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Design-ability in the Circular Economy of Textiles

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Abstract: Recent research underscores the importance of longevity, defined as the combination of high and long-term usage frequency and durability, in the textile and fashion industry's shift toward circularity and sustainability. This paper explores and discusses the designer's ability to design for longevity of textiles. Thus, focus is on the potential role of textile designers, examining the extent to which the skills and competencies of the designer may potentially have an actual influence on longevity. Additionally, the paper discusses the systemic context that creates opportunities for design to contribute to the longevity of textiles and garments. Theoretically, the paper draws on Young's framework of levels of context—specifically design in context and designing context—as well as Pineda et al.'s emphasis on the relationship between contexts and the designed object. Empirically, the study is based on data collected from an ongoing research project, [Project X], in which a consortium of academic institutions and industry partners explores opportunities for textile recovery through material-led experiments with recycled textile fibres, further processed in a local R&D factory setup. This paper demonstrates that the challenges of recycling extend beyond design strategies and material experiments, encompassing cultural perceptions and the opportunities available to designers. Furthermore, by highlighting the competencies required to facilitate relationships and collective knowledge building through textile prototypes, the paper supports previous research suggesting that designers play a central role in the transition toward sustainability.

Introduction

The textile and fashion industries consume vast resources and generate significant waste, leading to severe environmental consequences (European Parliament, 2024). Over the past decade, these industries have increasingly relied on material sourcing, including textile recycling, as a solution to their environmental sustainability challenges. However, research indicates that textile recycling represents a 'weak' approach to the circular economy, positioned at the lower end of the 9R framework of circularity (Bauwens et al., 2020; Kirchherr et al., 2023). This aligns with the EU waste hierarchy, which prioritizes reducing new production as the most impactful measure, while considering fibre recycling to have a substantially lower impact in fostering a circular transition (European Union, 2008).

It is widely argued that up to 80% of a product's environmental impact and costs are determined during the design stage (Graedel et al., 1995; Diaz et al., 2021), underscoring the critical role of design in sustainability. The Brundtland Report (1987) and current policies, such as the newly extended Eco Design Directive, emphasize the importance of design in developing durable and sustainable textiles (European Union, 2024). These perspectives position designers as key agents in facilitating a more circular textile industry (Pineda et al., 2024). Yet, despite efforts to embed longevity into materials and products, the industry's environmental and social impacts remain severe (Geneva Environment Network, 2024; Moreira et al., 2022). The ever-increasing volume of textiles produced and consumed continues to offset improvements at the product level (Fletcher, 2017; Beaurain et al., 2023).

Thus, while designers might have the potential to influence up to 80% of a product's environmental impact, research suggests that their sustainability efforts are often limited to material selection and product-level durability. These efforts fail to address broader issues, such as those related to business models (Karell & Niinimäki, 2020; Klepp et al., 2023).

This limitation places significant pressure on individual design teams to drive the transition toward sustainability, while restricting their ability to address larger systemic challenges (Hasling & Ræbild, 2017). A more nuanced understanding of designers' competencies—shaped by company strategies and production systems—is crucial to facilitating design-led change (Riisberg, 2006; Lerberg et al., 2010; Karell & Niinimäki, 2020; Pineda et al., 2024).

This paper explores how designers, when given room for manoeuvre, can contribute to the longevity of textiles, defined as the intersection of technical, functional, aesthetic, and emotional qualities (Hasling & Ræbild, 2017; Jørgensen & Bang, 2024). Focusing on textile designers' explorations with yarns made from recycled fibres, this paper provides a deeper understanding of the challenges and opportunities related to creating durable, high-quality textiles from recycled fibres, for both garments and interiors, as well as a more nuanced understanding of the role that design can play in the transition of the textile and fashion industries toward sustainability.

[Project X]

Empirically, this paper draws on qualitative data from an ongoing research project—referred to as [Project X]—which explores the challenges and opportunities of local textile recycling and production in Denmark. The project aims to generate knowledge on extending the textile lifespan, improving the quality for reuse, and ensuring recyclability without the use of harmful substances. Denmark faces over 30 years of lost infrastructure, expertise, and competencies in textile processing, making it a particularly challenging context for advancing textile practices. The country lacks the necessary infrastructure and expertise to effectively process and recycle locally discarded textiles (Keys et al., 2023). These challenges are both technical and cultural in nature. While imperfections are inherent in recycled yarns and textiles, most design teams and brands are unfamiliar with the aesthetics of imperfection and small-scale production for niche markets—conditions that contrast with the dominant logic of mass production (Larsen, 2025). In response [Project X] has established a local Research and Development (R&D) factory, enabling project partners to experiment with textile production from fibre to fabric. Fibers, yarns, and textile prototypes are developed and tested based on various criteria, including technical, functional, and aesthetic considerations.

The designer's role in sustainability

The traditional understanding of a fashion and textile designer is that of a professional who designs textile products, such as garments and fabrics, and combines them into range plans, lineups, and collections, taking into account the delicate interplay between technical, functional, aesthetic, and emotional factors. In commercial settings, the typical fashion designer operates within an aesthetic space defined by trends, brand strategies, and commercial interests, while the typical textile designer also works with technical and functional materials development. However, despite the fact that designers are often seen as central figures in sustainability fashion literature, their ability to drive environmental and social change is frequently more limited than previously suggested (Larsen, 2025). This limitation is sometimes due to a lack of knowledge about materials, recycling, and best practices. However, research also shows that company strategies often dictate and restrict design work, leaving designers with little room for meaningful influence (Bang & Jørgensen, 2024; Fletcher, 2017; Hornbuckle, 2018; Karell & Niinimäki, 2020).

Exploring the role of design in the transition towards sustainability, Young (2008) suggests that the design of concrete products, configurations, technical details, and components is design in context; designing at the level of system thinking is designing context; and designing at the level of policy formation and ideology is design of context. While design today is seen to operate at all three levels, Pineda et al. (2024) highlight the need to further analyse and unpack the relationship within and between context and the designed object.

Given the textile and fashion industries' reliance on recycled materials, it is essential to explore the challenges and opportunities for sustainability in textile recycling (Keys et al., 2023). This paper aims to contribute to the understanding of the role design plays in the transition toward sustainability by drawing on Young's (2008) framework to examine textile

recycling as a field that presents inherent challenges to promoting longevity. A critical question is to determine under what circumstances designers could assume a more prominent role in the emerging circular economy, where the management of existing resources becomes essential, and traditional production and design models are no longer sustainable (Larsen, 2025; Pineda et al., 2024). Additionally, it is crucial to consider what this role would entail and how it will shape designers' approaches to design, including the models, tools, and processes they employ (Bang & Jørgensen, 2024; Fletcher & Grose 2012; Harsaae & Bang, 2024; Harsaae & Bang, 2023; Ladekarl et al., 2023).

Methodology

In this paper, we analyse and discuss empirical data from [Project X], which runs from 2023 to 2026 and involves 13 partners from academia and industry (see Table 1).

Partner	Organisation
A	Interior textiles
B	Fashion
C	Workwear
D	Knit manufacturer
E	Weave manufacturer
F	Textile recycling
G	Textile recycling
H	National business Cluster
I	Research and Innovation
J	University
K	University College
L	University
M	University

Table 1: Project participants

[Project X] is organised in five cross-sectoral work packages (see Table 2).

Work Package	Title
WP1	New feedstock and fibre spinning
WP2	From yarn to printed fabric
WP3	Material driven design for circularity
WP4	Circular economy framework
WP5	Project management

Table 2: Cross-sectoral work packages

Methodologically, the paper employs a combination of qualitative research (Kvale, 2007; Spradley, 2016), practice-based research (Cross, 1982; Schön, 1983, Lawson, 2004), and material-driven design methods (Karana et al., 2015).

The data consists of a substantial number of textile prototypes/datasheets, worksheets and other physical material, field notes and follow-up interviews from workshops and structured material dialogues between partners.

Physical textile prototypes are core in the project (Ravnløkke et al., 2016; Star, 2010). WPs 1, 2 and 3 explore recycled materials from different perspectives: 1) spinning (from fibre to yarn), 2) technical and aesthetic exploration of new yarns (from yarn to weave, print and knit) and 3) idea development (from yarn to weave, knit and print). The woven, knitted and printed prototypes have been further supported with technical testing, such as rub test. All protypes and processes are registered in datasheets for transparency and further development across work packages.

Biannual workshops are core of the project and includes representatives from all partners across the project. The workshops were also driven by the principle of boundary objects through textile prototypes as a way to create shared understandings (Star, 2010). The workshops have been documented through fieldnotes and worksheets (Spradley, 2016), as well as follow-up interviews (Kvale, 2007). The worksheets and other physical material were inspired by the material driven design method (Karana et al., 2015) and included a series of questions developed to critically examine the textile prototypes' potential for longevity through design and material choice. This included questions relating to the material, design, use and construction perspective.

In analysing the data, we focus on three areas, drawing on Young (2008) and Pineda et al. (2024): first, design in context - the concrete product level; second, the systemic perspective – engaging stakeholders in knowledge exchange; and third, designing relationships - how designers facilitate dialogue between product and system to support longevity

through durability, long-term usage and high use frequency. The final area also considers knowledge building across stakeholders and varying levels of expertise.

Analysis — Prototyping for longevity

Design in context: What happens on the product level.

In [Project X], textile development begins with yarns containing recycled fibres spun in WP1. These yarns are handed over first to WP2 for functional and aesthetic exploration, then to WP3 for idea development. The yarns are explored on looms and knitting machines. Initial tests include basic weave structures such as twill variations and plain weave, and basic knit structures such as single and double jersey, followed by more experimental textures incorporating floats and decorative patterns. (see Figure 1).

Figure 1. Woven samples with recycled yarn [Project X] ©

At the R&D factory, the textile design team and the spinners work side by side in direct collaboration, with the designers actively participating in the spinning process. One textile designer noted: *"... having the opportunity to take part in the process of spinning is an eye opener, both in terms of the process itself, but also in relation to working with recycled fibres."* This hands-on involvement clarified challenges such as ensuring that shredded fibres are long enough to spin and gives value to the yarn. Designing in context (Young, 2008), the textile designer's core challenge lies in balancing the technical strength with visual and tactile appeal. During prototype development, WP2 and WP3 collaborated to adapt handwoven samples for industrial production tools. Drawing on a specific prototype from one of the trial plans we will illustrate how this collaboration unfolded between the product (textile) and the system (designing context).

Kombi.b.13 (Figure 2) is handwoven on an ARM loom. Its weave structure consists of a plain weave structure, supplemented with floating threads crossing up to a maximum of four warp threads to create a diamond-like pattern. The prototype is woven with a standard cotton warp of combed cotton 34/2 and a weft yarn, which is spun in WP1 containing recycled fibres.

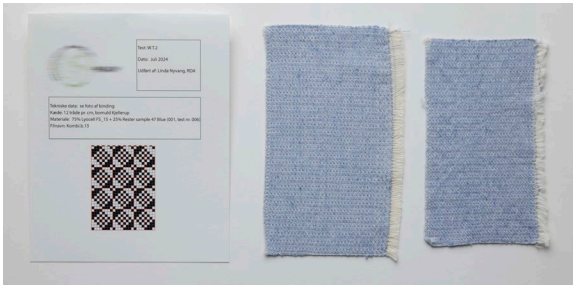

Figure 2. Prototype "Kombi.b.13" [Project X] ©

The prototype, along with many others, was presented and scrutinized at two project workshops, where it played a central role in the project's exploration into local value chains for recycled and more sustainable fibre production. We applied a variation of the material driven design method to guide the dialogue and investigation.

Designing contexts: Knowledge exchange on a systemic level.

[Project X]'s workshop series provides a foundation for evaluating the potential applications and longevity of the developed textiles, as perceived by stakeholders across the consortium. Drawing on a material-driven design approach, the workshops enable a practical, hands-on process for material and product development, as well as dialogue and knowledge exchange.

During a workshop (12.09.2024), the prototype (Figure 2) for instance received the following comments: *"Beautiful weave structure"*; "*Suitable as residential curtain fabric, but not for the contract market"*; *"Considered too thin with too many floats for upholstery"*; *"Good elasticity, especially diagonally"*; *"Even structure and uniform colour"* and *"Slightly nubby texture [visible fibre specs]"* (representatives from C and K).

Based on such feedback, it was decided to further develop the prototype – an iteration aimed at improving it in response to qualitative feedback from the industrial partners. The revised prototype, now featuring three threads per pick, resulted in a firmer and stiffer textile. This also altered its visual expression, making the diamond pattern more pronounced (Figure 3).

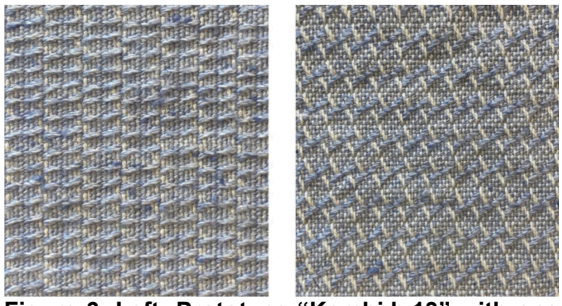

Figure 3. Left: Prototype "Kombi.b.13" with one thread per pick. Right: "Kombi.b.13" with three threads per pick. [Project X] ©

At the next project workshop (31.10.24), the updated prototype was evaluated again. One group remarked: *"Stable, slightly stiff/hard, moderate elasticity"*; *"Dense structure, durable surface, suitable as outer fabric – not for garments worn close to the body"*; *"Unique expression with 3D pattern that may have branding potential and stands out from more basic products"*; "*Stable and durable despite its open and lightweight appearance*" (representatives from B, C, K and M).

Following these workshops, WP2 and WP3 adapted the handwoven prototype to an industrial sample loom to further explore its scalability (Figure 4).

Experiences from both versions showed that a more balanced structure could be achieved by reducing the weft density. It was also noted that the analogue loom's weft density could not be transferred directly to the digital loom, due to space limitations in the warp. As a result, weft density was adjusted from 32 wefts/cm to 16 and 24 wefts/cm respectively. This adjustment also made the diamond pattern appear more balanced, as illustrated in Figure 3 left.

Figure 4. Prototype "Kombi.b.13", transferred to an industrial sample loom. [Project X] ©

The workshop discussions highlight the opportunities for companies to expand their product range through storytelling, potentially enhancing product value and exclusivity. Although recycled fibres are not yet fully sufficient for all applications, stakeholders see them as a step towards meeting new regulations. The work of WP3, particularly the workshop series, demonstrates how designers, when given the necessary space and infrastructure, can add nuances to our understanding of textile applications and questions of sustainability. Thus, through design, we reveal both the possibilities and limitations of textiles and foster dialogue on urgently needed advancements.

Discussion: Material longevity and the role of the designer

With the local R&D factory at the heart of [Project X], the project operates at the level of *design in context* (product) and *designing context* (system) (Young, 2008). Using physical textile prototypes as tools for dialogue, discussions become tangible and actionable among the participants. These prototypes provoke reflection and help reframe what counts as value for both industry and end users. In this setting, the designer takes on a critical and constructive role, challenging norms and exposing overlooked potentials. The designer's role extends to actively articulating and making the dilemmas and constraints associated with the use of recycled fibres in textile design tangible. Moreover, in [Project X] the designer

holds a strong position in facilitating knowledge production and interdisciplinary exchange across the value chain.

This collaborative framework illustrates how designers can play a broader and significantly more impactful role in designing for textile longevity. By actively engaging across the entire development chain—from fibre testing and material dialogues to industry workshops—the designer is strongly positioned to develop knowledge and thereby contribute to systemic change. The framework also highlights the value of bringing stakeholders together, into the spinning lab, textile workshops, and collaborative sessions. This fieldwork underscores the role of design in exploring and developing material qualities, with prototypes functioning as tools for knowledge exchange (Star, 2010; Ravnløkke et al., 2016). By facilitating mutual understanding between designers, manufacturers, and other stakeholders, [Project X] not only fosters knowledge sharing but also positions the designer as a facilitator—bridging technical and creative insights and enabling cross-sectoral and cross-disciplinary collaboration instead of stakeholders working in silos.

Initial findings suggest that no one can develop recycled materials in isolation. To mature how textile recycling is perceived, practised, and implemented, stakeholders must collaborate across the value chain. Only with supportive infrastructure can designers apply their skills fully and significantly advance the longevity of materials and products.

Moreover, the iterative development of more nuanced assessment schemes that incorporate environmental, design, and business aspects should be embedded into this process to fully understand the relevance of the collaborative development work and the designer's role within it. This has been a central topic in the consortium, contributing to a shared language and deeper understanding of barriers and potentials in textile recycling.

These reflections align with previous research showing that design practices must be embedded in diverse knowledge domains—artistic, technical, economic, and production-based—to achieve high-value outcomes (Karell & Niinimäki, 2020). When the design phase is seen as part of a broader system, as in Buchanan's (1998) augmented concept of design, cultural, economic, and political structures function as interlocked components of the process.

Conclusions

As the starting point of this paper, we explore the potential role of designers in promoting textile longevity. If the impact of the designer is viewed as being limited to the materials- and product level, mirroring the actual situation in most of the industry today, it becomes highly questionable whether design truly accounts for 80% of a product's environmental impact and potential for longevity. Design practices are always nested within a web of framing conditions. With the linear business model and fast fashion logic as dominant forces, designers have little to no opportunity to drive meaningful change.

Supporting previous research in the field (Karell & Niinimäki, 2020; Pineda et al., 2024), [Project X] suggests that a designer's potential cannot be realized at the material and product level alone but must be understood within —and critically— between contexts. Within this lies an opportunity to fully utilize the designer's ability to create value from textile resources and gain greater agency over the environmental impact of materials and products.

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