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# The role of redesign on product circularity: an analysis of the fashion industry

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## Abstract

The circular economy theme was placed at the centre of this study to analyse the role of the redesign phase in the circularity of products. The fashion industry was chosen for analysis as much attention has been paid to the environmental impacts of this industry over time. Through a literature review, this paper contextualises the analysis from a circular economy perspective and delves into the existing literature contributions on the so-called R-strategies. The research then focuses on the redesign strategy, which then directs the focus to subcategories of the analysis, such as design strategies, eco-design and design for the environment. An in-depth literature review on these topics served as the basis for the development of the study framework, which presents the main design strategies to promote the circularity of products. The research was conducted through a qualitative exploratory research, in which interviews were conducted with 5 companies to analyse the impact of design practises in promoting circular economy in companies in the fashion industry. The main results obtained concern both the contribution to literature and the contribution to management. On the one hand, this study contributes to the literature related to the circular economy and its implementation in a company; on the other hand, the work could provide insights into the decision-making process of a company when planning product strategies that are in line with the circular economy concept. The relevance of the study lies in the fact that the potential of design in promoting product circularity has not been fully explored. Therefore, this research contributes to both theory and practice by providing a new field of analysis in the literature on this topic.

Keywords: circular economy; design strategies; eco-design; redesign; fashion industry; product circularity

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## 1) Introduction

The linear economy is a take-make-waste model in which goods are produced from raw materials, sold, used and then incinerated or disposed of as waste when they reach their end-of- life (Neves & Marques, 2022). Huysman et al. (2017) point out that "a linear economy approach results in many environmental challenges: resources become depleted and end up as waste and emissions". The European Commission (2011) has already stated that the transition to a resource-efficient and ultimately regenerative circular economy is one of the solutions to be adopted.

There are many different definitions of the circular economy (CE) in the literature (Kirchherr et al., 2017). In their review of 114 CE definitions, Kirchherr et al. (2017, p. 224) define CE as "an economic system that is based on business models which replace the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes". The authors also highlighted that in a CE model, products are designed for longevity and durability. When they reach the end of their life, they are used as parts for a new product or recycled instead of being discarded. The CE brings in the idea of restoration and replaces the traditional concept of end-of-life, shifting to the use of renewable energy and aims to eliminate waste through the superior design of materials, products, systems and business models (Michelini et al., 2017). The CE is widely promoted as an alternative model of production and consumption, a growth strategy that enables the 'decoupling' of resource use from economic growth, contributing to sustainable development (Reike et al., 2017). Through this process, the life cycle of products is extended, and more attention is paid to the activities that maintain value in the form of energy, labour and materials. While such decoupling is intuitively appealing, the actual transition to new, circular modes of production and consumption implies a holistic undertaking with far-reaching technical, economic and societal implications (Koehler et al., 2019). The implementation of a CE requires the adoption of some circularity strategies, namely the 3Rs model, which stands for the three main strategies of Reduce, Reuse and Recycle (Manickam & Duraisamy, 2019). As the topic of the CE has become more prominent in the literature, the 3Rs model has evolved to include more R-strategies. Apart from the fact that there is no consensus on which 'R' model is considered the most accurate to support CE, there is a consensus in the literature that a CE requires human economic activities in line with the 3 Rs strategies (Xing et al. 2017; Shao-ping & Yun-jie, 2010). While the original 3 Rs model includes Reduce, Reuse, Recycle, the 7 Rs model introduces 4 new circularity strategies, namely Redesign, Repair, Renovate and Recover (Manickam & Duraisamy, 2019). These additional strategies focus on different phases of the product life cycle.

Among them, the Redesign phase is one of the most important ones as it is responsible for defining the key requirements of the product and thus has a strong influence on all R-strategies (Johansen et al. 2022; Iacovidou et al., 2019; Eriksen et al. 2020).

Many authors have explored the concept of CE to arrive at a clear and embracing definition (Ghisellini et al., 2016; Kirchherr et al., 2017; Velenturf and Purnell, 2021), to understand how to measure its impact (Moraga et al., 2019) and to describe the different R-strategies and their implications (Reike et al., 2017; Diaz et al., 2021). Much of the literature was found to address the end-of-life phases, namely recycling and repair processes, suggesting that the other phases are currently neglected (Rizos, V. et al. 2017; Kirchherr et al., 2017; Johansen et al. 2022). In this context, the following research question arises: *What influence does the redesign phase have on the product life cycle and its circularity?* To fill this gap, this thesis aims to (i) analyse the role of the redesign phase in the circularity of products; and (ii) to identify all the design strategies that exist in a company and in a specific industry in order to understand what influence design has on the whole process. The research will be conducted in the fashion industry, focusing on the implementation of circular strategies to promote the circularity of plastics in the fashion industry. The study will recommend best practices and guidelines for companies that want to implement redesign strategies to achieve circularity in their products, thus making a valuable contribution to the field of sustainable product design and circular economy.

This master thesis is divided into 6 main chapters, starting with this first introductory chapter. The second chapter is dedicated to the literature review. This chapter presents all the relevant literature, including books and academic articles, which were analysed and served as a basis for the development of the study framework. The third chapter presents the methodology used to conduct this exploratory study in the fashion industry. This chapter presents the structure of the analysis conducted and the organisational details of the interviews conducted. The following chapter, entitled Analysis of Results, is an in-depth analysis of the interviews conducted. This chapter is of key importance as it contains some important contributions from brand owners, founders and creative directors who are directly involved in the process of product redesign. Chapter 5 is entitled Discussion. This chapter presents a comparison between the information presented in the literature review and the insights shared by the interviewees. It also presents interesting findings from the interviews that provide a holistic view of the redesign process and the practical implications for a company in the fashion industry. In the sixth and final chapter, the conclusions of this master thesis are presented. This highlights the limitations of the study conducted, the relevance to the literature

and possible future research that could be conducted to complement this study and the literature that addresses the importance of redesign for the circularity of products.

# 2) Literature Review

## 2.1 Circular Economy and R-strategies

Although the linear economy has contributed to rapid economic growth and global development for many years, it incurs in resource losses in several ways, such as production chain and end-of-life waste, excessive energy consumption and consequent erosion of different ecosystems (Babbitt et al., 2021; Michelini et al., 2017). On the other hand, the CE is a regenerative system in which resource use and waste, emissions and energy losses are minimized by slowing, closing and narrowing material and energy cycles (Ellen MacArthur Foundation, 2023). The underlying purpose of adopting CE practices is reducing virgin material consumption, eliminating waste and decouple growth from material use (Campbell-Johnston et al., 2020). The concept of CE is of great interest to any company that incorporates manufacturing into its processes, as it provides a framework that allows them to align their organizational goals with the 17 Sustainable Development Goals (SDGs) developed by the United Nations (Diaz et al., 2021). These SDGs cover several goals such as urgently addressing climate change and its impacts by 2030 have been developed to stimulate the operationalization and integration of sustainability in organizations around the world, while addressing the current and future needs of stakeholders (Fonseca et al., 2020). In regards to the scope of this master thesis it is important to mention some of these goals, especially those related to the efficiency usage of plastic products, namely Industry, Innovation and Infrastructure (SDG 9), Responsible Consumption and Production (SDG 12), Climate Action (SDG 13) (Tarazona et al., 2022). This can be seen as an attempt to reconcile two seemingly opposing paradigms: sustainable development and economic growth (Hák et al., 2016). Many of the SDGs can be achieved through the implementation of some CE practices, namely the R-strategies, such as redesign, repair, reuse, remanufacturing, refurbishing, and recycling strategies (Geissdoerfer et al., 2017; Reike et al., 2017). Achieving the SDGs is a complex process that requires company-level engagement (Tarazona et al., 2022) therefore, a deep understanding of the role of each R-strategy is necessary to get an overview of how companies can address the CE when intervening in the product life cycle and the entire product value chain. At the same time, some R-strategies also consider the consumer as a key enabler of the CE and therefore they are not a fully controllable factor for the companies themselves (Campbell-Johnston et al., 2020). As previously identified, the 7 R strategies are focusing on a specific phase of the product life cycle, and can be described as follows:

- Redesign refers to the definition of requirements of a product at the beginning of its life cycle (Despeisse & Ford, 2015);
- Renovate refers to the process of facilitating the replacement and upgrade of product parts (Liu & Zhao, 2019).
- Recover refers to the process of recovering materials that have already been used to reintroduce them as raw material for future productions; this strategy, altogether with the recyclying one relates ti solid waste otherwise destined for landfill, or burned without heat recovery (Morseletto, 2020).
- Reuse refers to the process by which a product that has already been used does not need to be adapted to function as good as new, meaning that an item or parts of items that still have potential for use after repeated use (Campbell-Johnston et al., 2020).
- Reduce focuses on using things with care to decrease the amount of waste generated and thus use less substances, materials, product components, or entire products (Diaz et al., 2021).
- Repair can be described as the process of repairing products rather than throwing them away (Rodriguez, 2022).
- Recycle means using waste itself as a resource (Xing et al. 2017). It can be also described as processing mixed streams of post-consumer products or post-consumer waste streams, including shredding, melting, and other processes to capture (nearly) pure materials (Campbell-Johnston et al, 2020).

Narrowing now to the redesign strategy, the focus of this study, it has been identified that this phase has two main objectives. The first seeks to gain a though grasp of the problems that the original product represents in terms of its functionality and effects on the environment, thus identifying in which areas significant adjustments could be made (Bahmra, 2013). The second objective is to optimize the key components to produce an ideal evaluation of the original product that effectively balances benefits and environmental advantages (Bahmra, 2013). The concept of the redesign phase is crucial as it is placed at the beginning of the product life cycle and thus influences all R-strategies and the resulting circularity of the whole product (Liu & Zhao, 2019). This phase is fundamental as it directly influences the characteristics that make the product more sustainable, such as material, energy and cost efficiency (Despeisse & Ford, 2015). This thesis will focus on the importance and impact of the redesign phase on the product circularity. To do this,

it is important to start by introducing the concept of design, which will be done in the next sub-section.

## 2.2 Design

Design is an interdisciplinary and multi-level study that has different definitions depending on the field of application (Telenko et al., 2016). The design of a product has the ability to influence a product's durability, lifespan and its potential for end-of-life reuse or recycling, thus displacing demand for future critical material extraction (Forst, 2018).

In presenting the concept of design, it is crucial to highlight the so-called closed loop and product development process for sustainable product design, which serves as the basis for designing products for CE (Hapuwatte & Jawahir, 2021). The concept of design forms the basis for the product development process (PDP), which can be described as a sequence of four phases: Understand, Explore, Define and Refine, and Implement (Waage, 2007). According to Waage, (2007) the first phase is about understanding the problem and observing and illuminating the customer. The second phase is about exploring possible solutions to the problem, which often includes rough prototyping (Waage, 2007). In the third phase, the best solution is developed into a product, and in the final phase, the product is finally manufactured (Waage, 2007). The process is not always linear, and the product development team may choose to do some phases simultaneously or jump between them (Franzén & Guo, 2021). The aim of this thesis is to identify the transversality and impact of the design phase along the product life cycle by identifying all the design strategies that were considered during the development of the product design. As the aim is to analyse these impacts in the context of the CE, the concept of eco-design is introduced to provide a framework for our study.

### 2.2.1 Eco-design

Eco-design plays a crucial role in implementing the CE model by ensuring that products and materials are designed to be durable, reusable and recyclable, thereby reducing waste and minimizing the consumption of natural resources (Corona et al., 2019). The European Parliament adopted the Circular Economy Action Plan (CEAP) which is part of the European Union's 8th Environmental Action Plan to 2030 and one of the cornerstones of the European Green Deal (Horn et al., 2023). The circularity of products has emerged as a crucial aspect of sustainability, as it involves designing products so that they can be recycled, repaired or reused at the end of their life cycle (Alamerew et al., 2020). By prioritizing eco-design practices, companies can create products that can be easily repaired, upgraded or disassembled, extending their life cycle and

promoting a CE (Gallagher et al., 2017). It is estimated that most environmental impacts can be mitigated through design decisions that determine up to 80% of a product's life cycle impacts (EC, 2014; Schwarz et al., 2017). Moreover, a major portion of a product's cost will be made at the end of product design stage (Hapuwatte & Jawahir, 2019). The authors also mention that environmentally conscious features need to be introduced at the design stage of a product to have a significant impact on its environmental profile (Hapuwatte & Jawahir, 2019). It has been noted that traditional approaches to eco-design have not focused on critical materials or are not well aligned with the challenges associated with their extraction, use and recovery (Peck et al., 2015). Eco-design aims to minimize the overall environmental impact of the product by incorporating environmental criteria related to the entire life cycle of the product into the design process (Kong et al., 2022). Eco-design thus goes beyond improving just one or two negative environmental aspects of a product; it considers the product as a whole (Spreafico & Landi, 2022). The goal can be either to redesign a product to improve its environmental impact or to design an entirely new product with inherently better environmental performance (Kostecki, 1998).

The concept of eco-design goes hand in hand with another similar concept that is central to the development of this thesis: circular design, which refers to design that aims to create cycles, conserve resources, go through multiple cycles, have a long life span and change the system (Hapuwatte & Jawahir, 2021). Implementing eco-design practices poses a number of challenges for companies, especially at the product development stage (Dekoninck et al., 2016). For example, some of the main challenges include the fact that all phases of the product life cycle need to be considered together and the fact that sustainability needs to be approached by considering three main subcategories, namely social, economic and environmental (Stark et al., 2017). The complexity of the design phase can be analysed using the diagram of the decision-making process by Stark et al. (2017) (figure 1).

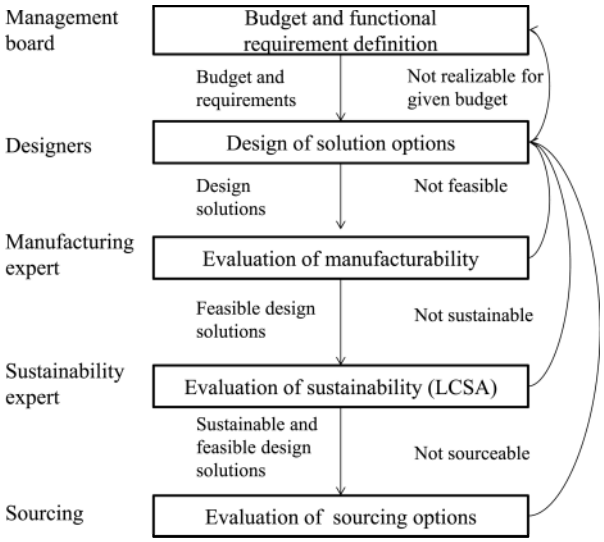


Fig 1. Design decision-making process

Source: Stark et al. (2017)

Fig.1 shows how sustainable product design is at the heart of the decision-making process and how each step depends on it (Stark et al., 2017). The main complexity that emerges from the diagram is that all decisions in this process need to be made by an interdisciplinary team consisting of designers, project managers, a manufacturing engineer and a sustainability expert (Stark et al., 2017). There are several strategies that can be used in developing an eco-design. Each of them focuses on a specific aspect of the circular economy, but at the same time is strictly dependent on and influences all other design strategies that exist in a company (Gallagher et al., 2017). The strategies include various tools and indicators that are intended to focus on the different stages of the product life cycle. Stark et al. (2017) has identified six life cycle phases and six associated design strategies, which are shown in Fig. 2:

| Life cycle phase | Design Strategy |
|---|---|
| Initial needs analysis | *New concept development* (dematerialization, shared use of the product, integration of functions, functional optimization of the product/components) |
| Production and supply of materials and components | *Selection of low-impact materials* (clean, renewable, low-energy content, recycled/recyclable, positive social income e.g. by generating local income); *Reduction of material usage* (weight/volume reduction) |
| In-house production | *Optimization of production techniques* (process alternatives, less waste, low/clean energy demand, few/clean consumables, safety/cleanliness of workplace) |
| Distribution | *Optimization of the distribution system* (less/clean/reusable packaging, energy-efficient transport mode, energy-efficient logistics, involve local suppliers) |
| Utilization | *Reduction of impact in the usage phase* (Low-energy consumption, clean energy source, few/clean consumables, no wastage of energy or consumables, health supporting and/or added social value)<br>*Optimization of initial lifetime* (reliability and durability, easy maintenance and repair, modular product structure, classic design, strong product–user relation, involve local maintenance and service systems) |
| Recovery and disposal | *Optimization of the end-of-life system* (reuse of products/components, remanufacturing/refurbishing, e-cycling of materials, safe incineration, taking into account local (informal) collection/recycling systems) |

Fig. 2 Eco-design Strategies

Source: Stark et al. (2017)

Each phase of the product life cycle offers opportunities to reduce environmental impact and increase social benefit. The first phase of initial needs analysis is an opportunity to develop new concepts that prioritize dematerialization, product sharing, integration of functions and functional optimization of the product and its components (Stark et al. 2017). In the phase of production and supply of materials and components, the design strategy refers to the selection of materials with lower environmental impacts, such as clean, renewable materials, materials with low energy consumption that can be recycled or directly recycled and that generate positive social income can reduce the overall environmental impact of the product (Ljungberg, 2007). The author also suggests that reducing material consumption, for example through weight or volume reduction, can also be beneficial. The in-house production phase offers opportunities to optimize production techniques. These include the use of process alternatives to reduce waste, low or clean energy demand, fewer or cleaner consumables, and workplace safety and cleanliness (Kaya, 2011). In the distribution phase, optimization of the distribution system can be achieved through less or cleaner and reusable packaging, the use of energy-efficient transport, energy-efficient logistics and the involvement of local suppliers (Dabic et al., 2010). The utilization phase is an opportunity to reduce the environmental impact of the product through low energy consumption, clean energy sources, few or clean consumables, no waste of energy or consumables and added health and/or social values (Cheah et al. 2013). In addition, optimizing the initial use phase through measures such as reliability

and durability, ease of maintenance and repair, modular product structure, classic design, strong product-user relationships and the integration of local maintenance and service systems can further reduce the overall environmental impact of the product (Telenko et al., 2016). Finally, the recovery and disposal phase offer opportunities to optimize the end-of-life system, this can be achieved through product/component reuse, remanufacturing/repair, electronic recycling of materials, safe incineration and consideration of local collection/recycling systems (Krikke et al., 2010). By considering these design strategies at each stage of the product life cycle, it is possible to reduce the environmental impact of the product, increase its social value and contribute to a more sustainable future (Telenko et al., 2016).

A final strategy we would like to introduce in terms of the importance of the design phase for sustainability is the concept of Design for Environment. DfE can be described as an area of product design methodology that includes tools, methods and principles that help designers reduce environmental impacts (Telenko et al., 2016). Through an extensive literature review, Telenko et al. (2016) identifies a set of 76 DfE guidelines that have been compiled and aligned for use in the early stages of product design with minimal environmental impact. The importance of the DfE approach is that it is central to designers seeking to design both environmentally sustainable and commercially viable products (Sun et al., 2003). The author mentions that by integrating DfE principles and tools into the design process, products can be created that have a positive environmental impact at all stages of the product life cycle. Figure 3 outlines the main strategies discussed:

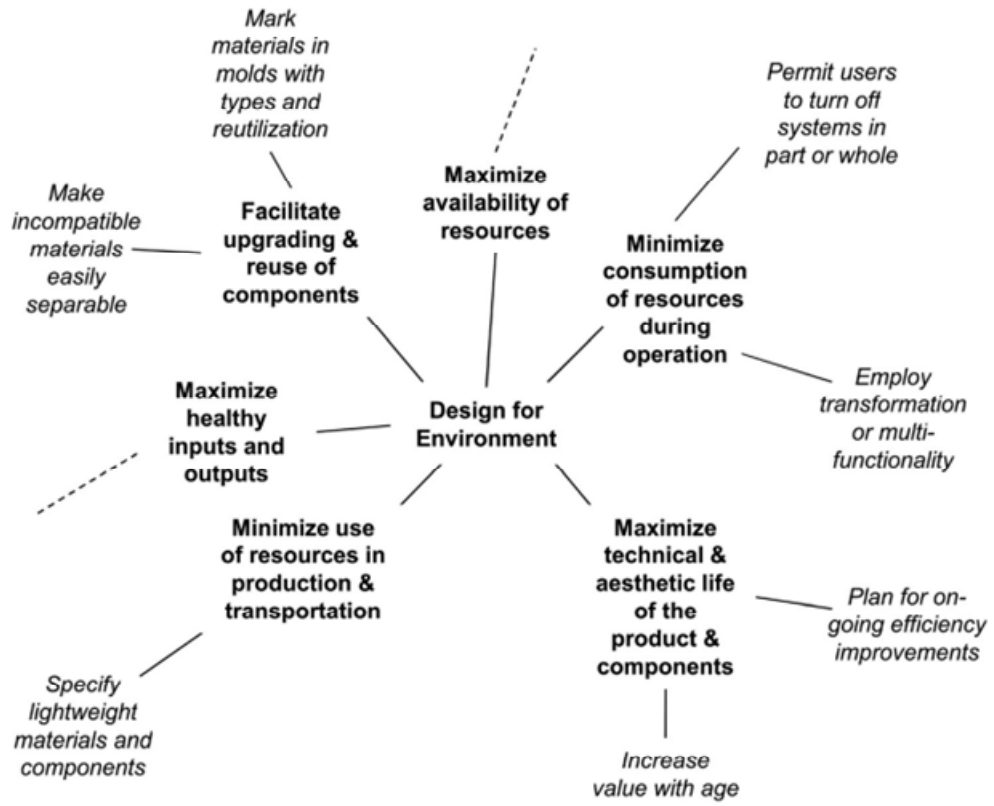


Fig. 3 Design for Environment mind map

Source: Telenko et al., 2016

All of the Design for Environment strategies presented in the mind map are included in the conceptual framework, which provides additional insight and in-depth analysis of the design strategies identified in the Stark et al. (2017) paper. Each design strategy identified in the Stark et al. (2017) study will be further explored and extended by considering the Design for Environment operations.

The combination of the diagrams shown above (Figs. 1, 2, 3) forms the basis of our study framework, as shown in Table 1.

Table 1. Study framework

| Organizational Level | Design Strategy | Design for Environment | References |
|---|---|---|---|
| **Designers** | Product concept development | Optimization of product; Integration of functions; Maximize technical life of the product & components | Stark et al. (2017) Telenko et al., 2016; |
| **Manufacturing experts** | Optimization of production techniques<br>Optimization of distribution system<br>Optimization of product lifetime | Minimize use of resources in production and transportation; easy maintenance; durability. | Stark et al. (2017) Telenko et al., 2016; |
| **Sustainability Experts** | Selection of low-impact materials | Maximize availability of resources | Stark et al. (2017) Telenko et al., 2016; |
| | Optimization of the end-of-life | Facilitate upgrading, reuse and recyclability of components | Stark et al. (2017) Telenko et al., 2016; |

This study framework aims to explore the relationship between the design strategies within an organization, the departments of an organization identified in the study by Stark et al. (2017), and the sub-relationships established between each strategy and department and the existing design goals and strategies (Telenko et al., 2016) used to promote the circularity of products.

The concept of a circular product is based on the concept of sustainable product design, which is central to the development of this framework, as it is mandatory to the decision-making process and requires the involvement of an interdisciplinary team of designers, project managers, a manufacturing engineer and a sustainability expert Stark et al. (2017). Eco-design strategies have been developed to guide the integration of sustainability aspects. These strategies include a set of principles and practices for designing products, systems and processes that minimize negative environmental impacts while maximizing social and economic benefits (Telenko et al., 2016). In developing the framework, the organizational level identified by Stark et al. (2017) as the

'management board' was not considered. This decision was made because, given the scope of this study and the profile of the companies interviewed, the responsibility of defining the budget and functional requirements is fully integrated into the process of product concept development which is responsibility of the design department.

As outlined in the framework, each department is considered responsible for many design goals and corresponding design strategies that have been identified as strategies for environmentally sound design (Telenko et al., 2016). As we can see in Table 1, the design department is responsible for developing the product concept and thus optimizing the product itself as well as integrating functions. The manufacturing experts play a central role in optimizing the production techniques, the distribution system and the life cycle of a product. This allows many strategies to be implemented, for example the use of clean energy, energy-efficient logistics, longevity of the product (Kumar et al., 2017; Telenko et al., 2016). On the other side, sustainability experts are responsible for selecting environmentally friendly materials and optimizing the end-of-life and this can be achieved by selecting renewable energy, evaluating sourcing options, remanufacturing and reusing products (Kumar et al., 2017; Telenko et al., 2016).

In this study, we conduct a comprehensive analysis of the developed framework (table 1) by interviewing brand owners and experts in the fashion industry, which will provide a deeper understanding of the importance of each department and specific design strategy in promoting the circular economy of products. The application of the framework will be useful to gain further insight into the different theories and identify specific impacts and relationships in the design phase within a company.

# 3) Methodology

Redesigning a product is a crucial aspect of the product life cycle, as it involves changing the design of a product to make it more sustainable, durable and resource efficient, thereby reducing waste and minimizing the environmental impact of the product throughout its life cycle (Corona et al., 2019). To achieve the research objectives, this study will focus on analysing interviews conducted with brand owners and fashion industry experts who can provide valuable information on common variables and impacts of the redesign phase. This analysis will provide a comprehensive understanding of the role that redesign plays in the product life cycle and in the broader context of the circular economy. The focus will be given on the design strategies that are put in place in different companies to promote sustainability and circular economy practices.

## 3.1. Analysis of the method

This study is mainly conducted using a qualitative research method to collect a large amount of data. According to Leedy and Ormrod (2019), qualitative exploratory research is a useful method to answer research questions that require interpretation as it allows for a deeper analysis of the topic under study. This approach is about exploring and understanding the subjective perspectives of individuals or groups in relation to a new or developing phenomenon (Creswell and Creswell, 1994). To answer the research question, the investigation is conducted in 3 main phases: (i) defining the case; (ii) collecting and analysing the data obtained in the interviews; and (iii) interpreting the data and reporting the findings (Crowe et al., 2011). In the first phase, the research questions were formulated based on the literature presented above, with the main aim of defining the case in a concise and appropriate manner. In the following phase the interviews have been conducted and subsequently analysed. Lastly, the information and data has been collected and analysed in the scope of the research question that has been defined.

The qualitative study will use a qualitative research methodology to collect data from key stakeholders who were involved in the redesign phase. This qualitative research will be developed using semi-structured interviews with experts from different organizations. The analysis can be extended to other departments or specialists to collect important information on circular economy, product life cycle management and related areas relevant to the findings of this research. The main objective of these interviews is to gain in-depth insights and perspectives on the topic and to identify the challenges, impacts and opportunities associated with redesigning a product. More specifically, the aim is to explore the design strategies and departments identified in the literature review (Stark er al. 2017) to gain a deep understanding of the involvement of each department in

specific strategies and to present a clear hierarchy of relationships. It is also presented which practices of Design for Sustainability (Telenko et al., 2016) are used in the organization under study and the importance of each of these practices in the different phases.

### 3.2. Data Collection & Unit of Analysis

Demonstrating the trustworthiness of data collection is one aspect that supports the researcher's ultimate argument regarding the trustworthiness of a study (Elo et al., 2014). At the same time, Graneheim & Lundman (2004) states that selecting the most appropriate method of data collection is essential to ensuring the credibility of the content analysis. For these reasons, the method of data collection and the selection of the unit of analysis are of central importance when conducting case study research. For the development of the interviews, it was decided to proceed with an interview script with open ended questions, in other to gather insights that might be relevant to answering the research question. The questions were then formulated using a semi-structured data collection method. The set of questions was developed to address a particular design strategy and to gather relevant insights into how the company is working to implement it in its organization and what sub-relationships exist between these strategies. Care was taken not to over-direct participants' responses in order to obtain inductive data (Elo et al., 2014).

Purposive sampling, a method commonly used in content analysis studies, was used to select the samples (Kyngaes, Elo, Poelkki, Kaeaeriaeinen, & Kanste, 2011). Purposive sampling was chosen as it is excellent for this qualitative research where the researcher is interested in asking the questions to the person who has the best knowledge about the research topic. For this research the profiles presented in the table 2 below has been chosen:

Table 2. Interviewed companies and representative's profile

| Company | Sector | Company's Dimension (number of employees) | Representative's profile (company position) | The time of the representative's employment with the company (+/-) |
|---|---|---|---|---|
| A | Fashion accessories and footwear retail | <25 | Founder, Creative Director | 15 years |
| B | Apparel & footwear retail | <25 | Head of Product Development | 12 years |
| C | Footwear research centre | n/a | Senior Researcher | 18 years |
| D | Fashion accessories and footwear retail | <25 | CEO and Design Director | 6 years |
| E | Fashion footwear retail | +/- 150 | Brand Manager | 9 years |

The aim was to interview many different companies in the fashion industry that are committed to sustainable practises. In this way, we were able to gather relevant knowledge about the complexities, challenges and existing needs of implementing sustainable practises in a company. At the same time, in order to answer the research question and to identify existing design strategies and the relationships between them and between the company's departments, different profiles were selected for the interviews, such as founder, creative director, CEO, Design director, head of product development, brand manager. These profiles were selected as it was important to collect information from profiles that have a clear overview of the company processes and the impact that each design strategy identified in the literature review can have on the whole organisation.

### 3.3. Data Analysis

In this phase, it is essential to analyse all the data collected by the units of analysis identified for the development of this case study. The data analysis phase has two main objectives: first, to link the data to propositions, and second, to establish criteria for interpreting the findings (Yin, 2003). In addition, there are several strategies that can be used to analyse the results, including pattern matching, explanations, time series analysis, logical models and cross-case syntheses. Regardless of

the strategy used, the aim of data analysis is to consider all evidence and present it separately from any interpretation.

In the case of this study, the analysis focuses on linking the information from the literature review conducted and the information provided by all participants interviewed. At the same time, this information is central to interpreting the framework developed and confirming or redefining the different impacts and relationships identified.

### 3.3.1 Content Analysis

Content analysis is known as a method of analysing documents that allows the researcher to examine theoretical issues in order to improve understanding of the data (Elo & Kyngäs, 2008). Through content analysis it is possible to divide words and phrases into fewer content-related categories, each of which contains content with similar meaning (Cavanagh 1997). Content analysis was needed to provide a systematic and objective means of drawing valid conclusions from the written data presented in the literature review to describe the findings of this research (Downe-Wamboldt, 1992).

By conducting this analysis, we were able to obtain a condensed and comprehensive description of the framework and data obtained through the interviews (Elo & Kyngäs, 2008). Since the structure of this analysis is operationalized based on prior knowledge and the purpose of the study is gather relevant insights and compare them with the literature review and the conceptual framework, the approach to be used is a deductive content analysis. A deductive approach draws on a prior theory or model and therefore moves from the general to the specific (Burns & Grove 2005).

Content analysis was conducted using NVivo software to divide respondents' transcripts into several thematic categories relevant to this study. The categories of analysis identified and used for this analysis, based on the conceptual framework developed, are listed in Table 3.

Table 3. Categories of analysis

| MACRO CATEGORIES OF ANALYSIS | SUB-CATEGORIES OF ANALYSIS |
|---|---|
| Product concept development | Optimization of product; Integration of functions; Maximize technical life of the product & components |
| Optimization of production techniques | Minimize use of resources in production and transportation; Easy maintenance; Durability |
| Optimization of distribution system | |
| Optimization of product lifetime | |
| Selection of low-impact materials | Maximize availability of resources |
| Optimization of the end-of-life | Facilitate upgrading, reuse and recyclability of components |

The findings of this study will contribute to the existing literature on CE and product design by highlighting the importance of the redesign phase in achieving circularity and sustainability. The study will provide insights into the design strategies that companies can adopt to achieve circularity in their products and the benefits that such strategies can bring to the company and the environment.

## 4. Results analysis

With growing global awareness of environmental and ethical issues, the industry is undergoing a radical transformation driven by technology, innovation, circular economy and a growing commitment to sustainability (Ikram, 2022). The fashion industry is a complex ecosystem with different actors, from designers and manufacturers to retailers and consumers, as the interviews with experts revealed. Rising attention has been given to this ecosystem and to this industry for its negative environmental impact, poor labour practices and amount of waste generation (Buchel et al., 2022). However, the interviews show that many companies are changing this behaviour towards more sustainable practices.

From some interviews, it appears that technology is playing a central role in changing practices in the industry. From advanced materials to innovative manufacturing processes, technology is changing the way fashion products are designed, produced and even recycled. By using cutting-edge materials such as sustainable plastics and bio-based components, various environmental aspects are taken into account. Few examples were presented by the founder of company A, which mentioned that they are trying to introduce in the company several bio-based material such as the Banatex and the Pinatex, bio materials obtained respectively from the banana and pineapple plants. Fashion designers and entrepreneurs are redefining the boundaries of sustainable practices by reducing the negative footprint while maximizing innovation. The current landscape reflects a growing emphasis on the circular economy, ethical sourcing and transparency throughout the supply chain. The role of designers in this process is central, as they are responsible for developing eco-designs by experimenting with new materials, technologies and production methods to create garments and accessories that are environmentally sustainable. Achieving sustainable goals in the industry requires collaboration between different departments and players within a company, such as designers, engineers and manufacturing experts.

Several drivers for sustainability have been identified in the industry, the most important, however, is the central role of consumers, who are increasingly opting for sustainable purchasing options. This is happening because they are becoming more aware of the environmental and social impacts of their fashion choices, leading to demand for products that align with their values.

The challenge is to spread these efforts throughout the industry and raise consumer awareness of the importance of eco-design. The outlook is promising as the fashion industry increasingly recognizes that design and eco-design are essential pillars to achieve the circular economy, reduce environmental impact and redefine the way we perceive and consume fashion. The interviews

conducted shed light on how fashion professionals address these challenges, highlighting in particular the role of design and eco-design within a company and within the industry as a catalyst for the circular economy of products.

The focus of the results analysis is to analyse the results of all interviews conducted with experts and brand owners of fashion brands. In order to highlight the findings of the interviews in a way that provides the relevant insights presented in the literature review and conceptual framework, the findings are divided into six main categories. The categories relate to the design strategies identified in the conceptual framework (presented in table 1), namely: product concept development; optimization of production techniques; optimization of distribution system; optimization of product lifetime; selection of low-impact materials; and optimization of the end-of-life.

### 4.1. Product Concept Development

The development of a product concept serves as the basis for a holistic and integrated approach to sustainable design strategies throughout the life cycle of a product. Each of the design strategies presented above is closely linked to the development of a product concept and contributes to the creation of products that are environmentally sustainable, resource efficient and comply with the principles of the circular economy. Product concept development in the context of this research refers to the process of developing and refining innovative ideas for new products or product improvements that focus on environmental and social aspects throughout the life cycle. This approach focuses on developing products that not only meet consumer needs and market requirements, but also comply with the principles of sustainability, resource efficiency and circular economy. This concept is closely linked to the concept of eco-design, which was seen as central to this phase by all interviewees. The concept of eco-design aims to minimize the overall environmental impact of the product by incorporating environmental criteria related to the whole life cycle of the product into the design process. Eco-design thus goes beyond correcting only one or two negative environmental aspects of a product and considers the product as a whole. The goal can be either to redesign a product to improve its environmental impact or to design a completely new product with inherently better environmental performance.

The foundations of sustainable fashion lie in the design of the products themselves, with design being a key factor - a principle that was explored in depth in the interviews. Many of the concepts and strategies presented above can be placed in this category, as the development of the product concept forms the basis for all design strategies. In conducting the interviews and analysing the interviewees' responses in light of the conceptual framework developed, many interesting points

were raised. The transversality and importance of design for the whole company and strategies was raised by all interviewees. For example, the senior researcher responsible for the footwear research centre that has been interviewed, emphasized the importance of integrating sustainability into the product concept from the beginning. The researcher explained that by setting clear sustainability goals at the concept stage, the company can ensure that all subsequent design and production decisions are in line with these goals. This proactive approach is likely to lead to better results than integrating sustainability into an existing concept after the fact.

The researcher also stated that: "The industry needs to consider the concept of a product that promotes durability. We want products to stay in use as long as possible. We just need to finish them and think about their final destination, but as far away as possible. But if we want to think about shoes for recycling, for example, that has to be achieved from the beginning." This point is crucial to show that the development of the product concept has a direct impact on all the design strategies presented and needs to be analysed and implemented by all the departments identified in the conceptual framework, namely: designers, manufacturing experts, sustainability experts, board of directors.

An interesting point raised by the founder of company A is that the application of eco-design can influence the recognition value of products and how important it is to look at the whole design process from a sustainability perspective. The interviewee from company A emphasizes the importance of incorporating eco-design strategies into the product concept development process, as eco-design principles guide the development of products that address ethical, functional and sustainability concerns. The founder of company A mentions that it is important to design objects that are not only for immediate consumption, but also have a timeless aesthetic that ensures they will still be relevant in years to come by balancing sustainability, aesthetics and consumer desires. An important stage in the development of product concepts is prototyping and experimenting with materials to refine the product concepts and ensure they are consistent with the brand's values. While the interviewee from company B shares more or less the same ideas as the first two interviewees (companies A and C), the design director of company C focuses on the idea that sustainable design does not necessarily need to be marketed as such, but should rather emphasize quality and unique design. When developing a product concept, the entire product life cycle must be considered, from material selection to production processes and end-of-life options. The design process takes into account consumer needs, comfort and responsible consumption, she explains.

Using the example of shoes with stitched soles in a classic design, she shows how design decisions can influence repairability and longevity.

### 4.2. Optimization of production techniques

Optimization of production techniques refers to the strategic and systematic refinement of manufacturing processes with the primary objective of improving the sustainability of products throughout their life cycle. This approach involves the integration of innovative methods, technologies and design principles that minimize resource consumption, waste generation and environmental impact, while promoting the efficient recovery and reintegration of materials.

Overall, this theme was highlighted in all interviews conducted, suggesting that the fashion world is paying close attention to optimizing production techniques when it comes to achieving product circularity. The importance of design and eco-design in this strategy was highlighted in all interviews. The founder of company A narrative sheds light on the transformative potential of technology-based approaches. Introducing 3D knitting technology into a business not only enables precision and customization, but also a fundamental break with the wasteful practices of traditional pattern cutting.

This transition is in line with the core ideas of circular design, which emphasize resource efficiency and the reduction of material waste (Hapuwatte & Jawahir, 2021). All respondents indicated that in the production processes of the company where they work, waste generation, reuse and reduction of energy consumption are techniques that are central to optimizing production techniques.

The founder of company A emphasizes that using as few materials and resources as possible, reusing existing materials whenever possible, minimizing waste and promoting environmentally friendly production processes are key principles. The interviewee from company A explained that the brand was founded with sustainability in mind. Therefore, the founder is constantly experimenting with new materials and technologies such as 3D printing to test their suitability for sustainable production. 3D printing was also mentioned by the senior researcher, who works at the footwear research centre (company C). The researcher offered an interesting overview of the industry, as the research centre works directly with over 100 fashion companies in Portugal. On this point, the interviewee from company C agreed that 3D technology allows for greater design freedom, less material waste and intricate geometries that were previously unattainable, and that this could lead to a more efficient production process. The interviewee of company B highlighted that outsourcing of production is necessary for a number of reasons such as cost, material

availability and expertise. This collaboration with factories in different countries aims to optimize production processes and costs. He emphasized that researching and testing materials, optimizing the manufacturing process for sustainability and evaluating the feasibility of production methods is a necessary process towards sustainability.

This last point is very important because it shows that the development of new production techniques to achieve a more sustainable product and production itself is not an automatic process, but the result of investment, experimentation, research and development in materials engineering and a commitment to achieving sustainability goals. His perspective further emphasizes this shift by highlighting the principles of lean manufacturing, which inherently reduce energy consumption and material use. This dual approach to quality improvement and environmental protection illustrates how production optimization can be seamlessly aligned with the circular economy and shows that innovative techniques and sustainability goals can co-exist.

In analysing the optimization of production techniques, an interesting pattern has emerged. This pattern is that these strategies for optimizing production techniques are directly linked to several other strategies that appear in the conceptual framework and subsequently in the literature review. For example, several respondents emphasized that optimizing production techniques is closely linked to the selection of materials for production itself. At the same time, all interviewees emphasized the introduction of a more sustainable adhesive for the shoes, a water-based adhesive. It became clear that the choice of this particular material has a profound impact on production techniques, as in this case it takes much more time to dry, which in turn means that more space is needed, the know-how of the workers has to be different and long drying times mean high energy consumption and negative economic impacts for the company.

An interesting contribution also came from the CEO of company D, who presented other practices of her company to optimize production techniques. She emphasized that the company's current goal is to produce small quantities of products, avoid mass production and aim for a just-in-time production system. Even though the brand outsources most of its production, the fact that most of its factories are located in Portugal means that it has control over the entire production system and is aware of this. At the same time, developing sustainable production practices becomes a simpler process. She also talks about the complexity of production, especially for larger companies or brands. The challenges relate to the sourcing of materials and the production process itself, which can become more complicated and expensive when sustainability and circular economy are at the forefront.

### 4.3. Optimization of the distribution system

Distribution system optimization is about designing and managing the transportation of goods, products and materials in a way that minimizes environmental impacts, reduces resource consumption and supports overall sustainability goals. This approach focuses on improving efficiency, reducing emissions and maximizing resource use throughout the supply chain. As with all of the strategies presented above, we were able to identify similar patterns and a clear link and impact with other strategies when analysing respondents' answers. Optimizing the distribution system to trigger sustainability means making conscious decisions throughout the product life cycle. The greatest impact was found in material selection and choice of production location.

In fact, all respondents said they were aware of the impact of emissions and pollution caused by the transport and distribution system. Many of the respondents mentioned that their brand is constantly looking for ways to produce locally to minimize transport-related emissions. In addition, her company tries to work with factories that prioritize sustainable transport practices and technological advances to optimize distribution and production.

The senior researcher confirms that the industry should focus on a local production model with distributed production centres, as this can significantly reduce carbon emissions associated with long-distance transport. This approach could also better reflect regional preferences and could be central to the future development of the industry's attention to this issue.

The head of the product development of company B shared the same opinion, perfectly aligned with that of the other interviewees and confirms the company's interest in local production. At the same time, he brought in an interesting point of view by explaining that sourcing certain materials in Europe is still not possible, mainly because of the price, availability and know-how in the production/extraction of certain materials. According to him, this is a problem because transport from Asian countries to Europe is not sustainable, but it is the only option at the moment. The development and use of new materials in the industry will be key to reducing transport emissions by sourcing locally.

The contribution of the CEO of the company D was crucial as she also raised other issues that were very interesting for this research. The interview briefly discusses the importance of European brands adopting sustainable practices due to stricter regulations and how this can affect their distribution strategies. She emphasizes the importance of rethinking return policies to reduce the number of product shipments. The main problem is not only the economic impact on development that remains with the companies, but also the fact that online shopping practices are not sustainable

at all in terms of emissions, as the user has the possibility to try several products or even sizes and send most of them back to the company after choosing the right one. The goal is to only produce to order to reduce emissions from production to storage to transport. Another aspect of her brand is that she focuses on producing bespoke and personalized products that are not covered by the returns policy. This forces the consumer to make a choice and buy a product that actually meets their needs and avoids emissions for alterations and returns. This is also the view of the brand manager of company E, which works with physical shops, one of which is outside Europe. He states that all the efforts made by companies are not enough to promote sustainability unless regulations are developed at a higher level, in this case referring to the policies of the European Union.

### 4.4. Optimization of Product Lifetime

The profound impact of extending product life is evident through a cross-sectional analysis of the interviews. This theme was mentioned in all interviews as an important strategy to achieve product circularity and promote sustainability. This trend was confirmed by the senior researcher as she shared insights from her experience at the footwear research centre, which revealed a strategic focus on longevity as a cornerstone of eco-design in the fashion industry. In an industry often driven by fleeting trends, this emphasis on making products that stand the test of time is a significant innovation.

The founder of company A states that her brand is proactivity seeking new design strategies to extend the life of their brand's products has led to successful results and has also highlighted some of the problems in implementing different design strategies simultaneously. The brand places great emphasis on durability and quality and strives to produce products that will last for several years. The products are designed to be repairable and easily upgradable, and the company offers repair services to extend the life of the products. At the same time, the footwear research centre highlights the importance of this strategy, giving a clear idea of the direction of this industry in Portugal. Both emphasize that optimizing durability is closely linked to other strategies such as material selection, production techniques and product concept development. Indeed, company A considers the quality and durability of certain materials central, mentioning few of them, such as microfiber, which can last several years compared to other materials.

These strategies are very important as they determine the longevity, maintenance and repairability of the product and thus have a strong impact on end-of-life strategies.

The head of product development of company B gave an important contribution to this strategy because it is also clear that for some companies, like the one he works with that manufactures safety footwear, longevity is not only an important sustainability goal, but also the foundation of their business model. He also points to the importance of customer expectations: "We have customers who try different brands until they find one that offers a product life that lasts about 6 months to a year. And that is our quality requirement". This shows that meeting sustainability criteria is key in product development, but to do so, products must also meet the quality requirements of the market.

Company E's brand manager explains that optimising product life in the company he works with is the most important strategy to promote the circular economy. An interesting point shared by the brand manager is that this strategy is key, but also highlights the need to invest in other specific processes and materials that are most likely not the most sustainable. This gives an interesting insight into how holistically each strategy needs to be considered and the impact this can have on the price of the final product.

Company D aims to produce products that will last for many years. The CEO states that she personally focuses on creating designs that are durable and versatile to encourage her customers to wear them with many different outfits so they do not have to buy multiple products for the same purpose. The CEO places great emphasis on quality in production techniques and materials to ensure longevity. She was the only one to highlight an interesting point, which is that companies should be responsible for teaching their customers how to take care of their products to prolong their life. She stressed that one of the services that should be introduced is the expansion of repair services that can maintain the quality and longevity of high-value products without having to dispose of them because of minor problems. This is an interesting point as companies have a strong influence on consumer buying behaviour and it would definitely be crucial in the industry to show them all the ways to extend the life of a product.

### 4.5. Selection of low-impact materials

The selection of low-impact materials and the use of materials is a fundamental aspect of sustainable design and the circular economy. It involves making informed decisions about the materials used in the manufacture of products, with the aim of minimizing the impact on the environment and society. This process involves careful consideration of raw material sourcing, processing methods, durability, recyclability and overall resource efficiency. We have just seen that

the previous section on optimizing product life is closely related to material selection. Therefore, this section presents how material selection influences other strategies.

The interviews show a common shift towards environmentally friendly materials and maximizing material benefits. Company A commitment to organic fibers and emphasis on natural, biodegradable materials for footwear signal a growing awareness of the environmental footprint of material sourcing. Company B collaboration with suppliers to use material waste for smaller accessories illustrates the circular principle of minimizing waste and optimizing resource use.

The CEO of company A shows a great general interest and focus on sustainability which has led to her company being the most experimental in various areas among the companies interviewed. When selecting materials, the creative director states that they focus on using materials with a low environmental impact, such as recycled and locally sourced materials. Ethical considerations play a role in material selection, as she avoids materials that are produced under questionable conditions. The exploration of innovative materials such as Pinatex (made from pineapple leaf fibres), coconut fibers and Bananatex (material made from banana trunks) shows a commitment to sustainability and the adoption of more sustainable practices. When analysing the detailed answers of the founder of company A, it becomes clear how comprehensive this strategy is. Not only the link mentioned above with optimizing the life cycle of the product, but also the importance of taking into account the social sphere, such as the working conditions in the place where a certain material is sourced or extracted. At the same time, the importance of considering the cost and environmental impact (through the carbon footprint) of transporting the material, depending on where it was sourced, was highlighted.

The senior researcher of the research centre (company C) notes that thanks to greater attention to sustainable practices, many new materials are being researched and developed. Her analysis shows that opting for environmentally friendly materials such as bioplastics could significantly reduce the carbon footprint of the product. In addition, developing a product from recycled or upcycled materials could reduce the demand for raw materials and the extraction of new materials, which is in line with the circular economy model. At this point, it is interesting to present the senior researcher's contribution to the impact of material selection on the carbon footprint: "The materials in a product should represent between 60 and 80 per cent of the product's footprint. In other words, the selection of materials is fundamental to reducing the environmental footprint of products. The materials, the type of material, the amount of material used, the efficiency with which the material is used, because the more we use, the less we have to consume. This is undoubtedly

the most important factor in reducing the environmental footprint of our products. As with most products, the materials are the component that has the biggest impact on your environmental footprint, and even your environmental performance".

The head of production development of company B highlighted how important it is for the company he works with to use reliable materials to meet the European standards of the final product. For a product where safety, durability and resistance are the most important features, it is difficult to introduce new materials as the market is not yet mature enough to produce such quality materials from 100% organic raw materials. To him, one of the most important analyses is the carbon footprint analysis when it comes to what material could be used for a specific purpose. An interesting indication that emerged with the interview with company B is that it seems necessary that most companies in the industry should invest in new materials and test them in order to incorporate them into production. In doing so, they should use materials with certifications and properties that reduce environmental impact, such as recycled polyester. The link between material selection and life cycle optimization is clear in the head of product development words: "Yes, I put enormous effort into making sure that 70 per cent of the product is thermoplastic, because if 70 per cent of the products are thermoplastic at the end of their life cycle when they are disassembled, we can calculate that about 50 per cent of them can be recycled".

Company D contribution in this section is crucial because it touches on all the above issues and provides a detailed distinction between sustainable and circular materials. The founder emphasizes that these terms often overlap and give a wrong picture of what circular economy really means. She gives an example of "vegan leather" and points out that some materials that are marketed as sustainable do not necessarily fit into the concept of circular economy. She mentions that materials such as organic leather, which is made from corn, are considered sustainable but are not fully circular as they are discarded after use. Another interesting point she raises is the importance of material selection, including the packaging of the product. In this case, reusability and recyclability depend 100% on material selection.

Almost all respondents highlighted a few points when it comes to innovative, sustainable materials. First, as already mentioned, the reliability and durability of the material itself. Secondly, the possibility to reuse the material, as technological progress makes it increasingly possible to reuse the "waste" generated during production when making new clothes, which is very difficult with new materials that have never been used before. In addition, many of the new bio-based materials,

while sustainable, have limited availability and are more expensive (due to the maturity of the material) than conventional materials.

### 4.6. Optimization of End-of-Life

The vision of the circular economy is brought to life by the many strategies to optimize the end-of-life phase of fashion products. As can be seen from the literature review, much of the literature deals with the end-of-life phases, namely the recycling and repair processes. Optimization of the end-of-life phase can be achieved through product/component reuse, remanufacturing/repair, electronic recycling of materials, safe incineration and consideration of local (informal) collection/recycling systems.

The focus of this work is to analyse and review the impact of design and eco-design on end-of-life optimization. It is about understanding why design is important to trigger sustainable end-of-life practices. At its core, it is about ensuring that they can be effectively managed, reused, recycled or safely disposed of at the end of their useful life. This approach is in line with the principles of the circular economy, as it minimizes waste and maximizes the potential of materials to be returned to the production cycle. Considering end-of-life in product design can significantly improve the overall sustainability of products.

Company A is active on several levels when it comes to optimizing the end- of-life of a product. Most of these are directly related to product design, while some others are related to operations. The brand actively takes care of end-of-life by reusing and recycling materials from old products. Unsold or unused products are integrated into a platform for resale to reduce waste and enable circular economy. The company is exploring techniques such as disassembling shoes and reusing components for new products or recycling materials. The CEO of company A points out that there are some products and materials that are more likely to be reused and that this needs to be considered at the design stage. For example, she says, 'Anything left over from the cuts is always used for necklaces and earrings, which we also make." She stresses the importance of the design phase to optimize end-of-life, and also points out that there are different considerations to take into account when it comes to recycling, for example. This is because some materials, such as certain plastics, lose their properties after recycling, leading to end-of-life management issues. The overall quality of production and materials must be considered as a whole in the design phase, so that the various materials used in production can be reused and given a second purpose.

The modular footwear design presented in the interview with company B offers a tangible solution that allows for easy replacement and repair of components, extending the life of the product. The

head of product development believes that we still have a long way to go before we achieve the circular economy, but every brand should commit to experimenting, prototyping and exploring new possibilities when it comes to extending the end of a product's life. Company B, for example, will soon introduce a safety shoe that has been considered in the context of the circular economy. The aim is to consider the degradability, reusability and recyclability of the product at the design stage, in this case aiming for 60% recyclability and reusability.

The opinion of the senior researcher suggests designing the product so that it can be disassembled to facilitate recycling and reprocessing. Smart separation of the different materials would make recycling more efficient. In addition, the modular design of the product could allow the reuse of components.

On the other hand, the CEO of company D points out the challenges of implementing repair and circular economy for brands due to logistical barriers, trust issues and the need for efficient processes. She notes that while repair and circular economy are important, the complexity is in the implementation, especially for global brands. The company is also proactively working to extend end-of-life by storing leftovers and unused materials for possible future use, taking a proactive approach to waste reduction.

# 5. Discussion

The analysis of the results provided interesting insights and contributions to this research. Not only did it provide an interesting addition to the literature used, but it also provided new insights that go beyond the scope of this thesis. The discussion will be divided for each design strategy presented in the results analysis chapter to provide the above insights into each strategy.

## 5.1. Product Concept Development

This design strategy was presented as central to optimising the first phase of use through measures such as reliability and durability, ease of maintenance and repair, modular product structure, classic design, strong product-user relationships, definition of budget and product requirements (Telenko et al., 2016). The development of the product concept was seen as directly linked to most of the other strategies presented in the analysis. As almost all interviewees are directly responsible for defining the product concept, the great influence that this phase has on defining product durability, maintenance and reuse/recycling opportunities was highlighted, which has implications for optimising end-of-life, optimising production techniques and optimising product lifetime strategies.

As far as this design strategy is concerned, the findings expressed by the interviewees seem to be consistent with the literature and the framework presented. In addition to this direct link, an interesting point emerged from the interviews: the emphasis on emotional longevity as a design criterion sheds light on the evolving understanding of the role of emotions in the consumer-product relationship. The insights of the interviewees further underline this by emphasising user-centred design that aims to satisfy genuine needs and thus avoid impulsive consumption. This collective approach in the interviews reveals the intersection of aesthetics, functionality and sustainability in the initial phase of product ideation. The concept of designing for emotional longevity or durability offers a broader interpretation of the study framework presented, which could in some ways complement the framework itself.

## 5.2. Optimization of production techniques

This strategy was highlighted throughout the literature review as it offers the opportunity to reduce the environmental impact of the product through low energy consumption, clean energy sources, few or clean consumables, no waste of energy or consumables and additional health and/or social values (Cheah et al. 2013).

In the results analysis chapter, it was shown that the introduction of sustainable production techniques often requires significant changes in traditional production methods and behaviours. At

the same time, it has been shown that the optimisation of production techniques needs to be coordinated with all other design strategies, as each of them has a major impact on the overall circularity of the product. Each design strategy applied will catalyse some other strategies and constrain the implementation of others. For example, it was highlighted that this strategy is closely linked the selection of materials with a low environmental impact, as it became clear in the interviews that the introduction of more sustainable materials also needs to consider the impact on production. A clear example given by many of the interviewees is the impact that the use of the more sustainable 'water-based' adhesive has on production, as it takes more than twice the time to dry and requires additional energy and logistics costs.

Overall, respondents also stressed the importance of centralising production facilities in a single location (even if this is done through outsourcing) in order to reduce the overall carbon footprint from transport and related processes that would be required if there were multiple production facilities. An interesting issue raised by some respondents when discussing this strategy is the so-called greenwashing. Few respondents stressed the importance of reviewing the overall activities of large companies to assess their environmental impacts and green practises, rather than focusing only on a specific or few product lines realised with eco-design practises.

### 5.3. Optimization of distribution techniques

Based on the literature review, optimising the distribution system can be achieved by using less or cleaner and reusable packaging, using energy-efficient transport, energy-efficient logistics and involving local suppliers (Dabic et al., 2010).

The interviewees saw this strategy in a similar way compared to the literature. All interviewees stressed the importance of improving the level of reusability of packaging and continuously reducing unnecessary printable information that can be accessed in a digital version. The interviews show that distribution is a strategic lever to achieve the circular economy and highlight innovative approaches that minimise the industry's carbon footprint. These strategies embody the industry's transition from traditional retail to localised, efficient and sustainable distribution channels. By reshaping the way products reach consumers, the fashion and footwear industry might become more aligned with the principles of the circular economy and its environmental imperatives.

Other interesting findings or practises highlighted in the results analysis include giving preference to local materials when possible. It was highlighted that many materials are still not available for local sourcing, forcing companies to source them from other distant markets, which affects the overall carbon footprint of distribution. Other interesting ideas include production to order, which

limits the possibilities of overproduction and the possibility of a high rate of returns, which has a negative impact on the environmental impact of distribution.

### 5.4. Optimization of product lifetime

As mentioned in the literature review, product lifespan optimisation refers to the deliberate extension of a product's useful life through various strategies and measures (Gallagher et al., 2017). Overall, it was mentioned by all interviewees that the strategy to extend product life is often in line with the companies' vision and goals, as well as with the company's target group of customers. Company B's contribution shows the importance of longevity to the company's practise, while other companies in the industry may be targeting customers who are mainly focused on other attributes such as price, convenience and aesthetics, resulting in less interest in product longevity.

Optimising product lifespan was discussed as central by interviewees, especially when analysing the overall sustainability of products. It was highlighted that creating products that are durable, repairable and allow consumers to buy other products less frequently is key in terms of sustainability. Overall the centricity of this design strategy is clear in the words of the respondents as well as the literature presents this topic. The centrality of this strategy was also highlighted, as in order to promote product longevity and durability, a company must profoundly reorient and redesign material selection and production techniques.

### 5.5. Selection of low impact materials

As outlined in other design strategies, the selection of environmentally friendly materials is central when it comes to the circularity of the product (Stark et al. 2017). As revealed in the interviews, this strategy has an impact on optimising production and distribution techniques, so it is necessary to evaluate this strategy holistically and consider the overall impact.

These cases show that the selection of materials is no longer just a matter of aesthetics, but has become a strategic endeavour aimed at reducing the industry's impact on the environment. As mentioned by some interviewees, the biggest impact of the material selection strategy lies in the transport issue. As the founder of Company A pointed out, there are many new environmentally friendly materials in the fashion industry, especially bio-based products, but they are mainly produced outside Europe. The challenge is to consider the whole carbon footprint of the material, from extraction to transport to production sites, recycling options and energy costs. By looking holistically at the life cycle of materials, fashion experts can redefine the industry's relationship with resources.

### 5.6. Optimization of the end-of-life

This strategy was highlighted by all interviewees as one of the most important in assessing the circularity of products, as it allows the product life cycle to be closed and the product to be reused for future applications (Hapuwatte & Jawahir, 2021). This strategy, when aligned with other strategies, is central for the product to be consistent with the R-strategies presented in the literature review, especially Recover, Repair and Recycle (Morseletto, 2020; Rodriguez, 2022; Xing et al. 2017).

Focusing on durability and longevity of design reduces the likelihood of products quickly becoming waste. It was highlighted that a few respondents are implementing several initiatives to optimise the end-of-life of products, such as the buy-back programme, which is a proactive approach to closing the loop and encourages consumers to return products for recycling. Many other initiatives have been implemented in the respondents' companies, such as the use of recyclable materials and the reuse of components of used products to realise new designs.

These examples illustrate a move away from the linear "take-produce-dispose" model and demonstrate the industry's commitment to waste reduction and sustainable product lifecycles. As fashion brands embrace repair, remanufacturing and recycling as integral parts of their business, the contours of the circular economy are taking shape in the industry.

# 6. Conclusions

The aim of this master thesis was to answer the research question: What is the influence of the redesign phase on the product life cycle and its circularity. Overall, the development of the thesis allows for an interesting overview of the information available in the literature on the circular economy and its implementation challenges. In delving deeper into the topic, it was possible to identify several strategies that are considered central to the implementation of the circular economy in the literature, such as the 7 R-strategies. To answer the research question, several product design strategies were then identified in the literature, which helped to create a study design that was used to develop the interviews and analyse the results.

## 6.1. Objectives

In the following sub-section, the objectives of this Master's thesis and the results achieved are presented:

(i) *Analyse the role of the redesign phase in the circularity of products*. This objective was not fully achieved, mainly due to the profile of the companies surveyed. Most of the companies interviewed are "born circular", which means that their companies have started sustainable and circular practises that are already integrated into business practises. This made it impossible to fully analyse the impact of the redesign phase on the circularity of products, apart from a few examples presented by some respondents. On the other hand, the work focused on the eco-design practises that have been integrated into the business practises of the companies considered for the analysis since their inception. The concept of eco-design as presented has many similarities with the concept of the redesign phase. The outcome analysis chapters highlighted the general implications of implementing eco-design practises, which indirectly provide interesting insights and analysis points for companies considering implementing circular practises for their products through redesign.

(ii) *Identify all the design strategies that exist in a company and in a specific industry in order to understand what influence design has on the whole process*. This objective was fully achieved, as stated in the results analysis chapter and in the further discussion. The analysis of the results provided interesting insights into the implementation of design strategies in a company and offered a holistic view of how the strategies are closely linked. The design strategies presented in the literature review were analysed with all interviewees having a comprehensive knowledge of the impact of eco-design practises on a company in the fashion industry. The interviews not only provided important evidence for the analysis of the design strategies in the literature review, but also brought to light unexpected insights related to the redesign phase and the topic of eco-design. In particular, it highlighted the

importance of looking at design strategies holistically and considering the specific sub-relationships that exist between them, which have a major impact on the company's sustainable practises. Another insight that emerged is the so-called emotional design, which according to some interviewees further emphasises the importance of the concept of user-centred design. This finding broadens the scope of the study and offers insights for future research.

### 6.2. Literature and business contribution

This master thesis contributes to the literature dealing with the circular economy and the implementation of circular economy policies and practises within an organisation. The thesis not only focuses on end-of-life strategies, which are one of the most frequently addressed topics in the circular economy, but also gives a central role to the redesign phase, which is at the beginning of the product life cycle and, as outlined, has implications for the totality of implemented and implementable circular product strategies.

It is believed that this work offers a contribution to management that focuses on the footwear industry. The analysis was conducted through interviews with experts in the footwear industry and provides insights that support the literature presented in the paper, while expanding on the topic by providing practical insights into the state of the industry in implementing circular strategies. The work could provide insights into a company's decision-making process when planning to implement product strategies that are in line with the circular economy concept.

### 6.3. Limitations and suggestions for future research

Considering that this thesis focuses on a specific industry, namely footwear fashion, it might be relevant for the literature to analyse different industries in order to compare the results obtained in different industries. It is believed that due to the differences between the industries, the eco-design strategies as well as the impact on the organisational level and on the circularity of the products could be different depending on the industry.

The analysis of the results of this work also suggests that many eco-design strategies may be influenced by local, regional or national policies that allow or limit the possibilities of implementing such strategies in the organisation's decision-making process. Future research could then focus on the different eco-design opportunities that exist in different regions and provide an overview of the ecosystem in which the analysed organisations operate. For future research, it could be interesting to conduct an analysis of the impact of the redesign phase on the circularity of products, focusing on the profile of the companies studied. As noted in this work, many factors can influence the implementation of design strategies, such as the size of the company, the economic power, the

geographical location of the operations or the outsourcing practises in place in the companies. All these factors can have a direct impact on the ability of a company to implement a sustainable circular economy and favour certain companies over others. Therefore, it would be interesting to conduct an analysis of companies with different profiles through interviews to assess the alignment or discrepancies of circular economy practises in each company and make a comprehensive comparison.

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