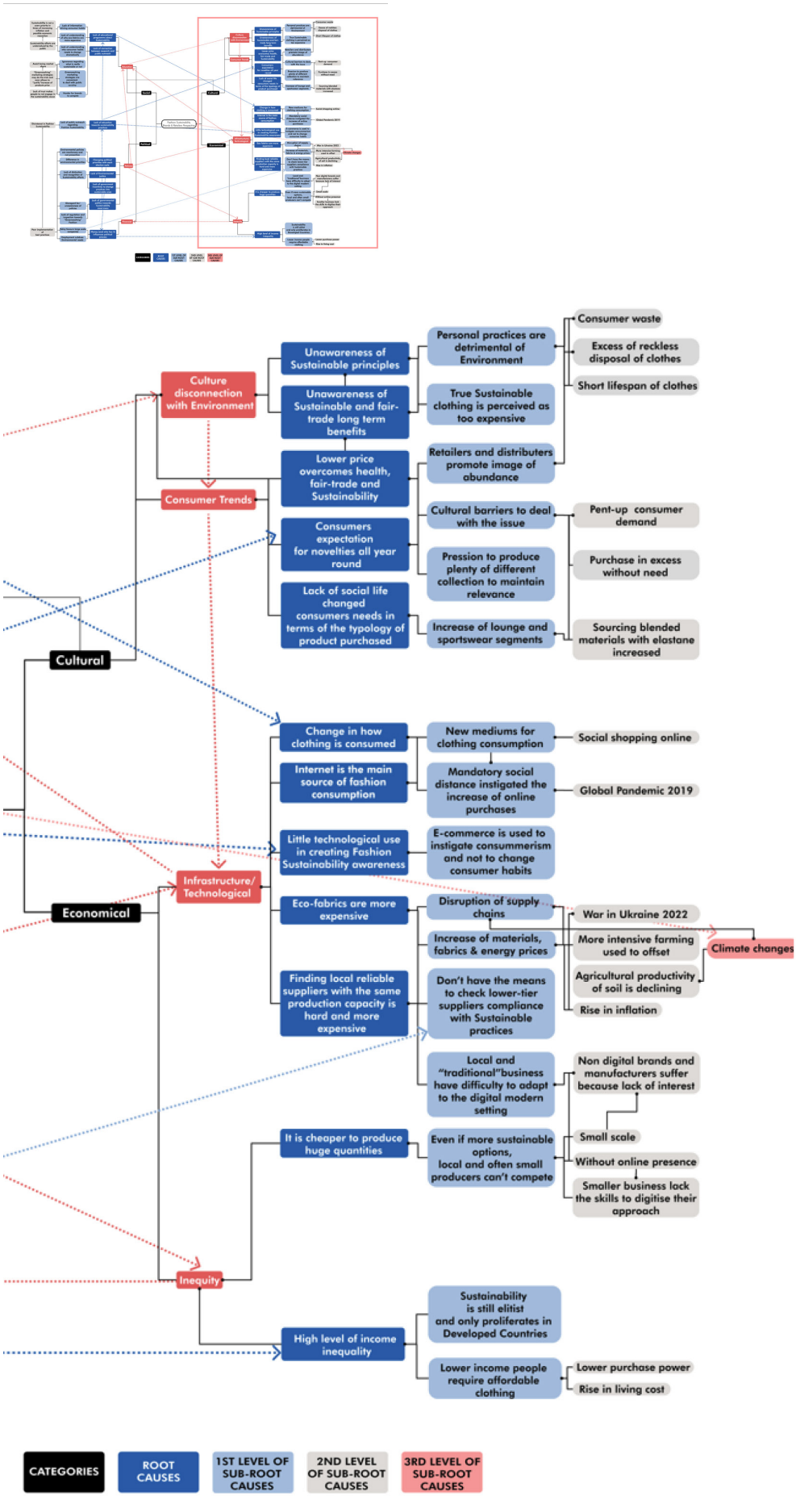


Figure 41 - Wicked Problem Systems Map - Brands & Retailers Perspective - 1/2

Figure 42 - Wicked Problem Systems Map - Brands & Retailers Perspective - 2/2



WICKED PROBLEM SOCIO-TECHNICAL MAP

Moreover, a Fashion Sustainability- 'wicked problem' Scope map has been developed in order to overview the evolution of this issue over time within a range of a few decades ago all the way into the future and how the "interconnectedness of social, economic, and natural systems" works (IRWIN, 2015, 2018; IRWIN, KOSSOFF & TONKINWISE, 2015).With this map (figure 43)is also possible to identify patterns (patterns of artefacts, institutions, rules, and norms) in the transformation over time of the socio-technical regimes (BERKHOUT ET AL., 2004; GEELS, 2010) that usually starts on an entrance influential level of 'niche' although the 'societal level' to the 'mainstream level' (where it is widely adopted).

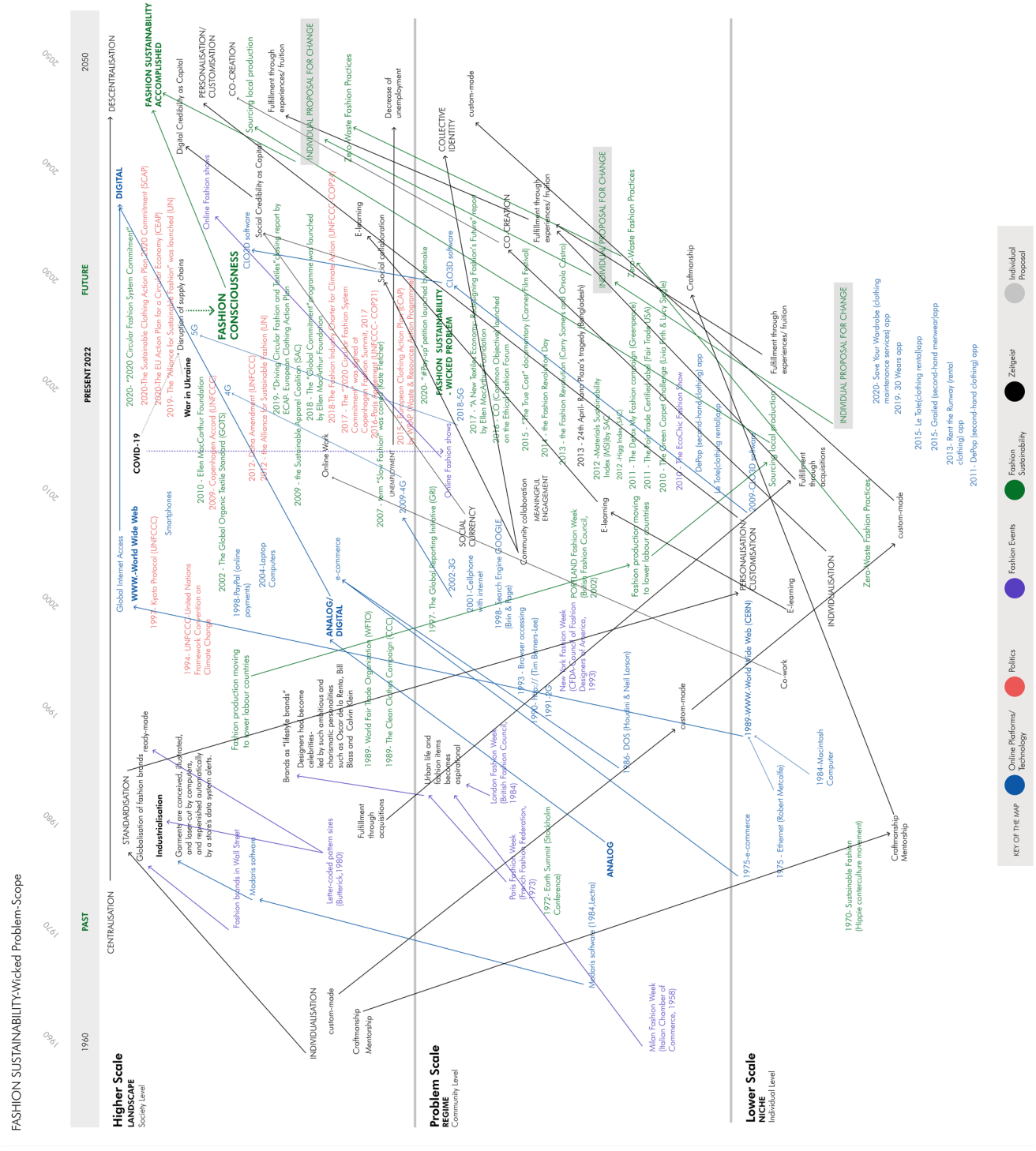


Figure 43 - Wicked Problem Social - Technical Map Overview

MAX-NEEF'S NEEDS AND SATISFIERS

To guide this dissertation's proposal, additionally, it was used the Max-Neef's Needs and Satisfiers (MAX-NEEF, 1991) framework, as seen on the following page in table 4, to better understand the different stakeholders' needs and how they are met by satisfiers, and how those can change over time, towards a path of holistic change.

By having the goal of Fashion Sustainability, this dissertation focuses on three Max-Neef's needs: Protection, Identity, Creation and Participation.

Although each need has *satisfiers* that designates solutions to complex problems over time, those can fail. In fact, they can have symbiotic, neutral, or even unintentionally detrimental effects. Max-Neef's framework forecasts qualifications for the satisfier's typologies: singular *singular satisfiers* (satisfy a single need without affecting others); *inhibiting satisfiers* (satisfy a need but seriously impair the possibility of satisfying other ones); *pseudo-satisfiers* (they seem to satisfy a need but actually, they don't); *violators and destroyers satisfiers* (paradoxically annihilated a possible satisfaction of a need) or even *synergistic satisfiers* (satisfy multiple needs at the same time; MAX-NEEF, 1999).

Important to note is that the adaptation of more 'synergistic satisfiers' enables the satisfaction of multiple needs at the same time and at multiple levels of scale consequently the catalyzation of systems- level changes. For instance, for many years, within the Fashion Retail Industry, the need for '*identity*' was satisfied exclusively by the purchase of luxury goods. In fact, for a lot of users, self-esteem can be and often is linked to feelings of exclusivity and a sense of accomplishment. The major motivator in the purchase act is the price of the item, often and even though deceptive, is perceived as value. Moreover, often people derive value from owning what others cannot own due to price barriers. Their sense of identity and belonging is accomplished by reiterating their social status by paying for a non-necessity product or service.

This dissertation's proposal is guided to contribute to the user's behaviour shift moving away from consumerism towards fashion sustainability by making possible for this '*identity* needs' to be satisfied in a different way. By increasing the awareness of clothing choices' impact, aligned with an increasing consciousness regarding climate urgency, users can engage in more mindful shopping experiences, purchasing mindfully resourced pieces and being part of a community. The sense of belonging and self-esteem might rely on "making the difference".

Despite sustainability being often a second or third motivation factor when buying luxury goods, this arguably, might be considered a 'pseudo satisfier' as it might be a low self-esteem reflection, inconsequential over time and with no long-term effectiveness.

When we talk about clothes instinctively, we think about the basic function of covering

Table 4 - Max-Neef's Needs and Satisfiers

MAX NEEF'S NEEDS & SATISFIERS

FUNDAMENTAL HUMAN NEEDS according to existencial characteristics / according to axiological characteristics FUNDAMENTAL HUMAN NEEDS	BEING (qualities)	HAVING (things)	DOING (actions)	INTERACTING (settings)		SATISFIER
SUBSISTENCE	physical health mental health equilibrium adaptability	food shelter work	feed rest work	living environment social setting		Subsistence: enhancing local production and small local businesses (for repair services).
PROTECTION	care adaptability autonomy	equilibrium solidarity autonomy health systems family rights social security	co-operate take-care of plan help become affiliate	social environment dwelling		Protection: settling production agreements with local companies it is assured the continuity of the maintenance and disposal services and materials to the user and the income of working families.
AFFECTION	respect generosity	critical conscience receptiveness astonishment relationship with nature	take-care of share	intimate spaces of togetherness privacy		Affection: critical conscience and respect for the environment, preserving the relationship with nature.
UNDERSTANDING	critical capacity curiosity intuition educational		analyse study get to know investigate cooperate	schools families universities communities	Interaction design for fashion co-creation and modular apparel generative system	Understanding: new awareness and knowledge regarding the impact of fashion choices on the environment an the recognition of the need of an holistic change regarding new garments' purchases and consumer's behaviour
PARTICIPATION	receptiveness respect dedication determination adaptability solidarity willingness	responsabilities duties rights	dissent express opinions share ideas further engagement play	local communities, activism organisations		Participation: by having the receptiveness and willingness to try out a different shopping experience, participating in the process of making their own pieces with a positive outcome, users are more willing to further engage and to deepened their relationship with the clothes, potentially extended their lifespan.
IDLENESS	imagination tranquility spontaneity	piece of mind tranquility	day-dream remember relax have-fun	local communities, activist organisations		Idleness: by making a conscious choice in the making of their garment, users are likely to experience tranquility and piece of mind, nurturing their relationship with both their social environment and nature.
CREATION	imagination passion boldness intuition inventiveness autonomy curiosity rationality	determination abilities skills techniques	design compose build invent customise	daily life physical/online settings, spaces for expression		Creation:by personalising the final pieces users can explore their creativity, autonomy and boldness
IDENTITY	sense of belonging self-esteem consistency hedonism	habits customs values norms	personalise decide on confront commit oneself personal growth	places one belongs to, everyday settings		Identity: one one hand sense of belonging and self-esteem by "making the difference",engaging in more mindfull shopping experience, being part of that community and, on the other hand, to purchase customised pieces.
FREEDOM	autonomy activism passion self-esteem open-mindedness	equal rights	choose run risks dissent be different from develop awareness	anywhere		Freedom: people can personalise their garments, customising materials, textures, colours and shapes, and the chance to modify it during the day according to mood or occasion. It contributes positively to their self-expression hence self-esteem.

our body – the *protection* against cold weather. However, nowadays this primary use of clothes is bygone and "protection" as a need has a wider range of meaning. Assuming more urgent needs have been satisfied (e.g.: subsistence needs), "protection" is achieved by satisfiers such as: care; social security; health systems; co-operation; adaptability; family; solidarity and rights.

Considering the Fashion Sustainability- 'wicked problem', protection can be satisfied by settling production agreements with local companies to assure the continuity of the sustainably sourced materials, maintenance (repair) and disposal services (recycling) to the user and the income of working families.

Regarding the need for participation, this one is obtained through the interaction with local communities, organisations or even activism activities. It implies the receptiveness and willingness to try out a different shopping experience, participating in the process of making their own pieces with a positive outcome. Users are more willing to further engage and deepen their relationship with the clothes, hopefully extending their lifespan.

Deeply interconnected with the need for participation comes the need for creation. Accepting that all daily-life settings are potentially a place for self-expression, activities like designing, composing, inventing, building, and customising are performed. Those involve passion, imagination, curiosity and users can explore their creativity, autonomy, and boldness by personalising or customising their clothing.

MAX-NEEF'S Hopes & Aspirations/ Fears & Concerns - now and future

FASHION SUSTAINABILITY	**User**
Concerns & Fears	
• Environmental crisis • Economic and social crisis • New pandemics and increase of health issues • Increase of the need for medical assistance • More travelling and social gathering restrictions • Inflation of prices • Unemployment • Decrease of acquisition power • Acquisition of non-recycable materials due to lack of information therefore contributing to the environmental crises • Acquisition of non-ethical brands • Not having a credible disposal solution for their purchased items • Increase of prices leading to non affordable pieces • Elitist eco-friendly brands and non-trustable	

FASHION SUSTAINABILITY	**Brands & Retailers**
Concerns & Fears	
• Lack of fibres sourcing • Increase of issues in the supply chain • Lack of reliable production sourcing • Scalling of fabric and production prices • Increase of customer's consumption of "green" products • Gaining bad reputation • Decrease of brand's loyalty • Lack of profitability • Decrease of market share • Economic recession • Lack of investment • Closing down physical stores • Responsible for higher unemployment rates • Bankrupcy	

FASHION SUSTAINABILITY	**Suppliers**
Concerns & Fears	
• Economic recession • Lack of ressources available to produce • Lack of labour force • Lack of reliable production capacity • Lost of reliable contracts • Lack of financial stability • Lack of credibility • Replacement for local suppliers • Scalling of fibers/fabrics prices • Uncapable to outsource • Gaining bad reputation • Bankrupcy • Lack of technology capacity to secure sustainable practices • Lack of capacity to pay cost of non-compliance while operating • Loss of license to operate	

FASHION SUSTAINABILITY	**Government & Institutions**
Concerns & Fears	
• Economic recession • Health and Social crises • Unemployment • Lack of commitment from brands, retailers and suppliers and users towards zero-waste and recycle policies • Need to take unpopular environmental choices to keep jobs • To be held accountable for the increase of environmental crises • Lack of scalling regarding already implemented sustainable strategies • Downward spiral of health care costs and social issues due to climate change issues • Lack of votes and supporters to stay in power	

Table 5 - "Concerns & Fears"

Following this, for each stakeholder, it was identified their "Concerns & Fears"(table 5),

FASHION SUSTAINABILITY	User
Hopes & Aspirations	
• Less elitist sustainable brands • Radication of 'greenwashing' marketing strategies • Increase of engaging and interactive sustainable brands • Higher purchasing power • More exposure to sustainable fashion practices at early age • More incentives to consume sustainable products • Access more information regarding suppliers work conditions and brands sustainable programms • Be more invested in purchasing sustainable fashion • More offer in personalised sustainable fashion	

FASHION SUSTAINABILITY	Brands & Retailers
Hopes & Aspirations	
• Increase of customers engagement • Provide product/service/ experience • More reliable supply chains • More accountability of the sub-contracted companies in terms of ethical and environmental practices during production • Civic and public recognition of good sustainable practices • More interest in sustainability from the public and consumers • Increase brand's loyalty • Increase of business profitability • Implement programms to engage both supplier and customers in sustainable activities • Help customers to make informed choices through labelling and "knowledge"promotion and cause campaigns • Increase of product certifications	

FASHION SUSTAINABILITY	Suppliers
Hopes & Aspirations	
• Increase of commercial commitments • Financial stability • Having work force capacity and be seen as a reliable employer • Capacity to respect brand's requirements and standarts • Capacity to reshape business models • Capacity to re-image the way suppliers are perceived as creators of value and how they contribute to a more sustainable world • Receive governmental support to implement sustainable changes in production activities • Seen as key-supplier for brands • Considered to be reliable • Business growth/expansion • Association with good causes	

FASHION SUSTAINABILITY	Government & Institutions
Hopes & Aspirations	
• Increase of publics interest in Sustainability • Increase the offer to public and its visibility • Implement programms to make Fashion Sustainability more inclusive • Seen has a leader that promotes and helps to implement industry consortia and initiatives to accelerate collective action • Implement Sustainability school programms • Capitalization of new investment from sustainable brands • Increase Fashion Sustainability and its economic impact • Provide economic incentives to suppliers that are making sustainable transitions • Develop legislation regarding retailers and suppliers transparency • Increase of voters to maintain power	

Table 6 - "Hopes & Aspirations"

"Hopes & Aspirations" (table 6), "Beliefs & Affects Now" (table 7) and "Beliefs & Affects in 2050" (table 8).

FASHION SUSTAINABILITY	User
Beliefs & Assumptions Now	
• Sustainable Fashion is expensive • Sustainable clothes are outnumbered • Sustainable products are not a priority due to decreasing of purchase power • Lack of knowledge regarding certification labelling when purchasing • Lack of trust in brands, retailers and suppliers • Lack of interest in Fashion Sustainability • Absence of education regarding Fashion Sustainability • Lack of brands and retailers providing information and services regarding "end-of-product" solutions • Lack of engagement with sustainable brands and products - perceived as elitist or trendy • "Greenwashing" marketing strategies make people not truly trust eco-products or labels	

FASHION SUSTAINABILITY	Brands & Retailers
Beliefs & Assumptions Now	
• Sustainable efforts are not visible enough to public or they are undervalued • It is cheaper to produce in huge quantities therefore the transition to a sustainable business model is not easy • Finding local reliable suppliers is not possible everywhere • Finding reliable suppliers that can adapt to consumers demand is a hard job • Need money and support to keep working and inovate • Sourcing eco-fabrics is more expensive and in a context of economic inflation is harder to be perceived as a priority to the costumer • Huge discrepancy regarding consumer's behaviour towards Fashion Sustainability around the world • Don't have the resources to investigate the sustainable standards compliance of lower-tier suppliers • Fear of public scrutiny	

FASHION SUSTAINABILITY	Suppliers
Beliefs & Assumptions Now	
• Lack of commercial commitments that insure production over the year • Lack of financial stability • Lack of investment capacity to change business model and practices towards sustainability • Don't have the resources to investigate the sustainable standards compliance of lower-tier suppliers • Lack of incentives to have environmental management systems • Lack of understanding of the need to implement procedures for handling red-flag social problems such as sexual harassment, retaliation by supervisors, and hazardous labor conditions • Workforce based on temporary workers making it difficult to implement viable environmental, health, and safety programs	

FASHION SUSTAINABILITY	Government & Institutions
Beliefs & Assumptions Now	
• Lack of financial resources to enforce legislation • Lack of external investment in the country leading to economic contraction • Political compromises with non-sustainable retailers inhibit governmental action • Lack of resources to confiscate non-sustainable production • Decrease of public health due to environmental problems • Questioning and challenging of government in power • Arise of new cultural expressions as a show of dissatisfaction such as radical environmental activism • Lose ellections • Inability for standing in office: lost of power, status-quo, life-style • Belitting of fashion's significance as design field contributes to it being negleted in terms of sustainable education programms	

Table 7 - "Beliefs & Affects Now"

FASHION SUSTAINABILITY	User

Beliefs & Assumptions 2050

- Valorisation of Nature as a societal value
- Technology will bring new forms of fashion customisation
- Zero-waste products, recycled and reclycable are mainstream
- Digital culture will increase the offers of brands dramatically
- More efficient new ways of production will make sustainable products affordable for everyone
- Fashion Sustainability is a common day practice around the globe
- Existence of fashion sustainability programms at schools
- Reverse climate changes
- Better living conditions
- Globalised equality & equitity; diversity & inclusion
- Enabled to personalise clothing choices making each purchase an experience
- Being more involved in Sustainable practices
- Find suitable brands to be loyal to

FASHION SUSTAINABILITY	Brands & Retailers

Beliefs & Assumptions 2050

- Investment and valorization of society regarding Fashion Sustainability
- 100% Sustainable brands and products
- Provide sustainability across all product stages (pre-use, use and post-use)
- Able to provide good and healthy work conditions
- Increase of brand's loyalty
- Increase of profitability
- Seen as a product/service/ experience provider
- Perceived as selling values instead of products
- Inspire and instigate Sustainable practices
- Increase of global awareness of Sustainability
- Fashion Sustainability is a societal value therefore a concern when purchasing a product or service
- Adapt production to real needs and not to consumers demand
- Limited collections offer throughout the year

FASHION SUSTAINABILITY	Suppliers

Beliefs & Assumptions 2050

- Change business model paradigms and implement sustainable practices
- Net-zero greenhouse gas emissions achievement
- Attractive to more investments
- Permanent and loyal workforce
- Financial stability and growth
- Implemented health and safety procedures
- Be encourage financially and morally by other stakeholders to implement Sustainable Practices
- Establishment of good work conditions
- Well perceived by society
- Seen as reliable business partner
- Employment generator

FASHION SUSTAINABILITY	Government & Institutions

Beliefs & Assumptions 2050

- Achievement of Net-zero greenhouse gas emissions
- Reverse of climate change issues
- Decrease of emigration flows and armed conflits
- Increase of equality and equatity
- Increase of purchase power
- Reinforced legislation and budget to have assets that enable both suppliers and retailers to be inspected and made accountable, according to Sustainable conformity
- Give fiscal incentives to Sustainable practices compliance
- Synergy between Education and Environment Ministries in the development of school programms and initiatives regarding Fashion Sustainability
- Good image amongs voters
- Economic growth
- Continuity of Government

Table 8 - "Beliefs & Affects in 2050"

FASHION SUSTAINABILITY	User

Concerns & Fears

- Environmental crisis
- Economic and social crisis
- New pandemics and increase of health issues
- Increase of the need for medical assistance
- More travelling and social gathering restrictions
- Inflation of prices
- Unemployment
- Decrease of acquisition power
- Acquisition of non-recycable materials due to lack of information therefore contributing to the environmental crises
- Acquisition of non-ethical brands
- Not having a credible disposal solution for their purchased items
- Increase of prices leading to non affordable pieces
- Elitist eco-friendly brands and non-trustable

FASHION SUSTAINABILITY	Brands & Retailers

Concerns & Fears

- Lack of fibres sourcing
- Increase of issues in the supply chain
- Lack of reliable production sourcing
- Scalling of fabric and production prices
- Increase of customer's consumption of "green" products
- Gaining bad reputation
- Decrease of brand's loyalty
- Lack of profitability
- Decrease of market share
- Economic recession
- Lack of investment
- Closing down physical stores
- Responsible for higher unemployment rates
- Bankrupcy

FASHION SUSTAINABILITY	Suppliers

Concerns & Fears

- Economic recession
- Lack of ressources available to produce
- Lack of labour force
- Lack of reliable production capacity
- Lost of reliable contracts
- Lack of financial stability
- Lack of credibility
- Replacement for local suppliers
- Scalling of fibers/fabrics prices
- Uncapable to outsource
- Gaining bad reputation
- Bankrupcy
- Lack of technology capacity to secure sustainable practices
- Lack of capacity to pay cost of non-compliance while operating
- Loss of license to operate

FASHION SUSTAINABILITY	Government & Institutions

Concerns & Fears

- Economic recession
- Health and Social crises
- Unemployment
- Lack of commitment from brands, retailers and suppliers and users towards zero-waste and recycle policies
- Need to take unpopular environmental choices to keep jobs
- To be held accountable for the increase of environmental crises
- Lack of scalling regarding already implemented sustainable strategies
- Downward spiral of health care costs and social issues due to climate change issues
- Lack of votes and supporters to stay in power

Table 9 - "Concerns & Fears" - Connections

Finally, it was mapped (figures 9-12)the affinity relationships between each stakeholder with the purpose to identify common beliefs, assumptions, concerns, fears, hopes and aspira-

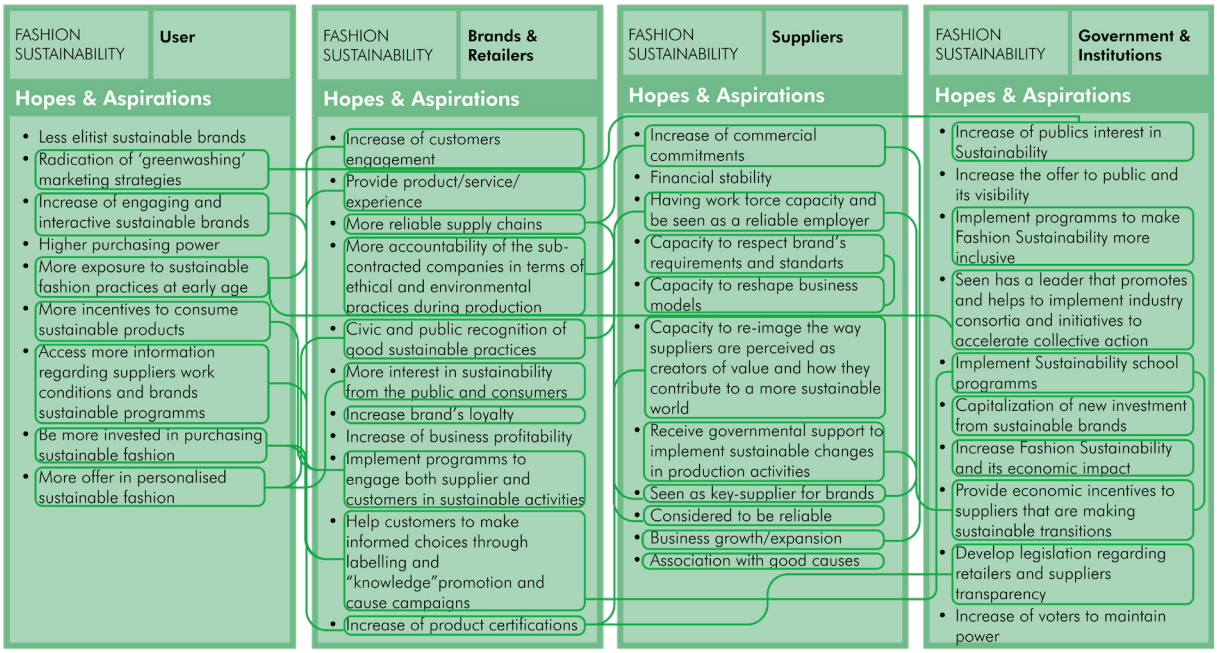


Table 10 - "Hopes & Aspirations" - Connections

tions.

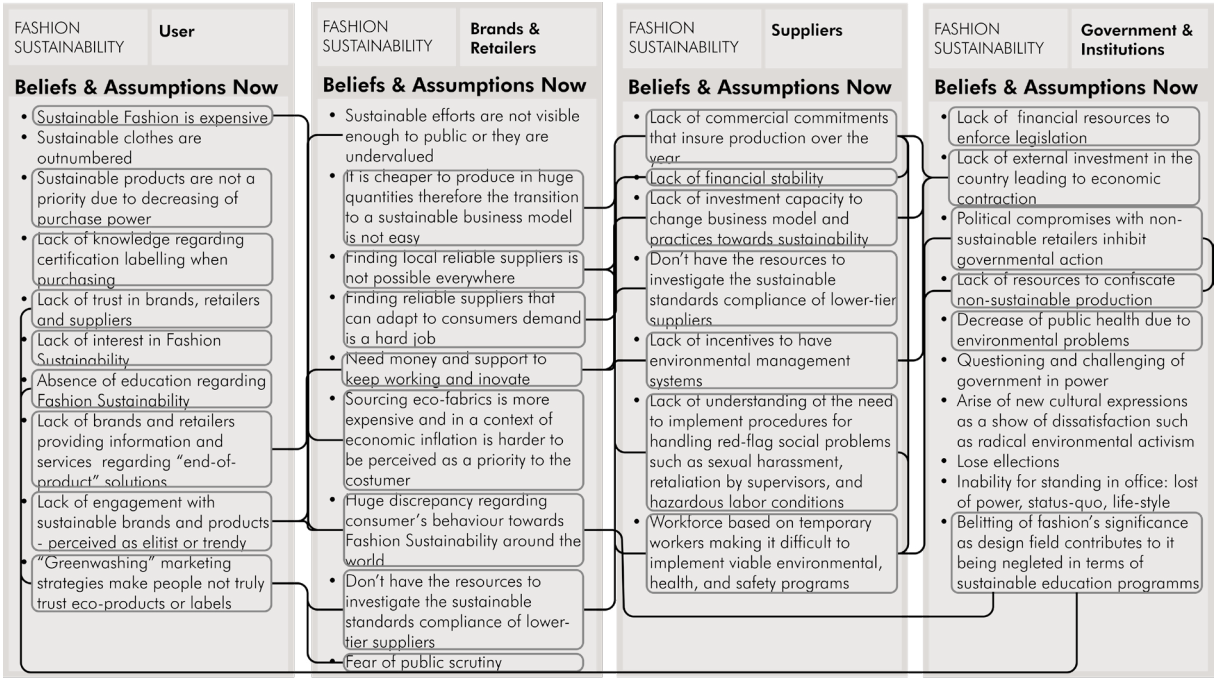


Table 11 - "Beliefs & Affects Now" - Connections

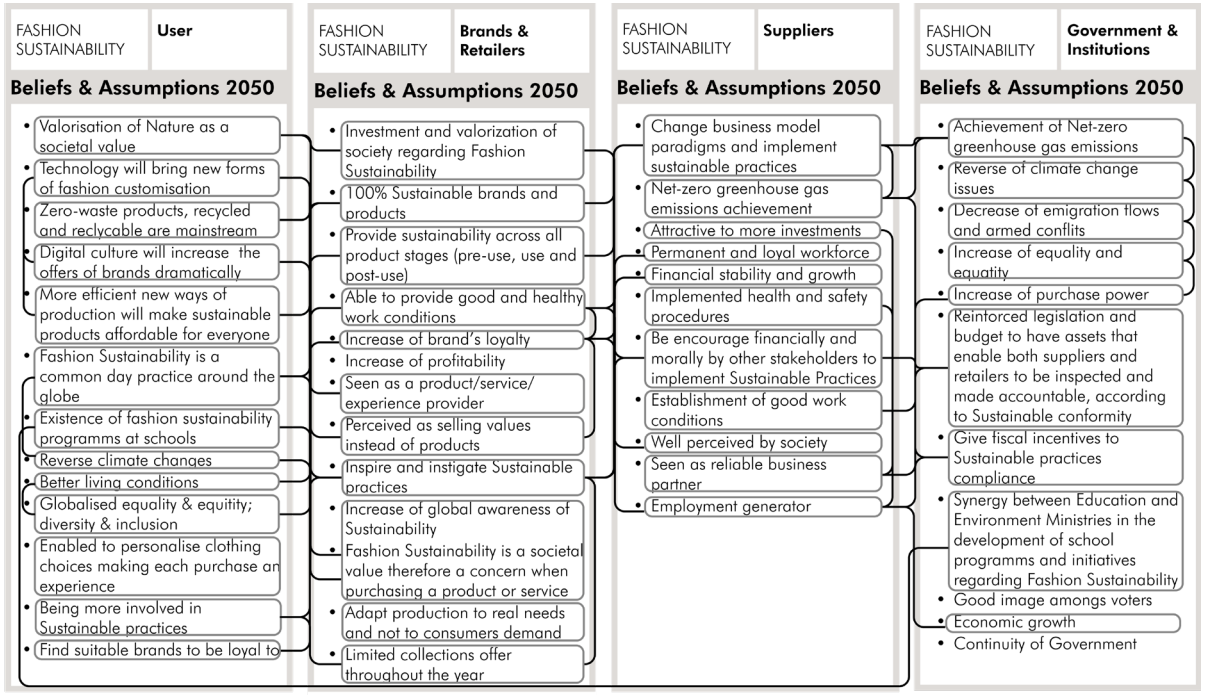


Table 12 - "Beliefs & Affects in 2050" - Connections

3.2.2 Fashion modular garments development process

Many approaches and frameworks for the fashion design development process have been developed by fashion and textile design academics (DEJONGE, 1984; WATKINS, 1988; LAMB & KALLAL, 1992; REGAN ET AL., 1998, cited in HUR, BEVERLEY & CASSIDY, 2013). Labat and Sokolowski ([1999]HUR, BEVERLEY & CASSIDY, 2013) provided a useful summary of some of the key models as shown in the table 13.

Particularly, in Fashion design studies two main lines of thought are commonly used: the 'Linear Framework', the 'Random Framework' centred on three stages : the 'idea', research and design.

The origin of the word 'idea' recalls the Greek word '*idein*' "to see" therefore the way of seeing remains at the core of its meaning. The way we see an idea bringing it into reality in a recognisable form dictates its final expression (DIEFFENBACHER, 2013).

The 'Linear Framework' builds the idea upon others in a coherent way to form a concept. Each ideia is derived from the last one and so one and themes evolve over the process. This method implies brainstorming, mind-mapping and journaling.

Contrasting with the last method, the 'Random Framework' has no apparent order and requires the identification of common connections, a process in which the designer selects key

ideias to develop and reach a cohesive concept. These frameworks are merely a tool and can co-exist together along the collection development process.

Another design based approach is the *'Practice-based design'* based on creative research "calls on the power of human imagination and open-minded exploration" (WALKER, 2013, cited in EARLEY ET AL., 2016) aiming to envision 'possible futures' whereas, scientific research employs systematic inquiry to establish facts and develop principles. Built on previous projects insights and reflections, practice-based research is a "cumulative process of inquiry, learning and knowledge advancement". (WALKER, 2013, cited in EARLEY ET AL., 2016).

Dejonge (1984)	Watkins (1988)	Lamb & Kallal (1992)	Regan et al. (1998)
Request made	Problem acceptance	Problem Identification	Problem Recognition
↓	↓	↓	↓
Situation Explored	Analyse Problem	Preliminary Idea	Problem definition
↓	↓	↓	↓
Problem Perceived	Define Problem	Design Refinement	Exploration of problem
↓	↓	↓	↓
Specs Described	Idea generation	Analysis	Search for alternatives
↓	↓	↓	↓
Criteria established	Select solution	Prototype Development	Evaluation & decisions
↓	↓	↓	↓
Prototype Development	Implement	Evaluation	Specification of solution
↓	↓	↓	↓
Evaluate	Evaluate	Implement	Communicatio n of solution

Table 13 - Summary of fashion design development processes (adapted from Labat and Sokolowski, 1999, as cited in Hur, Beverley & Cassidy, 2013).

PATTERN-MAKING

Considering that the present dissertation and the challenge at hand has a sustainability purpose in a transition design context , the materialisation of the idea- the clothing pattern making- has the same relevance as the idea itself.

As clothing fitting issues seem to be a common reason for clothing disposal and shortening garment's lifespan, it needs to be addressed. Improving clothing fitting can be made by using elastic materials however, as previously stated, cotton - elastane combination makes the recycling process complicated.

Constructing clothing patterns with sufficient seam allowance is implemented as a strategy to amend the clothing by adjusting it to user changes over time, or when the garment is inherited by new users - as shown in the "Make a change" project (2012) (NORDBERG ET AL., 2012, cited in LAITALA, BOKS & KLEPP, 2015).

Another method is using specific tailoring methods, such as diagonal cutting in woven fabrics to increase the flexibility, or through the use of flexible solutions that fit to several body sizes and contemplate the body dynamics and its relation with the involved fabric – a kinetic

pattern-making construction (LINDQVIST, 2015).

Moreover, another way of thinking about clothing is not to have it ready sewn to specific garments, but to use pieces - modules- of fabrics that can be worn differently (figure 45-46). In fact, the modular pattern making, as argues before, meets a lot of both users and environmental needs aligned with fashion sustainability.

Eventually, even if the kinetic pattern construction has the focus on the fitting rather than limiting the use of fabric in its production, It could be adapted to a modular system.In truth, by combining current best practises (i.e. hexagonal pattern layout) knowledge with existing guidelines (LINDQVIST, 2015; MCQUILLAN, 2019, 2020), studying the potential benefits that could be accomplished by combining these two methods of construction is the an important goal of this dissertation.

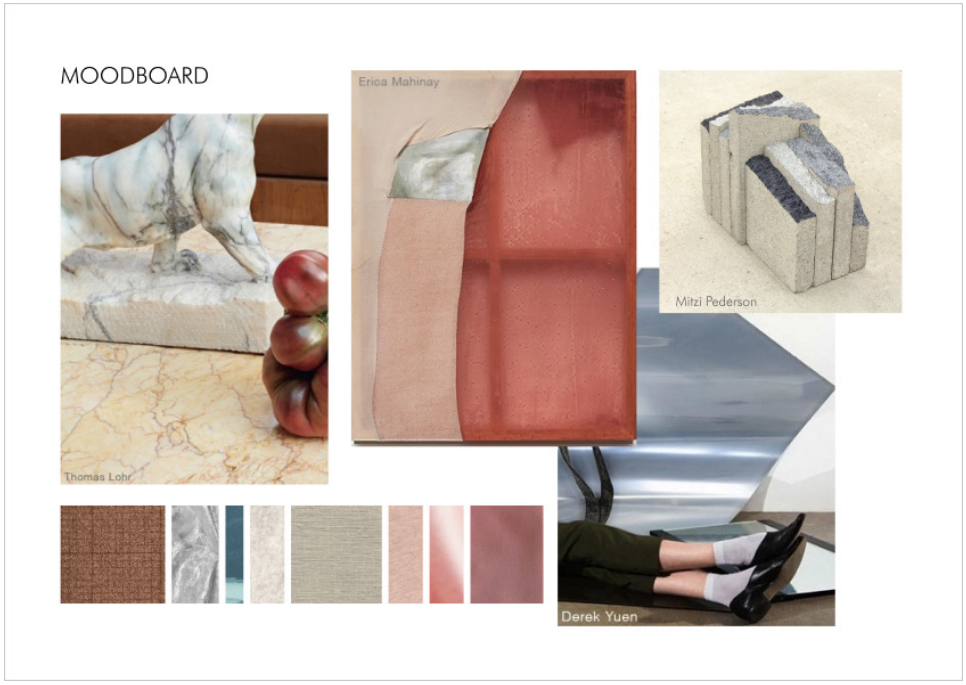


Figure 44 - Moodboard

Figure 45 - Patterns For Applied Examples

Figure 46- Patterns For Applied Examples

3.3 PRIORITISING REQUIREMENTS - MOSCOW

Due to the limitations of resources and time during the development of this dissertation, prioritising the requirements of the project was done. Considering the evolution of the research itself, those have been adjusted over time. In order to prioritise the requirements 'MoSCoW rules' were used to classify those into:

• Must have - as fundamental requirements the digital interface needs to give information regarding environmental and social impact according to choices made by the user. Moreover, the system needs to allow different garment choices. Without those two requirements, the system will be useless and ineffective.

• Should have – a more thorough pricing breakdown; the implementation of "Second Life" and "Enhance" pages that would enable a better grasp of the proposed service. Those would be essential if more time were available, but the system will be useful and usable without them.

• Could have – additional information regarding fabrics; further exploration of the potential of kinetic garment construction; adaptability of kinetic models to adjustable sizes and fit; further investigation regarding environmental impact data; explore the possibility to design for a total disassembling of the piece (such as linings, interior filler materials and zips).

• Want to have but Won't have this time round – different body fittings visualisation to access a more accurate fit idea; the total implementation of a website. Due to constrictions needs to be postponed until later development.

3.4 WEBSITE CHOICE AS MEDIUM

Nowadays, with the development of new internet technologies, the consumer-brand, as well as consumer-consumer relationships and interactions, have been changing drastically and with it also the value of co-creation landscape changed (SAWHNEY, VERONA, AND PRANDELLI 2005, cited in HOHER ET AL., 2010). These technologies, especially the website – the broader used digital format- can now be leveraged to co-create value with consumers in a more efficient manner (PRAHALAD & RAMASWAMY, 2004).

Websites are an interactive communication medium, e-shopping tool, a business-to-business platform, a tool for CRM (customer relationship management), therefore an important tool to deliver a service (SONG & ZINKHAN, 2008). Moreover, companies can now leverage these technologies to cocreate value with consumers in a more comprehensive and efficient manner

Therefore, the Website, which is the broader used digital format was initially idealised.

4. A SERVICE DESIGN PROPOSAL

As previously mentioned before, the circular economy is based around moving from offering products, generating value from the offer and flow of services, materials, and products. Moving away from products and transitioning to services is a growing reality (countries such as the UK - 77.7%, France - 78.9%) and USA - 76.7% are dominated by services) and reflects a transition of perspective (IND & COATES, 2013). Offering fashion as a service and not a product allows designers to adapt and constantly satisfy the market floats on tastes and consumer's needs.

Service design and its services dominant logic model connects what the organisation offers at the point of purchase to usage by consumers over time (BUJOR ET AL., 2017).

Additionally, Service Design is a practical approach and tool to disassociate the creation of value from resource use and shaping it around experience, touchpoints and service flow that suppress user needs (BOCKEN ET AL., 2016; POLAINE, LØVLIE, & REASON, 2013 cited in DENNINGTON, 2018).

Service Design shapes experiences by taking into consideration all people affected by the service enabling stakeholders' engagement also in the design process. It is collaborative at its core (STICKDORN ET AL., 2018).

For this reason, Service Design aligned with co-creation is an obvious path that has been followed to achieve the main purposes of the present dissertation and has the following characteristics:

- transformable shapes of clothing made buy modules that could be easily and in a fast manner recombined and re-assembled, without the need of skills like sewing in order to make clothing adjustable and updated to customer's needs.
- clothing with the improved fit (or adjustable);
- addressing the entire life cycle of the product from outsourcing the fabrics to its end-

of-life;

- using materials that can be perpetually recycled (fibre-to-fibre or
- making sure that during that process the extension of the lifespan of the product is boosted through the access to complementary services of reshaping the product, upcycling, repair, and donation;
- enabling a systemic change in consumer behaviour is incentivised by providing information regarding the environmental and social impact of their choices as well as, how to take good sustainable practices with the care of the product at home.

Regarding Fashion Sustainability, Service Design is of value because more than understanding consumer needs throughout the entire service, has the potential to contribute to the adoption of circular clothing models provided by companies and brands (DENNINGTON, 2018) as well as, promoting consumer behavioural changes at a systemic level. In fact, by having all stakeholders' needs in mind when mapping current and envisioning future situations of 'use' (PETTERSEN, 2015), Service Design has the capacity to reinforce acceptance.

4.1 PERSONAS

Service Design shapes experience by taking into consideration all people affected by the service enabling stakeholders' engagement also in the design process. It is collaborative at its core (STICKDORN ET AL., 2018).

Firstly and foremost, in the Service design process, proto-personas are defined. It is crucial deep knowledge regarding for whom a service is designed. As any new system/service is likely to be used by different types of people, it is important to develop several different personas. As seen in figures 47-49, it was established the need of defining three different proto-personas in different age groups and occupational activities, to better represent the whole spectrum of the target public.

Different people have different physical and psychological profiles, different goals, and aspirations, and differ in all the ways they expect from the service as well as different ways to use it. More than basic personal definitions made when defining a target public, the definition of proto-personas is a more thorough process.

The chart used to make proto-personas definition is divided into six different parts: the first column where basic info (name, gender, age, income, occupation, marital status, self-perception, and values) regarding the person is stated. In the second, a blue column (the tech info) considerations like technological devices used, their operation system, time spent on the

internet, social media used and attitude towards technology are made.

On the third, the green column, the online shopping experience is projected: the purchase frequency, what is bought, average money spent, the browsing behaviour, which are the physical shopping and if that is translated to the online shopping experience. In the white, central column, is where the usage scenarios are defined as well as the overall behaviour: user flow, motivations, expectations, and goals.

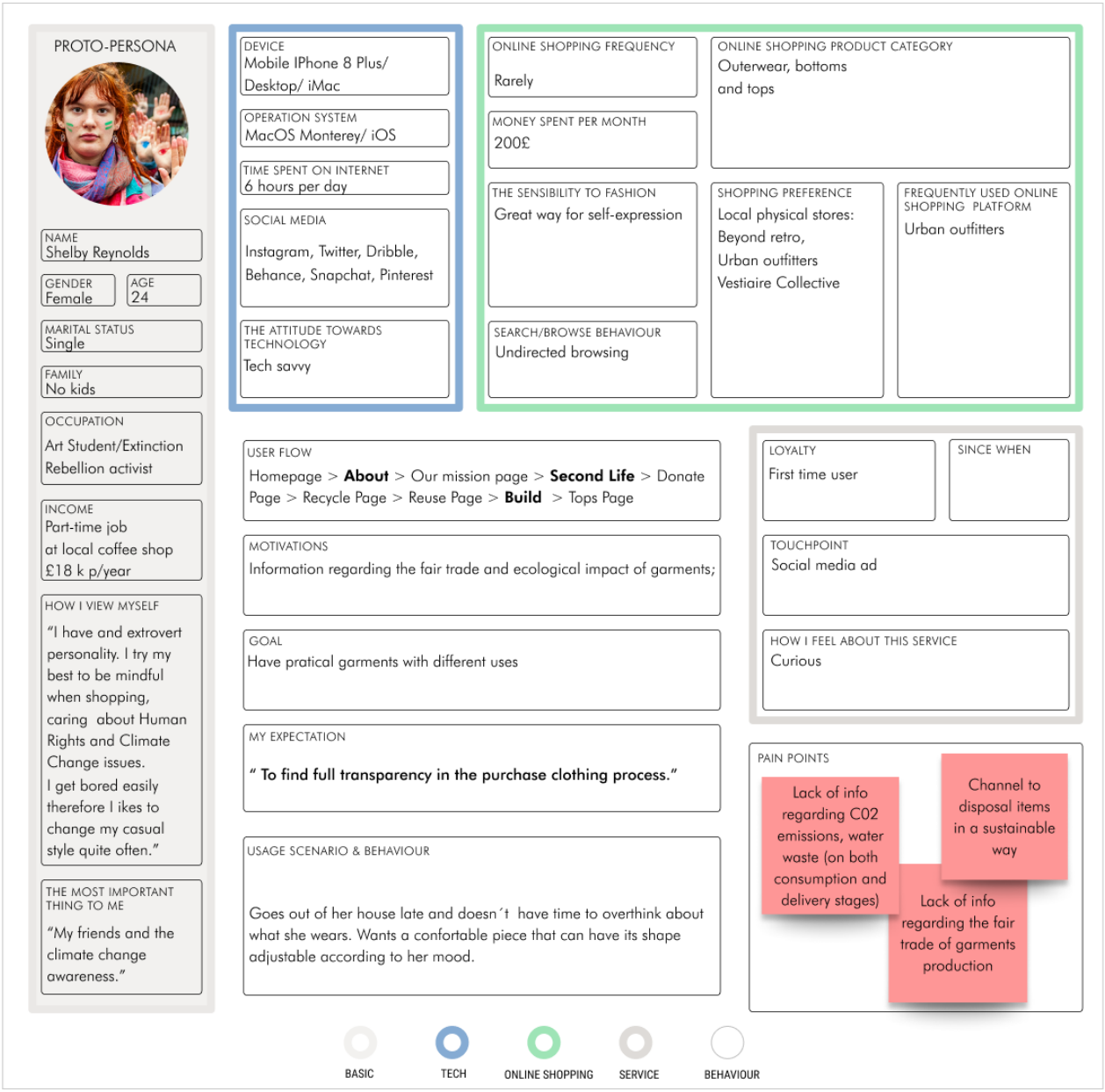


Figure 47 - Proto-persona #1

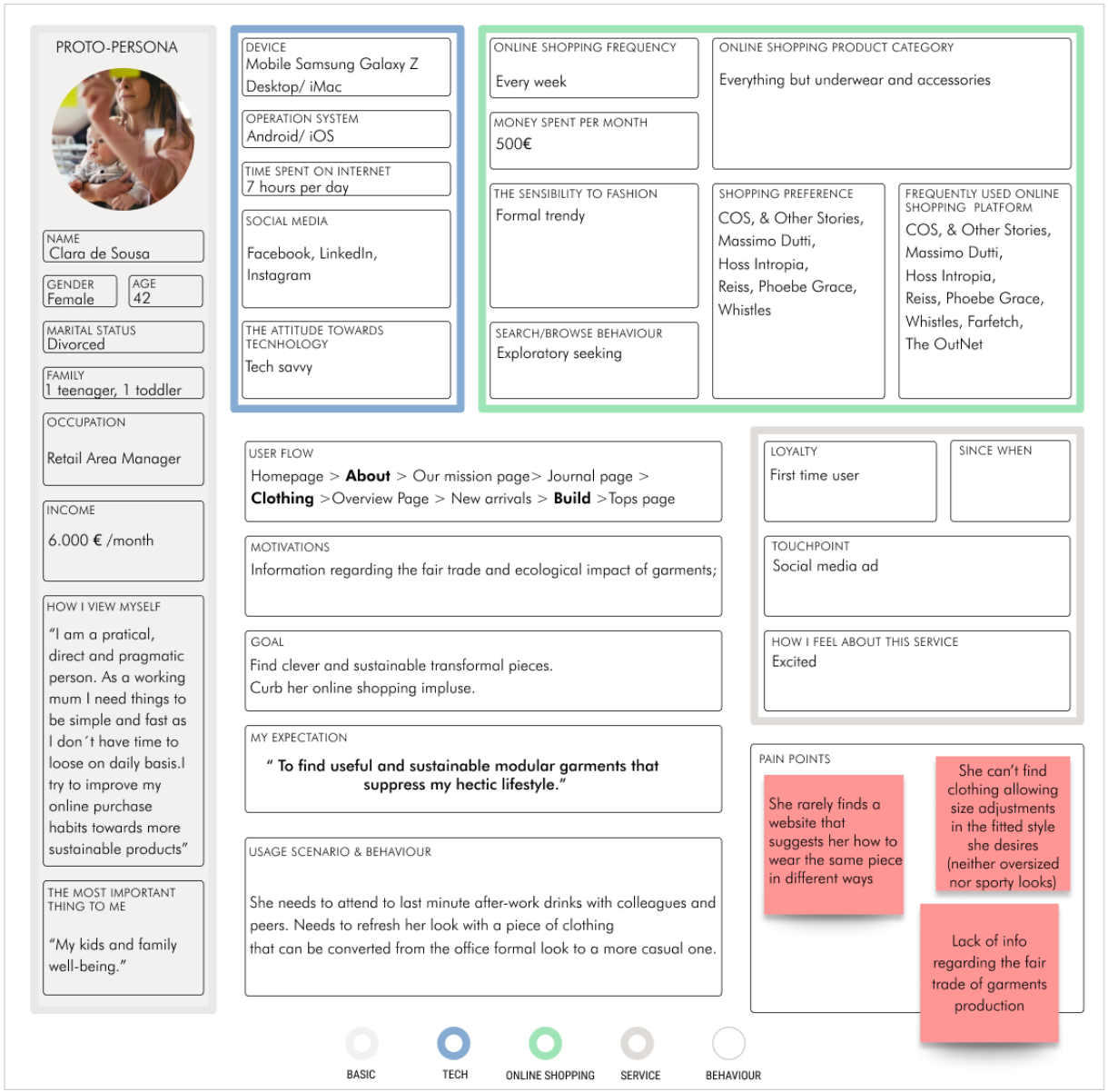


Figure 48 - Proto-persona #2

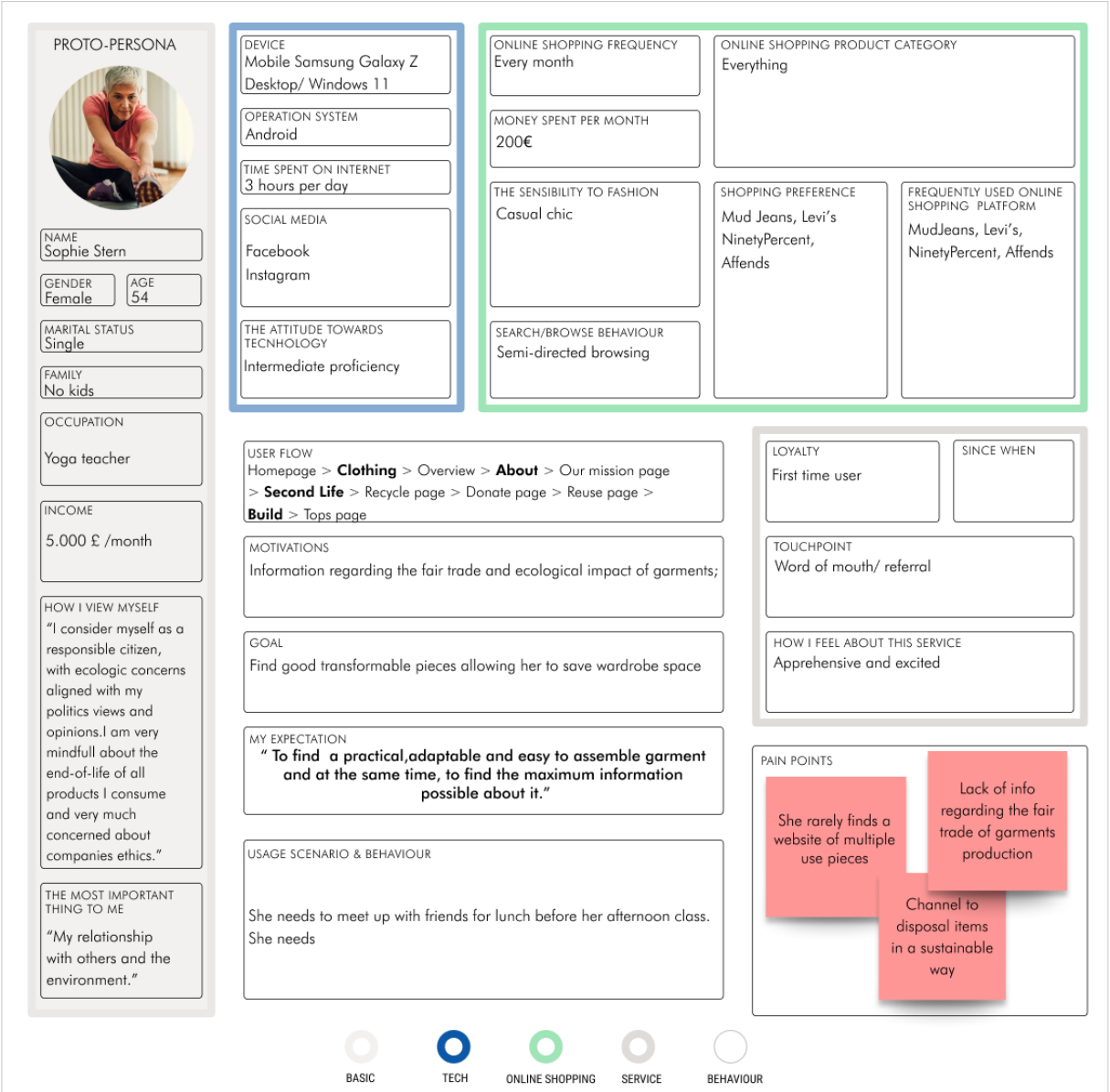


Figure 49- Proto-persona #3

4.2 USAGE SCENARIOS

Definition of usage scenarios is a key component in the design. By thinking how different people undertake activities, how they interact with the devices to access a product/service, what tasks they need to be done and in which context that might use our service defines the functions allocated to service and its overall design. It is the interaction design part of physical design (BENYON, 2014).

4.3 EMPATHY MAPS

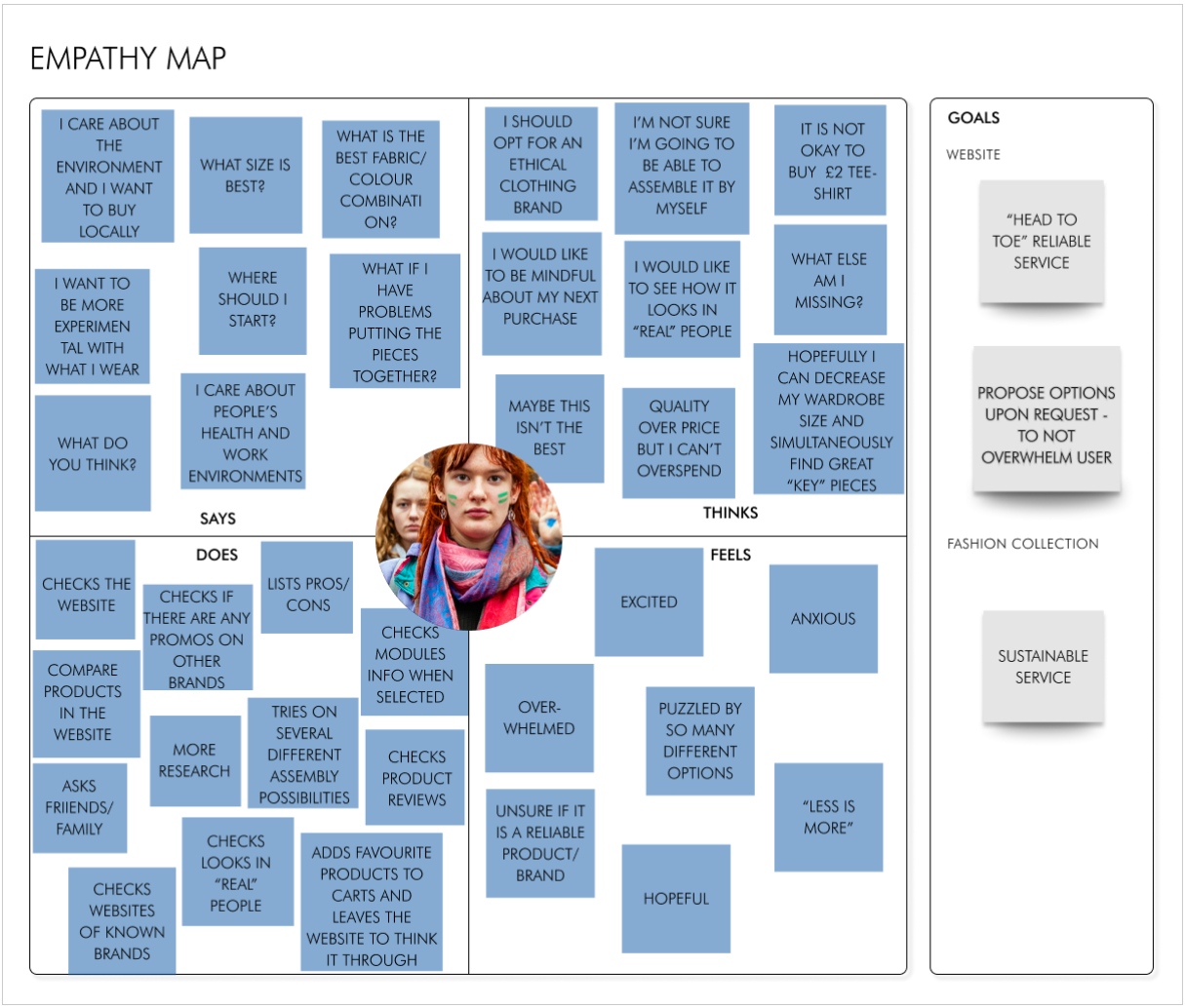


Figure 50 - Empathy Map- Proto-persona #1

After this, it is created Empathy Maps referring to each proto-persona, as seen below in the figures 49-51, in which is mapped out what the proto-persona says, thinks, does and what

it feels regarding the particular service that is being envisioned. Those considerations help to deepen the insights categorising the knowledge about the user. After user needs and goals can be summed up.

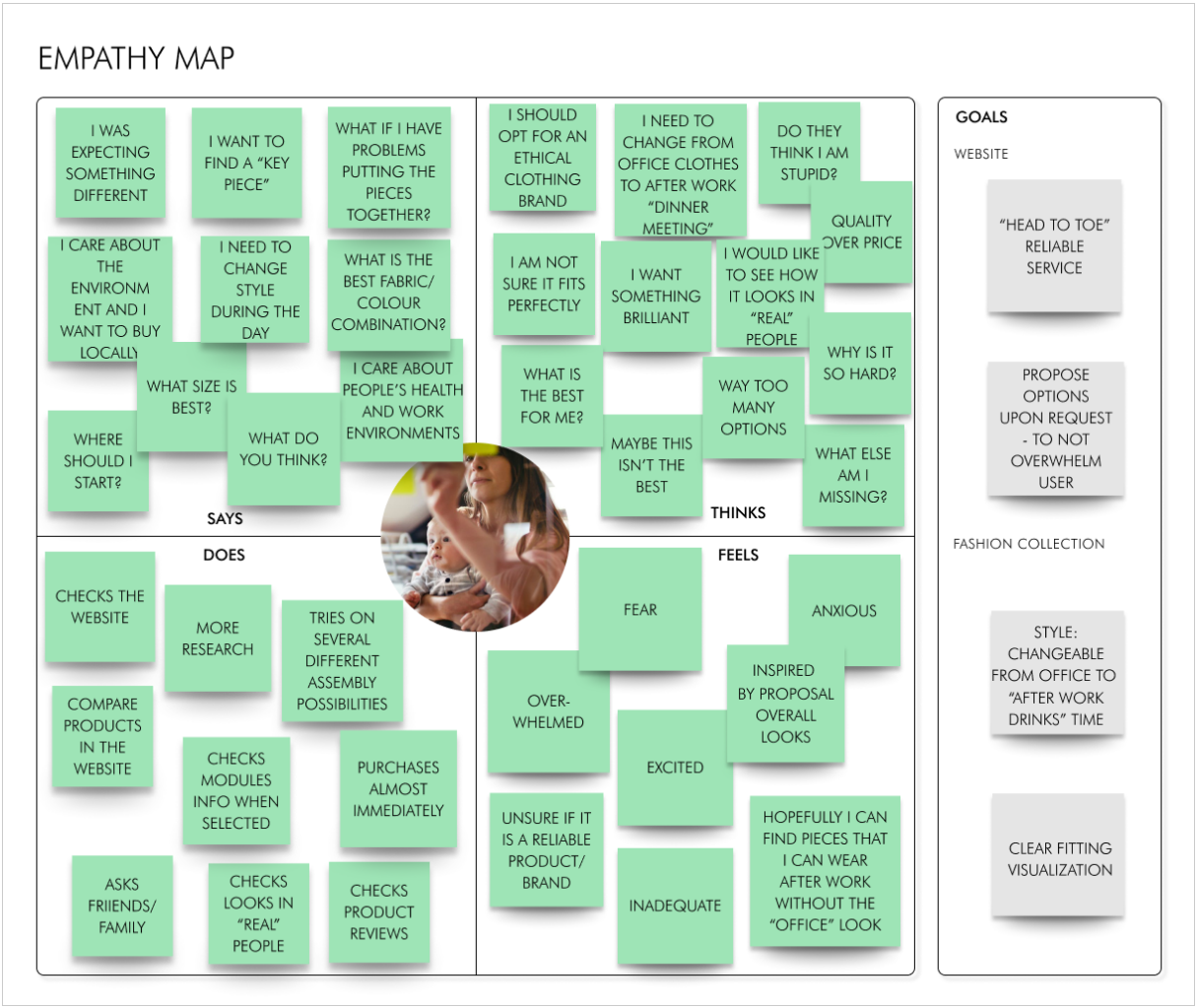


Figure 51 - Empathy Map- Proto-persona #2

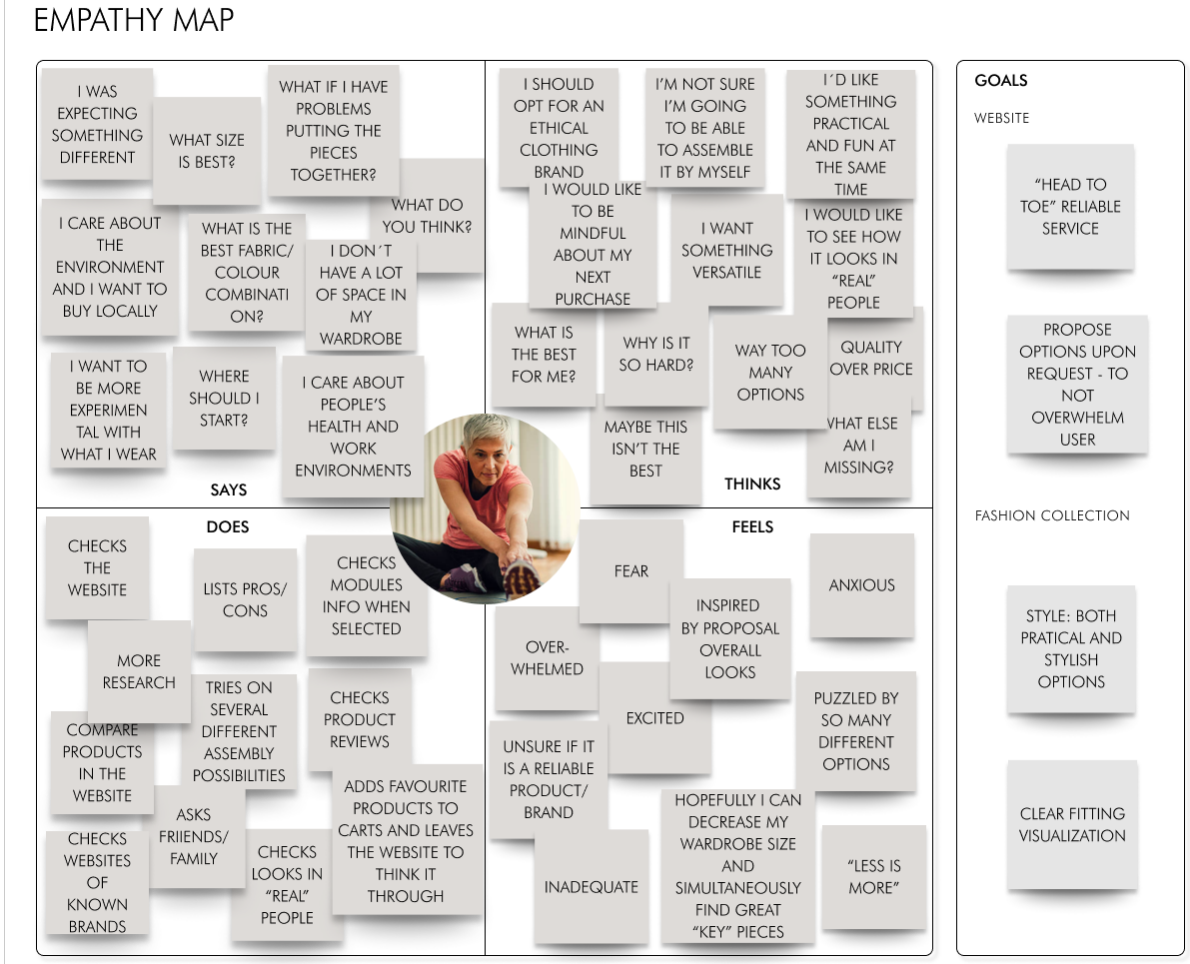


Figure 52 - Empathy Map- Proto-persona #3

4.4 AFFINITY MAPS

Following this process, an Affinity Map is done. The previous qualitative information about the users is gathered and organised on common grounds. In this case, as seen in figure 53, different categories came evident when grouping cards by similarity.

On the first try of defining the Affinity Map, four categories emerged: "ethical and sustainable services", "fewer pieces/more uses", "lifestyle looks", and "transformable clothing".

This process is useful to guide the functionalities of the proposed service and its characteristics: "ethical and sustainability" would be translated into the fabric sourcing, the information provided to the user, circular services available and prediction of clothing lifespan. The "lifestyle looks" would inform the existence of product overviews, and" looks views" along the website, possibly on a journal page.

During this process, it has been made clear that two categories were linked: "fewer pieces/more uses" and "transformable clothing" because both could be achieved by the same

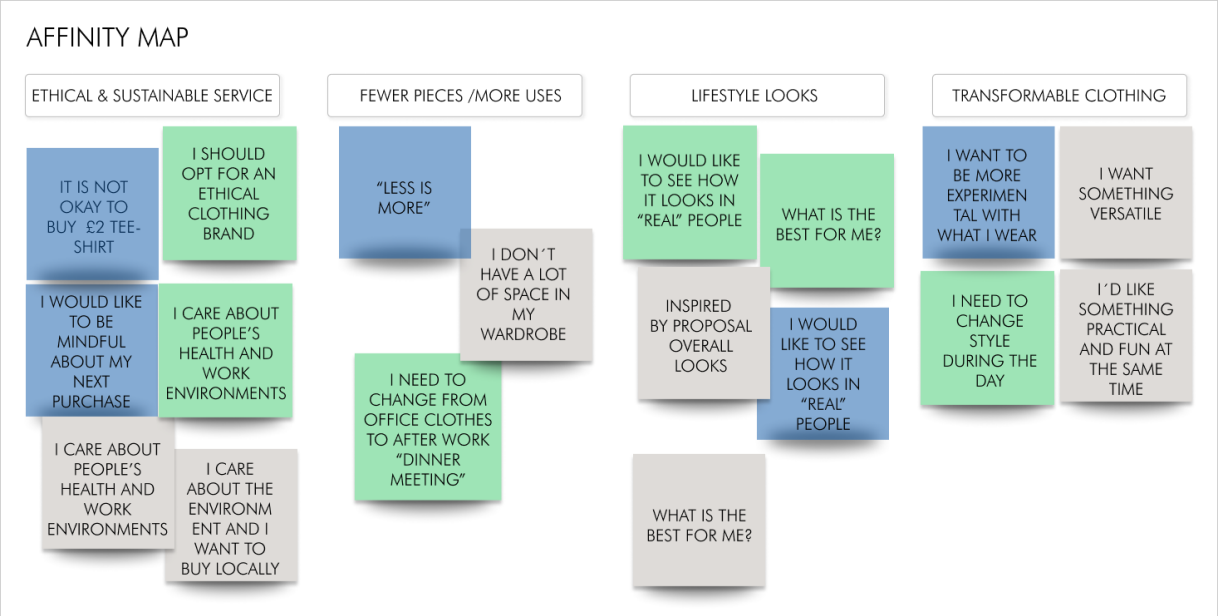


Figure 53 - AffinityMap - first approach

functionality: modularity of clothing. Hence, the Affinity Map was narrowed down to three categories as seen in figure 54.

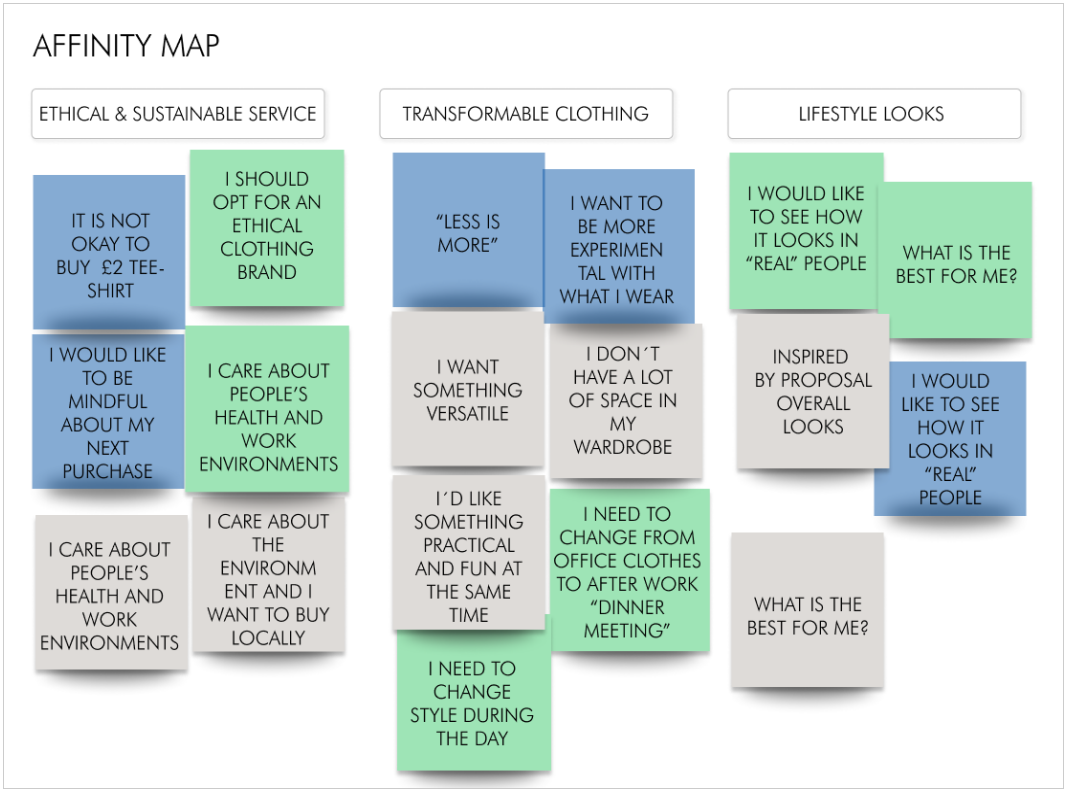


Figure 54 - Final Affinity Map

4.5 VALUE PROPOSITION CANVAS

After the user is profiled, it is important to identify the most persuasive value that the service will provide. For that reason, it was formulated the Value Proposition Canvas where it described the benefits that future users can expect from the proposed service.

The Value Proposition Canvas is made of two parts, as seen in figure 55, the Value Map (on the left-hand side) and the Customer Profile (on the right-hand side). The value is achieved when those two parts meet and "fit" each other (OSTERWALDER ET AL., 2015).

The Value Map is structured by: "Products/services"; "Pain relievers" and "Gain creators". "Products and services" indicate which are the functionalities of the service and their benefits; the "Pain relievers" describe how the proposed service eases customers' pains and "Gain creator" describes how it creates valuable experiences for the user.

Regarding the circular part, the Customer (segment) Profile describes the customer segment in a more structured way by breaking it down into its "Jobs to be done", "Gains" and "Pains".

"Gains" has an emotional strand as it describes the outcomes and benefits users want to achieve with the use of the proposed service. "Jobs to be done" describes the things the user is trying to do, problems to solve, tasks to be performed, and needs to satisfy. Those can have three different strands: "functional"– specific tasks to perform or problems to solve; "social"- regards gaining power or status usually perceived by others, and "emotional"- established by feelings of security and well-being.

"Pains" is deeply pragmatic, describing bad outcomes, risks and obstacles related to Jobs.

Despite "Jobs to be done" it could be pointed out also "Supporting Jobs". For instance, and in regard to the context of the use of the service, co-creation of value (happening when users participate in the design of the product) could be noted (OSTERWALDER ET AL., 2015).

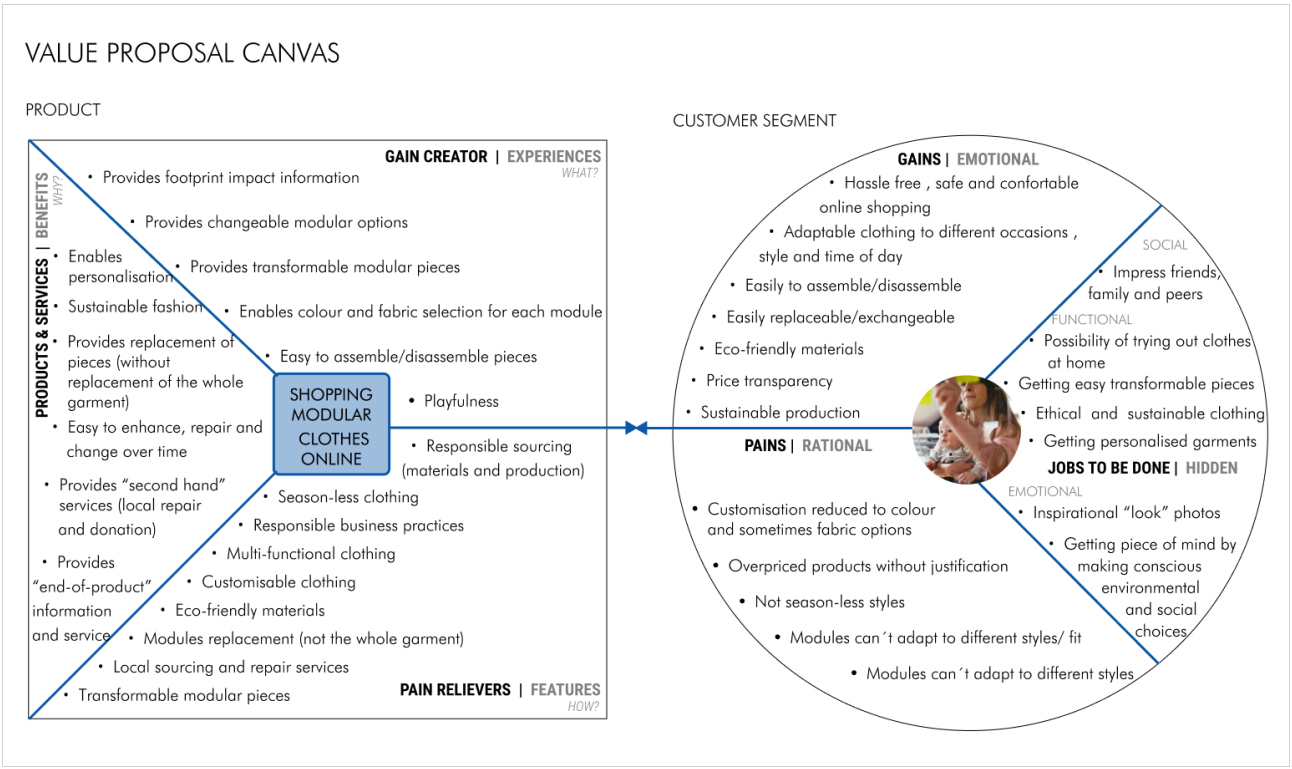


Figure 55 - Value Proposition Canvas

4.6 CUSTOMER JOURNEY MAP

When projecting how the service is going to work it is imperative to understand the different routes a user can take to perform a task, therefore formulating a Customer Journey Map (figure 56) is the next step to creating the service's narrative. This is a process that involves organising a series of interactions in a timeline. They are divided into seven different stages organised into three main decision phases: pre-purchase (awareness and consideration), purchase (decision, acquisition, and product delivery), and post-purchase (usage, retention/loyalty).

The timeline is populated with user thoughts and their emotional journey, giving away a holistic view of the overall customer experience which helps to undertake opportunities to assess pain points and enhanced experience.

During the customer's journey," customers are exposed to various service touchpoints, each with direct or indirect consequences on the purchase decision, customer behaviour, and overall experience" (SANTOS, 2021).

Despite at a first glance, appearing as a linear process, because implies compiling a series of user actions into a timeline, the customer's journey is often non-linear and in this case desirable, as the action might be looping between different touchpoints in a dynamic and circular process (LEMON & VERHOEF, 2016 cited in SANTOS, 2021).

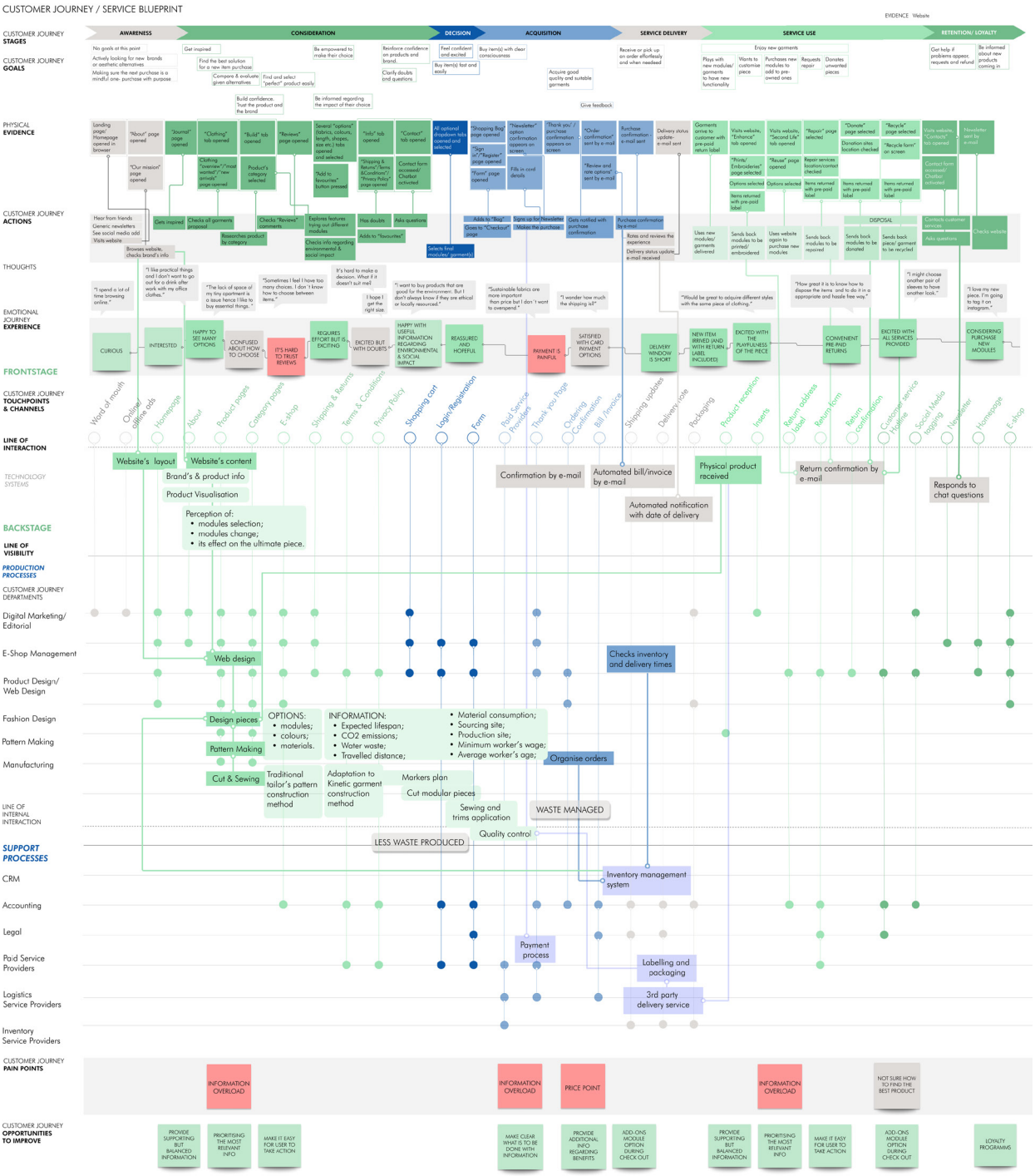
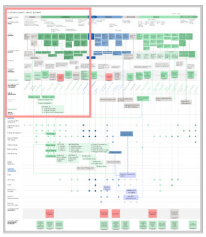


Figure 56 - Customer Journey Map/ Service Blueprint - Overall view



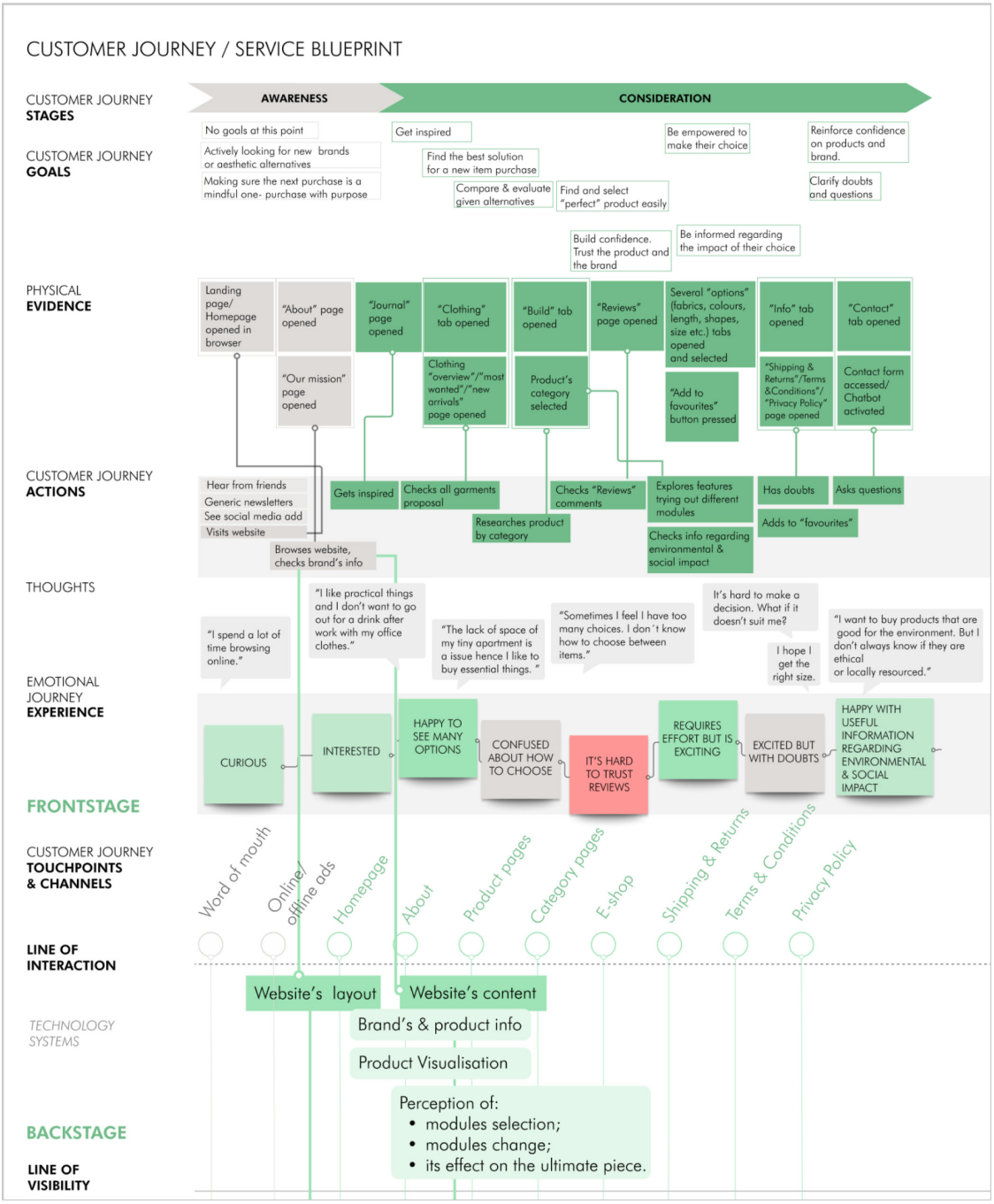
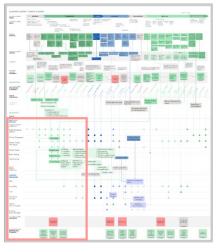


Figure 57 - Customer Journey Map/ Service Blueprint - 1/6



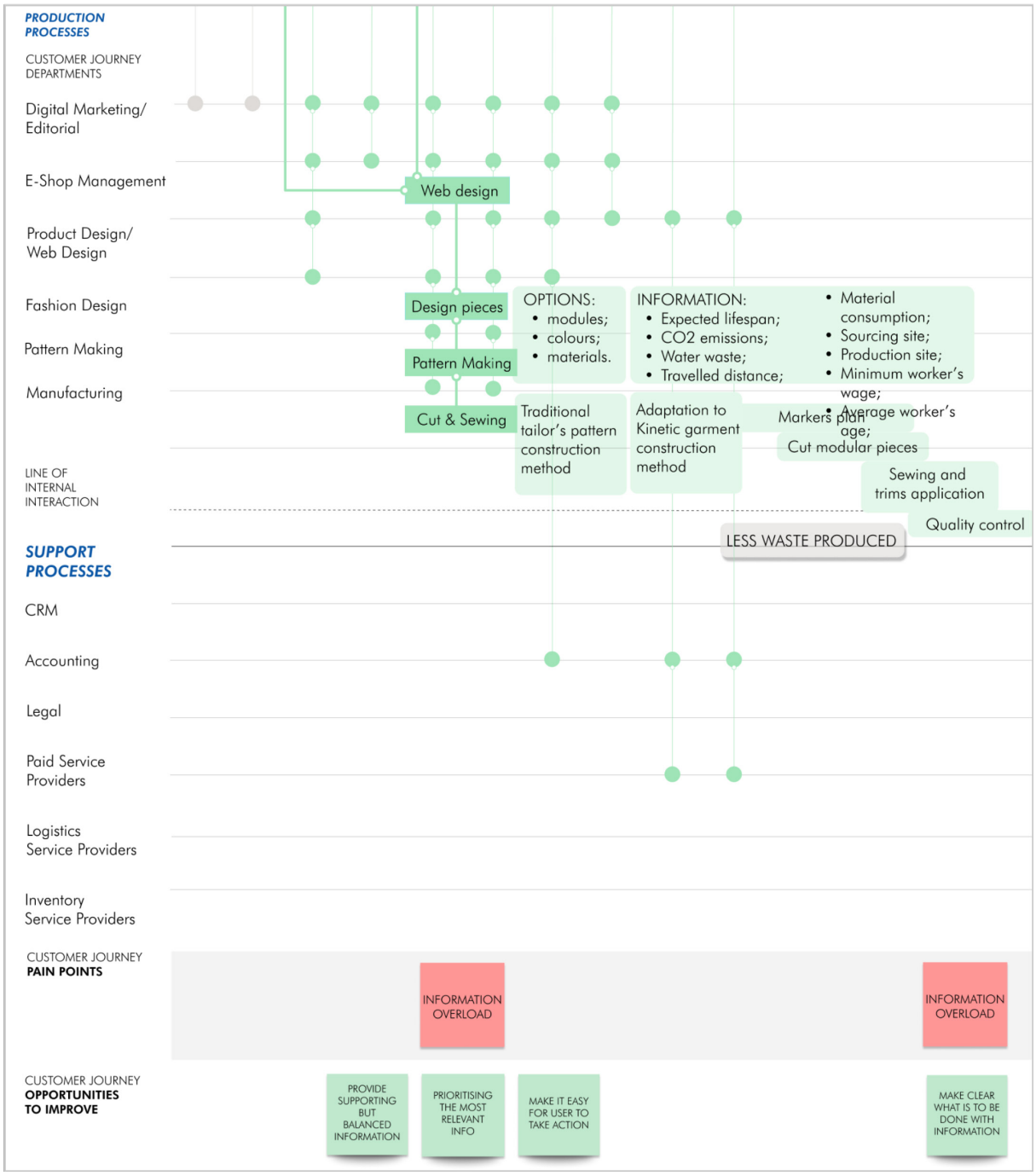
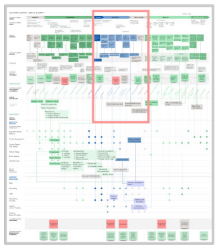


Figure 58- Customer Journey Map/ Service Blueprint - 2/6



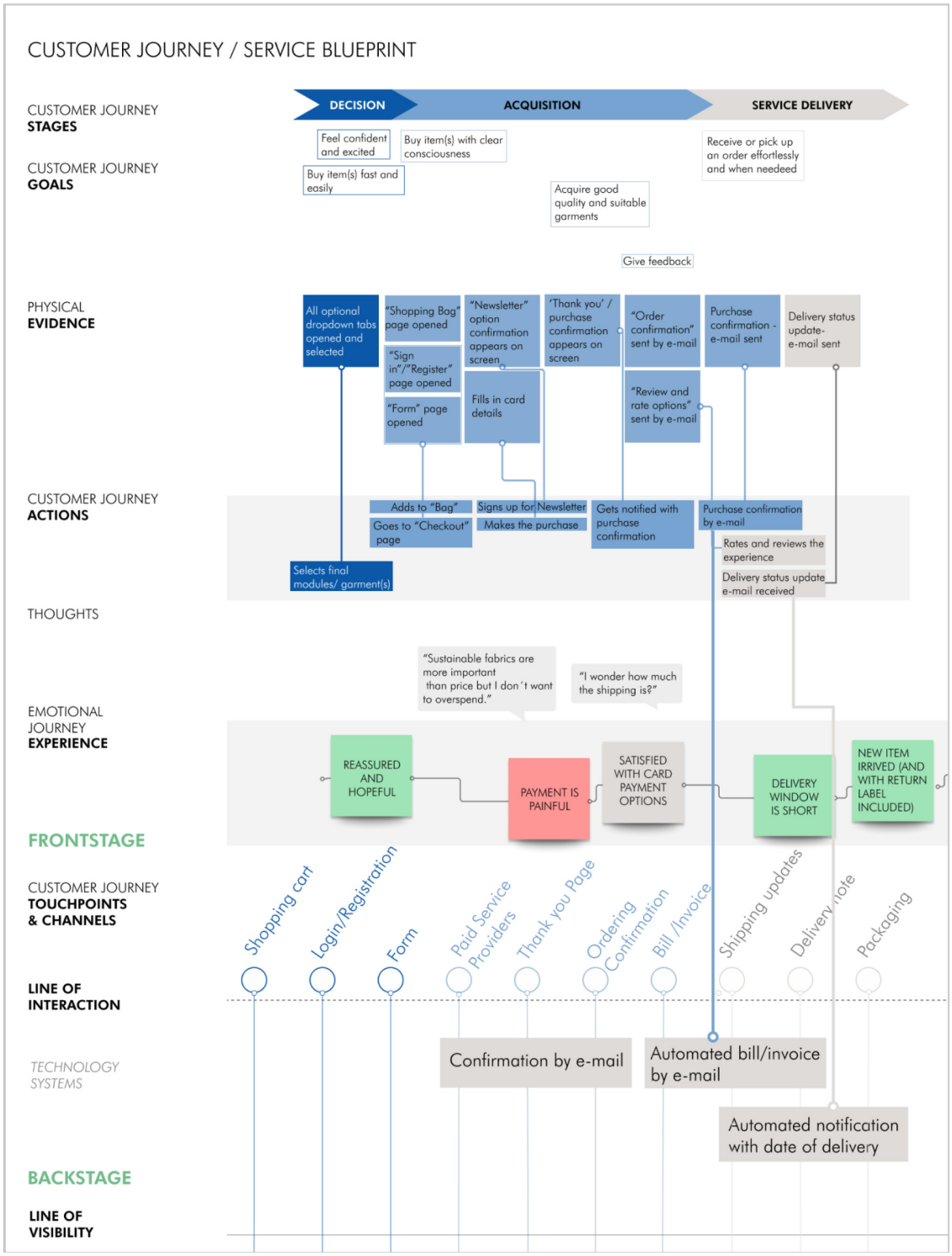
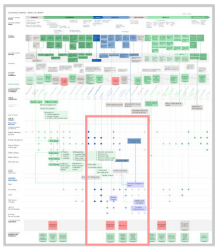


Figure 59 - Customer Journey Map/ Service Blueprint - 3/6



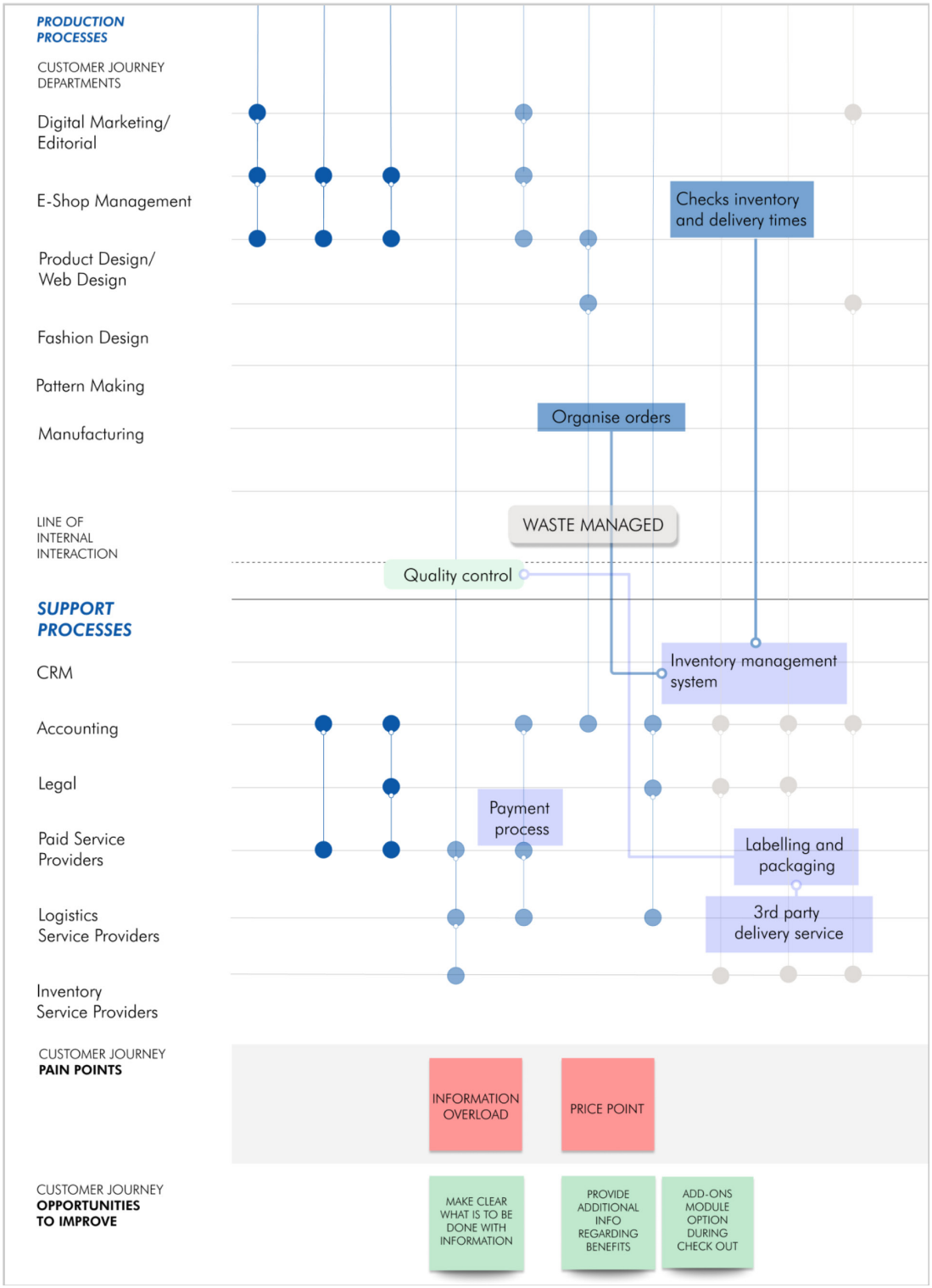
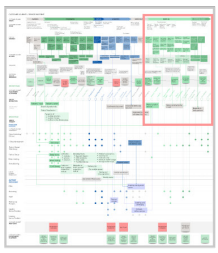


Figure 60 - Customer Journey Map/ Service Blueprint - 4/6



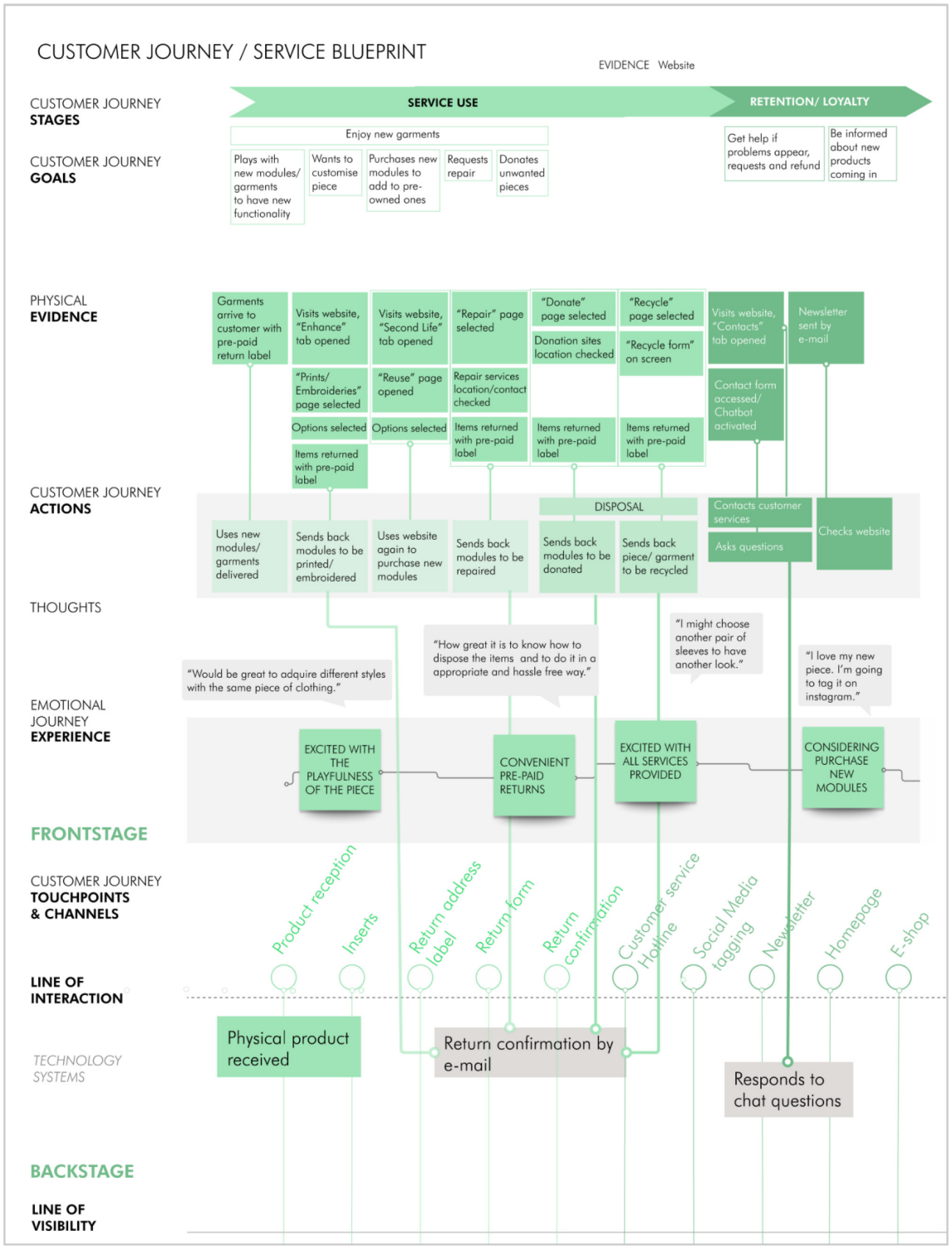


Figure 61 - Customer Journey Map/ Service Blueprint - 5/6

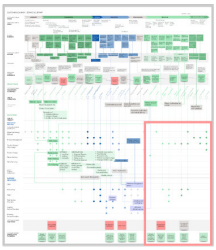


Figure 62 - Customer Journey Map/ Service Blueprint - 6/6

4.7 SERVICE BLUEPRINT

Following the Customer Journey Map, a Service Blueprint was formulated (figures 56-62). The Service Blueprint helps visualise the relationships between service components, and the physical and digital evidence of the user actions throughout its customer journey directly linked to the service touchpoints. In fact, the process that involves delivering and using the service is mapped, either is it seen or unseen by the user/customer.

Crucial to its comprehension is the identification of Frontage and Backstage actions as well as the Line of Interaction (which divides customer actions and front stage interactions), the Line of Visibility (which separates frontstage and backstage actions) and the Line of Internal Interactions (which sets the boundaries to the rest of the organisation – "processes below this line are support processes done by other departments/teams or outsourced"; STICKDORN ET AL., 2018, P. 54).

As a personal option, a simplified Service Blueprint has been integrated into the Customer Journey Map to better understand the links between every component.

5. UX/UI DESIGN

5.1 UX - USER EXPERIENCE

5.1.1 Online Customer Experience and its dimensions

When transporting the user experience to the online realm that experience has a very specific dimension since users have neither physical contact with the product nor human contact. It is "a multidimensional psychological subjective response to the online environment" (KLAUS, 2013; MARTIN ET AL., 2015; ROSE ET AL., 2012) which differs as much as the users accessing and using it. The understanding and interpretation of a website is linked to both spatial abilities as well as cultural context.

The understanding and knowledge that we possess of something is often referred to as a 'mental model' (NORMAN, 1998). Those mental models are developed by "interacting with systems, observing the relationships between their actions and the behaviours of the system" (BENYON, 2014).

According to (BLEIER ET AL., 2019, cited in VISONÁ & DE SOUZA, 2019), during the customer journey the online user experience encloses four dimensions: informativeness (cognitive); entertainment (affective); social presence (social), and sensory appeal (sensory).

Informativeness has a practical aspect of being useful (SCHLOSSER ET AL., 2006, cited in VISONÁ & DE SOUZA, 2019) as it regards the webpage's elements that help in decision-making (GENTILE ET AL., 2007, cited in VISONÁ & DE SOUZA, 2019). The entertainment generates excitement as it comprises "the fun and play of online shopping, despite its ability to facilitate or simplify a specific purchasing task" (BABIN ET AL., 1994; CHILDERS ET AL., 2001; MATHWICK ET AL., 2001, cited in VISONÁ & DE SOUZA, 2019). The social presence experience dimension infers "the feeling of the existence of

a human being without its physical presence “enhancing “the tangibility perceived by users and their feeling of psychological closeness to a product” or service (DARKE ET AL., 2016; ROGGEVEEN & SETHURAMAN, 2020, cited in VISONÁ & DE SOUZA, 2019).

Despite implicit sensory experience restrictions (such as smell, taste, or touch), online contexts have a sensory appeal to them. Those sensations are induced by the imagery with the use of elements such as pictures and videos. Therefore, it affects the user’s aesthetic perceptions (SCHMITT ET AL., 2015 CITED IN VISONÁ & DE SOUZA, 2019), the product performance (WEATHERS ET AL., 2007 CITED IN VISONÁ & DE SOUZA, 2019) and lastly, the use/purchase purposes (SCHLOSSER, 2003, cited in VISONÁ & DE SOUZA, 2019).

To accommodate the so desirable behavioural changes on the system level over time, Service Design falls back on UX/User Experience design since regards the entire process of formulating and integrating a product/service “beyond digital products and increasingly towards customer service journeys through several touchpoints and channels” (COCKBILL ET AL., 2022).

As we already went through defining personas and journey touchpoints,the service navigation on the website was designed as seen below in figures x-z, as well as its wireframes. The navigation map of the website works as a “walk through” being a key that maps out how users will experience and move through the site whilst the wireframes are outlines of the structure and are more focused on the website’s design. The website’s plan is directly informed by the previous Customer Journey Map/ Service Blueprint.

5.1.2 NAVIGATION WORKFLOW

To establish how the website is going to work, the principle of hierarchy was used to organise information. In fact, hierarchy forms the foundation for organising the needed content. The hierarchy concept allows vertical navigation (between multiple levels) but also lateral navigation established allowing jumps across branches, as seen in figures 63 -64.As a common ground, the global navigation was made providing a link to the homepage through the logo.

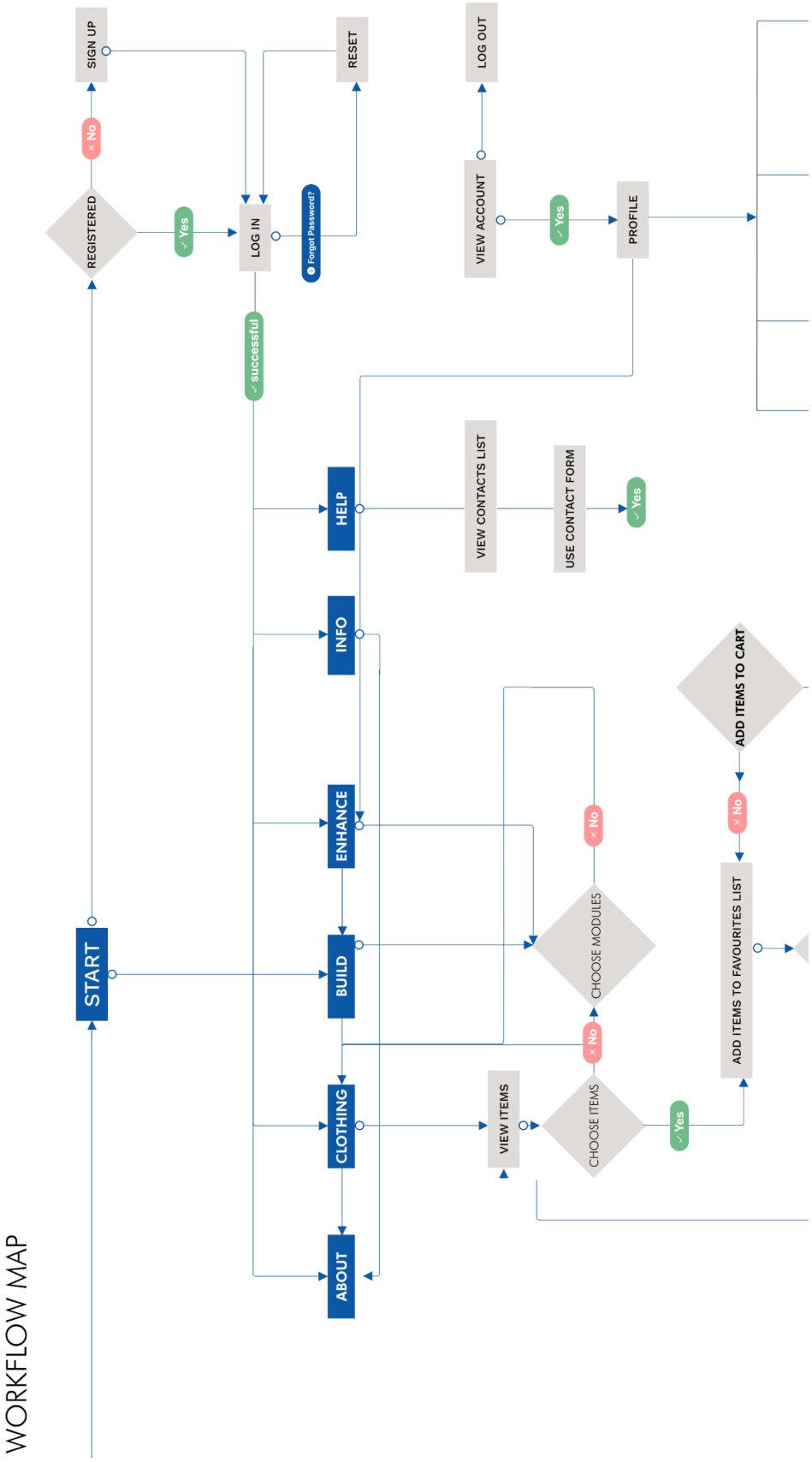


Figure 63 - Workflow Map 1/2

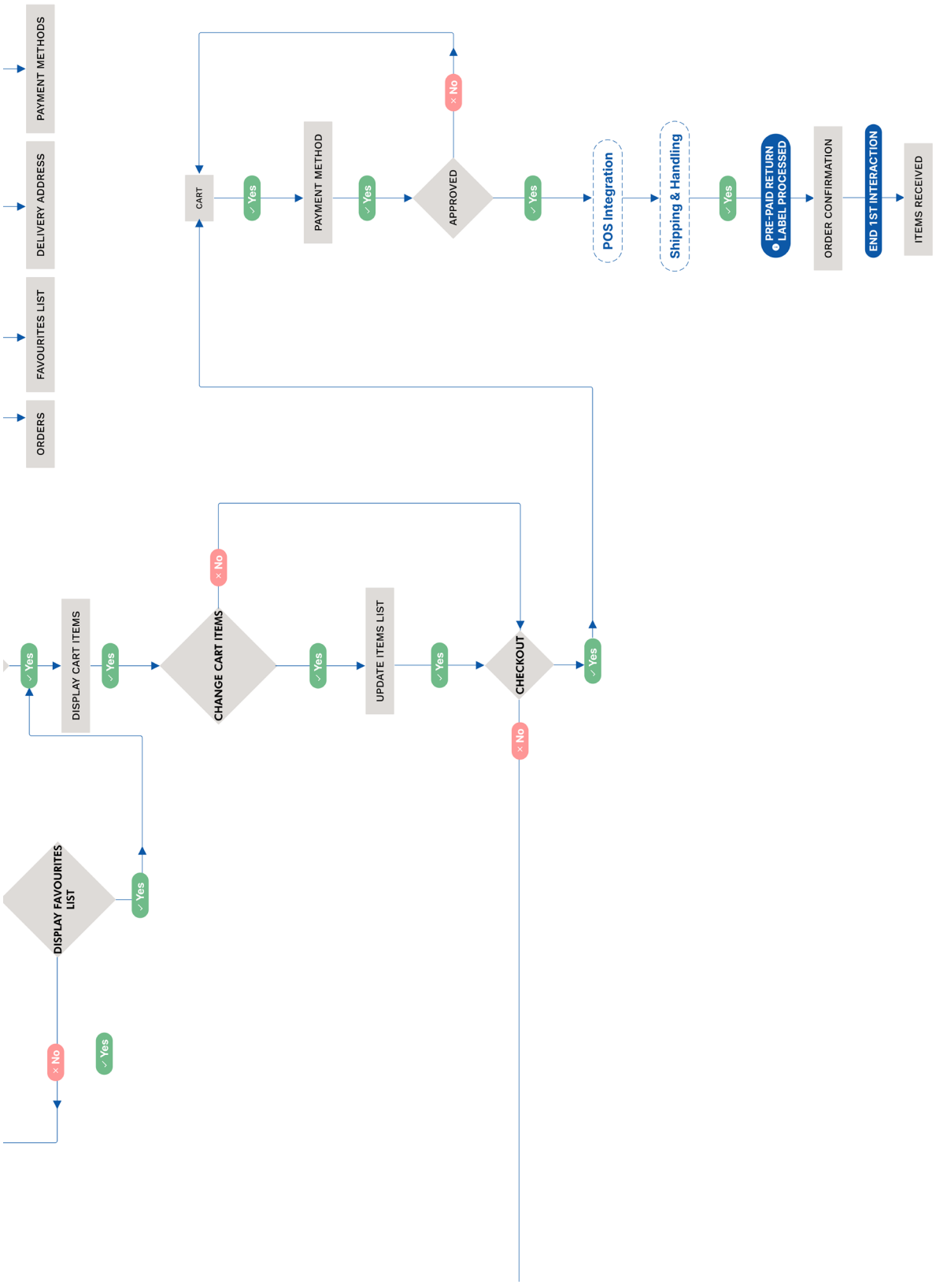


Figure 64 - Workflow Map 2/2

5.1.3 Website structure/Wireframes

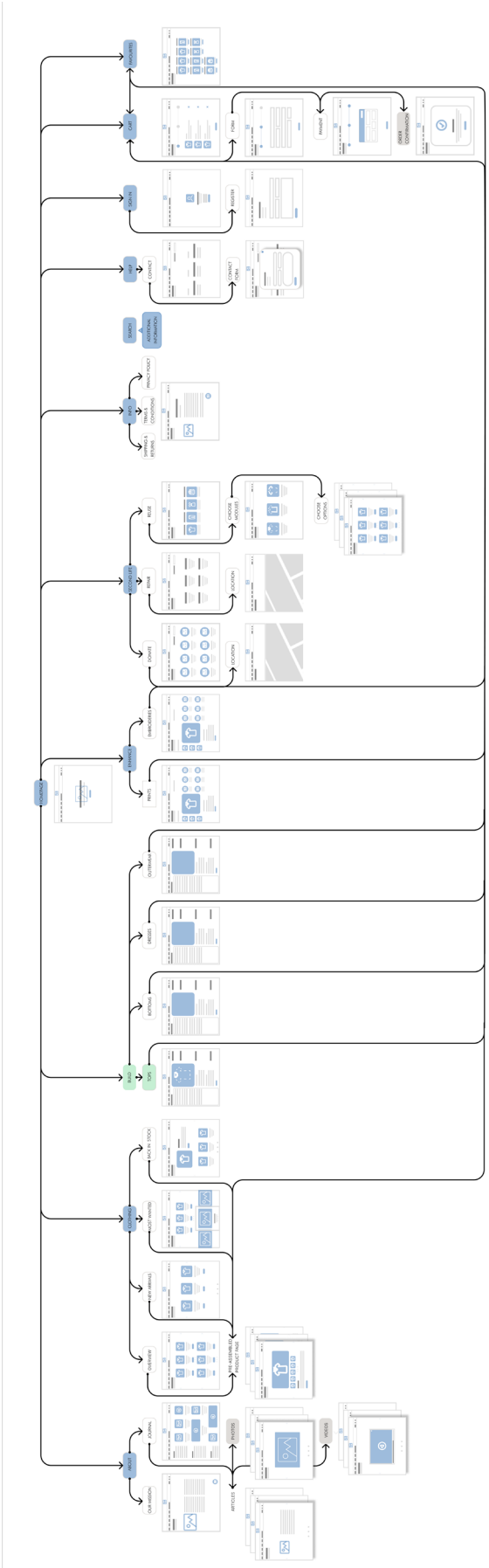
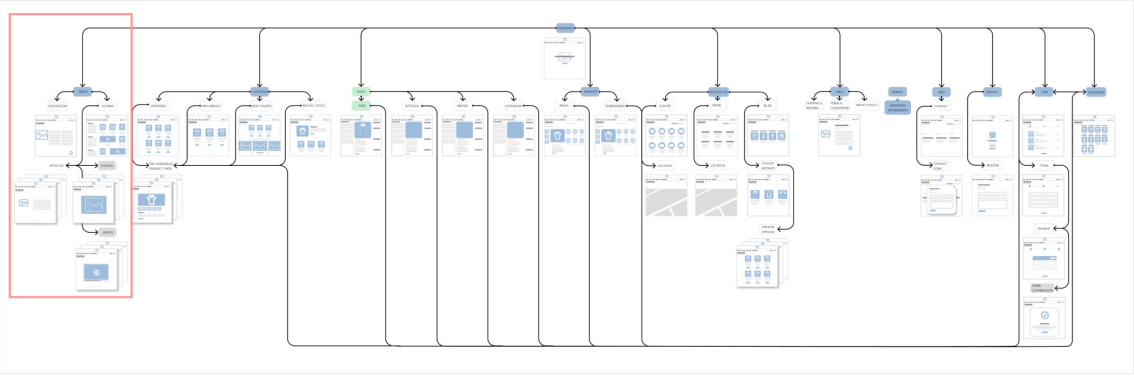


Figure 65- Website Structure/Wireframe-overall view



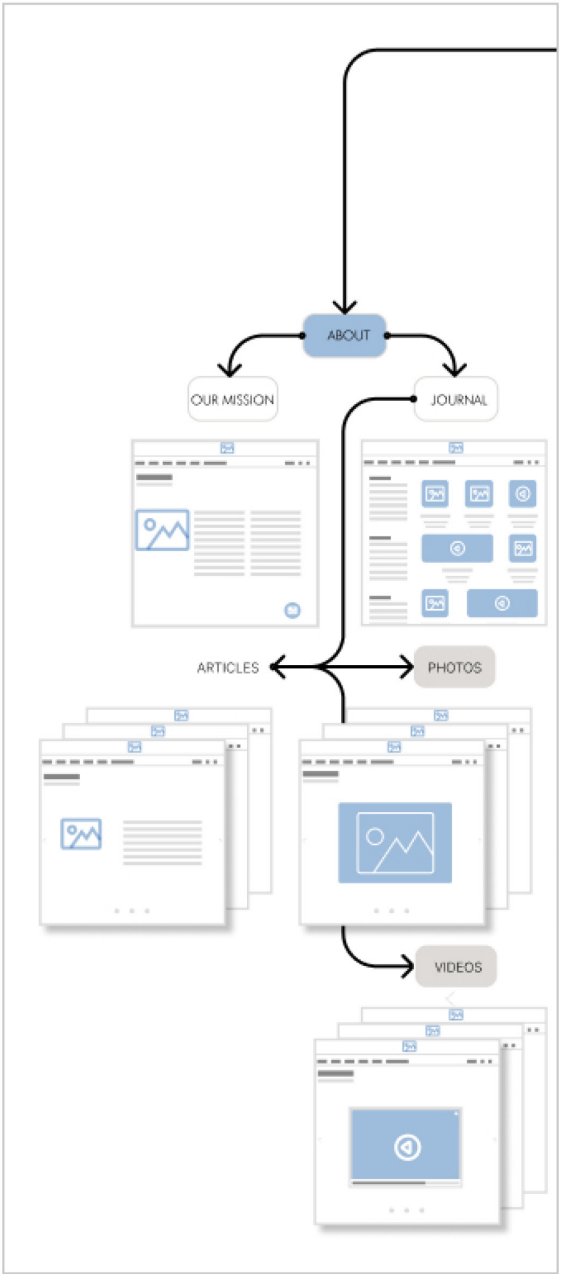
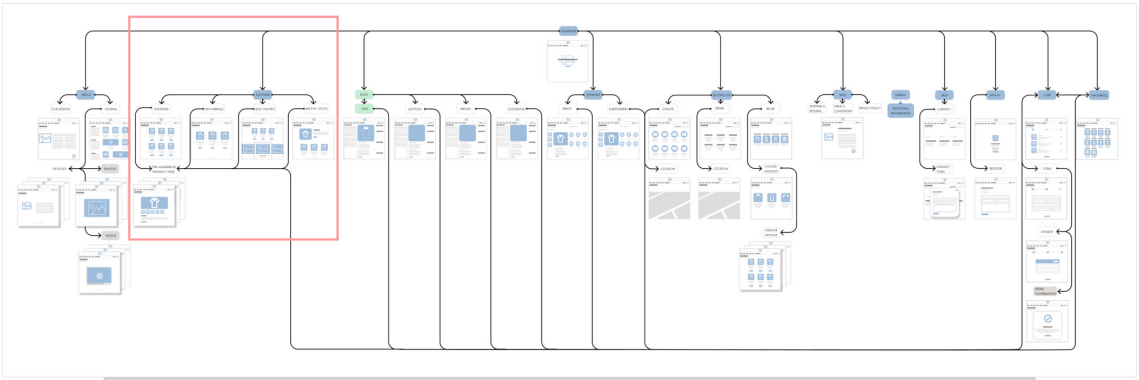


Figure 66 - Website Structure - 1/7



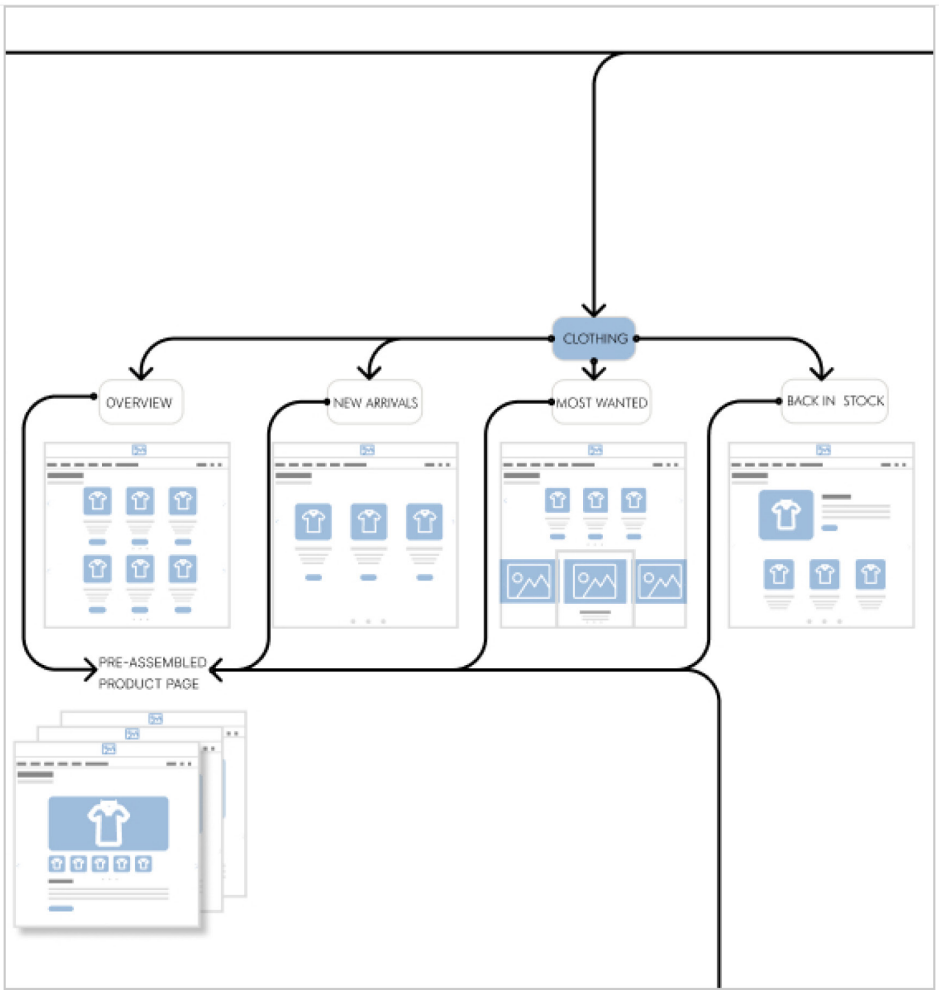
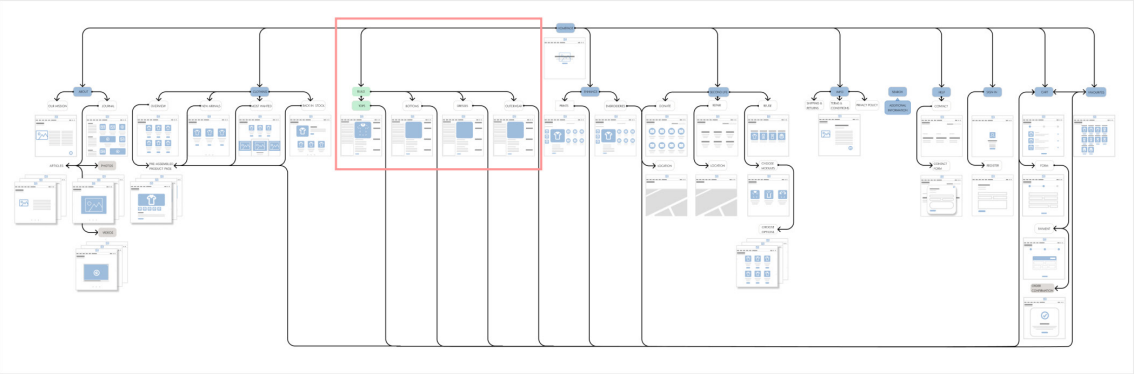


Figure 67 - Website Structure - 2/7



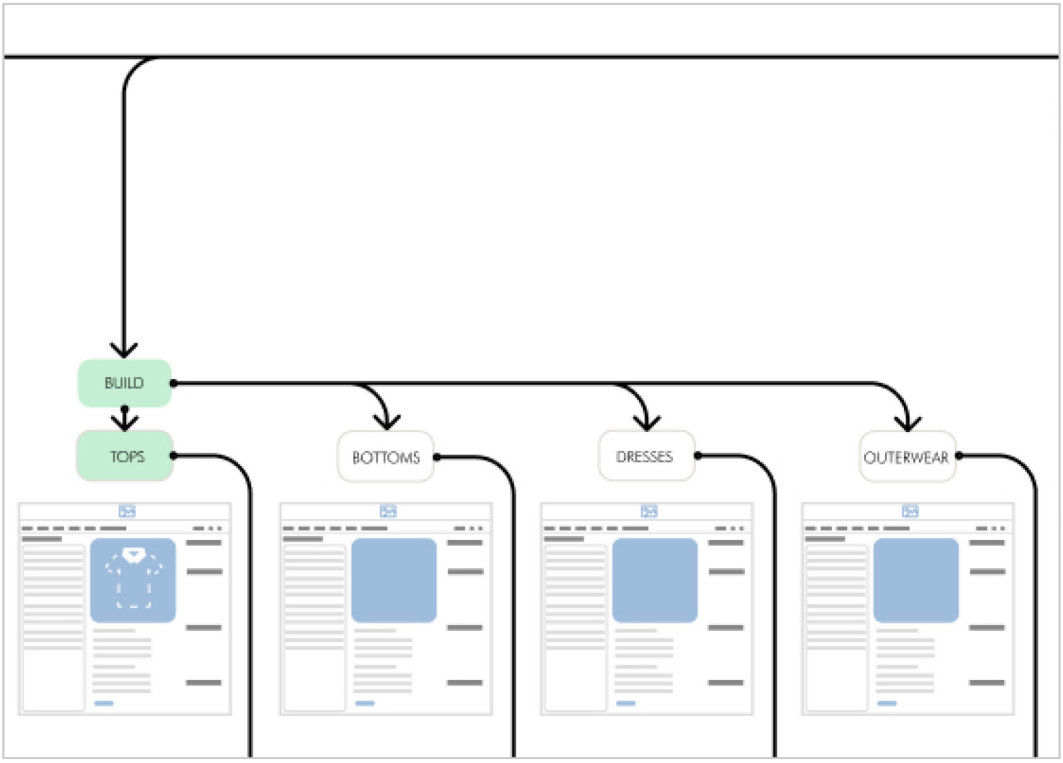
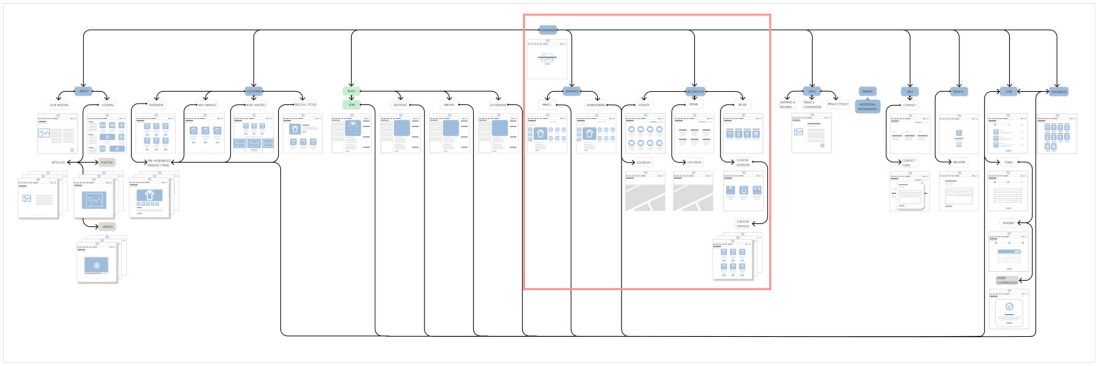


Figure 68- Website Structure - 3/7



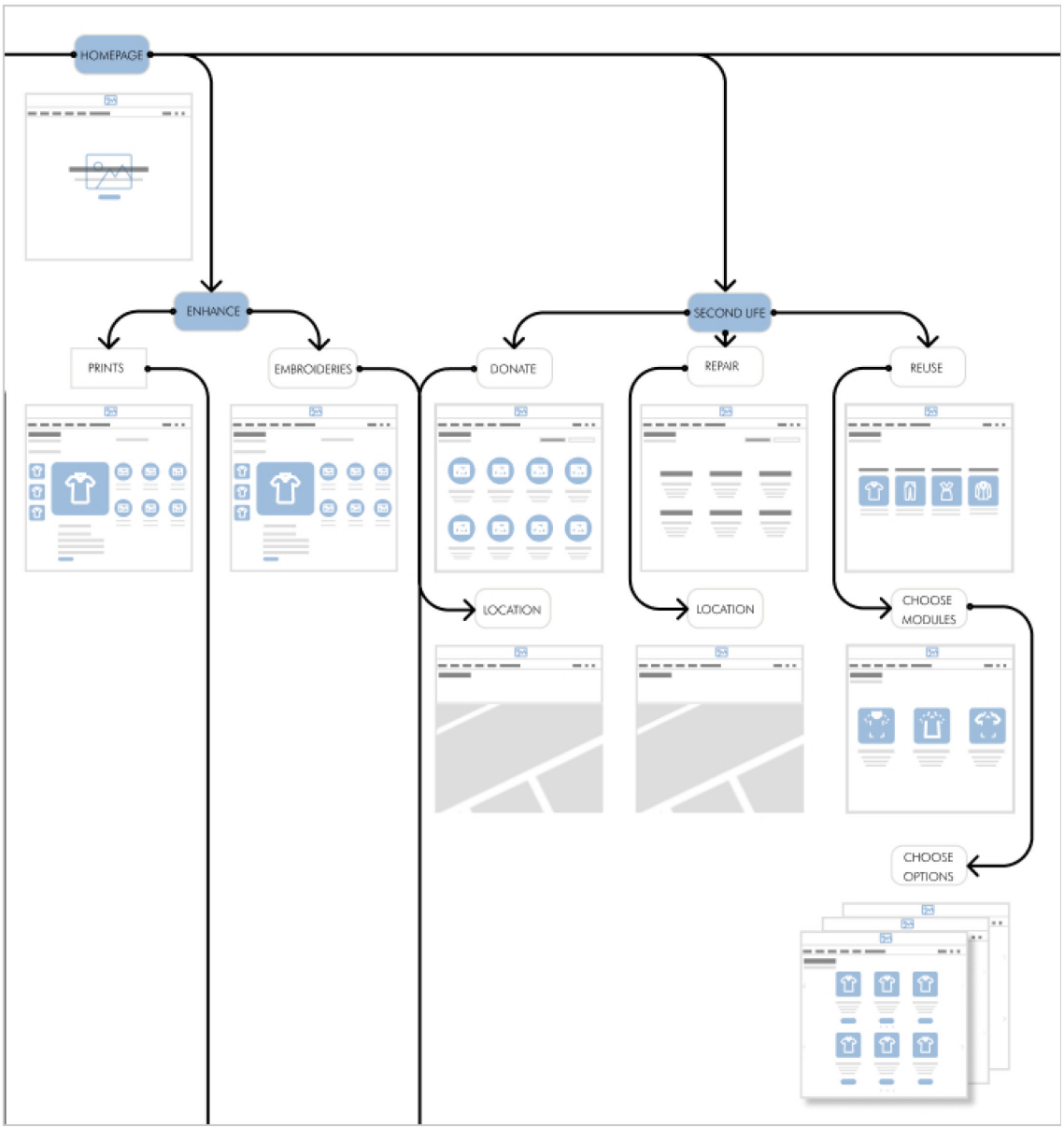
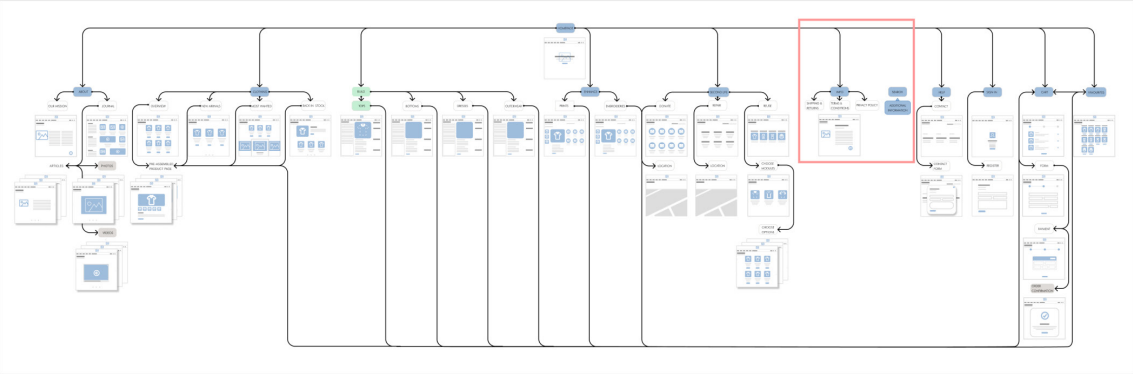


Figure 69- Website Structure - 4/7



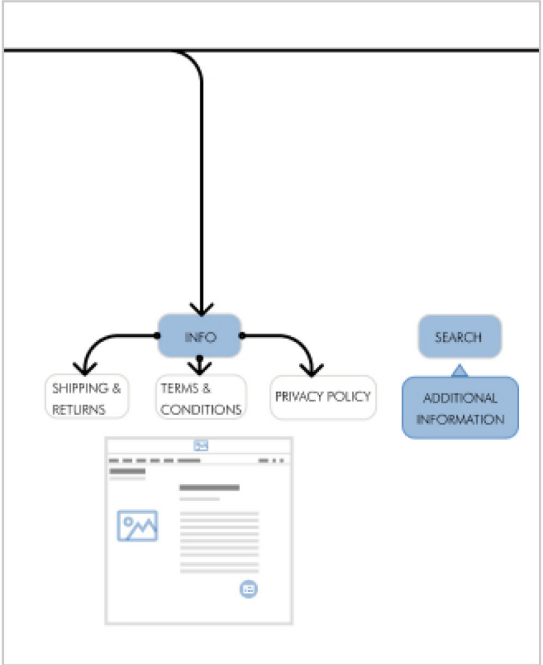
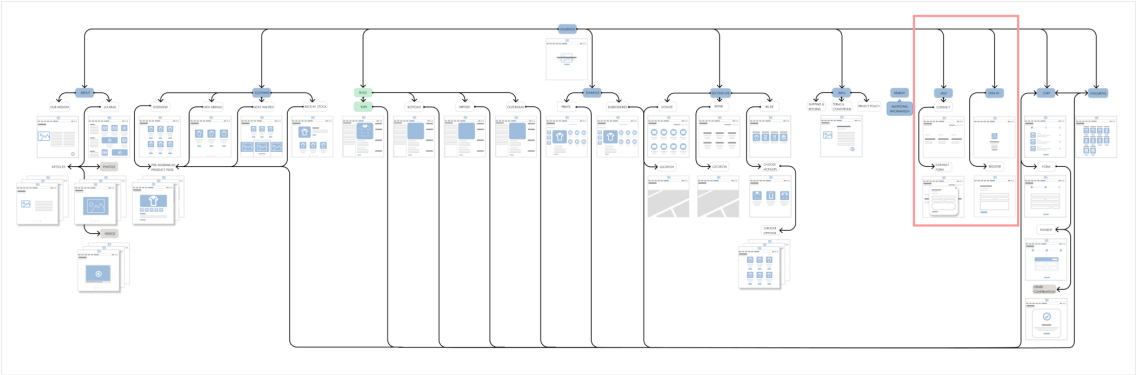


Figure 70 - Website Structure - 5/7



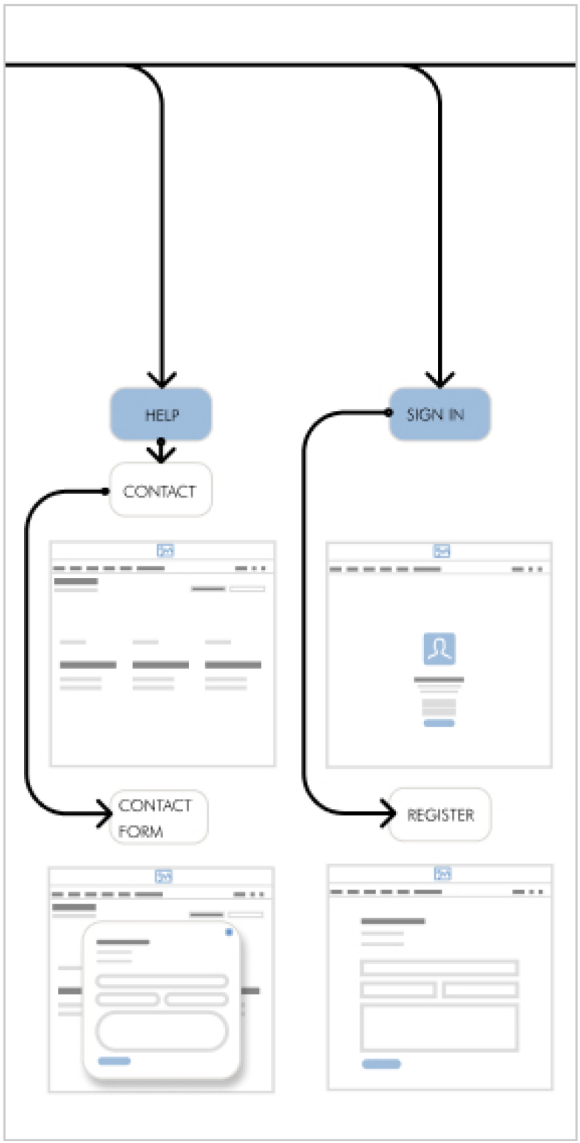


Figure 71 - Website Structure - 6/7

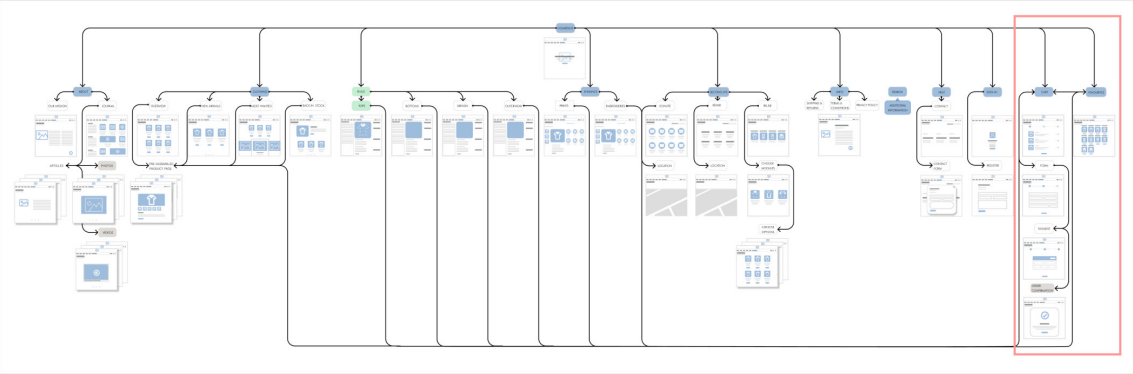


Figure 72 - Website Structure - 7/7

5.1.4 MOCK-UPS

After this, the process is conducted through the elaboration of mock-ups with special emphasis on the "Build" page which is the one with the main relevance for the purpose of this dissertation.

Mock-ups and prototypes have the interest of being simulations that come closer to the end result as they verify both aesthetic-formal and functional properties helping visualise the product/service in a more effective way (VISONÁ & DE SOUZA, 2019).

In the scope of this research, the various prototypes are tangible experiments. Both the website and the fashion garments are digitally built which allows to identify possible limitations of viability and facilitate the visualisation of the product.

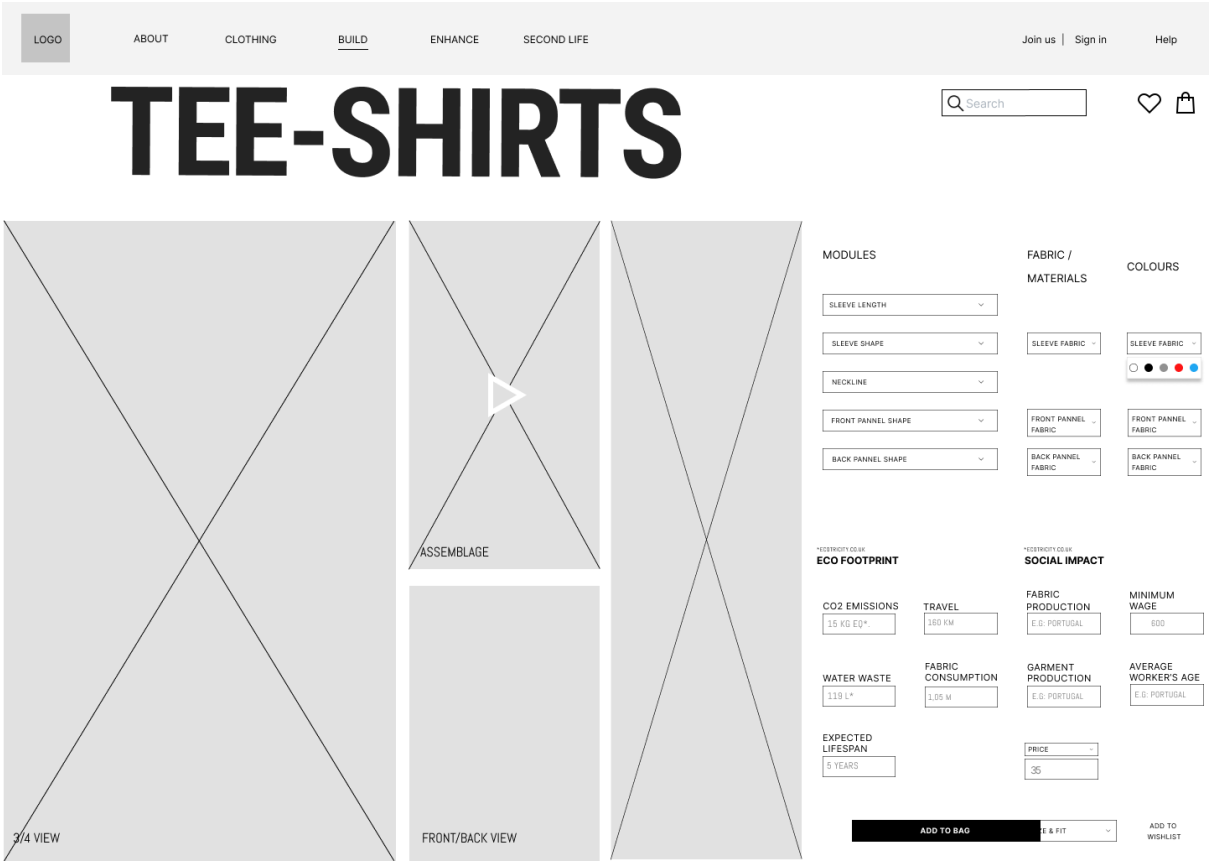


Figure 73- Mock-up #1

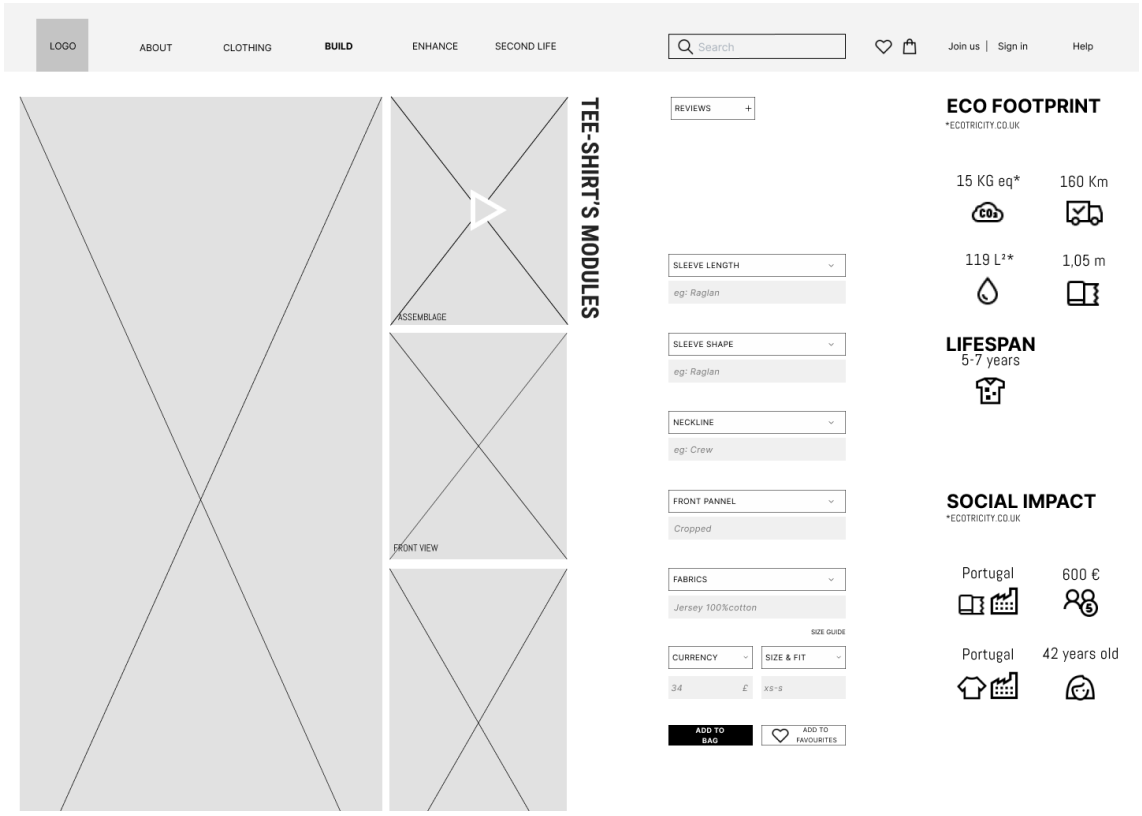


Figure 74 - Mock-up #2

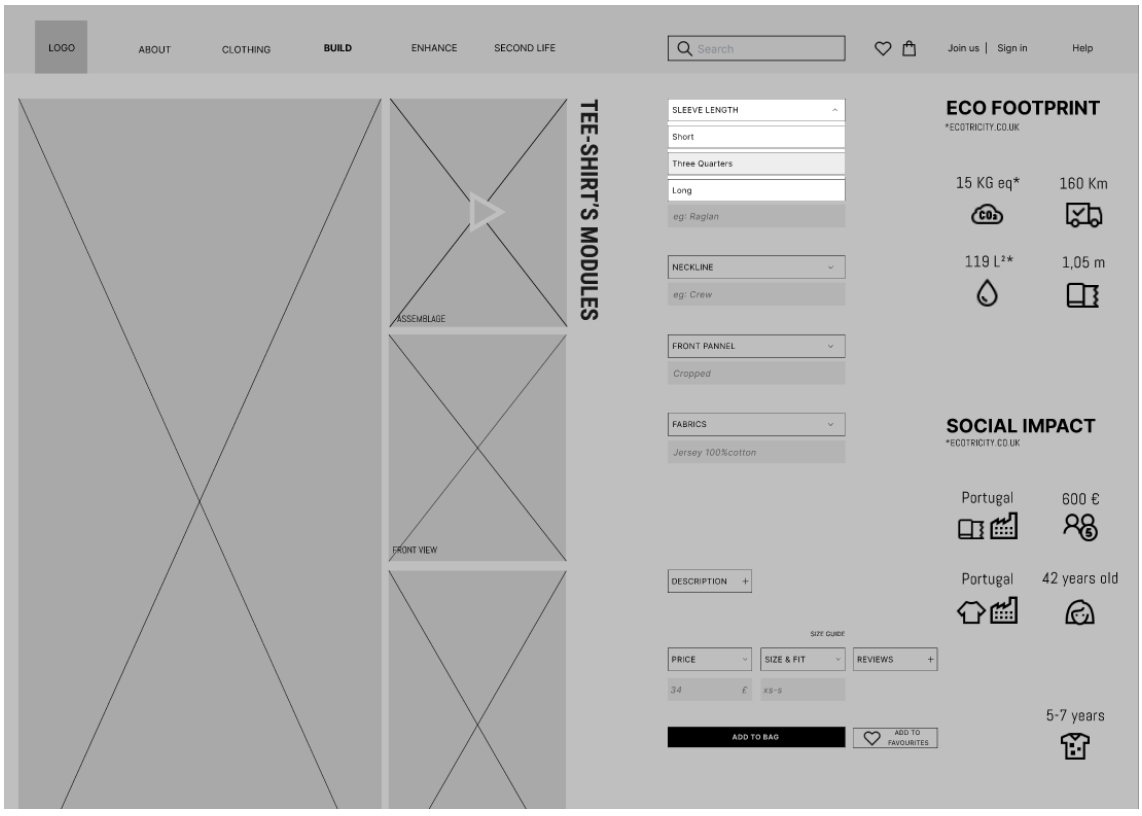


Figure 75 - Mock-up #2 - dropdown functions

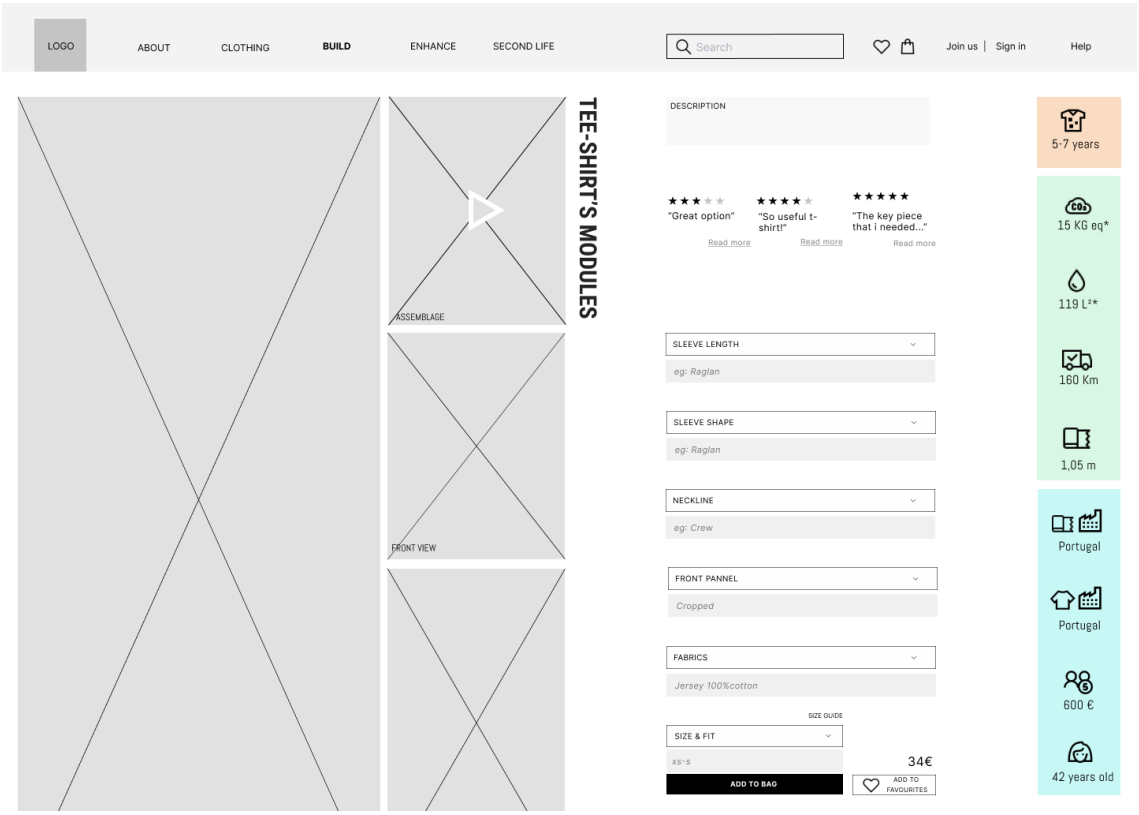


Figure 76- Mock-up #3

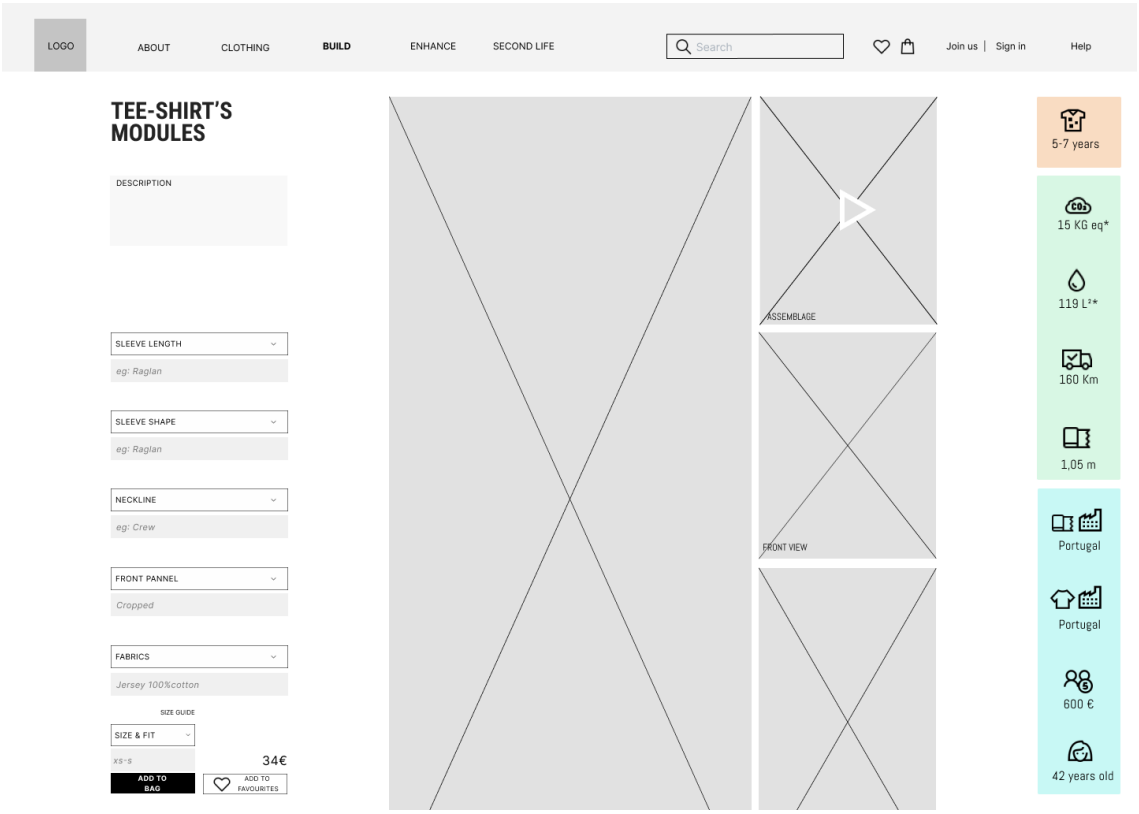


Figure 77 - Mock-up #4

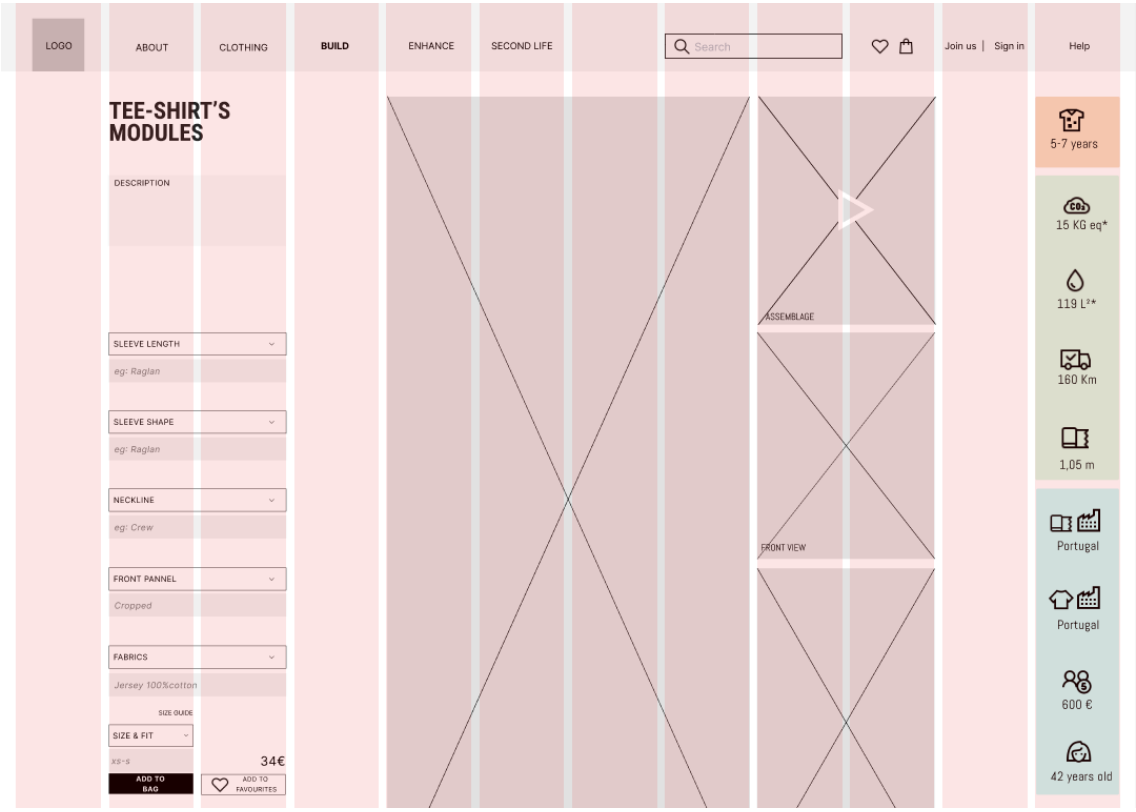


Figure 78- Mock-up #4- Grid

5.1.5 PROGRAMMING

On the development of the website it is used the specific language HTML5, Cascading Style Sheets (CSS) and JavaScript (JS).

5.2 UI-USER INTERFACE

User Interface Design is a discipline deeply linked to UX-User Experience Design because it involves everything whether physically, perceptual, or even conceptual existing in the system that users encounter (BENYON, 2014). The interface design plays a crucial role because it mediates the interaction people have with the system and their dialogue.

Physically people use all their senses to interact with systems. In fact, the physical interaction is made by many 'inputs' such as by pressing (e.g.: buttons), touching (e.g.: a screen), moving or clicking (e.g.: the mouse), rolling (e.g.: scroll wheel or rolling the thumb). Actions that are followed by the system 'outputs' feedback – the system´s response to the user' actions in real time.

Perceptually and concerning the visual aspects of the interface, people interact with a system through what they can see and understand (BENYON, 2014). The information displayed needs to be perceptible hence the importance of a clear and legible communication.

It reveals the understanding and knowledge that we possess of something (NORMAN, 1998). Conceptually people interact with systems using their 'mental models', knowing what the device is and how it works. To undertake the system navigation users need to know certain data is available and they need commands to operate it (BENYON, 2014).

5.2.1 ENGAGEMENT

On a primary level, humans as social beings and forcedly interact with each other. As individuals we are always linked through social interaction so that while an organisation may believe it controls the meaning of its brand(s), it can be argued that brand meanings and value are created by consumers and other stakeholders in a process of interaction (PRAHALAD & RAMASWAMY, 2004; NONAKA & TAKEUCHI, 1995, cited in IND & COATES, 2013).

Engagement happens only if the process of interaction is considered rewarding (FÜLLER, 2010, FERNANDES & REMELHETE, 2016).

Arguably, some key features of engagement can be identified: identity; adaptivity; immersion and flow (SHEDROFF, 2001, cited IN BENYON, 2014).

Identity is linked with self-expression therefore a sense of authenticity must be present. For instance, if during the interaction experience something happens that reminds the user that the experience is not real the engagement is lost. Adaptivity is about making things that can be experienced at many levels of skill and enjoyment. Narrative regards telling a good, convincing story. Immersion is not about the medium but the quality of the design that enables the feeling

of being involved within something. And at last, flow is the gradual change from one state to another (Csikszentmihalyi, 1990 cited by Benyon, 2014).

An immersive, focused, and meaningful experience is essential to inspire users to engage (Füller, 2010).

5.2.2 AESTHETICS AND COLOUR

To achieve meaningful interactions, ubiquitous digital environments not only need to be responsive to people's needs but also to provide engaging and aesthetic experiences (BENYON, 2014).

Aesthetics are a consequence of the emotions that a service or product must provide during its experience by the user. Positive emotions (such as "inspiration, desire, satisfaction, pleasant surprise, fascination, amusement, admiration") are the ones that should be emphasised to increase user engagement over negative emotions (such as "disgust, indignation, contempt, disappointment, dissatisfaction, boredom, and unpleasant surprise") (LAVIE & TRACTINSKY, 2004).

Aesthetics is a strong determinant of attractiveness of a system and the pleasure experienced by the user during the interaction (JORDAN, 1998 CITED IN LAVIE & TRACTINSKY, 2004, P. 277) determining the perception of ease of use.

In truth, visual aesthetics considers commands colour choices on the interface design but also has implications in the entire user experience (LAVIE & TRACTINSKY, 2004).

When approaching human experience and communication it is vital to reflect upon colour as it affects, often unconsciously, our mood, exciting it or soothing it evoking emotions, and affecting our wants.

In the emotion's spectrum, people's experiences are classified as visceral (the perceptual aesthetics of an experience itself), behavioural (positive emotional response will come from feeling in control and understanding of use) and reflective (lies into consideration personal values and self-worth (NORMAN, 2004).

Colour has the power to inspire our reactions and can even change the way we think. In fact, "through colour, we feel; we communicate; we heal" (cited in https://www.colorpsychology.org/).

Colour meanings can be innate or learned through social conventions. For the purpose of this dissertation, western conventions are in use.

The colours used were separated in two different sets: the main colours – revelling "classical aesthetics (clean, clear, pleasant, aesthetic, symmetrical) and the complementary colours – revelling "expressive aesthetics (original, sophisticated, fascinating, special effects, creative)"

(LAVIE & TRACTINSKY, 2004, P. 277; BENYON, 2014).

Arguably, aesthetics and usability are linked through simplicity (VAN DER HEIJDEN, 2003, cited in LAVIE & TRACTINSKY, 2004, P. 277) which can be a guideline in creating usable systems (LAVIE & TRACTINSKY, 2004), therefore, the main colours chosen for the interface design, as seen in figure 79, below, were conventionally used colours such as black, white and different shades of grey.

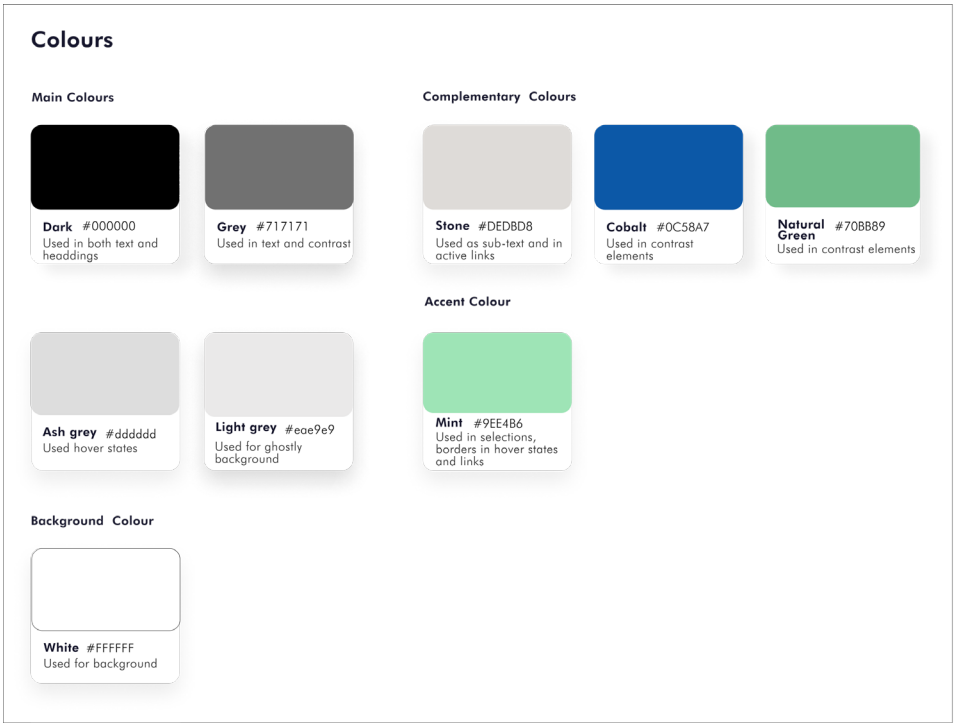


Figure 79 - Website's colours palette

Being neither dark nor white coloured, grey shades are used on the webpage's interface design because they are unresponsive and neutral allowing an impartial and formal visualisation of the pages.

Regarding the theme of Fashion Sustainability, the psychological meaning of the complementary colours were taken into consideration.

Invariably, green colour is associated with nature therefore associated with growth, renewul, balance, optimism and hopefulness. It is a relaxing and restful colour symbolising harmony, tranquillity and peace.

Two shades of green were at use for different purposes on the webpage's design: a darker one "Natural Green" and a light one "Mint." A darker hue of green conducts a more negative connotation evoking a sense of stagnation, isolation or even sickness (hence the expression 'green around the gills'). This colour is applied to the background of the Environmental Impact.

The lighter shade "Mint" is associated with freshness and creativity signifying growth, wellness, and good luck. This colour is used on focus elements such as selections, hover status and active links.

The blue colour is used on the background of the "Social Impact" information. Therefore, a darker blue shade, "Cobalt," has been chosen with the intention of comprising various meanings. Despite darker shades like "Cobalt," - the first inks to be developed and used by the Egyptians and thus associated with royalty for that reason - this blue is associated with both women and men being linked to the workforce (the indigo's blue denim trousers). Hence, it promotes trust and dependability (reason to be used on law enforcement uniforms).

Commonly associated with the calm ocean therefore with calmness and peace. It has mentally stimulating effects as it encourages serenity, orderliness, and tranquillity.

Dark shades of blue enhance decision-making, problem-solving capacity, and idea generation (even under pressure) but are related to painful experiences when referred to in music's'blue' genera.

TOP NAVIGATION BAR

Extensively used on websites, the top navigation bar (figure 80) sets the grouping of the service's functionalities and everything that supports the system, hierarchically organising the structure of information providing the site's content.

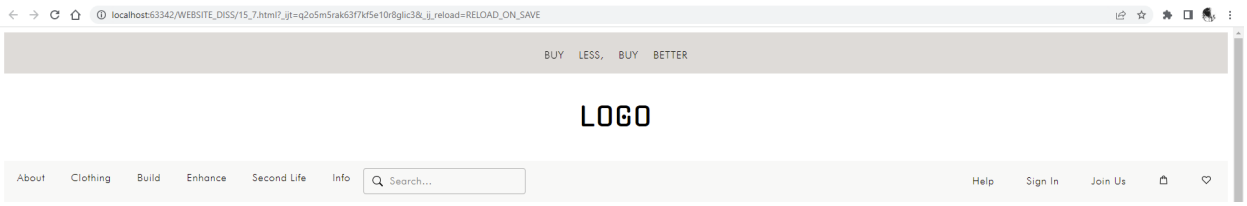


Figure 80 - "Header"- Navigation bar

Therefore, the navigation bar as the following topics:

- About > Our Mission; Journal;
- Clothing > Overview; New arrivals; Most Wanted; Back in Stock;
- Build > Tops; Bottoms; Dresses; Outerwear;
- Enhance > Prints; Embroideries;
- Second Life> Donate; Repair; Recycle; Reshape;
- Info> Shipping & Returns; Terms & Conditions; Privacy Policy;

The navigation bar (commonly called nav bar) is often splitted, as seen in figure 79, dividing functionalities of the service and the search menu from the user's "personal space": account login and registration. Also, often included in this part are the "bag" and "heart" that work as shortcuts to respectively shopping cart and favourite lists. The design of the top nav bar

relied on commonly used examples since the principle of consistency, despite being controversial (BENYON, 2014), is a helpful way to enable users to use recognisable features and understand the webpage in an intuitive manner.

With the goal of creating both physical and emotional dialogue between the user and the proposed product, system, and service (KOLKO, 2010), the principles of interaction guided the interface design. This is achieved by appropriating the existing functions and information content allowing users to perform intended tasks and features to be well perceived thus memorable.

For the sake of creating a garment the system needs to allow users to choose the shape of the garment (both body and sleeve shapes); its colour and fabric. For this reason, direct manipulation is needed as the main form of interaction. The on-screen elements are directly manipulated so that the user gives inputs to the system and the system responds with its outputs – a dynamic dialogue susceptible of being perceived (BENYON, 2014).

RADIO BUTTONS AND DROPDOWN LISTS

Direct manipulation implied the use of radio buttons and dropdown lists. The use of a series of radio buttons allows users to make exclusive choices whilst the dropdown lists have the advantage of displaying many options without having to search and recall names, hence avoiding ambiguity. Both radio and dropdown lists were evaluated throughout the process of design with several experiments.

Initially, for instance, as seen in figure 81, radio buttons were used to select the category of garment piece – functionality that would be discontinued later for the sake of versatility purposes. Also, both shapes and fabrics options are disclosed in several dropdown lists that are entangled, making its content dependent on one another.

An important consideration to make refers to the garment's colour selection. Often, in the context of e-commerce regarding the fashion sector, the colour selection is made by selecting a colour swatch (approach also tried on figure 85– experiment#3) that changes the colour of the clothing object instantly. The common user might think that a different picture is taken previously for each fabric/colour option but that is far from the truth. In terms of web design, this is often implemented by creating a vectorial SVG layer corresponding to the physical limits of the clothing itself which is placed on top of the image. When clicking and selecting the colour swatch is that previously selected colour that is applied on the SVG layer and merged on the clothing object.

Regarding the fashion design process, the reality is that not all fabrics are available in all colours therefore, for that reason, one might say that colour depends on the fabric selection or

even, colour is inherent to the fabric selection. For this reason, in this interface proposal, multiple dependencies between several dropdown menus were developed where the colours available for selection on the dropdown menu were defined by the pre-selection of the fabric. Moreover, as a possibility, the price of the piece was defined also by the fabric selection. This conceptual choice is justified by costs of fibre sourcing, fabric production, transportation and retail margin that are the main factors that interfere with price.

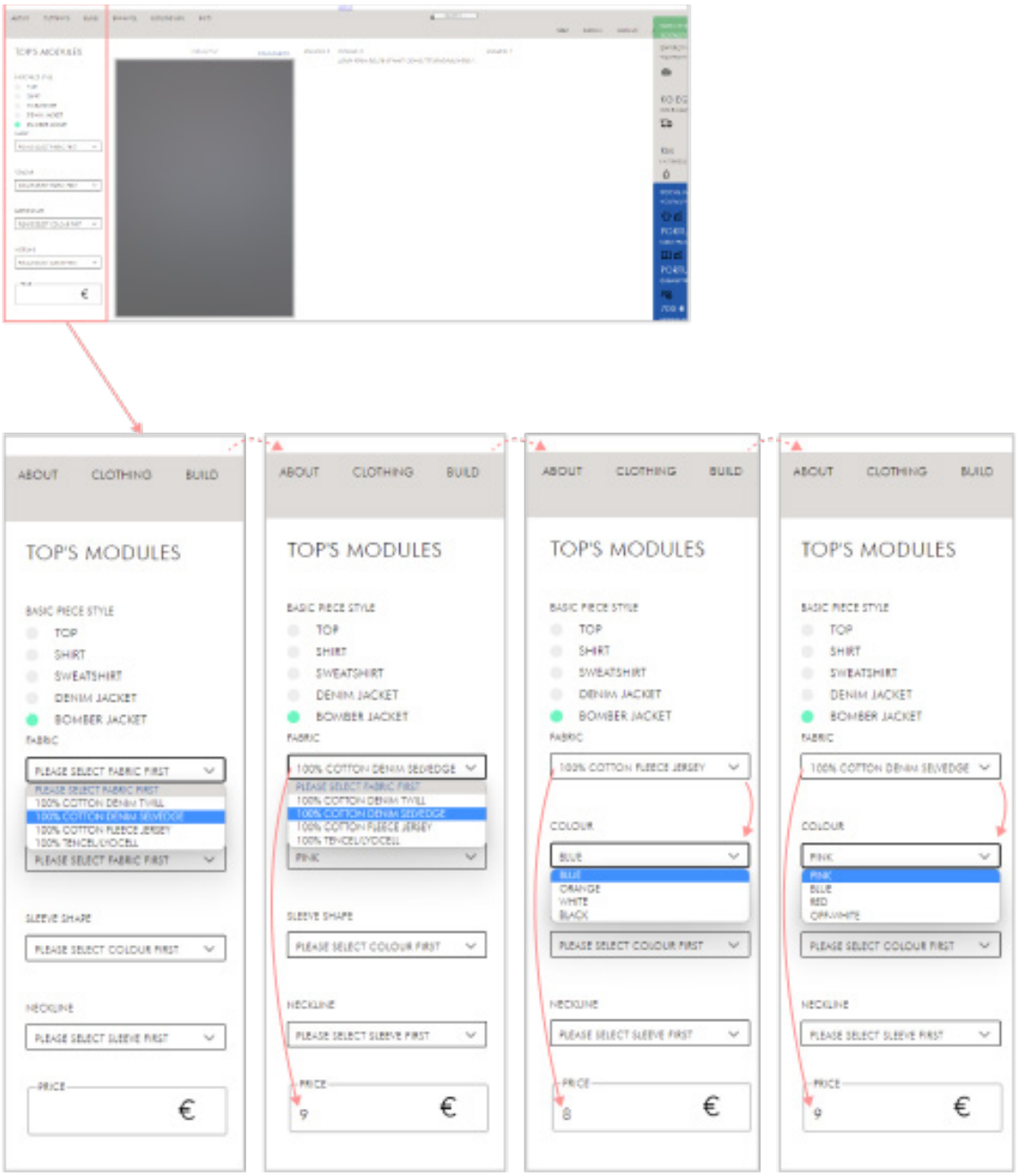


Figure 81 - Interface Design- Experiment #1 – dropdown lists

VISUAL ORGANISATION

To reduce the user's memory load, visual organisation of the interface is crucial. For this reason, it uses the chunking process by grouping meaningful elements of a task into one place. Moreover, the conceptual organisation of the space helps with the task of creating accurate mental models - one of the design principles - so that users will know how the system accessed by this interface works and what it does (BENYON, 2014).

As seen in figure 83, conceptually the visual camp is divided in three parts. The first third of the screen is the "input" part, where users make their choices (shapes and fabric selection); the middle part of the screen is the "output" part where the consequences of the inputs made (changes and options selection) are visible - where the final piece and its components are displayed.

Lastly, the last third of the screen is the information part - sustainable indicators calculated according to choices taken- which is intrinsically dependent on the inputs made on the first

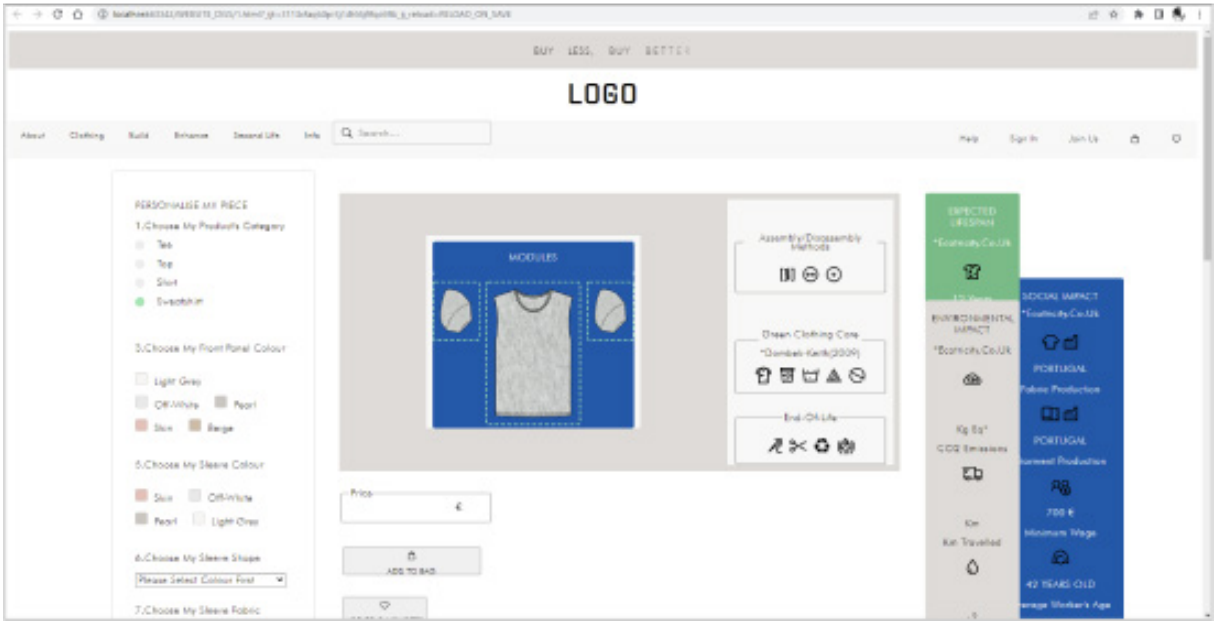


Figure 82 - Design Interface – Experiment #2

part (fabric and garment selection).

After some reflection, structural changes needed to be made. To increase clarity, additional information regarding product's care and maintenance as well as, the assembly methods and time should not be placed in the middle area but possibly below as pointed out in figure 84.

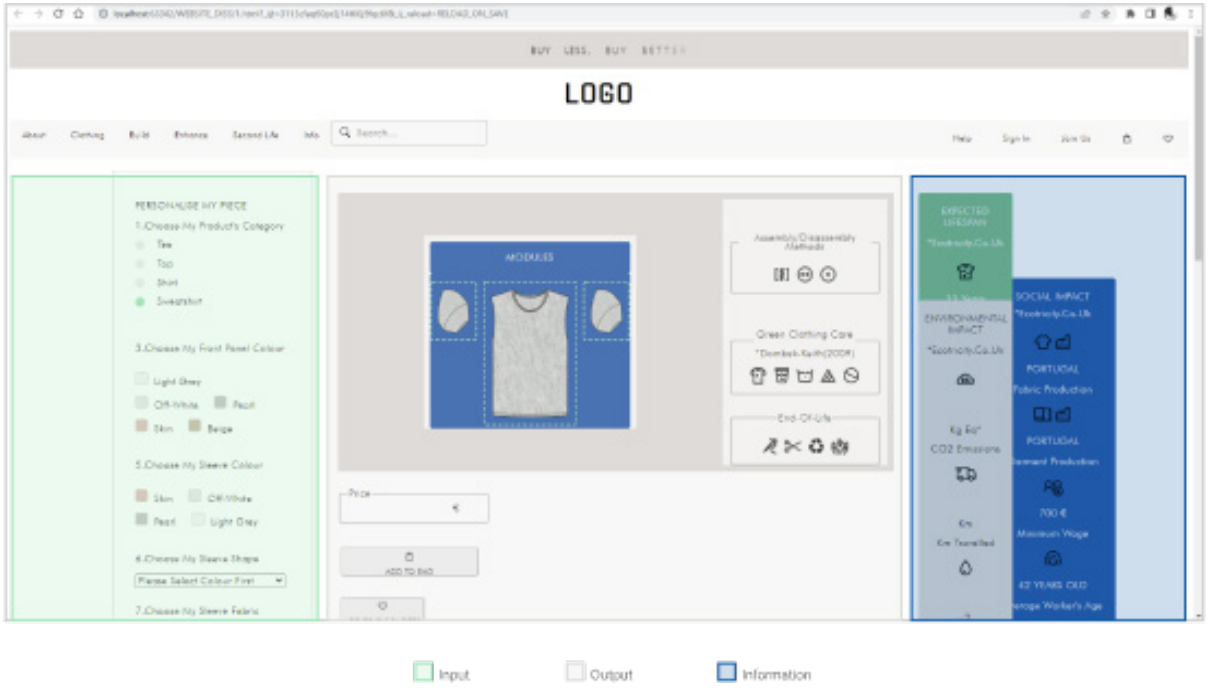


Figure 83- Interface's visual structure

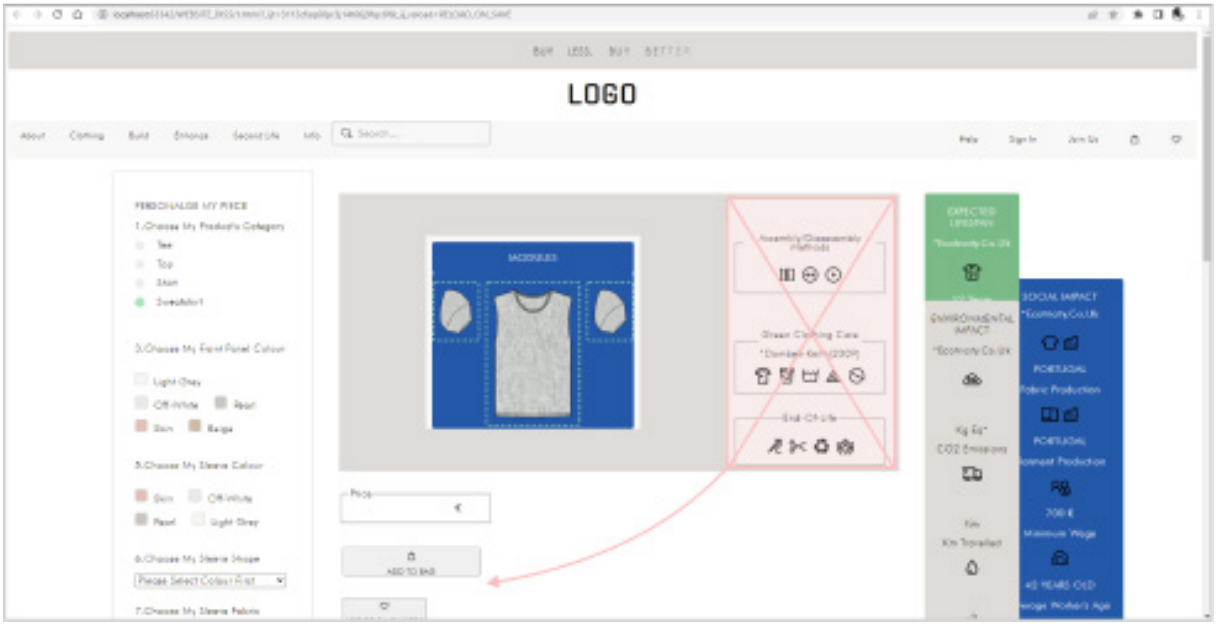


Figure 84 - Changes made on Interface's visual structure

At this stage, the dropdown dependencies were further explored. The fabric options were dependent on the shapes selection, as explained in figure 85.

The options of possible fabric to choose from are narrowed down to just three and for a practical standpoint were divided into synthetic and natural fabrics, to justify the display of washing and care instruction specifically to each of those groups of fabrics.

Even if practical, mixing info during the "input" part of the interaction is confusing and overwhelming. This is going to be corrected later on.

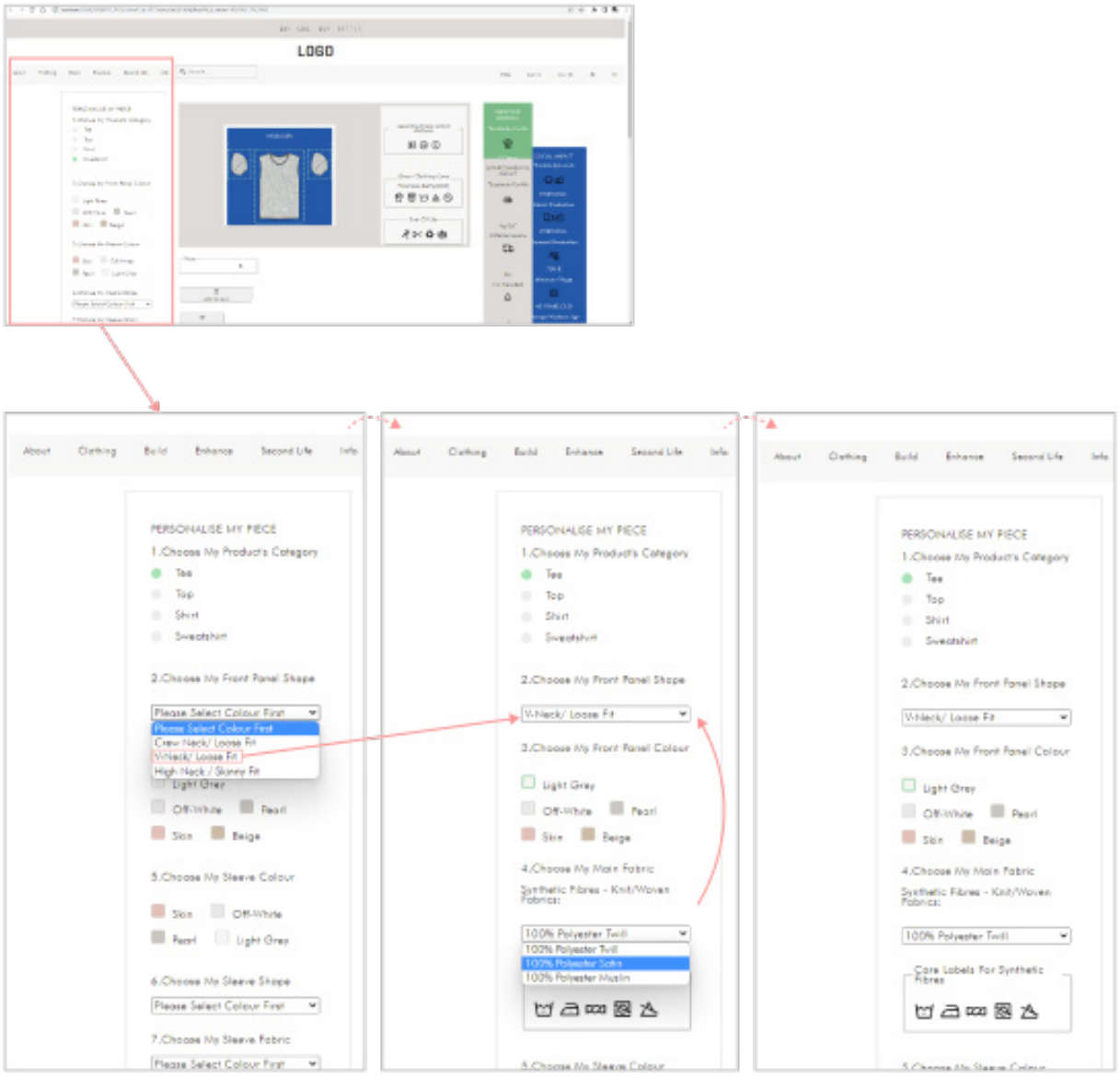


Figure 85 - Interface Design – Experiment #3 - Multiple dropdown dependencies

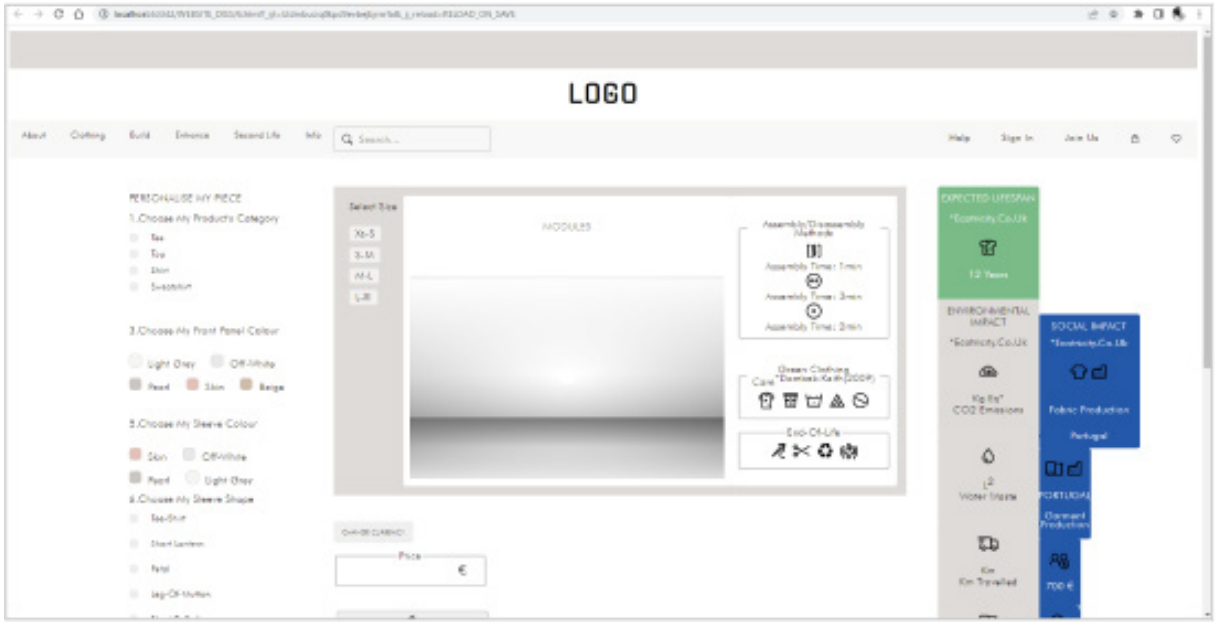


Figure 86- Interface design – Experiment #3

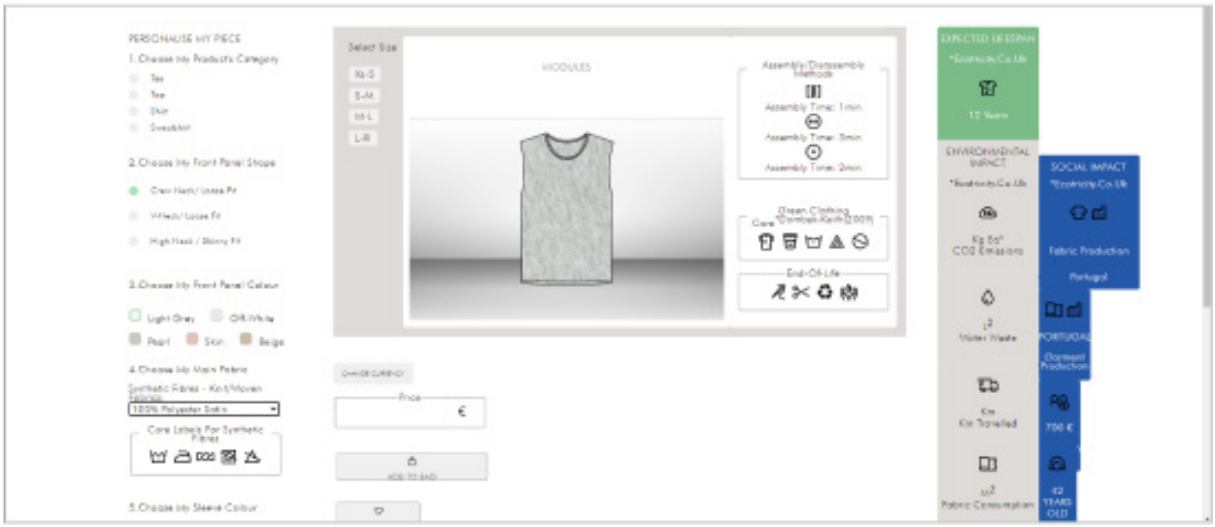


Figure 87 - Interface design – Experiment #3 - interaction

Another concern of projecting the “build” page interface was, from the beginning, the number of options that are needed to display in order to achieve an acceptable variety in proposed pieces and a good degree of playfulness.

In fact, the quantity of options displayed on the webpage at a certain time may overload the user with too many options to select from. A possible solution for this problem has been tested on experiment #4 (figure 88). Here further options remain hidden and become visible only upon previous radio button selection.

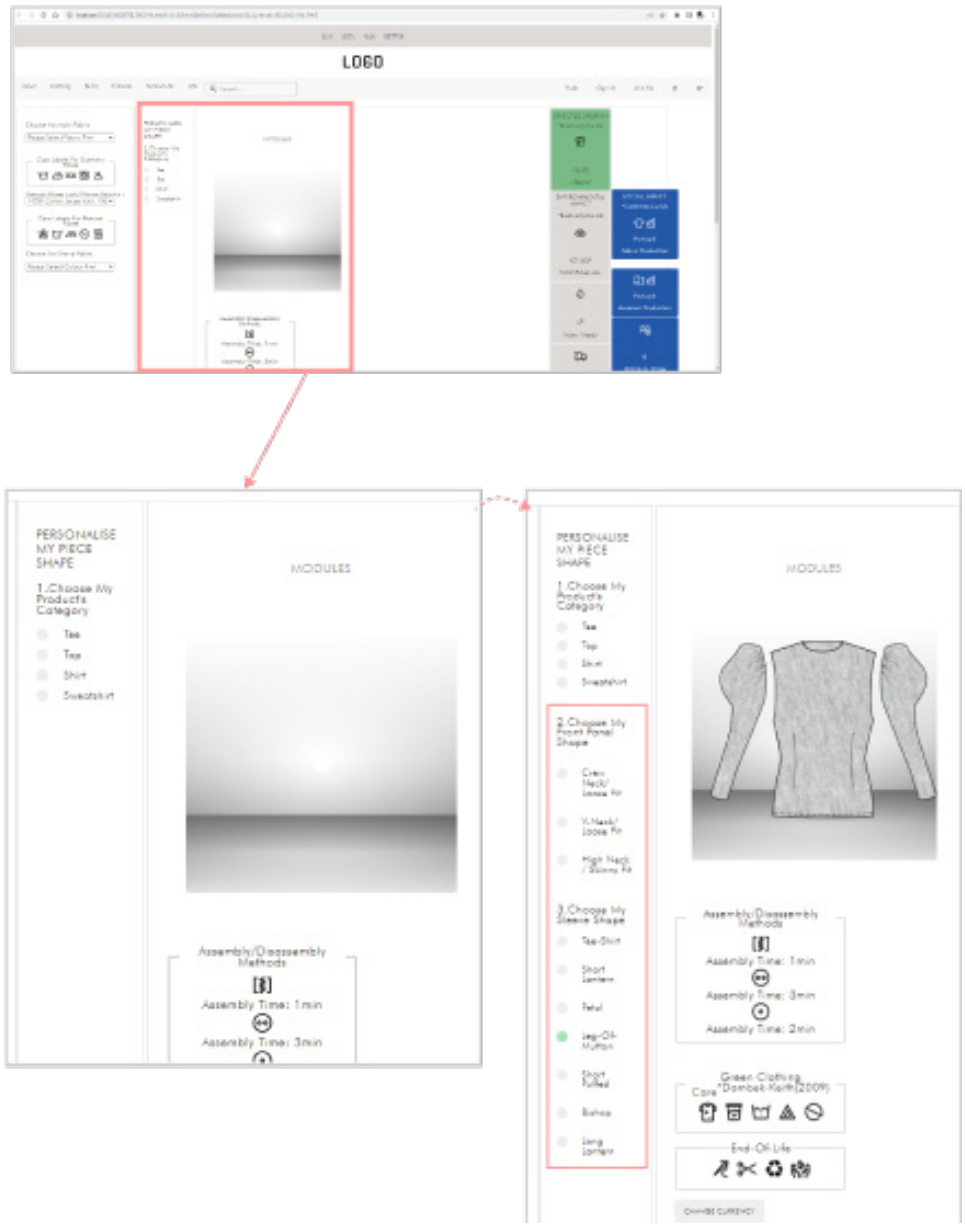


Figure 88 - Interface design – Experiment #4

As seen in figure 89, below, enabling the users to explore their capacity of transforming a piece into another with different use/occasions, by selecting/choosing the components of each garment allows wearers to become empowered as active contributors as they can personalise and participate in their wardrobe creation.

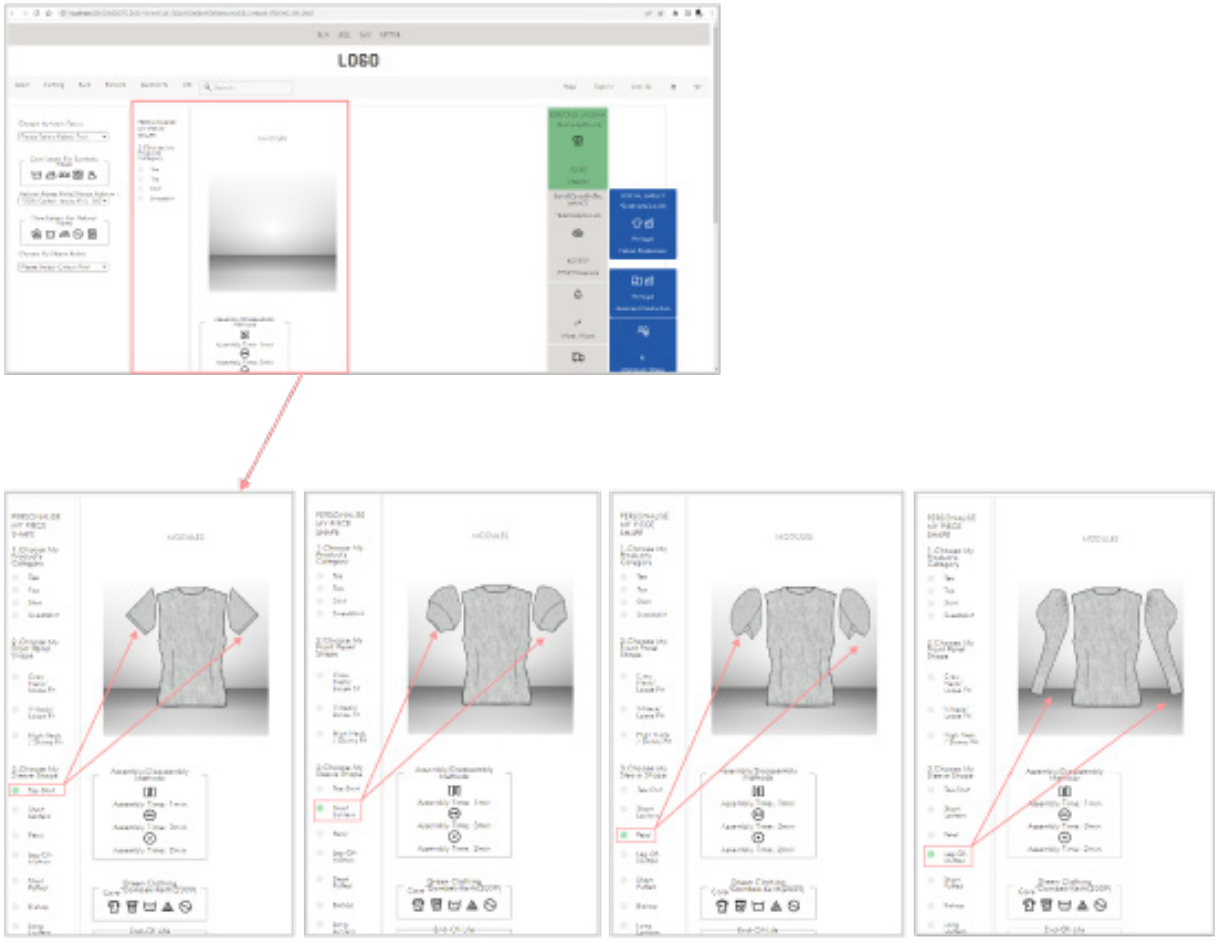


Figure 89 - Interface design – Experiment #4

ICONS & TOOLTIPS

With the objective of clarifying and minimising the use of blocks of text, the use of icons is fundamental in the design of the interface. That is evident in the evolution of the initial page mock-ups (figure 73 and 74).

Nevertheless, legibility (whether one can discriminate between icons or not) and interpretation (what it is that the icon is intended to convey) is always at stake due to the specificness of the themes involved and its technical jargon.

Referring to the informative sidenav (where information about a garment's lifespan, environmental and social impact is displayed), the legibility of the icons has been an issue throughout the whole process which is addressed when testing the model. The doubts refer to icon size and colour.

Moreover, as seen in figure 90, below, icons are used individually or in pairs aiming to

Figure 90 - Icon legibility testing (source: www.icons8.com)

achieve a certain meaning although the interpretation of the icon is also not a trivial issue. Even referring to an object might not translate its meaning. Also, aspects like size and contrast with its background colour is of concern.

Another pressing issue is when the use of icons is technical like washing up and clothing care instructions. Even under common use for decades, those icons are often disregarded as the user might not have the knowledge to decode its meaning.

For this reason, as seen in the next figure 91, the icons are accompanied by a tooltip – a pop-up textual label that appears to be effective and give extra help to the user to grasp its sense. This last one is triggered when the user hovers over the icon element.

Figure 91 - Interface design – Experiment #5 - Icons and tooltips

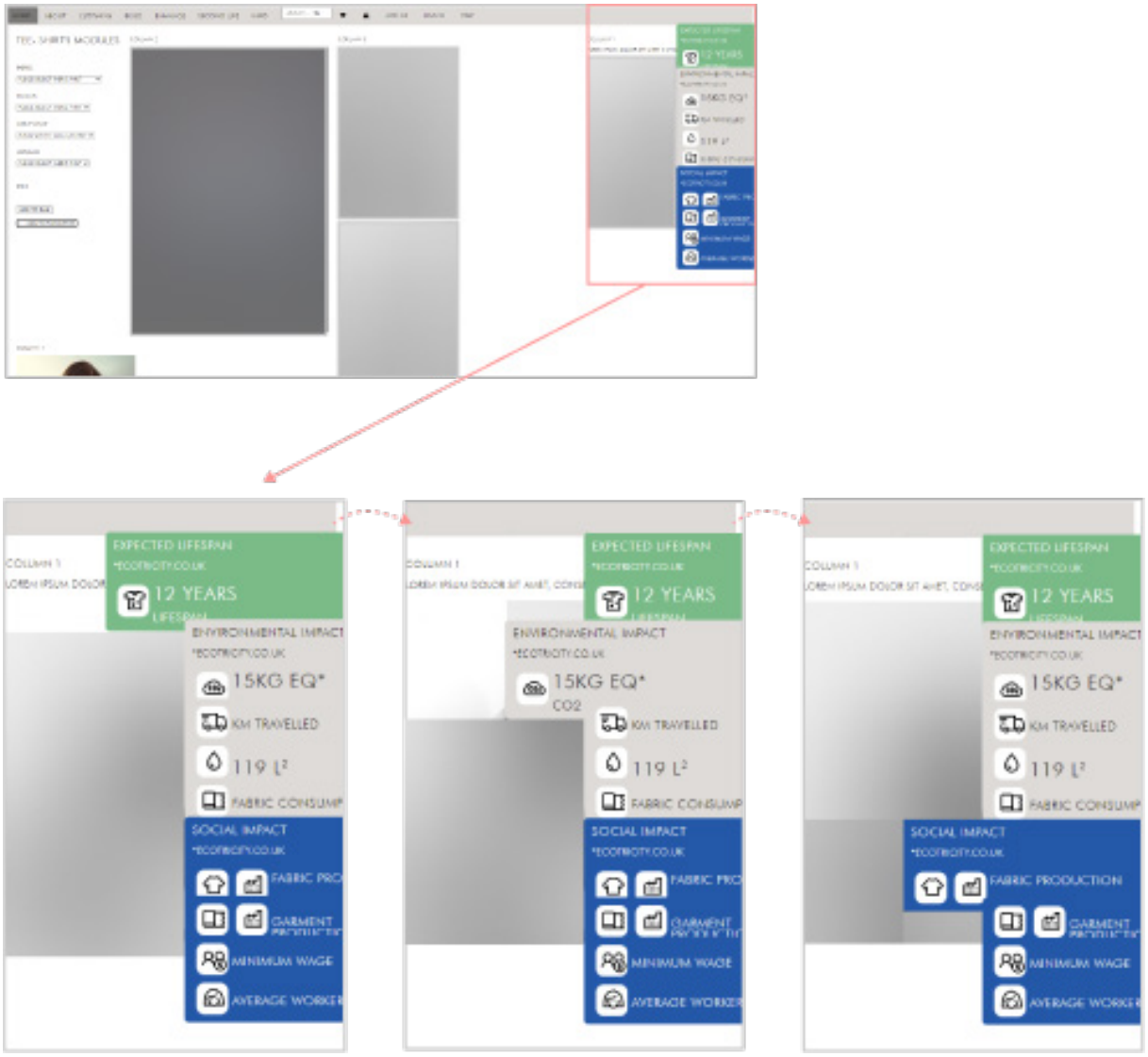


Figure 92 - IInterface Design – Experiment #1 - Hoverable “side nav” buttons

TOWARDS FINAL RESULTS

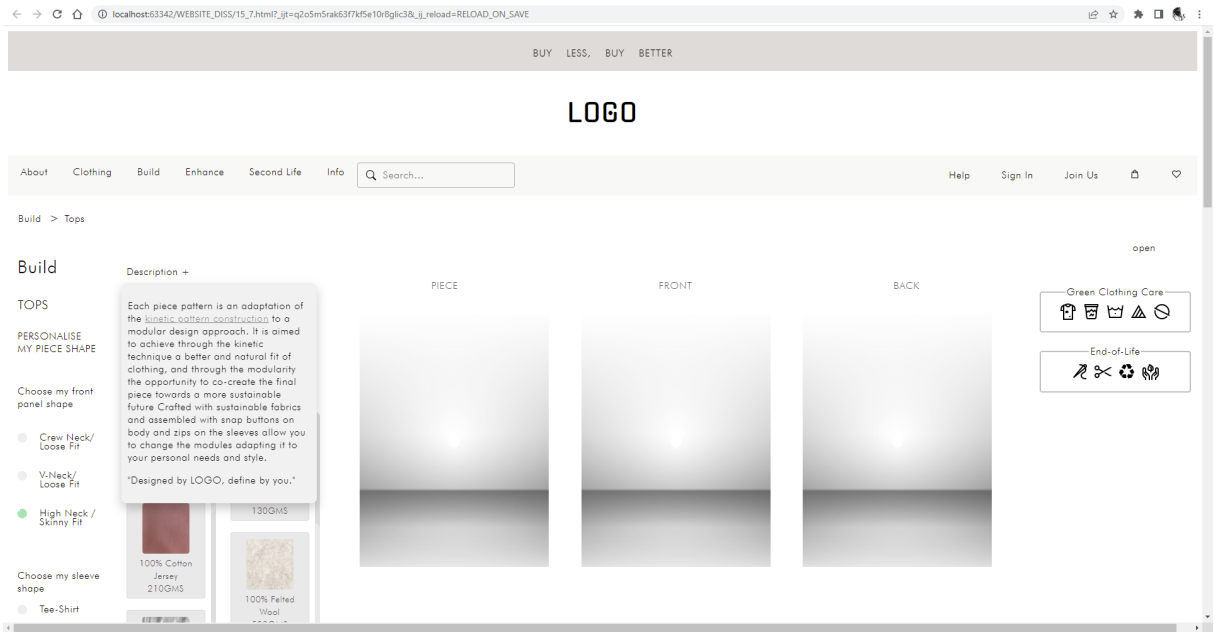


Figure 93- Interface design – Experiment #6

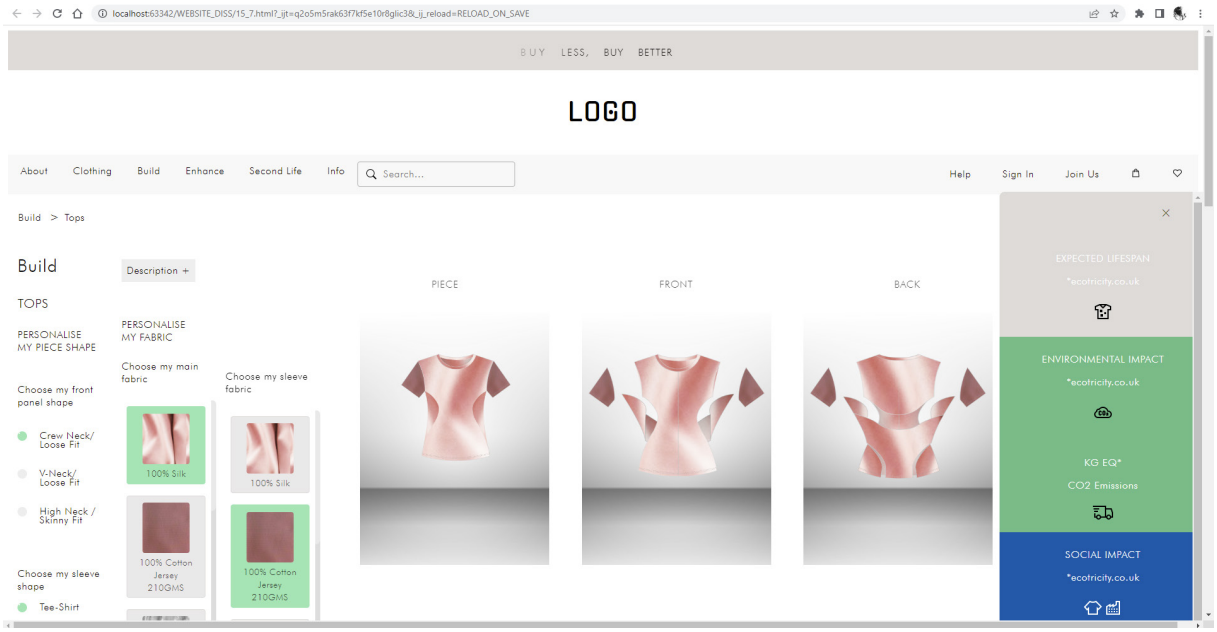


Figure 94 - Interface design – Experiment #6 - Interaction

6. EVALUATION

6.1 USABILITY TESTS

Testing usability is an important part of the design process because it allows the designer to identify the limitations of feasibility and then revisiting the initial concepts to identify other paths that can be explored as potential solutions. Before the final prototype development, evaluation/tests and analysis are projected to evaluate and observe users' actions and behaviour. The aim is that the digital artefact is going to operate as an integrated design platform - a technical foundation for a co-evolutionary garment design system.

Testing itself is an interactive process as it is performed within the design cycle: test, empirical measure, feedback, test analysis and redesign. And this process is repeated as many times as needed (GOULD ET AL., 1987, P. 758, cited in BENYON, 2014) by making design adjustments thus achieving better results (BENYON, 2014).

Understanding the user's behaviour is essential in designing any interactive solution that could reach the common user. The screen components, navigation and info/data provided must be incorporated with mechanisms to constantly instruct and guide the users. All these interaction features must contemplate users' diversity by being accessible and user-friendly (LAVIE & TRACTINSKY, 2004). For those reasons, usability evaluation plays a significant role (BENYON, 2014). With usability testing, two main principles are evaluated: ease of learning and ease of use.

In order to perform usability tests, the participants were previously selected taking into consideration the target public: all of them are adult females. A usability test script was previously elaborated (please refer to appendix for complete view) where four different use scenarios were described to users and then they were asked to perform specific tasks accordingly, which translate and reaffirm the proposed service. Those scenarios and tasks were specifically designed to assess if the service's substantial completion is deemed sufficiently completed to the point

where the user can use it for its intended purpose:

Task 1 – sustainability;

Task 2 – co-creation/customisation;

Task 3 – reshape and

Task 4 – repair service.

TASK COMPLETION - TASK 1 (SUSTAINABILITY)

Since your last online clothing purchase, you´ve been thinking to be more conscious about your next clothing choice as you become more aware of the importance of sustainability. Moreover, you would like to make sure that the tee-shirt you are purchasing is going to last so that you don't have to buy a new one in the next couple of months. Using this website, to buy a new tee-shirt, please show me how you can identify whether your choices are meeting your sustainability goals.

TASK COMPLETION - TASK 2 (CO-CREATION / CUSTOMISATION)

Imagine that you feel the need to acquire a versatile piece that can easily be converted from a casual working day tee-shirt to a fancier dinner-out top. Using this website, show me how you would identify and choose the different components/modules.

TASK COMPLETION - TASK 3 (RESHAPE)

Imagine that you´ve already purchased a piece that you would like to modify by adding new modules to complement it and achieve new looks. Show me how you would do it.

TASK COMPLETION - TASK 4 (REPAIR SERVICE)

Imagine that you need to repair a press button on a module that you purchased but you are not aware of where to go to fix it. Using the website, please show me how you would get that information.

The "ease of learning" can be estimated by measuring and comparing the time users take when interacting with an unfamiliar proposed system when compared with the time taken by users already familiar with the artefact. The "ease of use" perception can be estimated by

counting the number of operations required to execute the task successfully, although some operations might be significantly more complex, require more skill, or be more tiresome than others.

Objective factors such as task speed and number of user errors, and subjective user satisfaction are taken into consideration.

6.2 QUESTIONNAIRE - BEYOND USABILITY TESTS

Taking into consideration the goal of the developed interface, and the design process pursued, other considerations beyond usability are imperative to analyse (for analysis, please refer to appendix 2).

The usability test is complemented with a questionnaire (please refer to appendix 1) which, is divided into five sections:

- Briefly intent of the questionnaire;
- Participant's demographic info;
- Consumer habits;
- UI design;
- Attitude/Behavioural assessment

Concerning the answers to doubts, special emphasis is given to sections four and five. In section four - UI design perception and aesthetic and perceptual evaluation are made whilst in the fifth section- attitude/behavioural assessment enables us to confirm the strengths and weaknesses of the project´s concept. To help gauge it both 'Likert scale' and 'Differential Semantic scale' questions were used.

The ´Likert´ scale measures how much the users agree or disagree with statements, making it possible to assess their rationalised attitude towards them, whilst 'Semantic' differential scale measures where the users' view or attitude lies to a statement on a bipolar adjective scale.

7. CONTRIBUTIONS AND LESSONS LEARNED

7.1 DISCUSSION OF UNCERTAINTIES

As previously mentioned, the interface of the developed system should show the intertwined relations between the selection of resource materials and environmental /social impacts. The end-user can easily perceive the implications of their choices and make better-informed purchases. This is of great importance since, as previously mentioned, many products with "green label" claim environmental responsibility without the information to back it up (HO, 2003).

Moreover, it is aimed that the digital interface could work as a learning environment where information such as the garment´s expected lifespan, CO2 emission, water resources, material waste, materials provenience and labour source is given prior to clothing purchase and use (HUR, CASSIDY & THOMAS, 2013, PP. 14-15).

ESTIMATED LIFESPAN

Despite the fact that the data used to create the side info panel model shall be as precise, complete, consistent, and representative as possible with regards to the goal and scope of this study, a few issues arisen during the research process. For instance, the information regarding the lifespan of clothing items was and is hard to grasp as the studies that have been conducted present quite substantially different results (LAITALA & KLEPP , 2015). Moreover, the factors that determine a garment's lifespan are diverse and complex. Despite this fact, providing information regarding the lifespan of a product is an essential point that taken into consideration might help users to choose the fabric of her/his/hir piece more consciously.

The lifespan of all garments has been estimated at 1-3 years (BETON ET AL, 2014 AS CITED IN LAITALA & KLEPP, 2015) whereas other study points out 3.3 years as average active use (LANGLEY ET AL., 2013, CITED IN LAITALA & KLEPP , 2015). Others conclude that the average number of years the clothing owned by 40 years old women is 7 years (KLEPP, 2011) against 5.2 years (LAITALA & KLEPP, 2015).

As mentioned before, the lifespan of an item is the result of a lot of factors which makes it very difficult, almost impossible to analyse all of them in just one study. The nature and quality of the fabric that compose the garment itself have a significant impact on the product handling (determined by characteristics such as its thickness, stiffness and shear qualities and its friction, abrasion, and extension capacities) which affect its garments endurance and appearance during the wear and therefore its lifespan. In fact, clothing with defects is disposed of six months earlier than average (LAITALA & KLEPP, 2015).

Even here, the cultural, social and personal tolerance towards those "defects" plays a huge role: colour bleeding while washing reduces the average lifespan by about 2.5 years, whilst washed out clothes actually increase to 10.9 years, 5.5 years above the average (LAITALA & KLEPP, 2015).

More recently, another Dutch study which considered the owner's own estimation of garment's lifespan indicates that the average lifespan of some items is as follows: t-shirt 6.8 years; sweaters 7.1 years, skirts and dresses 15.2 years, trousers 6.2 years, blazers 11.5 years and jackets 11.6 years (UITDENBOGERD, BROUWER, & GROOT-MARCUS, 1998, P. 127 AS CITED IN LAITALA & KLEPP, 2015).

Age is a comprehensive factor that determines the length of clothing lifespan. Children and teenagers have the shortest length of clothing lifespan while adults above the age of 51 disposed of 4.6 years older clothing than the average (LAITALA & KLEPP, 2015).

Another important and relevant factor in the scope of this dissertation is how the level of control the users have in relation to the item he/she owns affects dramatically the length of clothing lifespan. The most unused items are the ones that the user didn't have any input on at the time of purchase such as gifted or inherited clothing.

In truth, how the items are acquired often affects their active use period. The most unused clothes are often the ones not tried on before purchase, or that were bought on sale (LAITALA & KLEPP, 2015).

Important to mention is that any given information regarding the clothing lifespan is only relevant if it can be matched by the time of active use. In fact, if each garment is worn twice before disposal its CO2 emissions are reduced to half, energy used is 42% reduced and water scarcity impact is 48% reduced (SANDIN ET AL., 2019).

Moreover, the functionality of the garment itself dictates the number of times a garment is used therefore affecting its care and maintenance. Laundering habits have a major influence in how a clothing item shall endure over time.

Assuming each item owned is worn and washed evenly an equation can be extrapolated (reference of the Global Laundering Study consumer data as cited in Cotton LCA Full Report Update 2016).

$$Lifetime \times Loads = Lifetime$$

According to this, the calculated washings for the lifetime of a t-shirt is 18, 22 washings

	Description	T-Shirts	Casual Collared Knit Shirts	Casual Woven Pants
Lifetime	Average months a garment is owned and worn on a regular basis (first life)	38.8	40.9	43.9
Loads	Average number of washings per month	7.0	5.0	4.5
Garments	Average number of garments owned	14.9	9.2	8.4
Lifetime$_G$	Total Washings in a Lifetime (first lifetime)	(38.8 x 7.0) / 14.9 = 18.2	(40.9 x 5.0) / 9.2 = 22.2	(43.9 x 4.5) / 8.4 = 23.5

Table 14 - Summary of Cotton Council International and Cotton Incorporated's Global Laundering Study data (Cotton LCA Full Report Update 2016. Retrieved July 2022 from https://cottoncultivated.cottoninc.com/2016-global-cotton-lca-full-report-update/)

for a casual collared shirt, and 24 washings for a pair of woven casual slacks.

ENVIRONMENTAL IMPACT

Despite abundant literature regarding the subject, information regarding environmental impact is hard to grasp because different studies have different metrics. Some studies have a cradle-to-cradle approach whereas others study the cradle-to-grave or even cradle-to-gate impacts

Some studies evaluate the impact of the garment piece whereas others are focused on fabric's weight.

Important is to note, that for the time being and considering the main purpose of the presented research, average values were calculated with awareness of and accepting the possible insufficient accuracy.

USED "ENVIRONMENTAL IMPACT" INFO DESCRIPTIONS

Kg CO2 equivalent (IPCC, 2013 cited in Cotton LCA Full Report Update, 2016) is the unit measure that translates the Global Warming Potential (GWP100). It measures greenhouse gas emissions such as CO2 and methane – the ones causing an increase in the absorption of radiation emitted by the earth, increasing the natural greenhouse effect which impacts harmfully both human and ecosystem' s health.

Initially it has been used Cubic metres of water (L^3) (thinkstep, 2014 cited in Cotton LCA Full Report Update, 2016) but along the way it became clear that this unit measure would not be suitable as the Blue Water Use (BWU) - amount of freshwater withdrawn from a watershed - is not an indicator of environmental impact without information about regional water availability. Therefore, this was later substituted by Litres of water equivalent (H2Oe) (PFISTER, KOEHLER, & HEL, 2009 CITED IN COTTON LCA FULL REPORT UPDATE, 2016) that measures Water Scarcity Footprint (WSF). This value refers to the amount of stress on water deprived regions. Using the water stress index (WSI) calculates the total annual freshwater withdrawals to hydrological availability.

KM TRAVELLED

The km travelled were estimated assuming road transportation means and based on all the km travelled during all phases of the product cycle:

- the physical distance between the location where the source fabric is produced;
- the distance between the location where the item's production would be eventually made;
- the distance between where the item is produced and the location of the end user
- the distance between where the user is and the EoL(end-of-life) location.

M2 FABRIC WASTE

For the time being, the m2 fabric waste is an estimated value based on previous studies that were conducted using conventional methods of cutting fabric and convencional clothing pattern markers. Further studies need to be made in order to adjust them to modular kinetic pattern markers. As reference, the values of the table 15 were taken into consideration.

In this particular study it is considered the average garment's weights, with the full awareness that those are not specific to garments variations that might influence its weight

(factors such as presence or absence of trims, number, and types of zips, press buttons, studs, pockets or aesthetic design elements)

Garment Type	g*/Garment	Cut-and-Sew Loss (%)	# of Garments/1,000 kg of Garments
Knit Collared Shirt	305	15.2%	3,278
Knit T-shirt	225	15.0%	4,444
Woven Pants	513	12.4%	1,949

*Grams of cotton per garment.

Table 15 - Mass of garments, cut-and-sew loss, and number of garments per 1,000 kg of finished garment (Cotton LCA Full Report Update 2016. Retrieved July 2022 from https://cottoncultivated.cottoninc.com/2016-global-cotton-lca-full-report-update/)

7.2 LIMITATIONS AND DIRECTIONS FOR FUTURE RESEARCH

The research presented has some limitations that are translated on the end results. Firstly, an almost certain confounding factor might have influenced the results - the fact that the website is projected in the English language – a second or third language to all users. At least one of the tests was performed by a person who is not familiarised at all with the language which demanded special guidance when performing certain tasks. For future research it would be interesting to make the test among native English speakers.

Another possible contaminating factor in this study relates to aesthetic and cultural values. For instance, considerations regarding the website's overall aesthetic could be influenced by it. One might speculate that if the test would have been among North European people, their sense of functionality and simplicity would be reflected in their opinion whereas, users in Portugal (where the tests were conducted) stressed the lack of colour because they don't share the same aesthetic notions.

INCREASING THE DEGREE OF CO-CREATION

The project at hand contemplates co-creation at a late stage when the garment is about to be delivered to the customer. Ideally, co-creation should be extended at all phases of the ser-

vice/product including the ideation of it. In fact, a higher level of consumer involvement in the preliminary stages, "idea-generation" and product concept development stage results in higher performance products (GRUNER AND HOMBURG 2000, CITED BY HOHER ET AL., 2010) and decreases the risk of failure. This could be achieved by engaging focus groups in the concept development process and actively seeking their input.

TRACKING THE ACHIEVEMENT OF THE GOAL OF EXTENDING THE CLOTHING LIFESPAN

To assess the overall success of the proposed service, the actual advantages and benefits of co-creation value need to be justified. In fact, the link between trial and repurchase (when more modules are acquired after the first garment by the same individual), overall sales, returns for repair or for further enhancement, need to be measured and revealed. Hence, further work needs to be developed and metrics that allow monitoring the value co-creation efforts comprehensively need to be developed in terms of back-end coding and database implementation.

FURTHER REALISM

Grasping digital objects such as clothing as a duplication of not-yet-developed garments as synthetic actors in a natural way raises some design issues (MAGNENAT-THALMANN & THALMANN, 1989; 1993).

The way the garment looks depends on the material/fabric selection, and the way it behaves (regarding the fabric's physical properties), different body fit as well as, body movement. Controlling the way a garment appears is hard to grasp.

Fortunately, nowadays great software exists that helps with this task. For instance, CLO 3D is a fashion design software program that not only creates "true-life garment visualisation" but also allows the construction of production-ready patterns. Despite this, considering the time restrictions of the project, only vectorial images were used leaving the CLO 3D image modelling for future work.

8. CONCLUSIONS

We aimed to create a meaningful, engaging and persuasive design proposal that could contribute to study a possible solution with the inherent complexity challenge of the Fashion Sustainability goal. Fashion's strong influence on culture and zeitgeist has the potential to positively influence motivations and achieve behavioural changes. This aligned with conceptualisation of a website is hoped to target the mainstream mass-market level.

Making people actively engage in co-creation enhances the chance of creating a different relationship between the user and the garment purchased. This is relevant because as stated before, at last instance, it is the user's willingness of maintaining and actively using the clothes that mainly contributes to increasing the length of clothing lifespan. Moreover, achieving co-creation through interactivity enhances that bond further. During this process of co-creation, it is also crucial to inform the customer so that he/she/ze can make choices more consciously regarding its social and environmental impacts.

Comfort, good fit, as well as fashionability, are factors that should be addressed when developing the product. Moreover, the use of eco-fabrics and transparency when providing both fabric and practices information are key factors for brands/product loyalty and increasing further engagement.

Thinking about sustainability as well as creating interactive co-creation experiences is putting people first, reckoning their diversity and emotional state. Hence, design is not a linear process but a dynamic one, changing overtime through trials and testing.

Accepting the failures as an opportunity to get precious feedback from users and peers allows the designer to understand what does not work despite preconceptions enabling the process to move forward in a constant evolution.

In conclusion, the design of "A Service and Interaction Design Case Towards Sustainable Transitions in Fashion" is about the Design Process, about discovery, sustainability and joy.

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10. APPENDICES

APPENDICE 1 - QUESTIONNAIRE

After the Usability Test, a Questionnaire was made to the participants through Google Forms application as follows:

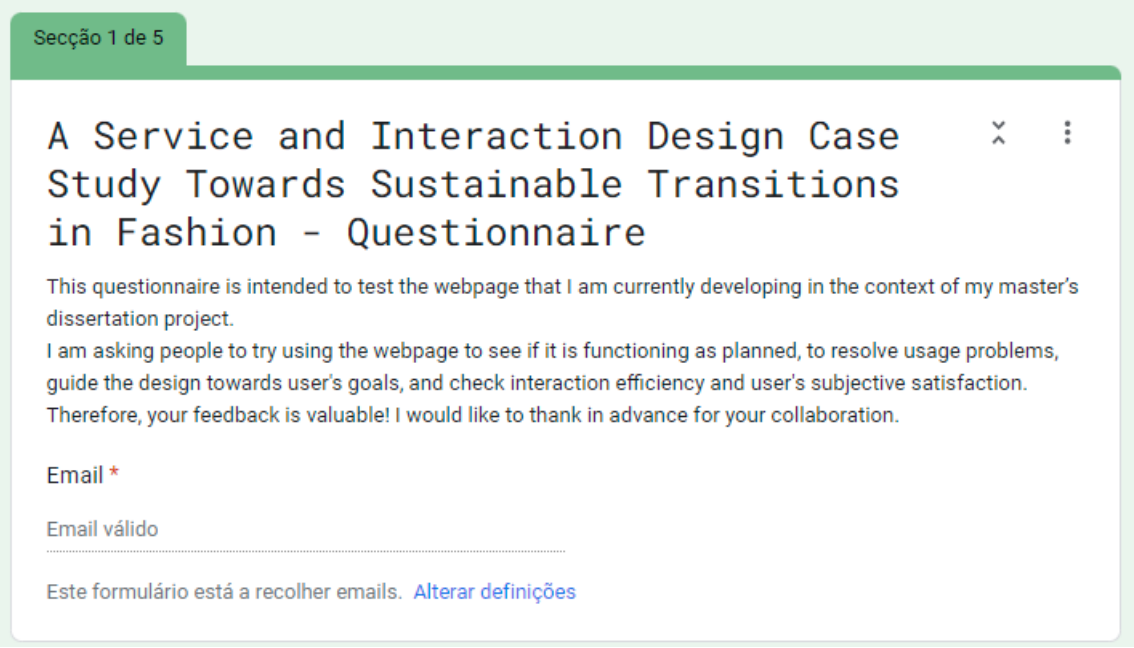


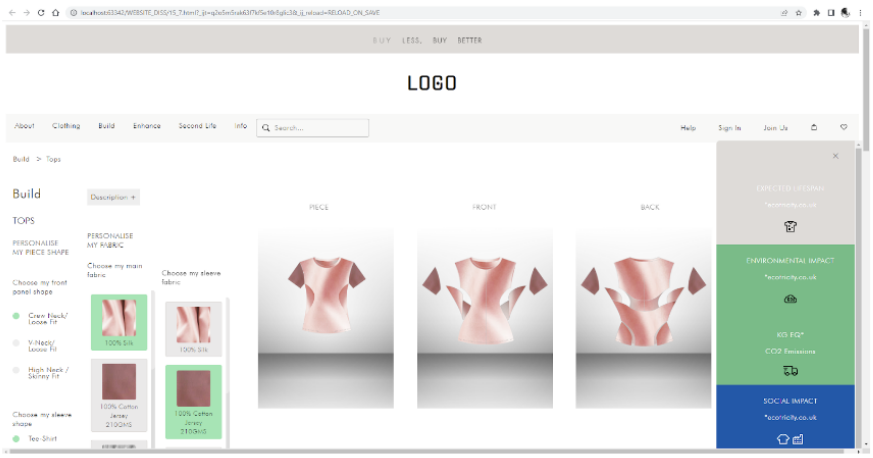
Figure 95 - Questionnaire - Intro

Secção 2 de 5

PARTICIPANT DEMOGRAPHICS

Descrição (opcional)

Interface Design



1.What is your age group? *

- [ ] 18-25
- [ ] 26-35
- [ ] 36-45
- [ ] 46-55
- [ ] 56-65
- [ ] Outra opção...

2.What is your gender identity? *

- [ ] Male
- [ ] Female
- [ ] Non-binary/Agender
- [ ] Third gender/Pangender
- [ ] I prefer not to say
- [ ] Outra opção...

Após a secção 2 Continuar para a secção seguinte

Figure 96 - Questionnaire - Participant Demographics

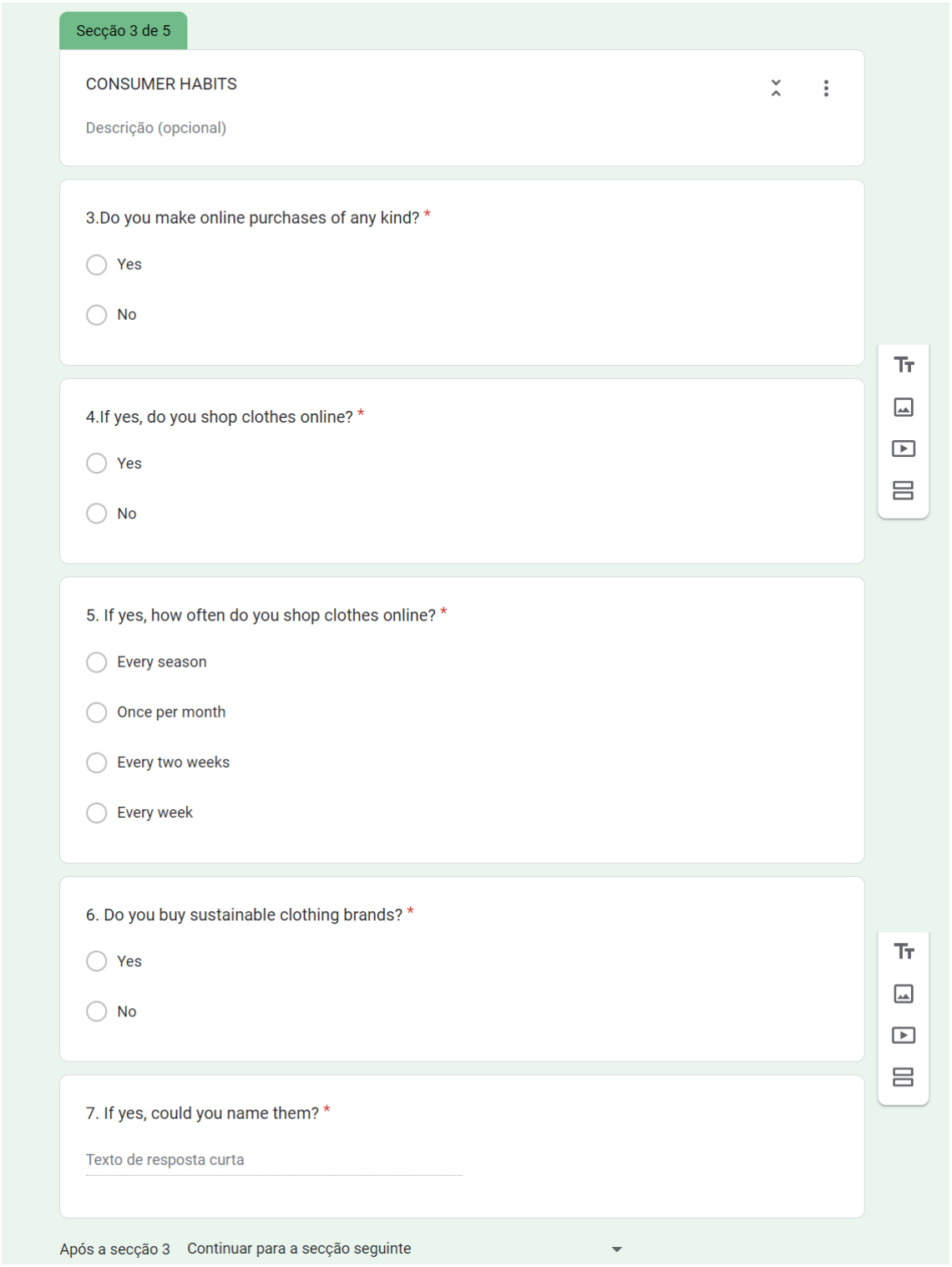


Figure 97 - Questionnaire - Consumer Habits

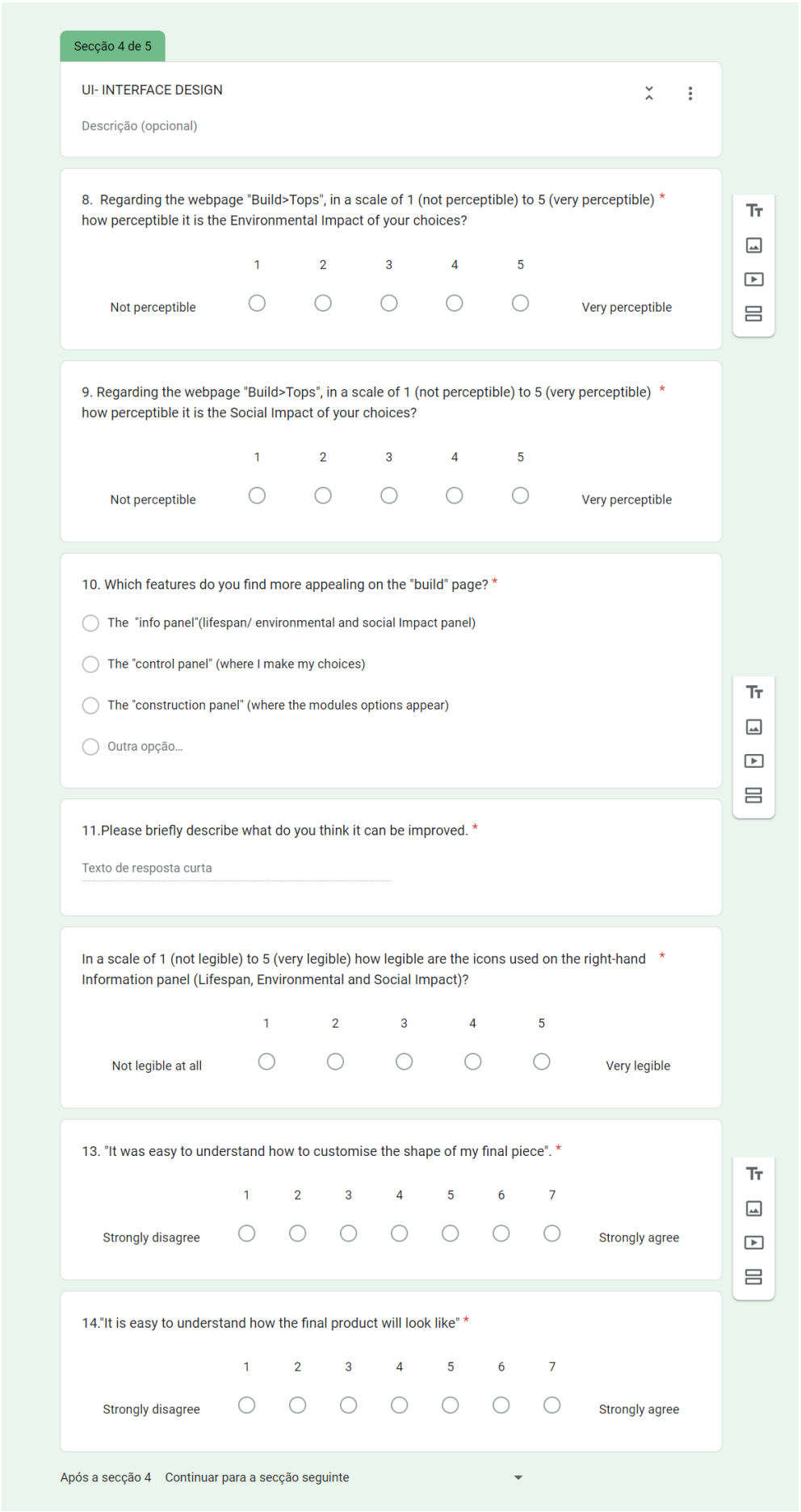
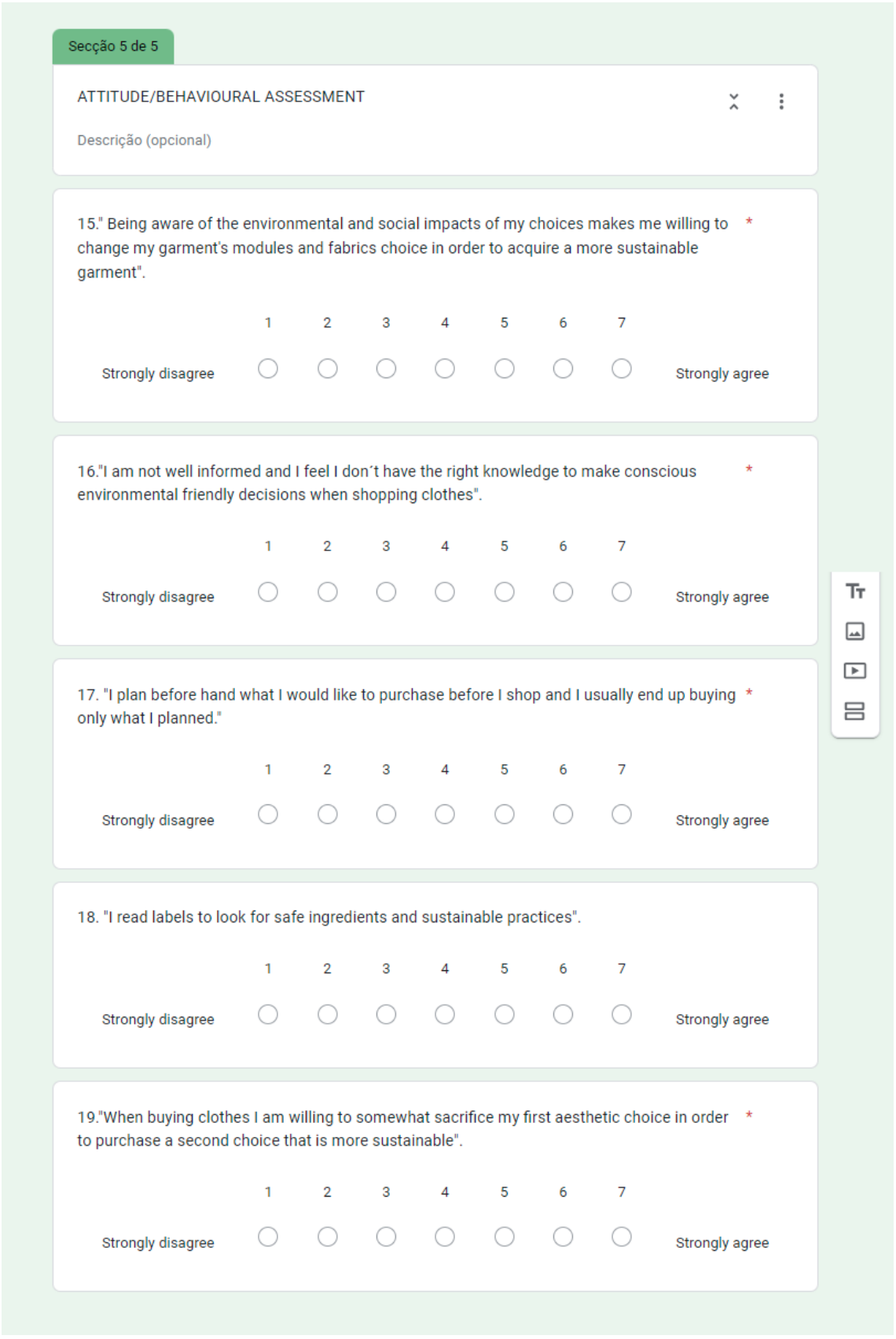


Figure 98 - Questionnaire - UI-User Interface


Secção 5 de 5

ATTITUDE/BEHAVIOURAL ASSESSMENT

Descrição (opcional)

15." Being aware of the environmental and social impacts of my choices makes me willing to change my garment's modules and fabrics choice in order to acquire a more sustainable garment". *

	1	2	3	4	5	6	7	
Strongly disagree	○	○	○	○	○	○	○	Strongly agree

16."I am not well informed and I feel I don´t have the right knowledge to make conscious environmental friendly decisions when shopping clothes". *

	1	2	3	4	5	6	7	
Strongly disagree	○	○	○	○	○	○	○	Strongly agree

17. "I plan before hand what I would like to purchase before I shop and I usually end up buying only what I planned." *

	1	2	3	4	5	6	7	
Strongly disagree	○	○	○	○	○	○	○	Strongly agree

18. "I read labels to look for safe ingredients and sustainable practices".

	1	2	3	4	5	6	7	
Strongly disagree	○	○	○	○	○	○	○	Strongly agree

19."When buying clothes I am willing to somewhat sacrifice my first aesthetic choice in order to purchase a second choice that is more sustainable". *

	1	2	3	4	5	6	7	
Strongly disagree	○	○	○	○	○	○	○	Strongly agree

Figure 99 - Questionnaire - Attitude/ Behavioural Assessment

APPENDICE 2 - RESULTS ANALYSIS

The test was conducted among six Portuguese adult women aged between twenty-one and sixty-three years old (figure 100). All of them have general online purchase habits (figure 102) with only one of them not buying clothes online (figure 103).

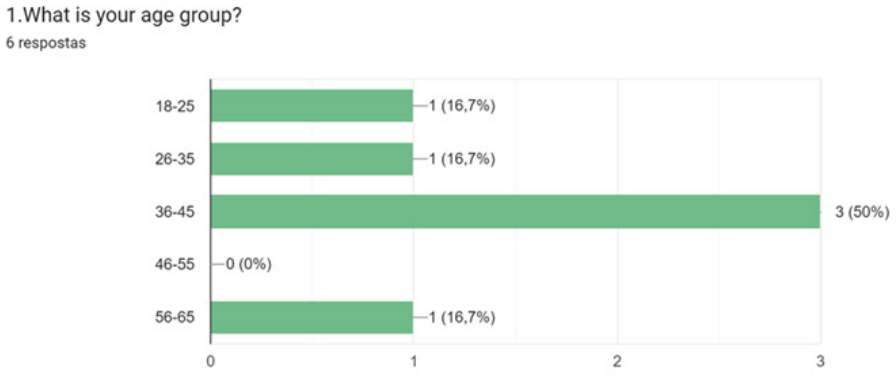


Figure 100 - Participant's age group.

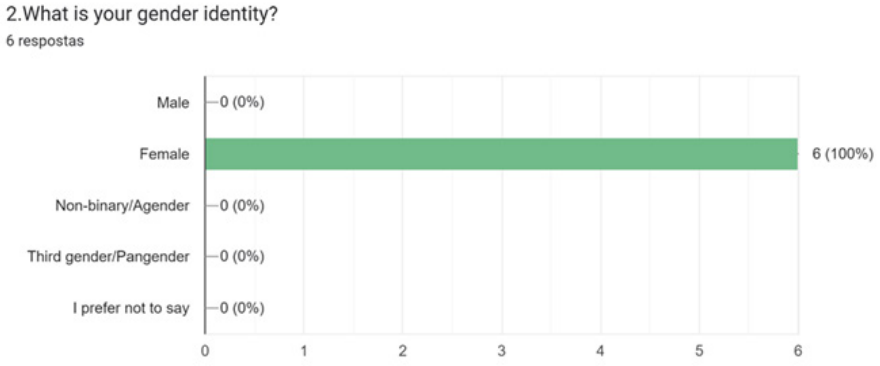


Figure 101 - Participant's gender identity.

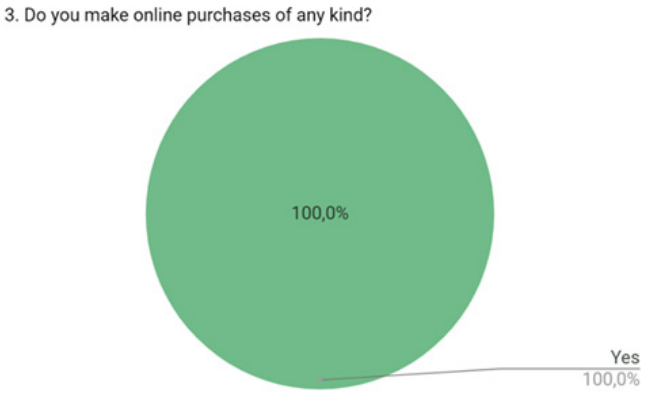


Figure 102 - Participant's Online purchases habits.

Two of the six women interviewed assumed that they don't buy sustainable clothes by stressing the fact that and quoting "truly sustainable clothes are too expensive".

Figure 103- Participant's Online clothes purchases habits.

Figure 104 - Participant's Online clothes purchases frequency.

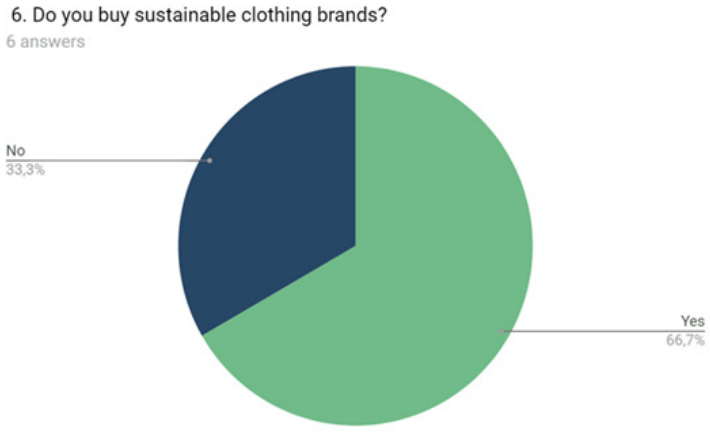


Figure 105 - Participant's Online sustainable clothes purchases habits.

Those remarks presume that those women are well informed and aware that a lot of "green" clothing available is not truly sustainable and greenwashing marketing strategies are in

place (please see subsection 2.1.3).

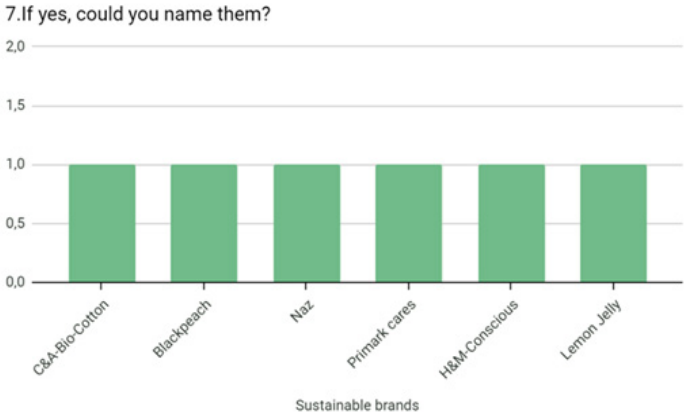


Figure 106 - Sustainable Brands

All the brands pointed out by the users as being sustainable belong to the fast fashion sector. The most well-known C&A-Bio-Cotton, Primark Cares and H&M-Conscious are sub-labels of allegedly sustainable products. Lemon Jelly is a local shoe and accessories brand (made in Portugal), a PETA (People for the Ethical Treatment of Animals) approved vegan using recycled and recyclable components and produced with 100% renewable energy therefore sustainable. Naz is also a local Portuguese clothing brand that provides total disclosure regarding who and where its production is made as well as product sourcing. Transparency, sustainability, and respect are their values as a brand. Unfortunately, despite being local, Blackpeach is a non-sustainable Portuguese brand which, reveals that not all users are aware of Sustainable practices.

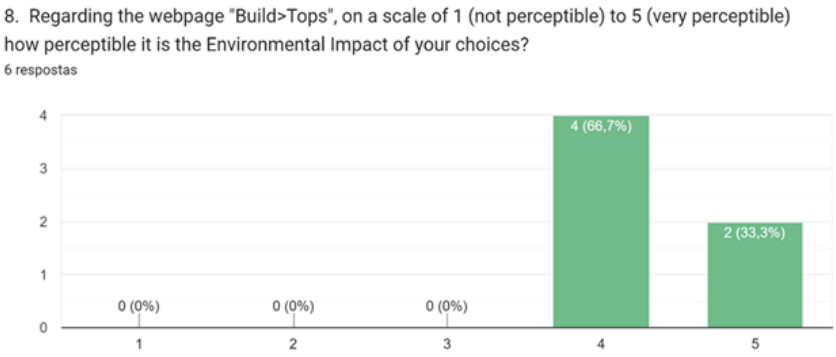


Figure 107 - Semantic differential scale question – Environmental

According to the UI-User Interface assessment, regarding the information side panel and comparing the Environmental and Social Impact (figure 111) panels' perceptiveness the first one

seems to be more unanimously perceptive than the other.

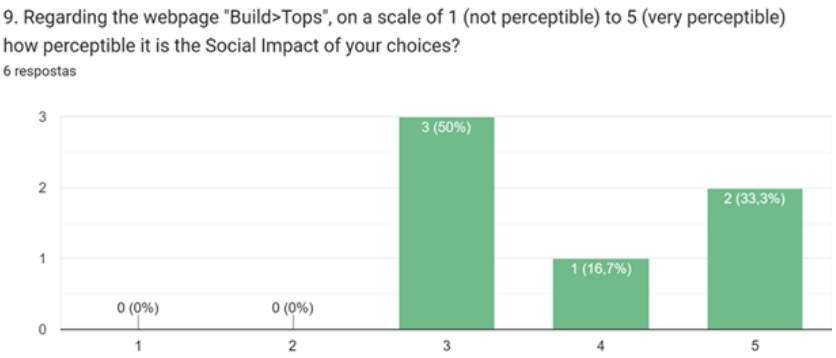


Figure 108 - Semantic differential scale question - Social Impact perceptiveness

This might be justified for its location (above the Environmental panel) that implies a "mouse hover" on it to be fully visible.

Important note is to say that on a website, despite common assumptionpresumption, the visual attention /search is not from left to right, or clockwise rather than anti-clockwise, because the visual attention is drawn towards features which are large, bright, and changing (BENYON, 2014).

For this reason, despite the information side panel being hidden when the interaction begins it is later triggered, after the fabric selection, becoming visible on the right-hand side of the screen. The movement when it appears, and its contrasting colours draw the user's attention.

As seen in the results (figure 111) the level of perceptiveness is not equal for all users. In fact, attention is a processing power that varies from person to person (KAHNEMAN, 1973 cited in BENYON, 2014) with a lot of variables interfering with it. The state of arousal is the most expressive one.

Despite the diverse opinions gathered, as seen in figure 109 below, the "control panel"

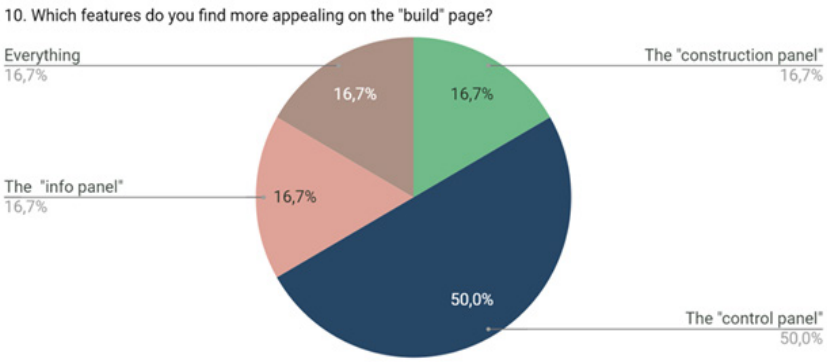


Figure 109 - More appealing aspect of the "Build" pagel perceptiveness.

where people make and select their choices regarding the shape and fabrics of their items is still the one that is favoured over the others.

An open question was made to assess users' opinions regarding what could have been improved. To sum up the answers a circular graphic was made, as seen in figure 110, below.

As previously reckoned beforehand, during the design and implementation process, the

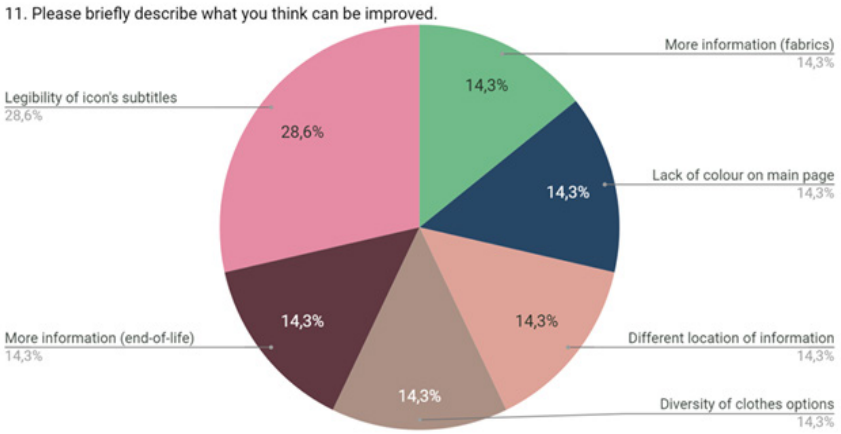


Figure 110 - Sum up of things that can be improved.

feedback from the users confirmed legibility issues. The icon's legibility was the main relevant point that should be improved, also assessed by a direct question. Also, the location of the lifespan information was pointed out by one user.

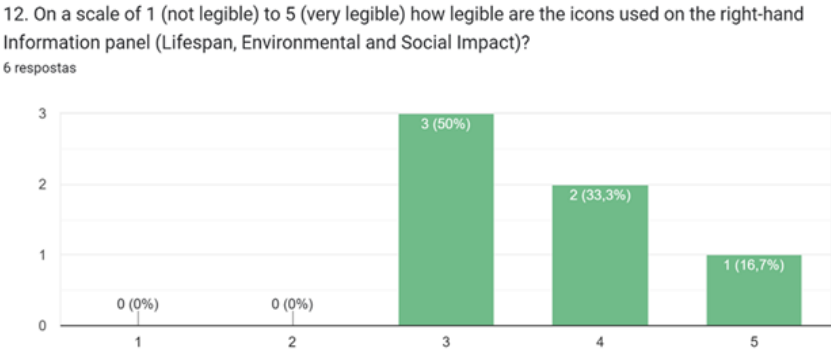


Figure 111 - Semantic differential scale question - Icons legibility assessment.

Regarding the content, the lack of information regarding the end-of-life of the product as well as additional information regarding the fabrics used was also remarked. Moreover, the diversity of clothes options was commented on.

Lack of colour was another factor that should be of improvement.

Summing up, the use of the chosen icons may reveal some ambiguity among not technological experienced users as they might think the icon features operations and therefore requires action.

In the lateral information panel, a better distinction between the space of each element

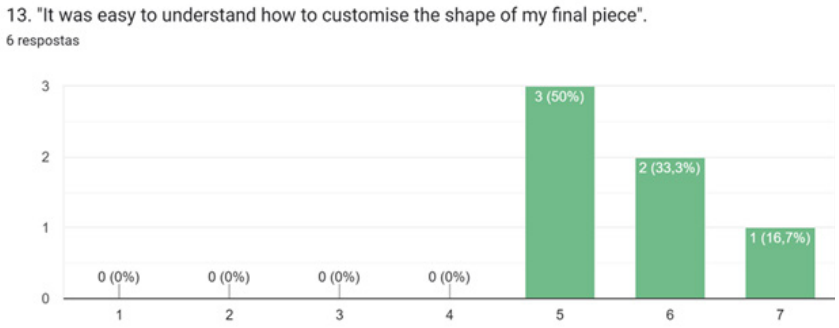


Figure 112 - UI – User interface assessment – Likert scale question – 1/2

needs to be considered so that the right subtitle needs to be visually linked to the corre-

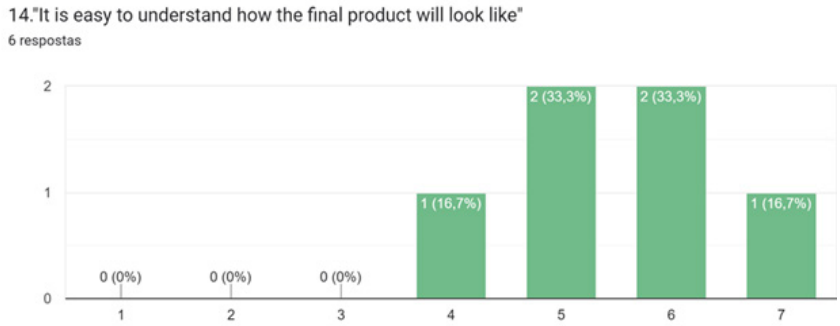


Figure 113 - UI – User interface assessment – Likert scale question – 2/2

spondent icon.

As every icon is distinct from all others in commonly used websites, the predominant importance of the icon's concept against its ambiguity needs to be further explored. Still, the use of more labels or even additional icon documentation might resolve some of that ambiguity.

The possibility of other overall combinations of colours needs to be tested.

Regarding the display of the output (where the front and back views of the final piece are displayed) it seems that those images spontaneously suggest the intent concept to the viewer.

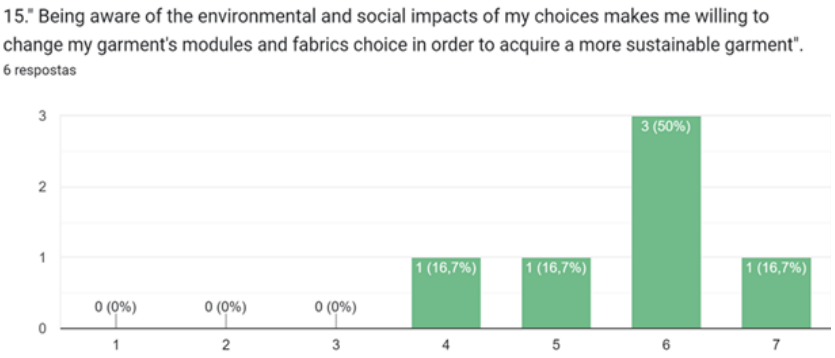


Figure 114- Attitude/behavioural assessment – Likert scale question – 1/5

Figure 115 - Attitude/behavioural assessment – Likert scale question – 2/5

Figure 116 - Attitude/behavioural assessment – Likert scale question – 3/5

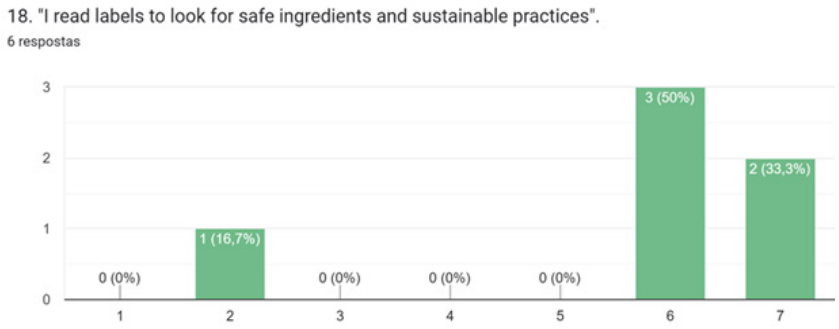


Figure 117- Attitude/behavioural assessment – Likert scale question – 4/5

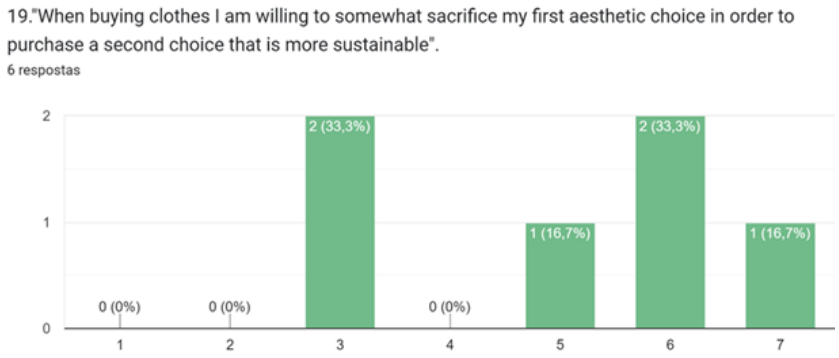


Figure 119 - Attitude/behavioural assessment – Likert scale question – 5/5

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