Is there Integration Between the Circular Economy and Ecodesign in the Fashion Industry?

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Abstract. *Changes in the phases of the production processes are fundamental to assist in the transition to the circular system, adapting to the demands imposed by the need to minimize environmental, social, and economic impacts. In this scenario, where changes are needed, the circular economy and ecodesign are studied as helpers in this process of seeking to reduce negative impacts. We have identified in the research that: (i) the principles of circular economy and ecodesign are congruent; (ii) the integration of circular economy and ecodesign drives new less invasive practices; (iii) driving factors favor the implementation of circular economy and eco-design principles; (iv) the principles of circular economy and ecodesign are articulated with the productive phases of clothing. The study concludes that, despite the implementation of new standards to increase the advancement of the clothing industry towards circularity, practical studies focusing on the circular economy and ecodesign are fundamental to the advancement of the fashion industry.*

Keywords. *Circular economy; ecodesign; sustainability; fashion industry.*

1 Introduction

Demand for sustainable products and the need to transform traditional products into circular products has increased significantly in recent years. With increasing awareness of the importance of sustainability, concern about environmental issues in product design has been a relevant trend (Wang; Shen, 2017).

Circular Economy (CE) promotes restoration or regeneration by intention and design; favors reuse and aims at waste disposal through the design of materials, products and systems (Ellen Macarthur Foundation, 2013). Thus, it presents itself as a macro tendency to minimize impacts caused by the generation and use of products, as the notion of waste disposal does not exist in the CE and is replaced by reuse and recycling (den Hollander *et al.,* 2017).

To achieve a system that meets the needs of society, organizations and the environment itself, the design process is critical as many aspects of reducing negative impacts of a product are determined through choices made at the design stage (creation) (Andriankaja *et al.,* 2015; Clancy *et al.,* 2015; Shen, 2016). Given this reality, ecodesign is seen as one of the most recognized and used strategies for the inclusion of environmental sustainability to reduce negative impacts throughout the product life cycle (Deutz *et al.,* 2013; Pauw *et al.,* 2014).

Thus, fashion brands have been striving to meet the demand for products produced with processes and practices that minimize social and environmental impacts at all stages of the production chain. Although awareness and research on reducing impacts on fashion production have grown significantly over the past decade, there are still incipient issues addressing the integration of circularity into the fashion design process (Han *et al.,* 2017). To reduce the impacts generated in the production processes and promote the transition to the CE, this study aims to associate the principles of circular economy with ecodesign, favoring the insertion of integrated practices to reduce environmental impacts throughout the productive process phases.

This is not an exhaustive review of research on the integration of CE and ecodesign in the fashion industry. Instead, our aim was to evaluate the most recurring topics related to these subjects and explore their relationships in light of the literature covering circular economics, ecodesign, and the fashion industry. According to the above aim, our research questions are: “How is Circular Economy conceptually related to ecodesign” (Q1)? and; “What are the articulations between the principles of circular economy and ecodesign with the productive phases of clothing” (Q2)?

The theoretical and practical relevance of the study is to present integrated practices between circular economy and ecodesign, which, articulated with the productive phases of clothing, show the benefits of building products by inserting the principles of CE and ecodesign. In addition, through the design contained in the literature, this study presents itself as a guide for future research dealing with CE and ecodesign focused on the industry.

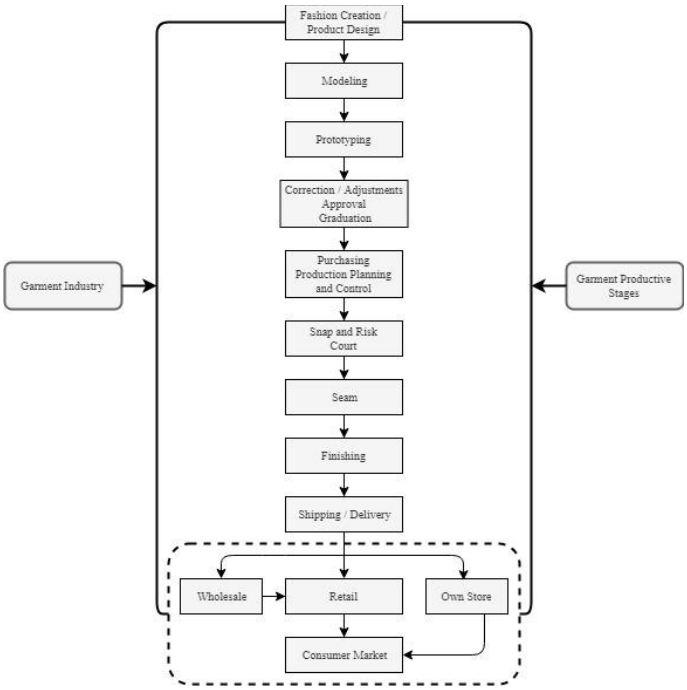
2 The Fashion Industry Towards Circularity

In the fashion industry, innovation and creativity are essential factors for success. Thus, the fashion product usually has a short life cycle that increases the challenges of circular economy integration in the sector (Dewi *et al.,* 2015). This promotes the need to control resource waste and avoid disposal by encouraging recycling, repair and reprocessing with industries other than fashion (Kozlowski; Searcy; Bardecki, 2018).

The garment industry is responsible for transforming fabric, made from natural, artificial or synthetic fibers, into personal (female, male, and children's), household (bed, table, and bath) garments, and decorative (curtains and awnings). For apparel production, textile materials are essential (Fontell; Heikkilä, 2017), and distribution involves segmented retail businesses including, for example, private label stores, department stores, and markets, as well as online versions of these (Bakker *et al.,* 2015).

This industry is part of the link of the fashion production chain and for the manufacture of products, it is necessary to fulfill the basic phases of production (Figure 1).

Figure 1 - Productive Basic Phases



Source: Sinha *et al.,* (2016); Pinheiro *et al.,* (2019)

The Creation Phase\Product Design is the process responsible for researching, choosing materials, defining colors, designing and trending products (Pinheiro *et al.,* 2019). This phase determines more than 80% of the environmental impacts of a product's life cycle (Mendoza *et al.,* 2017; Ellen Macarthur Foundation, 2013). Material efficiency and product design with material reduction are addressed in most design projects as it reduces costs and is considered good business practice. Specifically, the design phase is where problems

are solved and possible solutions are identified (Chen, 2015). At this stage the company's strategic objectives, together with the designer's choices, can have a major impact on the sustainability of a final apparel product, and at the design stage, the cost of intervention is relatively low (Chang; Lin; Chen, 2015; Clancy; Fröling; Peters, 2015; Köhler, 2013).

The modeling and prototyping phases are stages of materialization of the idea into product. For the elaboration of the modeling, the information from the creation phase and the technical sheet are used. The prototyping phase consists of the prototype manufacturing, considering the technical design.

After the prototype has been made, it will proceed to the live model test for suitability, fit and approval testing, and, if necessary, may receive adjustments. At this point, it is necessary that all discussions about inconsistencies between the idealized model and the physical product be conducted (Sinha *et al.,* 2016); sewing difficulties, modeling, among other aspects should be reviewed; this is called the Correction Phase \ Adjustments, and Approval. From then on, any change may be unfeasible due to the high costs that will be incurred if modifications are required.

The Mold Grading Phase is the process by which modeling is enlarged or graded from the base mold, thereby generating the same model in various sizes. The Material Purchasing Phase for the scale-making of products is the process of researching and purchasing the raw materials that will be used in the construction of the product.

The Production Planning and Control Phase (PPC) in the confectionery is responsible for the creative sector and its designers to create a very well-defined new range of products and to establish exactly the volume of fabrics and supplies that will be used in the production process. , in addition to the time that will be spent on each step.

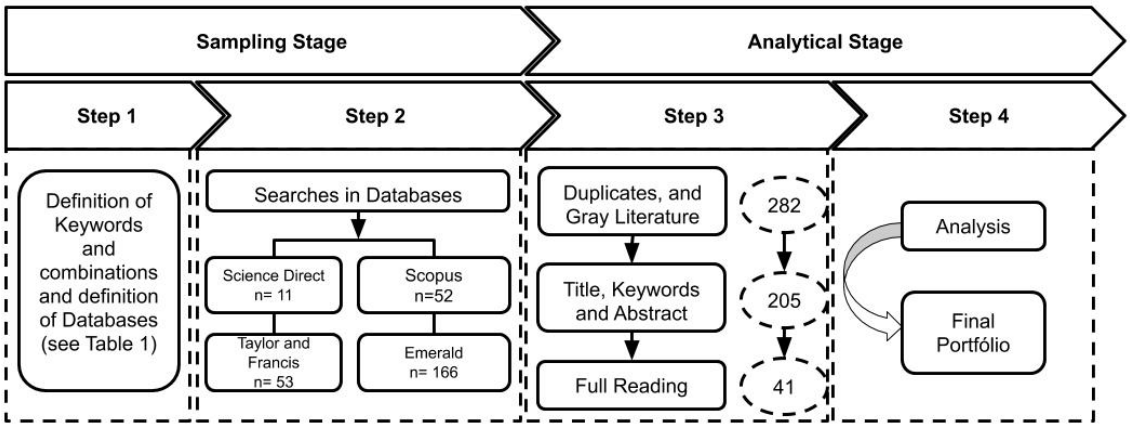
The Fitting and Scratching phases are responsible for fitting the molds to scale according to the requested grid for cutting. After fitting, the molds go through the Scratching process and then go to the Cutting phase, where the fabric is cut and the pieces lots go to the sewing. The Sewing Phase is the process of assembling the part. Wires, lines, and professional machines are employed to connect the components. This phase pertains to a substantial portion of the sector's workforce. The Finishing Phase is the final stage of the clothing production. Cleaning, ironing, and accessories are included. The product is ready to be destined to points of sale. In these phases, the level of technology implemented in the garment industries stands out. Highlight for machinery and software with advanced technologies in micro and small companies in the stages of fit and risk, cutting and sewing (Pinheiro *et al.,* 2019).

The Shipping Phase corresponds to the selection and separation of garments manufactured to be delivered from factories to sales outlets. The Delivery Phase is the process of shipping products to points of sale, which can be wholesale, retail, owned stores, multi-brand and/or department stores. With the products delivered, consumers will have direct access to the apparel product made. Retail is the main link between industry and consumer-users.

3 Methods

This section presents the methods used to conduct this research, including the workflow sequence and activities in each step. This literature review aims to associate the principles of circular economy with ecodesign, in order to favor the inclusion of integrated practices to reduce environmental impacts throughout the production process phases. Thus, the main foundations of CE and ecodesign in the theoretical field were revealed. Figure 2 illustrates the combination of sampling and analytical steps, including four process steps for the present study. A detailed description of the procedures used in the bibliographic search, selection, and filtering of the retrieved articles, as well as the aspects considered during the complete analysis of the articles that make up the final article portfolio, is provided.

Figure 2 - Article selection and analysis



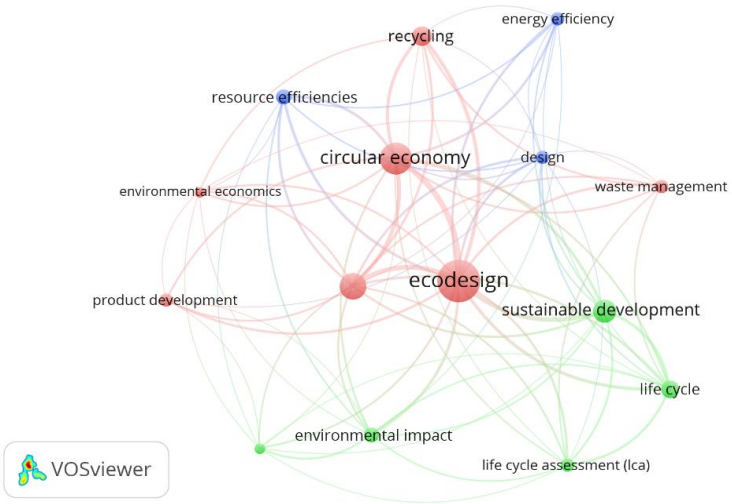
We start with a bibliometric analysis, guiding the initial sampling of articles. We then conduct a content analysis to reveal and categorize underlying theoretical development fundamentals. Finally, this analysis allowed us to problematize the predominant theoretical foundations and to identify areas for future contributions.

3.1 Sampling Stage

The process began by defining the keywords and combining them (Step 1) to drive data collection (Step 2).

Through preliminary investigations, keywords were identified by conducting tests with the keywords "circular economy" and "fashion industry" in the databases. The returned documents were selected and with the aid of the VOSviewer tool (Van Eck; Waltman, 2014), we verified the occurrence of keywords and clusters according to the bibliographic portfolio. Based on the co-occurrence of keywords with total word count, the map presented in Figure 3 was created, which highlights CE, ecodesign, and converging themes and establishes the final set of keywords and their combinations that were defined and used in the search (Table 1).

Figure 3 - Visualization of the keywords



Source: Vosviewer - Elaboration

In Step 2 (Searches in Databases), data were collected from the databases: Science Direct, Scopus, Taylor and Francis, and Emerald. The motivation for selecting databases includes highly cited scientific articles from journals that have an impact factor (Journal Citation Report / JCR) and feature publications relevant to the research area allowing greater availability of access to published materials. The gross portfolio comprises 282 articles. The queries shown in Table 1 were adjusted according to the particulars of each database.

Table 1 - Keywords and combinations – final search

Query	Science Direct	Scopus	Taylor and Francis	Emerald	Number of articles
“ecodesign” AND “circular economy”	11	47	53	17	126
“ecodesign” AND “circular economy” AND “fashion industry”	0	0	0	4	4
“circular economy” AND “fashion industry”	0	5	0	145	150
Total per database	11	54	53	166	

From the raw portfolio, a series of filters were applied to find only the studies aligned with the theme to be fully analyzed, as described in Step 3. Finally, to better expose future research motivations and expectations, reports by Ellen Foundation MacArthur, a major research group in the field, were also included in the review.

3.2 **Analytical Stage**

After identifying the bibliometric data, we began the selection of studies to compose the final portfolio of this study that was performed based on the following filters (Step 3):

- Duplicates and gray literature: All duplicates and documents that were not peer-reviewed research and journal articles were excluded. These documents were managed using the Zotero reference management tool. Of the gross portfolio of 282 articles, 205 remained:

- Title, keywords and abstract: All titles, keywords and abstracts were read and articles that did not show alignment for this study because they were not related to the topics covered were excluded. Therefore, 42 articles remained;

- Full Reading: The remaining 42 articles were read in full to verify the principles of CE; ecodesign and the existence of examples of CE practices or gaps revealing opportunities to implement them. Articles considered inappropriate or not related to the topics of this study were discarded. The reasons for discarding articles at this stage were: not having a strong relationship with the topics of the present study, not being clear or having superficial approaches and / or not making significant contributions to the body of the investigated literature. During the full reading of the articles Step 4 was performed. The issues taken into consideration were:

- Principles of circular economy;

- Principles of ecodesign;

- Essential topics for the study (eg garment industry, design, consumer, waste, garment industry).

The final portfolio consisted of 42 articles. For the analysis, no particular approach to the final portfolio articles (on the topics covered) was taken as a basis to avoid possible biased conclusions. After Step 4, we presented, according to the bibliographic portfolio, the practices from the intersection between CE and ecodesign for the fashion industry.

4 Data Analyze

4.1 **Principles of Circular Economy and Ecodesign**

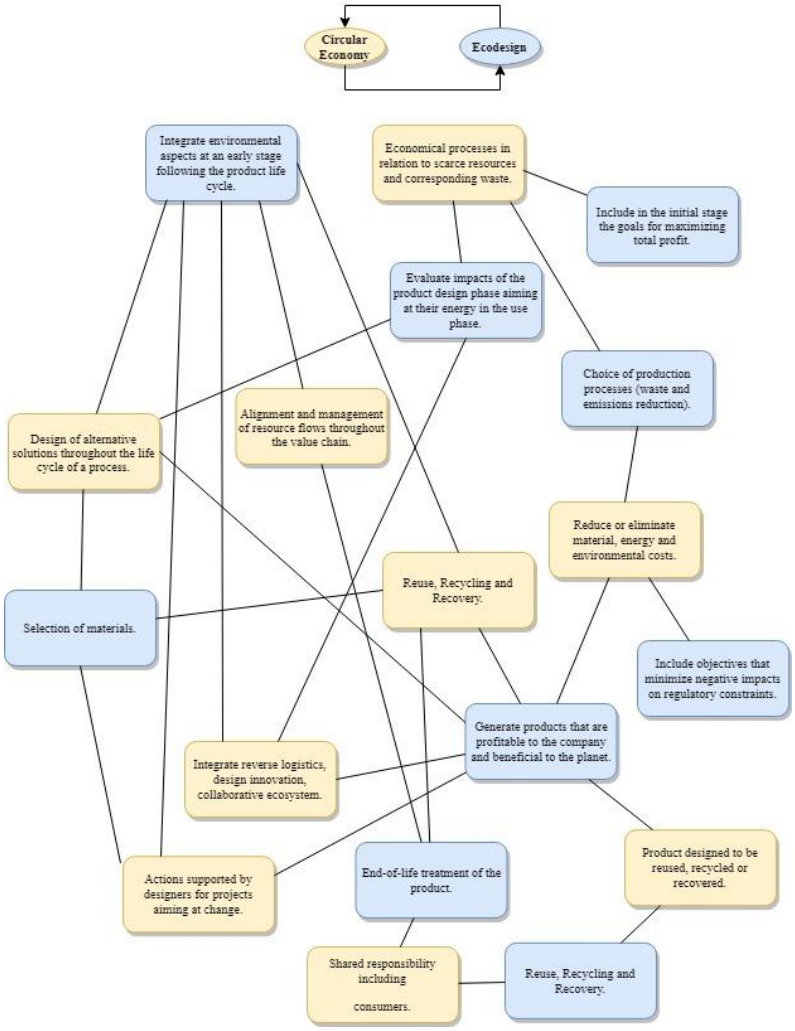
The principles of circular economics and ecodesign were identified with searches and analyzes in the bibliographic portfolio (Step 4). Based on the principles, we find that they have converging aspects of each other and thus, the ecodesign integrated with the principles of CE, favors and reveals the proposition of benefits for the clothing industry.

The ecodesign principles provide solutions and alternatives for reducing material costs, energy sources and environmental impacts at an early stage of the life cycle. And so, designers require experience to look at product life extension through longer life promotion, renewal, remanufacturing, and / or recycling (Mendoza *et al.,* 2017).

Improvements in resource efficiency, economic and environmental effects are enhanced by ecodesign in technological and production processes (Zhou *et al.,* 2016). A basic idea of the CE is that most products are designed and manufactured from biological resources that can be returned to the biosphere, as well as other renewable materials. For example, metals and plastics are designed from the beginning to be reused (Sihvonen; Partanen, 2017; Popa; Popa, 2014).

From studies by Ameli *et al.*, (2016), Deutz *et al.*, (2013), Ghisellini *et al.*, (2016), Gmelin; Seuring (2014), Goyal *et al.*, (2016), Köhler (2013), Pauw *et al.*, (2014), Scheepens *et al.*, (2016), and Vila *et al.*, (2015), the principles of CE and ecodesign were identified. Figure 5 highlights the possible relationships between the principles of CE and ecodesign, and the study question (Q1): "How does the Circular Economy conceptually relate to ecodesign?" is shown.

Figure 5 - Principles of Circular Economy and Ecodesign



Source: Authors

The circular economy is conceptually related to ecodesign. This is because the principles complement and/or strengthen each other. The CE request consists of a solution design with alternatives throughout the life cycle of any process; promotion of the generation of beneficial products for people, planet and profit generation; suggests integrating environmental aspects at an early stage into the product life cycle, which is associated with various circular economy principles, as shown in Figure 2. As part of the integration that minimizes environmental impacts is the selection of materials that will compose the product.

Material quality is an important point and is directly associated with product durability (Dalhammar, 2016; Sihvonen; Partanen, 2017). Durability is associated with positive issues that influence consumer choice of a product. Another important aspect is the assessment in the design phase of the impacts generated by the products in their use phase. With the evaluation, it is possible to reduce or eliminate material, energy and environmental costs, especially if there is at this moment a choice of production processes (reduction of waste and emissions).

In the relationship between CE principles and ecodesign the product must be designed to be reused, recycled or recovered. In this sense, it is essential that the actions are supported by designers, as these projects require radical changes and a long term to be implemented. In addition, reverse logistics, design innovation and collaborative ecosystem integration, with careful alignment and management of resource flows throughout the value chain; provide possibilities for end-of-life treatment of the product. It's emphasized that shared responsibility, including consumers, plays an essential role in promoting the circular economy. Consumers will influence from product creation to final destination.

Based on the bibliographic portfolio and Table 2, we present practices for the productive phases of the fashion industry that are essential for including circularity in the construction of the apparel product. In addition, the practices contained in Table 3 are guidelines to mitigate possible impacts that could be generated throughout the product life cycle.

Brainstorming actions and design problem identification can be integrated with environmental concerns, such as: waste / waste minimization; inclusion of goals for full maximization of textile materials; discussions about the possibilities of reuse, recycling and recovery (Talens Peiró et al., 2017); actions that consequently mitigate pollution caused by waste generation, use of toxic or non-renewable materials (Kozlowski et al., 2018). These actions, in addition to reducing environmental impacts, influence and promote cost reduction (Bakker et al., 2014), as well as promote waste minimization, pollution reduction, and toxic carbon emissions (Han *et al.*, 2017). Additionally, these actions enable the return of textile products or materials to the production cycle, thereby preventing their disposal in landfills (Koligkioni *et al.*, 2018).

4.2 **Integrated Practices for Circularity in the Fashion Industry**

The evidence identified in the bibliographic portfolio and shown in Figure 3 shows that the integration of the principles between CE and ecodesign provides practices for the fashion industry, which can be understood as a strategy for including circularity in the fashion industry. The identification of integrated practices is shown in Table 2.

Table 2 - Integration between CE and ecodesign practices

Integrated Practices	**Authors**
Consumer Satisfaction	Armstrong *et al.,* (2015)
Assess end-of-life product design impacts	Bakker *et al.,* (2014)
Integrar os aspectos ambientais na fase inicial	Talens Peiró *et al.,* (2017)
Waste prevention	Koligkioni *et al.,* (2018)
Include waste / waste minimization goals	Talens Peiró *et al.,* (2017); Han *et al.,* (2017); Masi *et al.,* (2018)
Waste collection and management	Koligkioni *et al.,* (2018)
Product Durability	Dalhammar (2016); Sihvonen; Partanen (2017)
Extend a product's use phase	Sihvonen; Partanen (2017)
Pollution Reduction and Toxic Carbon Emissions	Han *et al.,* (2017); Kozlowski *et al.,* (2018); Chen (2015)
Use of recycled and traceable organic materials	Wang; Shen (2017)
Reduce costs	Bakker *et al.,* (2014)
Choice of production processes	Niinimäki; Hassi (2011)
Reuse, recycling and recovery	Talens Peiró *et al.,* (2017); Sihvonen; Partanen (2017)
End of life treatment	Haas *et al.,* (2015)

Source: Authors

In order to support the integrated practices, with the help of the bibliographic portfolio, driving factors were defined that directly influence the practices previously identified and presented in Table 3. We understand that these factors help and direct the practices that emerge from the integration between CE and ecodesign and aimed at for production processes, they promote and / or increase circularity in the fashion industry (Table 3). According to information contained in the literature, we identified the following factors: (i) design; (ii) consumer public; (iii) Minimization of environmental impacts; (iv) Reduction of resource use; (v) end of life. The last factor (v) includes pre and post-consumer waste. The following parameters were used to select factors: (a) co-occurrence of word search factors using NVivo software; (b) analysis of issues identified in the bibliographic portfolio.

Table 3 - Integrated Practices and the driving factors

Integrated Practices	Fatores				
	Design	Consumer Audience	Minimization of environmental impacts	Resource Usage Reduction	End of life
Consumer Satisfaction	✓	✓	✓	✓	✓
Assess end-of-life product design impacts	✓	✓	✓	✓	✓
Integrate environmental aspects at an early stage	✓	✓	✓	✓	✓
Waste prevention	✓	✓	✓	✓	✓
Include waste / waste minimization goals	✓	✓	✓	✓	✓
Waste collection and management	✓	✓	✓	✓	✓
Product Durability	✓	✓	✓	✓	✓
Extend a product's use phase	✓	✓	✓	✓	✓
Pollution Reduction and Toxic Carbon Emissions	✓	✓	✓	✓	✓
Use of recycled and traceable organic materials	✓	✓	✓	✓	✓
Reduce costs	✓	✓	✓	✓	✓
Choice of Productive Processes	✓	✓	✓	✓	✓
Reuse, recycling and recovery	✓	✓	✓	✓	✓
End of life treatment	✓	✓	✓	✓	✓

Caption: (V): Factors Inserted to Promote Integrated Practices

The interaction between the designer and the consumer public tends to achieve consumer satisfaction regarding the product, which consequently assists in promoting prolonged use of the product. An added aspect of the consumer public factor is the change in consumer / user behavior. They are concerned with the ethical issues of the product, which is a trend that arises due to increased awareness of sustainability. With this, garment manufacturers have noted the growing importance of moving towards a more sustainable model (Parisi *et al.,* 2015).

Consumers present changes in habits and preferences, requesting transparency regarding the construction of products (Kumar et al., 2016). Armstrong et al. (2015) explain that consumers perceive the obsolescence and disposability of fashion products as problematic, as well as the poor quality and short life span of clothes are familiar issues for all consumers (Niinimäki; Hassi, 2011). For example, product durability has been raised among the key issues for purchasing a product (Sihvonen; Partanen, 2017). However, there are many consumers who have not yet been convinced about the benefits of sustainable fashion products (Kumar et al., 2016). Given this issue, environmental education can be a catalyst for changes in consumer behavior towards more sustainable individual fashion-related practices (Todeschini *et al.,* 2017).

However, environmental issues and functional requirements are rarely included in the design process, so there are many challenges to implementing CE within the product

design process. Integrating CE principles with ecodesign can be a relevant tool as it addresses a variety of aspects such as material selection (organic and recyclable), production process options (low carbon emission and waste generation), and final treatment of its useful life (repair and recycling) (Wang; Shen, 2017).

Concern with material selection extends to the product life cycle (Wang; Shen, 2017; Todeschini *et al.,* 2017). Reflecting on textile issues fits current international design trends and has a profound influence on ecodesign (Kozlowski *et al.,* 2018). Thus, the material selection step favors the reduction and use of materials with potential for contamination and non-renewable. In addition, choosing fabrics using renewable and environmentally friendly materials contributes to a low carbon economy (Chen, 2015). The use of organic and recyclable materials including materials such as recycled polyester, nylon and cotton and eco-materials (Niinimäki; Hassi, 2011) advantages product development with the concept of sustainability and ecodesign.

The selection of materials and other components of the garment product will determine the possibility for pre-consumer waste (generated in production processes and textile waste) and post-consumer waste (clothing discarded after use) to be reused, reused or recycled (Masi *et al.,* 2018).

Technological innovation in apparel materials and manufacturing processes enables a new way of thinking about business models that go beyond economies of scale and scope advantages generated by fast fashion (Parisi *et al.,* 2015). To minimize environmental impacts, CE can provide multiple value creation mechanisms, decoupled from finite resource consumption and waste generation, acting as a gateway to a more sustainable product development process (Heyes *et al.,* 2018).

The choice of production processes reduces costs and consequently the amount of waste and emissions generated. In the same vein, careful alignment and management of resource flows throughout the value chain promote the reduction of these emissions. It is of paramount importance that there is a production process-centric approach to avoid pollution throughout the product life cycle (resource extraction, production, distribution, use and end-of-life) (Popa; Popa, 2014).

Waste prevention is a goal to be achieved. Therefore, if idealized in product design can prevent and eliminate the generation of waste through the improvement in the production stages that involves from the creation of products to consumers. Furthermore, for waste prevention, the factory has to expend efforts on layout, process design and material management (Chang *et al.,* 2015). When it comes to textile waste, the amount is relatively small in weight, however, compared to other waste streams, it has a major impact on human health and the environment, and its rate is increasing due to high programmed obsolescence of fashion products (Bukhari *et al.,* 2018).

When it comes to product end-of-life, recycling is the least preferred option as it involves the destruction of product integrity. On the other hand, recycling is still, in practice, the most common strategy employed to achieve CE (Haas *et al.,* 2015). However,

recent studies show that recycling and reuse of textiles is more beneficial for the environment than landfill and incineration (Bukhari *et al.,* 2018). However, increased recycling activities depend on the existence of a market for recycled materials, regional recycling capacity, total energy used for recycling, and the knowledge of workers and designers about options for using recycled materials in other projects (Haas *et al.,* 2015). The recycling process involves the dismantling and disintegration of a product and its constituent components and subsequent reprocessing of product materials (den Hollander *et al.,* 2017).

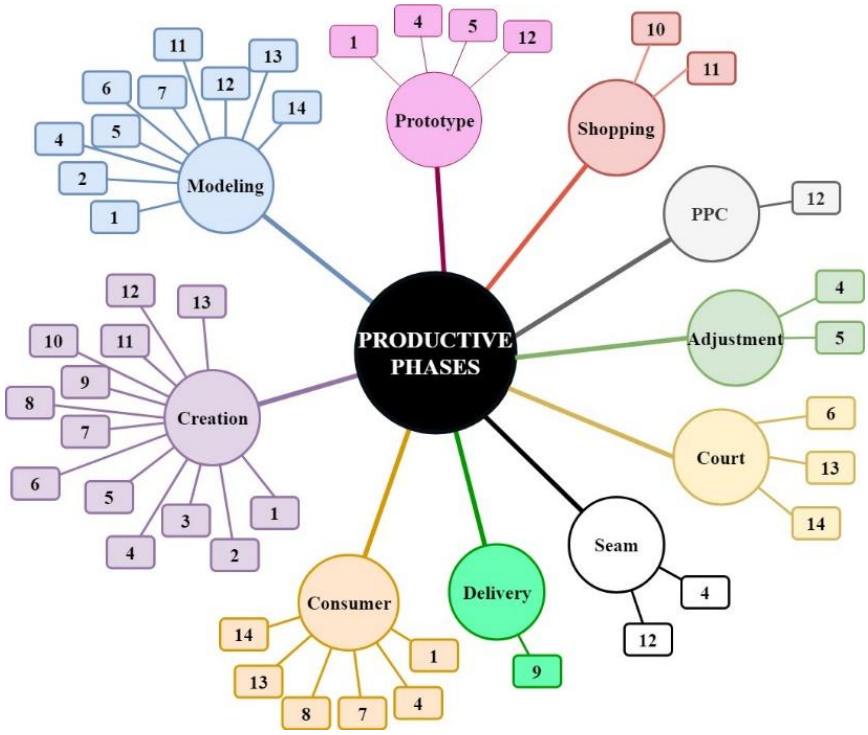
Repair refers to the right to repair a defective or broken product or component that returns to a usable state. Refurbishment consists of allowing a product to be used in a satisfactory condition by rebuilding or repairing major components that are close to failure, even where there are no apparent malfunctions in these components. Refurbishing involves the return of a product used for at least its original performance with a guarantee that it is equivalent or better than the newly manufactured product (Bakker *et al.,* 2014). The reuse or repeated use of objects/accessories/clothing, even for a single use, can be a method of reducing the huge amount of waste that reaches the landfill. Overall, the results show that reuse is preferable among end-of-life options (Koligkioni *et al.,* 2018).

Fashion industry experience and the infrastructure needed for remanufacturing, reuse and recycling of apparel currently lack sophistication in an era of fast fashion (Armstrong *et al.,* 2015). This is a subject that needs studies addressing the issues of reuse, remanufacturing and end-of-life that receive the least attention.

With the definition of integrated practices (Table 3) and the driving factors (Table 7) we present the relationship between integrated practices and production phases. Question two (Q2) of the study is answered through the discussions presented earlier and with Figure 3, which addresses the productive phases of clothing and the integrated practices defined in this study.

Based on the discussion presented and Figure 6, we respond to Q2: “What are the links between the principles of circular economy and ecodesign with the productive phases of clothing?”

Figure 6 - Production Phases and Integrated Practices



Subtitle:

(1) Consumer Satisfaction

(2) Assess end-of-life product design impacts

(3) Integrate environmental aspects at an early stage

(4) Waste prevention

(5) Include waste / waste minimization objectives

(6) Waste collection and management

(7) Durability of products

(8) Extend phase of use of a product

(9) Pollution Reduction and Toxic Carbon Emissions

(10) Use of organic, recycled and traceable materials.

(11) Reduce costs

(12) Choice of processes

(13) Reuse, recycling and recovery

(14) End of life treatment

As shown in Table 7 to integrated practices and the driving factors are congruent. All Factors defined (i); (ii); (iii); (iv), and (v) relate to all identified practices. Integrated practices are important for all phases, but stand out in some phases (Figure 4). The Creation phase has the most connections to integrated practices; followed by the modeling phase; Prototyping; Court; Fitting / Scratching; Purchasing; Seam; PCP; and, Shipping, Consumer.

In the present study, the following productive phases were not included: Correction / Approval, Graduation, Finishing, and shipping. The motivation for exclusion at this moment corresponds to the low influence identified in the literature of integrated practices in the referred productive phases. The Creation Steps: Modeling, Prototyping, Purchasing, PCP, Snapping and Risk, Court, Seam, Expedition, and Consumer are integrated practices that, when implemented in their respective phases, showcase the potencial for inclusion in the enhancement of circularity in the productive phases. As a result, industries benefit from things like reducing the use of non-renewable materials, producing post-use goods, and overcoming the difficulty of recycling or reusing waste produced during production due to raw material mixtures.

5 Conclusions

This study aimed to associate the principles of circular economy with ecodesign, favoring the inclusion of integrated practices to reduce environmental impacts throughout the phases of the production processes. The approach to the themes reuse, recycling and recovery should be presented because of their importance to the CE. The study shows that EC and ecodesign are relevant topics, with relatively recent global applicability and still incipient in the fashion industry. Developing EC research from a broad perspective to a more specific form of analysis shows that CE and ecodesign can help the fashion industry to reduce waste and reduce negative environmental impact by identifying point factors. That favor the insertion of integrated practices that emerge between CE and ecodesign.

It is evident that the concept of CE can be used to inspire long-term systematic and changes in the fashion industry for sustainable operations, for example the use of renewable materials and eco-materials in the manufacture of garment products and the minimization of problems, such as waste management and management.

The theoretical contribution of this paper lies in the fact that the integration between circular economy and ecodesign is potentially possible due to the complementarity of the objectives that both present. As for the practical contribution, tables are presented with the integration of circular economy and ecodesign, and factors that provide the understanding to implement new product development standards to help achieve circularity in the fashion industry.

However, the issue of material, energy and environmental costs is a limitation of the present study, as field research is necessary to quantify the costs and the practical implementation of the concepts presented, which are suggestions for future research.

This is a field of research and incipient applicability, which needs further investigation into its real benefits, especially in the sectors characterized by the ephemerality of its products, such as the fashion industry, with empirical research. It is noteworthy that studies are needed to show limits, barriers, limitations for applicability and execution of CE in the various sectors, as well as further investigations on the minimization of environmental risks.

After extensive research in the literature, it can be stated that there is no clear evidence of CE and ecodesign directed to the garment industry. In addition, despite being a widely discussed topic, it still has a gap in the literature regarding pre-and post-consumer textile waste in the garment industry. However, we reinforce and highlight the relevance of the theme and the need for studies for the application of actions in the garment industry for circularity in the garment industry.

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