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Article

Fit for the Future: Garment Quality and Product Lifetimes in a CE Context

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Abstract: The fashion industry is one of the most polluting industrial sectors in the world and its environmental impacts are huge. Garments are produced effectively at a low price, are of low quality, and are used for a very short time before ending up in increasing textile waste streams. One critical aspect in this context is the lifetime of a garment. Short garment lifetimes are the results of low quality and consumer dissatisfaction, or consumers' constant search for newness, resulting in the early disposal of garments. This study focused on the issue of garment quality and how it can be connected to product lifetime. The research used a case study approach, including company interviews about working for quality, and aimed to expand on the topic of how quality impacts product lifetimes. Data analysis was conducted according to the principles of descriptive analysis and the discussion expanded to the circular economy context, creating an extended understanding of garment quality in a circular economy.

Keywords: quality; lifetimes; circular economy; garment; sustainable fashion



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1. Introduction

The scale and speed of current apparel consumption and production have multiple negative environmental impacts. The linear system (design–manufacture–sale–disposal) is not only contributing to extensive damage to the ecosystem and causing a cluster of impacts such as climate change and loss of biodiversity [1], but also to the loss of huge amounts of valuable resources and materials [2].

As clothes are produced for the market at an ever-increasing pace, their average quality is not what it used to be. Consumers have been experiencing the decline in garment quality since the 1980s, before the time of outsourcing production and before the period of fast fashion and mass manufacturing in developing countries [3]. Although less resources and time are now spent on designing and manufacturing garments, it is unlikely that enough time is invested in the work for quality [4] or that the quality of all products is fully tested [5]. This, combined with cheaper fabrics and faster mass-processes, has led to products that last only a short time or a few washes. In the tight competition of fashion, it is not easy for producers to manufacture durable, long-lasting products [6], and it has been claimed that consumers are no longer even looking for the best quality. Therefore, it is believed that producing the best quality is not worthwhile, and garment quality can only be average or lower in the current linear system [7]. This is especially true in these times when fast fashion is the dominant reality, and production happens through cost savings on the other side of the globe. It seems that quality is systemically fading in terms of the way in which products are designed and manufactured. Although at the same time, it is stated that the price of a product is forgotten shortly after a purchase, but the quality is something consumers remember long after, and they also associate it with certain brands and their reputation [3,7]. Poor quality is connected to both consumer dissatisfaction and the early disposal of clothing, which results in large amounts of garments ending up in landfills. Textile waste streams have been increasing in all Western countries and recently

also in developing countries. The issues are complex, partly due to the lengthy and highly global supply chains of the industry, the tight global competition in the fashion sector, and the current business model based on fast fashion [8].

One of the approaches to tackling these issues is to extend the lifetime of garments by designing and producing clothes of higher quality [5,8–14]. Therefore, this study focused on determining how quality can contribute to extended product lifespans. The article first reviews the general aspects of garment quality through literature and previous studies. Then, it describes the knowledge on the connections between quality and lifespan within this industry that the study gained through a case study approach. We interviewed three textile and apparel companies about their practical work for quality and product lifespan extension efforts. Through the interviews and the data analysis, the study focuses on making visible how quality impacts product lifespans. Finally, bringing these aspects together, it aims to deepen the understanding of quality in the new era of a circular economy (CE).

2. Background

2.1. Linear System in Textile/Garment Industry

The epitome of linear product development is “planned obsolescence”, which is naturally the opposite of making products last [15]. Current economic and industrial systems are based on the rapid replacement of products and therefore products are no longer designed for long-time use, nor it is worthwhile to repair them [3]. In the clothing industry, prevalent linear production starts from the production of fibers, which are then spun into yarns, after which they are made into knitted or woven fabrics, and then further assembled into garments which, after use-time, end up in landfills [16]. The textile industry relies on low-quality products that speed from on-trend to obsolete in short time spans. The “fast fashion” phenomenon driven by an efficient system of clothing production, often in low-cost countries, has enabled companies to offer fashionable clothing for relatively low prices. This, in turn, may encourage consumers to buy more clothing, and to use and discard them in faster cycles [12].

It is estimated that this industrial sector annually produces up to 10% of global CO₂ emissions (although estimations differ according to sources), and that it is the world’s second largest water consumer with 79 billion cubic meters of water consumed annually [17–20]. In addition, it is estimated to produce as much as 92 million tonnes of textile waste annually [18], which either ends up in landfills or is incinerated. According to the Ellen MacArthur Foundation [12], at present, less than 1% of the textiles that are produced for clothing are subsequently recycled into new garments, and 87% of the materials used for the production of apparel is either landfilled or incinerated after its definitive use. This represents a lost opportunity of more than USD 100 billion (EUR 84 billion) annually, in addition to the negative impacts on the environment. Extending the use-time of clothes would be the most direct way of storing value and eliminating waste and pollution from the system [12].

As clothes are produced for the market at a constantly accelerating pace, their average quality is not what it used to be. The fast-fashion model has led to shortened, cheaper production processes and this affects garment quality [10]. For example, Benkirane et al. [21] examined the lifespan of 29 T-shirts of different brands through repeated washes. Based on a sensory evaluation by a non-trained panel, eight of those T-shirts reached a lifespan of 15 washes, six reached 30 washes, and only four reached the lifespan of (at least) 50 washes; here, lifespan was defined as the willingness to wear these garments under normal conditions [21].

Garments are not manufactured to last and are designed to endure possibly only 10 launders [22]. This seems to be the new “standard” in fast fashion [23]. According to Connor-Crabb and Rigby [9], in addition to the changes in the ways that clothes are produced, consumed, and used, expectations of the quality of garments have also changed: garments are no longer expected to last more than a few years or be passed down through

generations. Consumers are more prone to buying ever-changing fashion and following rapidly changing trends. As well as the number of wash times, the duration of clothing use can also be expressed as years of use or the number of use-times the garment can withstand without showing signs of wear and tear [12,14,21]. There are different ways to calculate the average age of garments, which is currently somewhere between 3.3 years [24] and 5.4 years [13]; this includes both active and inactive lifetimes. These figures may differ depending on the types of garments or cultural contexts. For example, socks and underwear have short lifespans, whereas the lifespan of nightwear and outerwear is above average [13]. The results of a Dutch study in 2007 estimated that at the time clothes were in active use for only for 44 days during their lifespan, and only worn for 2.4 to 3.1 days between the times they were washed, although at the same time the study showed that different product types varied greatly [25]. However, an emphasis on the “active” life of products is important. The longer a garment is in a consumer’s active use, the more likely it is to offset the production of a new textile product and thus have less environmental impacts [14].

Worldwide, compared to 15 years ago, the clothing production rate has approximately doubled, while at the same time, clothing utilization measured by the number of times a garment is worn before it is discarded has decreased by 36% [12]. According to the Ellen MacArthur Foundation [12], if a garment’s average use-time was doubled, the greenhouse gas (GHG) emissions of the clothing and textile industry, could decrease by 44%. These numbers highlight the significance of focusing not only on the environmental impacts of production but also on aiming to extend clothing lifespans and reducing the impacts of the use phase. In addition to this, the perspective of the CE underlines not only the extended use-time but also the importance of closing the material loop, which brings new attributes to quality. This is further discussed in the following section.

2.2. Circular Economy CE

The clothing and textile industry is a resource-intensive industry [26], and yet we seem to easily accept that all the efforts put into the creation of a product will be lost at the end of its use, when the product is discarded in a landfill. This does not only lead to great environmental damage but also to a significant economic loss. To avoid this loss, the recovery of products and their component materials should be clearly included in the design process of products [26].

According to Tischner and Charter, “80% of the environmental and social impacts of a product, incurred throughout its whole life-cycle” could be influenced at the point of the product’s design and development [27] (p. 120). These aspects create new challenges for design skills, because the products’ impacts have to be considered on a larger scope, and design needs to create a view further into the future, in order to construct and support the transformation into a circular system [2].

The CE approach, also referred to as “the new textile economy” [12] complements the ongoing efforts of making the textile system more sustainable through minimizing its negative impacts. The “Circular Economy Action Plan”, released in early 2020 by the European Commission [28], proposes a comprehensive “EU Strategy for Textiles”, which aims to strengthen innovation in the textile sector. It recommends increasing the reuse and recycling of garments and textiles. The CE is “an economic model, which aims to restore the value of resources, materials, and products as high as possible for the maximum amount of time, and then return the materials back to use in continuous cycles” [16] (p. 9). Its goal is to have products and materials circulating in a system of closed loops for as long as possible. Therefore, it aims to extend the use-time of garments instead of generating waste; waste prevention is prioritized in the waste management hierarchy [16]. It is a counter move to the dominant linear business model in which products end up in a landfill at the end of their lives, and lose their value. The emphasis of the current linear system of mass-manufacturing products in low-cost countries on cheap end-prices has led to products having weak intrinsic quality [3]. In addition, poor quality and cheap prices

have contributed to shortened product lifespans (*ibid.*). This gives the circular product design a very important role and demands a change not only in the ways in which products are designed, made, and used but also in the ways they are treated at the end of their lifetimes [26].

As regards the CE in the garment sector, it is essential to focus on extending the use-time of products and to determine how business models can support this. High technical quality enables a garment to be used for a longer time and enables further userships through, for example, renting, leasing and second-hand markets. Garment repair as a DIY activity or as a service provided by a company is also one way in which to extend use-time [29]. Garments and their materials can also be used in other sectors when the garment's first lifetime is over. Upcycling textile waste into new products or even recycling textile waste in another sector, e.g., as part of composite material in the automotive industry, is an important approach in a circular economy.

To extend the use-time of materials, redesigning new products from leftover or disposed garments could be encouraged more. This can be further supported by using technical, durable, and high-quality garments and materials, and therefore quality is essential for developing alternative ways in which to conduct the fashion business. Accordingly, quality enables alternative and more sustainable design and business models in the context of CE [2]. When the garment has begun to become waste at the end of its lifetime (or after several lifecycles), it can still be recycled as material in the industrial system. Therefore, closing the material loop is essential in the CE approach.

Accordingly, all products and materials are understood as valuable resources, which should be recollected and used more efficiently to create a circular system in the textile and fashion field. The aim is to reduce the use of virgin material, and therefore lower the environmental impacts of this industry.

2.3. Quality

Among researchers and consumers in the clothing and textiles field, there is a lack of consensus on how to identify quality [30]. Despite the broad spectrum of interpretations of quality, for most fashion businesses, quality seems to only include the very technical laboratory testing of intrinsic, physical characteristics, such as fabric strength, abrasion resistance, pilling, wrinkling, colorfastness, dimensional changes, and seam slippage. However, although this industry-based approach to quality might help standardize products, other views on quality, such as user experiences of the garment over the course of time, have not been identified [9].

Garment quality has an impact at the stage when the consumer decides to dispose of the product [31]. While aspects related to taste and aesthetics, such as no longer liking the style, color, or print, are common reasons for disposal, issues related to quality are a major reason for clothing disposal. Discussing clothing consumption and lifetimes, a study by Laitala et al. [32] registered 70 different reasons for disposal, such as defects in the garment, size, and fit issues, as well as changes in style and personal taste. Deficiencies in technical quality was the largest group of reasons for disposal, including defects such as holes or tears, worn appearance, fading of color, loss of elasticity, change of shape, and pilling [32]. Similar results were reported in a study of Chinese consumers: "wear and tear" was the most common reason to discard clothing [33].

Yet, the consumer's view of garment quality and opinion of whether the garment is still in acceptable condition or if it needs to be discarded is based on very individual assessments and often related to the physical or aesthetic failure of a garment [34]. Even though technical quality is important for garment durability, quality is also tightly linked to user satisfaction with clothing over time, and therefore also to how long the product is used [9]. The individual, subjective assessment of garment quality affects how clothing is worn and cared for, which then further impacts the physical condition of the garment over the course of time [9]. If a consumer considers a product to be of good quality, they care for it, and its lifespan becomes longer. In contrast, if they consider the quality of the

product to be poor, the lifespan might become shorter due to lack of attention or good maintenance. Consumer satisfaction with the quality of an apparel product can be measured in three phases: at the point of purchase, while using the item, and ultimately, when it is discarded [35]. As quality is generally first evaluated “pre-use” and then experienced “during use”, two classifications can be used: (1) objective quality, which is measurable and quantifiable, and observed before use, and (2) subjective quality, which is based on the garment quality, user behavior, and the experience of using the garment [9].

Quality experience is based on the usage phase of a product and can therefore also be referred to as “quality in use”. At this phase, the consumer compares their experiences during use to their pre-use presumptions of the product’s quality. Quality in use recognizes that it is everyday actions and experiences that reveal the quality of an apparel product, as it develops and is uncovered over time [9]. Quality experience is closely linked to consumer satisfaction or dissatisfaction with the product.

At the point at which the consumer makes their judgment about quality in use, the business’s quality assurance is put to the test and the consumer evaluates whether it meets their expectations. For most people, good quality is an almost universally accepted preference that reflects user satisfaction, whereas poor quality and the related failures of quality are seen as central reasons for user dissatisfaction [35]. This highlights the importance of understanding user expectations of quality so that companies can deliver quality that meets these expectations [9].

Insights into quality through use can offer new ideas for product design as well as for the design of systems (how products are sold, rented, maintained, disposed of, reused, recycled), at the same time stimulating pro-environmental practices. It is also important that decisions regarding design are based on research on quality in use, rather than solely on laboratory tests of the product’s technical and intrinsic properties. Viewing quality as a changeable product attribute that emerges through use can support the proposition of sustainability ascending from behavior and lifestyles instead of the design of the product itself [9].

Quality is a significant element for choosing certain wardrobe staples, such as coats, jumpers, jeans, socks, and underwear. As their style evolves slowly over time, many customers expect them to last, and often wear them until they have a noticeable defect [12]. Currently, information is insufficient for being able to judge the durability of the clothes on the market. Durability labelling could help customers evaluate the quality and recognize the value of buying longer-lasting items; potentially higher-priced items of higher quality. Such quality labelling should reflect objective criteria, be clearly defined and measurable, and ideally be consistent throughout the industry on a global scale. The label could be either voluntary or mandatory and have different minimum quality standards for different types of garments. For example, it could communicate minimum quality through the number of wash times the garment can withstand, or the number of times an item can be worn in general conditions without showing signs of wear and tear [12,14].

3. Research Design

As the goal of the study was to gain an insight into what quality is and how it is defined in companies working in the textile and apparel industry, as well as to determine how quality relates to product lifetimes and lifecycles, we selected a qualitative case study as our research strategy. Through three cases, we studied what quality means for professionals working in the industry.

We conducted four interviews with experts from three different textile and apparel companies. Table 1 presents a summary of the interviewees. The companies chosen for interviews were known to already address quality and circularity in their operations. Therefore, they were valuable assets for finding linkages between quality and lifetime extension.

Table 1. Information on interviewees and represented companies.

	Interviewees	Company Size	Business Model	Product Category
Company 1	1	small	B2B, B2C	Knitwear
Company 2	2	large	B2B, B2C	Children wear
Company 3	1	large	B2B	Workwear, specializing in rental services

The interviews were semi structured, each lasting 90–120 min. All the interviewees received the question template in advance. The resulting 62 data pages to be analyzed consisted of four interviews, transcribed into written form from voice recordings.

As the goal was to gain as much information as possible on the quality and lifetime of the products, we chose content analysis as the method for analyzing the interviews. As this approach is inductive, it is based on the actual research material. The inductive approach aims to form generalizations from remarks and individual observations [36]. The analysis was first used to go through the individual interviews and then to find the common themes in all four interviews.

In qualitative research in general, the conclusions made about the research material are not based on generalization, but on the idea that the general is repeated in private [36]. By examining individual cases, it is possible to highlight what is meaningful in the phenomenon and to identify the repetitive issues when examining the phenomenon from a prevalence perspective [37].

4. Results

4.1. Product and Material Quality

Product and material quality were the most referred to dimensions in the interviews. According to the interviewees, product quality consists of elements such as timeless design (a style that is not based on seasonal trends), functionality, adequate construction, and technical durability. It is about suitable material and construction combinations that guarantee functionality, safety, and performance of the product. All in all, companies are willing to invest a great deal of resources to find the perfect and most suitable materials for their products. Therefore, product and material quality are tightly intertwined and will be discussed together.

According to the interviewees, material and product quality are generally examined by either extensive laboratory testing or using and washing products in practice. All products, materials and components can be tested through adequate ISO or EN standards. The companies also considered several environmental certifications, such as GOTS (Global Organic Textile Standard), Oeko-Tex and Bluesign, and technical reports provided by the material suppliers to assure that the textiles had been produced in environmentally friendly and socially acceptable ways, and that they performed as expected. According to one of the interviewees, regardless of the certifications and reports, the company itself tests all its materials to be sure of their performance and safety, as the testing methods vary in different countries. Another interviewee noted that all their testing is to ensure that no unpleasant quality problems arise during use.

The interview results indicate that the extent of testing depends on the company size and the available resources. Material quality is tested for each material lot. Product quality is tested in-line during production and is also controlled when the product is finished and ready for shipping. In-line control also enables checking the many product parts, such as waddings, paddings, and tapings, that might be covered and no longer visible when the product is finished. The minimum number of products to be tested during these quality checks is based on AQL (acceptable quality limit), but some companies go beyond this and test more than is required.

Two of the companies emphasized that quality under specified limitations cannot even be considered for their collections. These limitations vary depending on the product

category. Different indicators are important for, for example, outdoor and indoor clothing. Therefore, material selection is often about meeting the technical expectations that create a base for desired performance.

Two of the companies worked with more technical applications and therefore had to consider and fulfil different claims and certifications. Therefore, for them, quality assurance was partly inevitable. Different countries have different legislation regarding, for example, chemical regulations, and different industries have different specifications in terms of, for example, fire safety or particle exemption. Companies need to be fully aware of these regulations and able to provide suitable solutions that correspond to these requirements.

As mentioned earlier, materials and products tests are conducted to assure technical quality and to prevent product performance problems. The technical aspects were emphasized in the interviews. However, it became clear that for the companies interviewed, technical quality is a way to ensure the quality, safety, and technical performance of their products, but they also simultaneously address the customer's needs and desires and regard this as part of product quality. They pay attention to how the customer experiences their garments and what kind of emotions their products evoke. They use colors, shapes, and product construction to arouse feelings such as joy, comfort, and safety. Positive consumer experience is something that companies wish to achieve with their products.

Timeless design was mentioned as one way of assuring a product's aesthetic quality. One of the companies focused on refining their old classic styles instead of putting great effort into developing new styles. They said that experience has taught them what their customers want—and that this is usually classic styles. The company added that their products have to cover different customer expectations and different use situations, as garments are a highly personal matter. It is not possible to fulfil everyone's needs and desires, but at least most of them can be met by gathering customer feedback and designing products for different personalities and visual preferences.

4.2. Lifespan Quality

Regarding the relationship between lifespan and product quality, aspects such as timeless design, adequate materials and product construction, high technical quality, and functionality were considered important. Two of the companies also emphasized that the right product in the right place and its correct use will lengthen product lifespan. Figure 1 presents the notions regarding lifespan quality.

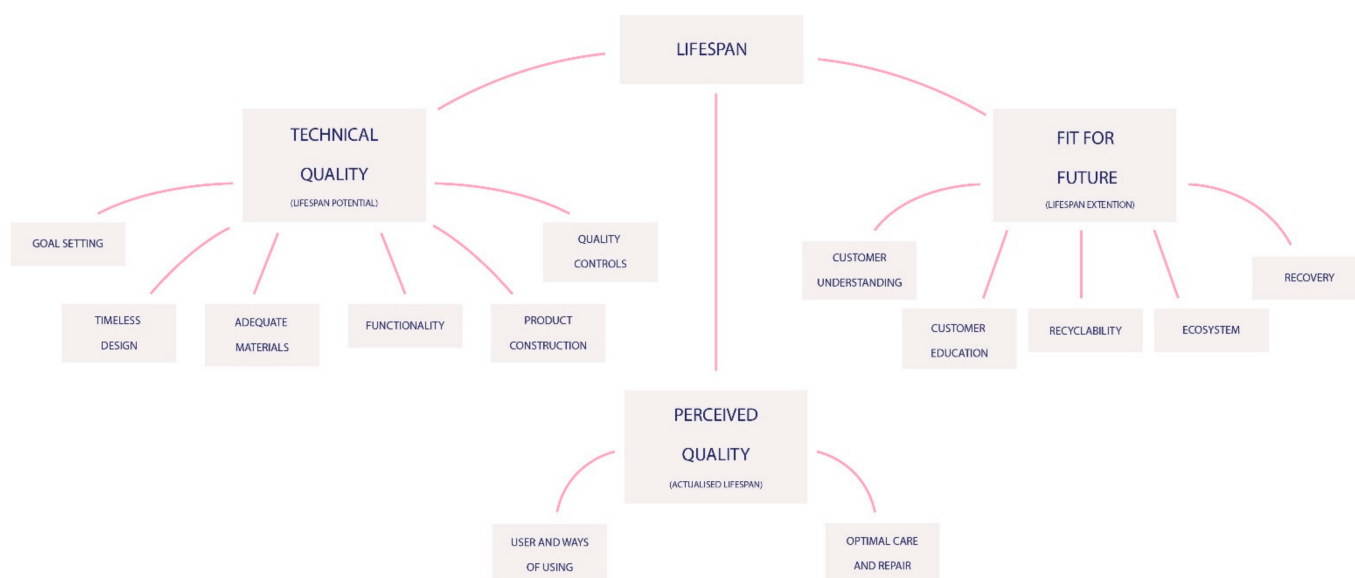


Figure 1. Lifespan quality.

The interviews revealed that the companies had set goals for their product lifespan. One of the companies claimed that the products were not designed or made for use by only one user, but many users. Another company estimated that their products lasted 5 to 10 years, depending on the user and the ways of use. One of the companies added that as they produced durable products, the products should have a sufficiently long and meaningful life. This implies that a product's lifespan has to match its durability and the resources used to achieve this durability. These lifespan goals are important, as the longer the garment is in active use by a consumer, the more likely it is to offset the production of a new textile product, thus reducing the industry's environmental impacts [14].

All the companies emphasized optimal care and maintenance as a significant factor for extending product life. It is important to determine which products customers need, but also how they use and care for these products. Since it is often the customers who care for the products, it is important for companies to share information on correct maintenance. Although correct care contributes to extending products' physical lifespans, the interviewees also highlighted the environmental benefits that optimized care creates.

The companies also believed that one way to extend product life is to use different recovery services. Some of the companies offered both instructions on care and repair and care and repair as a service, whereas others provided the consumers with repair kits that they could use at home or at a dressmaker's. The companies offered additional recovery services that supported circularity and extended lifespans. For example, by renting, the customer does not need to purchase the garments permanently and the products can have several users. In the same way, take-back services, in which the companies maintain and sell the products again, enable a new life for the product with a new consumer. One of the companies added that the care and recovery services that the companies provide for their products are a warranty that the company is committed to both the product and the customer.

4.3. Recyclability

Another important aspect of material and product quality was recyclability. One of the companies aimed to use mono-materials, as blends cause problems in recycling. They highlighted the importance of considering the end-of-life and recovery processes from the early stages of product development. They also emphasized cooperation between design and R&D departments in implementing sustainability in their products from the start.

The term "future-fit products" arose in one of the interviews. This is when the product is designed and made in a way that it does not create problems in the future. It covers the issues of how the product is to be disposed of at the end of its life. One of the companies emphasized that from the lifespan angle, it is vital that an ecosystem exists, or will exist in the near future, as it will make product and material circulation possible. Being active in the system and aware of upcoming technologies was believed to be important, as it enables thinking ahead and planning real possibilities for a product. The interviews also suggested that companies think about how quality allows products and materials to circulate in the system for longer. This is a very new attribute of quality and is linked to the notion of the CE, as it aims to extend the use-time of products and enable their recyclability as well as the recyclability of the product materials. One company mentioned that their goal was to have their products circulating in the system for as long as possible. High quality makes it possible for products to stay in use for longer and even have several users, but it also makes it possible to recycle the materials at the end of the product lifespan through mechanical or chemical recycling technologies [38]. This is one reason why quality is controlled to such a great extent in the sampling and production phases.

4.4. Quality through Responsibility

Responsibility was also mentioned as a viewpoint on quality in all the interviews. According to a general definition [39], responsibility means "a state of being responsible". It is either obligated or free-willing acceptance of accountability for one's actions [39]. In

the business context, it is often referred as “corporate social responsibility”, signifying a concept whereby companies take social and environmental concerns into account in their business operations and interaction with other stakeholders [40]. Similarly, according to the interviewed companies, responsibility relates to the environmental, social, and economic impacts of their products and operations, and includes risk management.

Responsibility means that the companies are responsible for their products throughout their whole lifespan, as well as for the impacts their product and operations might have, near and far. Therefore responsibility (Figure 2) concerns aspects such as transparency, safety, minimizing environmental impacts, and activity in the ecosystem. Some of the companies’ impacts can be measured and ranked, but not all necessarily have a calculated value. Responsibility is tracked through, for example, certifications, lifecycle assessment (LCA), and visiting or auditing the factories to guarantee that responsibility is actualized throughout the company’s processes. Responsibility is today communicated to consumers through different types of sustainability and responsibility reports.

The interviewees described how responsibility is also gaining significant importance in the minds of consumers. For example, consumers are concerned about the level of responsibility of products as well as companies’ business in general, and therefore, expect transparency from companies. One of the interviewees explained that nowadays consumers want to know more, and may think, “I would like to follow, why I am with them”, indicating that customers are looking for a reason why they should buy from a certain brand instead of another, and responsibility plays an important role in this. Therefore, responsibility can be a meaningful theme for a consumer, and weigh as one of the aspects of quality.



Figure 2. Responsibility as a measure of quality.

4.5. Operational Quality

The interviews revealed that quality is indeed a comprehensive concept. In some companies, it also extends to managerial and operational levels, including, for example, leadership and process management. This aspect of quality can be called operational quality.

A company’s goals for quality and responsibility are set on the managerial level. Emphasizing quality also in leadership, helps company employees be successful in their work. As pointed out by one of the interviewees, the quality of leadership correlates with high work satisfaction, which further connects with customer satisfaction; these are

measured through various surveys. Adequate recruitment was mentioned as part of quality, highlighting the role of individual employees. For example, one of the companies noticed that the recruiting of people with a certain environmental mindset and an understanding of social aspects, responsibility became a natural part of their operations.

Process management means that all company processes are defined carefully beforehand and are communicated inside the company. This can also be considered as an important element of managing quality. As one of the interviewees underlined, producing items of good quality is not achieved by inspections and testing; it originates from making things the way they are planned and agreed. According to this, each department is responsible for ensuring that everything that leaves their hands is of high quality. As mentioned by another company, this can be further supported by an appropriate data management system. The system helps storing all the necessary information regarding, for example, collections, materials, and certifications, and communicating it correctly to other parties of the supply chain. In this way, data management plays an important role in both the company's operational quality and transparency. These comments suggest that creating good quality is essentially supported by predefined quality goals, and realized by following these goals.

4.6. Quality in a CE Context

As the larger context of the study is the transition from the linear business model to the CE, our goal was to understand how quality can contribute to product lifetimes and support product or material circulation inside the system. Therefore, the notions of quality and lifetime were gathered and merged with the CE approach diagram (Figure 3). This is a simple way of presenting the aspects of quality and lifetime that should be implemented in the circular design and product development process. It also illustrates the point at which these aspects should be considered and put into practice in order to guarantee longer, extended lifespans.

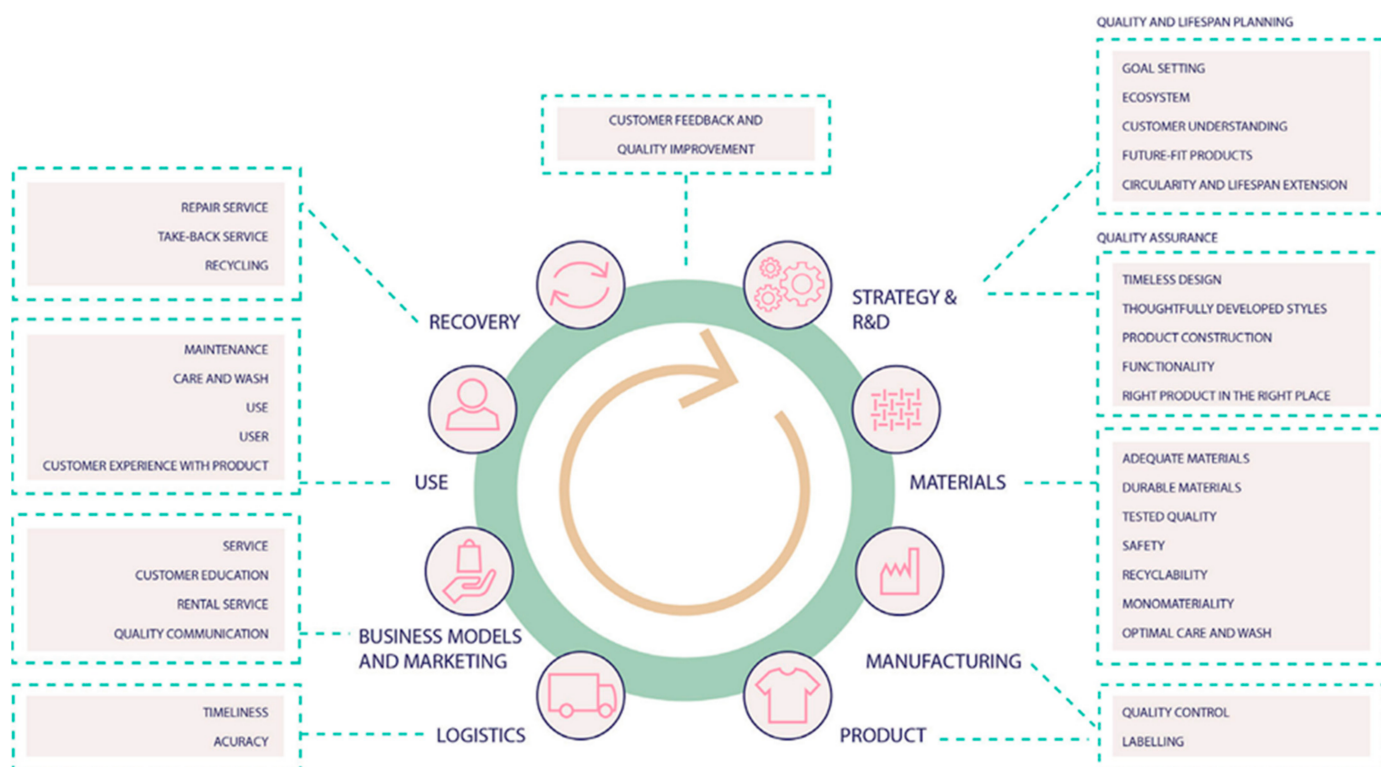


Figure 3. Quality and lifetime in CE context.

As the diagram shows, the goals of product quality and lifespan must be addressed and planned already in the initial strategy and R&D phase. This is the point at which the ways to reach these goals are defined and engineered into the product. It is also the point at which the product's circularity potential is established and the means to extend its lifespan are contemplated. The interviews highlighted that this potential has to be included from the beginning of the product development process, and that design and R&D departments should cooperate in order to truly implement sustainability in their products. In addition, an ecosystem must exist that can take care of different recovery methods, after the initial use phase, such as product take-back, repair, sorting, and recycling. Therefore, the stakeholders of the ecosystem have to be known already in the strategy phase in order to guarantee successful end-of-life and recovery processes.

Understanding customer needs and expectations were also mentioned as an important aspect of product development. It was highlighted that products should not be created just for the sake of creating something new, but instead it was seen to be more valuable to create collections that consist of mainly classics, which have been thoughtfully developed on the basis of testing, experience with the products, and customer feedback. Timeless design was mentioned as an important factor for making products future-fit.

Physically durable materials, appropriate product construction, safety, recyclability, and functionality, for example, were said to be important attributes for product quality. They are part of companies' quality assurance, which creates a sturdy foundation for products to circulate in the system for longer. They can be considered pre-conditions for longer lifespans.

High product quality and a longer lifespan also make it possible for companies to add different recovery methods to their agenda. Therefore, high technical quality is also an important aspect from the recycling point of view. Mechanical textile waste recycling gives the best results when the material still has some level of quality. If very poor (high wear and tear) material is mechanically recycled, up to 30–50% of virgin material needs to be added so that the quality of the material becomes sufficient. In addition, chemical textile waste recycling has an optimal level for material (e.g., viscosity level in waste cellulose material) entered into the system so that it is possible to produce even 100% recycled textile material with sufficient quality [2]. Moreover, the aspect of product recyclability is important, and these requirements need to be taken into account already in the design phase so that the product is easy to disassemble, and all the materials are suitable for a pre-defined recycling path, i.e., the garment is designed to be suitable for recycling.

5. Discussion

Although the quality of a garment is multi-dimensional and even vaguely defined [35], the work that companies do in this sector is intensive. The study showed that companies' quality-related work considers the whole lifecycle of the garment. Quality assurance work is followed by quality control, both in-line during production and for finished products. The purpose of both quality assurance and control is to assure that no unpleasant quality failures arise during use which could then lead to consumer dissatisfaction and premature disposal of the product. Quality assurance alone cannot guarantee the long lifespan of a product, as consumers' experiences and use practices of the products can also be determining factors in the length of a product's lifespan.

All the companies interviewed had invested resources into finding the correct ways of washing and caring for their products. Optimal care is already studied in the product development phase and is then communicated to the customers through product labelling and at the point of purchase. All consumers do not know exactly how to care for their products. The ability to extend product lifespans and knowledge on optimal care has to be given to them even in other forms than care labels. This is why some companies even offer more detailed care instructions (e.g., through internet or during purchase event). Alternatively, the companies can provide repair and maintenance service to their customers. Through these different recovery methods, the products can avoid premature disposal.

Recovery methods can also be seen as a warranty for products; companies are committed to the product and consumer satisfaction, even after the point of purchase.

By implementing these quality and lifespan aspects into the design and development of products it is possible to extend the use phase, ensure the best circulation of products and materials, and support a more self-sustaining system. Through emphasizing quality and lifespan it is possible to move towards a system that produces high quality, sustainable products, and materials that in the future can be fed into the same system as raw materials, substituting the use of virgin materials. This approach also supports the CE approach by extending the use-time and by providing products and materials that are suitable for circulation.

The first objective of this study was to understand how quality is defined in the textile and apparel context. The interviews supported the view that to a large extent, textile and apparel companies measure and assure quality through comprehensive testing, both in laboratories and practice. However, at the same time it became clear that the companies try to understand their customers' quality expectations through elaborate sales work and multichannel feedback. Therefore, the companies' quality goals are also greatly dependent on their products' users.

In addition, the companies also emphasized responsibility and lifespan as equally important measures of quality to knowledge from the literature and earlier research. This showed that these themes are gaining popularity and significance.

The study also aimed to better understand how textile and apparel companies address product lifetimes. It became evident that all the interviewed companies had set goals for product lifetime expectancies. This leads to the third question of how quality contributes to product lifespans. The connection between the two was already studied through a literature review, and the interviews supported the argument that quality and lifespan are highly intertwined. The predefined lifetime expectancy determines to a large extent what quality the company aims to achieve. However, at the same time, the companies aim for high quality regardless of everything, as they know that it will to some extent guarantee consumer satisfaction and longer product lifetime.

The main goal of this study was to find the connections between textile/garment quality and lifetimes by answering the main research question: how can the lifetime of a product be extended by imposing good quality? Based on the findings of this study, quality and lifetime are highly connected. In the CE context, the product development process starts from quality and lifetime goal-setting, which is followed by the quality assurance phase. In the quality assurance phase, the product's expected lifetime and circularity potential are built up through aspects such as the technical durability, recyclability and timeless design of the product and materials. The findings from the interviews showed that the decisions made at the early stages of product development have far-reaching effects that influence even end-of-product-life processes. In the later sales, use and recovery phases, the companies can support quality and lifetime extension through improved communication about quality and different care and recovery services. In this way, companies can even have an impact in these later phases in a garment's lifetime, which are traditionally thought to be out of their reach as the connection with the user is often lost after the sales transaction. Our findings show that timeless design, technically durable materials, high-quality assembly work, and product functionality are important factors for product quality. They are part of companies' quality assurance work, which creates a foundation for the products' extended use-time and a base for products to circulate in the system for longer.

High quality also enhances the circularity of the garments through several uses and even through several users (reuse as a product). Moreover, high quality enhances material recycling even after the product's lifecycle is over. High quality allows products and materials to circulate in the system for longer and high-quality material is easier to recycle into new fibers (easier to reach high-quality end products through material recycling).

6. Conclusions

To summarize the findings of this study in a CE context, we highlight the following aspects. High technical quality makes it possible for products to stay in use for longer and even to have several users. Moreover, if consumers think a garment is of good quality, they care for it better, which contributes to the physical condition of the product over the course of time, which in turn extends the lifespan of the product. This can be understood as quality in use. Good quality contributes even when the lifetime of the product is ending; a material can extend its life through fiber recycling. This can be understood as quality for recycling. Overall, it seems that the companies under study perceived products with longer lifespans to be of higher quality and to have more value than those with short lifespans. In a CE context, the aspect of recyclability extends the quality definition to include the second and even third lifecycle of a material after the first lifecycle of a product is over. This aspect can be described as lifetime quality, which is a new attribute for garment quality, and especially important in a CE context.

It must be noted that quality is connected to product-level attributes, use context, and the company level (strategic and operational levels). To summarize which quality attributes are needed when a system is moving towards the CE and which elements are essential or even critical in this transformation, we list the technical quality of the materials, quality in use, quality for recycling, and lifetime quality. These attributes can enable extended product lifetime and textile circulation and can even be connected to product design that aims to be fit for the future. Moreover, operational quality ensures that a company's quality work is part of all company actions and quality through responsibility concerns the managerial level in operations and describes the extended sustainability approach, which is needed while transforming into a CE through new operations. These two last mentioned quality levels are also needed when creating products that are fit for the future and suitable for circulation.

Quality and extended product lifetimes can have a meaningful impact on the environmental footprint of the textile and apparel industry. By truly understanding the connection between the two, we can see how a textile product's lifespan can be extended by promoting good quality and how this further affects the overall environmental impacts of the product, through even several lifecycles. However, this study focused on making connections visible, not on measuring impacts, so this aspect needs further investigation. Truly understanding the CE principles and how the CE differs from the current linear economy is essential to be able to change the way in which products are designed, produced, used, and disposed of, and moreover how a product's lifecycles can be multiplied through material recycling. This understanding will help incorporate quality and lifetime thinking into design and production processes, and take material circulation into consideration already in the design phase. This new understanding of quality can help design products that are based on the fit for the future principles, and therefore, enable and support the transformation into a CE in the textile industry.

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