Seamlessness and Monomateriality in Sustainable Garment Design. A Knit/Woven Trouser Prototype

Ludovica Rosato
Alma Mater Studiorum
— Università di Bologna
ludovica.rosato2@unibo.it
ORCID 0000-0002-4713-6445

Juri-Apollo Drews
Ensadlab, Ecole des Arts Décoratifs
— PSL University
juri-apollo.drews@ensad.fr
ORCID 0000-0002-7566-5731

Antoine Tour
Ensadlab, Ecole des Arts Décoratifs
— PSL University
antoine.tour@ensad.fr
ORCID 0000-0002-2286-7372

Jean-François Bassereau
Ensadlab, Ecole des Arts Décoratifs
— PSL University
jean-francois.bassereau@ensad.fr
ORCID 0000-0003-0280-4646

Aurélie Mosse
Ensadlab, Ecole des Arts Décoratifs
— PSL University
aurelie.mosse@ensad.fr
ORCID 0000-0003-3777-1055

Abstract
This article points out strategies for designers to reduce the generation of pre- and post-consumer waste in the textile industry by focusing on the aspects of seamlessness, mono-materiality and mechanical recyclability. It further presents “Trouser prototype 1”, a proposal for a seamless, mono-material and fully recyclable garment that uses knit/weave hybrids and innovative fastening systems and that arose from an international and interdisciplinary design collaboration.

Keywords
Mono-materiality
Recyclability
Zero-waste fashion design
Seamlessness
Knit/weave hybrids

Introduction

As designers, we have a considerable influence on the ecological impact of our products. Acquiring detailed knowledge about these phases, e.g. on current production or recycling technology, could therefore be considered a key asset for designers trying to minimise the damage their products do to the environment. This article lists some of the aspects textile and fashion designers who are willing to conceive more sustainable clothing can take into account for their designs. It also presents *Trouser Prototype 1*, a practice-based design research prototype for cut- and seamlessly woven trousers developed by Juri-Apollo Drews that integrates a knitted fastening mechanism by Ludovica Rosato, as well as the production and end-of-life scenarios that were taken into account for its design. The research focuses on the importance of considering environmental criteria throughout the design process by taking into account existing technologies and questioning established assembly techniques. "Trouser Prototype 1" is not an industrial product, but an experimentation that can open up a discussion on certain problematic aspects designers face in the current textile industry, and possibly pave the way for future applications as well as participate in the discussion on the role of the designer in the development of solutions to reduce pre- and post-consumer waste in the textile and fashion industries. In the present prototype, we focus on the uses of techniques that make it possible to reduce pre- and post-consumer waste; a second part of that research will later focus on replicating the process in other materials.

Pre- And Post-consumer Textile Waste and Strategies for Reducing Them

The textile industry in particular is considered to be one of the most polluting economic sectors (Cobbing & Vicaire, 2017). While holistic and systemic approaches to designing more sustainable garments have emerged in recent years (Coscieme et al., 2022; Ellen MacArthur Foundation, 2021; McQuillan, 2020; Niinimäki, 2017), attempts by a vast majority of textile and garment manufacturers to implement such strategies in the production and disposal of their products remain sporadic and superficial. In garment production, for example, the widespread use of the cut-and-sew technique leads to the generation of about 10 to 20% of pre-consumer textile waste, i.e. the leftovers from the process of cutting non-rectangular pieces from rectangular fabrics (Abernathy et al., 1999; Cooklin, 1997). This leads to the considerable number of 60 billion square metres of newly produced fabric that are designated for landfill or incineration each year (Rissanen & McQuillan, 2016). Fast fashion consumption patterns are a further source of waste, since many garments are only worn 7 to 10 times before being discarded (Ellen MacArthur Foundation, 2021). Large amounts of this post-consumer waste is disposed of in landfill sites, leading to the waste of potentially reusable resources[1]. A strategy for designers would be to anticipate using a Design for Recycling approach (Karell, 2021), meaning that they must be informed about current textile recycling processes in order to make the optimal later reutilisation of the material a central criterion during the design phase.

1
Currently, only 30-35% of post-consumer textiles are reused, less than 1% is recycled within a closed loop system, 10% in open loop recycling, while 60% are sent to incineration or landfill facilities (McKinsey & Company, 2022).

diid No. 80 — 2023
Doi: 10.30682/diid8023j

Pre-consumer Waste Reduction Through Integral Garment Design

Among the strategies to reduce pre-consumer waste, techniques for making seamless or whole garments have gained in importance in recent years. These aim at producing whole garments directly in the desired shape, without the need to assemble them from cut-out pattern pieces. In this way, waste generated by pattern cutting can be eliminated. Although this method remains marginal in the current industry due to the low cost of fabric (McQuillan, 2020), an increasing scarcity of raw materials could increase interest in such methods in the future. Besides, integral garment techniques offer better structural stability as they eliminate seams that are potential breaking points in a garment (Nawaz & Nayak, 2015). Considerable progress has been made recently to produce commercially successful integral garments by knitting (ibid.; Gries et al., 2022), underlining that whole garment manufacturing provides both ecological and economic advantages (Allwood et al., 2006; Fletcher, 2014). However, three-dimensional or integral non-rectangular weaving remains a rather unexplored technique in garment production (Thomas, 2009). Some tubular, multilayer or elastic-based weaving solutions can be found in fields such as medicine and aeronautics, with sporadic attempts by engineers to apply them to the fashion context (LaPointe et al., 1988; Behera & Mishra, 2008; Ng et al., 2007; Wang et al., 2009). Integral weaving approaches as well as other alternative ways to assemble garments have emerged in design-based research as well (McQuillan, 2020; Piper, 2019; Harvey et al., 2019; Vicerial, 2019). Juri-Apollo Drews' ongoing practice-based PhD project *No Cuts No Seams* develops innovative solutions to produce woven garments in complex three-dimensional shapes that require neither cutting nor sewing (Drews, 2019).

Design Strategies to Reduce Post-consumer Waste

Post-consumer waste can be reduced by garment life-cycle design and knowledge about applicable recycling technologies (Karell, 2021). Mechanical recycling, i.e. shredding textiles and producing new threads from the shreds, is currently the most widespread strategy for all types of textile recycling (ibid.). This process shortens the fibres and reduces their strength compared to virgin materials (Ghezzo & Vannucci, 2018). However, shredded fibres from heavily worn garments appear to have a longer length than those from less worn garments, thus increasing their reuse value (Aronsson & Persson, 2020). In order to shred a garment, rigid components such as buttons and zippers must be removed because they could affect the purity of the shredded material or cause damage to machines (Riemens et al., 2021). Today, this is mostly done manually and leads to a considerable loss of reusable material (ibid.). In addition, mechanical recycling does not allow for the separation of textiles composed of material blends into their original components. Indeed, in order to save costs and to guarantee good performance, many apparel fabrics are largely composed of mixed, interwoven fibres (Fashionary, 2020) that are difficult to separate industrially during disposal and often contain additional chemicals that are potentially harmful to the environment.

If post-consumer waste is to be avoided or at least optimised, the selection of (mono)materials is thus a central design decision that must be made at the beginning of the product's conception. Garments composed entirely of one unblended material and whose attachment systems are composed of that same material can be a solution to ease their reutilisation after mechanical recycling. Another strategy could be to design garments composed of modules that are easily disassemblable (Forst, 2020), with each module being strictly mono-material.

It should further be mentioned that considerations of materiality, recyclability and fasteners during the design phase must be associated with the design of the garment's extended life cycles. It is thus not only important to consider end-of-life scenarios, but also to employ strategies that push the necessity for recycling as far into the future as possible (Circular.fashion, 2019). The number of times a garment is worn has a direct impact on its ecological footprint, since the energy needed for production is only needed once. Therefore, increasing a garment's longevity decreases the need for the production of new garments, with designing for inner loops being an example for a strategy to achieve this (Earley & Forst, 2019).

Seamlessness and Monomateriality: Trouser Prototype 1

Trouser Prototype 1 Fig 1 is a practice-based research that was conceived with the aim of developing design solutions to eliminate pre-consumer waste and to limit post-consumer waste to closed-loop recycling. The research focus was on the garment's innovative seamless production, as well as on its absolute mono-materiality, its durability and its future mechanical recycling possibilities. Using practice-based methodology (Koskinen, 2012; Mosse & Bassereau, 2019), we aim to participate in the discussion on the role of the designer in the development of solutions to reduce textile waste. The creation of prototypes is a fundamental tool in design research as they materialise possible futures and outline possible trajectories of innovation (Iñiguez et al., 2014; Celaschi et al., 2014a; Celaschi et al., 2014b; Stappers, 2013).

Trouser Prototype 1 is a seamlessly woven-to-shape trouser, meaning that it avoids the generation of pre-consumer cut waste entirely by using experimental hand-weaving techniques developed by Juri-Apollo Drews which allow for shaped weaving, as well as for direct links between woven and knitted surfaces. It is completely mono-material, since instead of buttons and zippers it uses the Knitted Fasteners developed by Ludovica Rosato in her PhD thesis project. It therefore facilitates post-consumer recycling because it can be shredded in one piece given that no rigid elements were added to the garment. For this particular prototype, a solid cotton thread was used to test the feasibility and stability of the seamless weaving/knitting techniques, even though a future adaptation to more sustainable materials such as linen or hemp (Rana et al., 2014) is envisioned.

diid No. 80 — 2023
Doi: 10.30682/diid8023j

Fig. 1
Trouser Prototype 1, credits: Juri-Apollo Drews.

Knitted Fasteners

The prototype includes a *Knitted Fastener (*KFs*)* Fig. 2, which is an experiment developed by Ludovica Rosato during her PhD thesis aiming to enable fastenings in mono-material garments. Fasteners constitute connection points between fabrics and act as an adjusting and/or opening element (Mitchell & McLoughlin, 2014). KFs are a prototype of fasteners integrated into the fabric that aim to allow these components to be used in compliance with existing recycling technologies. KFs are the combination of buttonholes and loops varying in number, size and position that can offer different fastening, fixing and adjusting systems. This freedom of configuration allows the creation of different aesthetic shapes at the junction points and gives the fashion designer the creative freedom to customise fasteners without affecting contemporary recycling processes. The connection between the fabrics is achieved by inserting the loops of one flap into the buttonholes of the other. The loops are then concatenated vertically with each other. The concatenation closure system is derived from the interlacing of two loops. Fig. 3 This system allows for both a "punctual" connection like that of a row of buttons, and a "linear" connection like that of a zipper. This creates an opening and closing system that attempts to improve the performance of a button system by simulating that of a zipper.

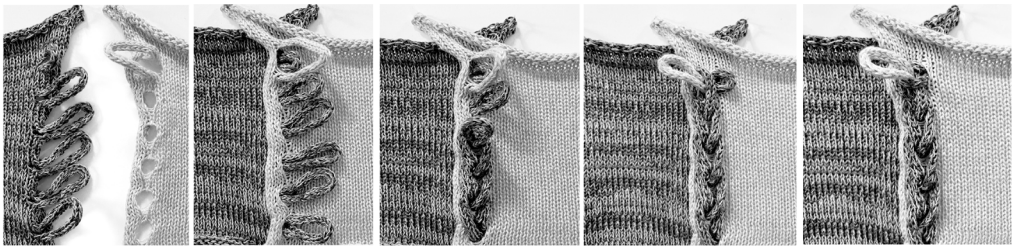

Fig. 2
Knitted fasteners developed for the prototype, credits: Ludovica Rosato.

Fig. 3
Knitted fasteners: The concatenation closure system, credits: Ludovica Rosato.

Combining Knit and Weave

In order to integrate a KF into the woven surface of the trousers, a technique called modular weaving developed by Juri-Apollo Drews (Drews, in press; Drews, McQuillan & Mosse, in press) was used. Two triangular patches were knitted that can be joined by a KF system. Loops of varying sizes were left on the slanted selvedges of these knitted modules. During the weaving process, these were interlocked with individual weft threads, thus aligning with the weft and allowing for a direct and seamless transition between the knitted and the woven surfaces. This procedure is similar to the clasped or locked weft tapestry weaving technique, which permits the use of discontinued weft threads in order to create multi-coloured motifs. A thread used for the knitted part thus briefly turns into a woven weft

diid No. 80 — 2023
Doi: 10.30682/diid8023j

thread, before returning into the knitted surface Fig. 4. Hybridising knits and wovens into one and the same fabric is not a common practice in fabric production, yet the potential for applications beyond the apparel sector is great since it permits a seamless and very stable connection between rigid and flexible zones within the same mono-material fabric.

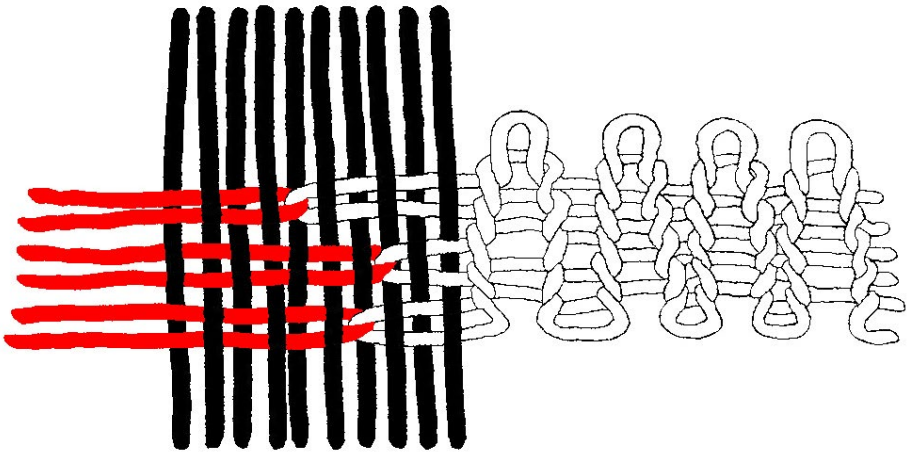

Fig. 4
Schematic drawing of seamlessly joined knitted and woven surfaces, credits: Juri-Apollo Drews.

Longevity and Transparency as Design Criteria

The longevity of a garment is enhanced by the integration of the knitted surface at the waist level, since its natural elasticity allows for the wearer to gain or lose some weight without the need for a new garment. Another strategy to prolong the garment's lifespan is to provide concrete information on its production method, material composition, wearability and recyclability through text woven into the fabric itself Fig. 5. In the current system, the exact composition of the material is not known precisely and therefore not many textile fibres are actually processed into new yarns. To the recycling facility in which the garment is destined to be shredded, however, *Trouser Prototype 1* clearly communicates that the garment is fit for mechanical recycling and can be respun into a high-quality recycled yarn after the shredding process. This direct communication is also expected to reassure the wearer and create a sense of emotional attachment. Indeed, users might find it difficult to feel responsible for a product whose materials they are unaware of and are unable to handle when it no longer meets their needs (Rau & Oberhuber, 2019). Informing the user on the sustainable processes applied and thereby inviting them to play an active role in the garment's life cycles is a powerful awareness strategy as it creates amazement and affection towards the product and prolongs the relationship between user and artefact (Chapman, 2009; Karana et al., 2017).

Fig. 5
Informative text woven into the prototype, credits: Juri-Apollo Drews.

Conclusion

Trouser Prototype 1 presented here contributes to an advancement in the research into sustainable solutions to reduce pre- and post-consumer textile waste. The knit/woven strategies presented here, as well as the technical and aesthetic strategies to prolong the garment's use cycle as much as possible and designing in absolute mono-material for optimal recyclability of the fibres could be contributions to a reduction of both types of waste. Yet they can only be parts of the solutions to the numerous challenges the textile and garment industries are facing to manage a transition towards more sustainable production, retail/consumption and material recycling patterns.

Based on this first prototype, the potential of integral knit/woven fabrics beyond the apparel sector could be further studied in the future. In addition, the customisation, transformability and repairability of the garment and its fastening system during the cycle of use should also be studied in greater depth. The same holds true for the use of differently coloured threads in the same fabric which might have an impact on the homogeneity of the outcome material after the mechanical recycling process, and design-for-disassembly or single-colour solutions should be considered. Other recycling processes not planned for here should be taken into account, as should the biodegradability of the material beyond the recycling process.

Ludovica Rosato
Ph.D., Research Fellow, her research focuses on the designer's role in the transition to the new uses of polymers in the textile sector. Since 2019 she is a member of the Advanced Design Unit with which she carries out activities of applied research and education. She earned an undergraduate degree in Industrial Design and a Master's degree in Advanced Design.

diid No. 80 — 2023
Doi: 10.30682/diid8023j

The prototype aims to open up the discussion on the need to consider garments, but also all goods in general, as materials in transformation whose flow is the responsibility of the designer. This process can be transversally applied to several sectors, such as architecture or packaging, for example, where waste is a critical element and where material cyclicity is strongly linked to product usability and temporariness. We are committed to promoting a way of designing that encourages the hybridisation of techniques and approaches on a micro and macro scale and promotes strategies of regeneration of value to humankind and the planet it inhabits.

Author roles acknowledgement

The article was co-written by all authors except paragraph 3.1 which was written by Ludovica Rosato and paragraph 3.2 written by Juri-Apollo Drews.

Juri-Apollo Drews
Ph.D. student financed by Université Paris Sciences et Lettres (PSL) through the SACRe (Sciences Arts Création Recherche) doctoral programme. His practice-based research supervised by Aurélie Mosse (Ensadlab Paris), Claudia Mareis (HU Berlin) and Holly McQuillan (TU Delft) focuses on the replacement of the cut-and-sew technique by integral garment weaving. He holds a Master's degree in Textile Design (EnsAD Paris/KH Berlin) and a BA degree in Cultural Studies (Maastricht University).

Antoine Tour
Ph.D. student in partnership with the Campus Mode Métiers d'Art, Design. Supervised by Jean-François Bassereau (Ensadlab Paris) and Nounja Jamil (Campus MoMADe) his research focuses on material classification, through a methodology that considers different states of matter: properties, qualities, values. He graduated with a Master's degree in Object Design (EnsAD Paris), Design and Materials (Mines/Ensad Nancy).

Jean-François Bassereau
Interior Architect (Beaux-Arts) and Industrial Designer (EnsAD), J.F Bassereau taught at Arts et Métiers for 18 years, his research is in Sensory Design. Director of SENSOLAB research, he is also a Professor, authorised to direct Research at the Mines School. He teaches at EnsAD and co-leads the Soft Matters research group within Ensadlab.

Aurélie Mosse
She is a design-led researcher working at the intersection of textile, architecture and new technologies. Co-leading the Soft Matters research group of Ensadlab at the École des Arts Décoratifs, PSL University, her current research investigates how microbially-induced materials can inform more resilient and poetic perspectives of inhabitation.

References

Aronsson, J., & Persson, A. (2020). Tearing of post-consumer cotton T-shirts and jeans of varying degree of wear. *Journal of Engineered Fibers and Fabrics*, *15*, 155892502090132. https://doi.org/10.1177/1558925020901322

Abernathy, F. H., Dunlop, J. T., Hammond, J. H., & Weil, D. (1999). *A Stitch in Time: Lean Retailing and the Transformation of Manufacturing - Lessons from the Apparel and Textile Industries*. Oxford University Press.

Allwood, J. M., Ellebæk Laursen, S., Malvido de Rodríguez, C., & Bocken, N. M. P. (2006). *Well Dressed? The Present and Future Sustainability of Clothing and Textiles in the United Kingdom*. Univ. of Cambridge Inst. for Manufacturing. https://www.ifm.eng.cam.ac.uk/uploads/Resources/Other_Reports/UK_textiles.pdf

Behera, B. K., & Mishra, R. (2008). 3-dimensional weaving. *Indian Journal of Fibre & Textile Research*, *33*, 274-287.

Celaschi, F., Iñiguez Flores, R., González, X. A., García, A. L., Trotta, G., León Morán, R., López Nuño, N., & Rossa, A. (2014a). Advanced Design Exploration Field A Systematic Repertory Of Scientific And Design Opportunities. In *The Shapes of the Future as the Front End of Design Driven Innovation* (pp. 21-44). PorruaPrint.

Celaschi, F., Celi, M., & Formia, E. (2014b). Quando il design incontra il futuro. When Design Meets Future. *Planning Design Technology.* Utopia. Futuro. Past, Present, *3*, 20–29.

Chapman, J. (2009). Design for (emotional) durability. *Design Issues, 25*(4), 29-35.

Circular.fashion. (2019). *CIRCULAR DESIGN KIT Design strategies for material cyclability and longevity.*

Cobbing, M., & Vicaire, Y. (2017). *Fashion at the Cross Roads. A review of initiatives to slow and close the loop in the fashion industry*. Greenpeace e. V. Germany. https://www.greenpeace.org/static/planet4-international-stateless/2017/09/76e05528-fashion-at-the-crossroads.pdf

Coscieme, L., Manshoven, S., Gillabel, J., Grossi, F., & Mortensen, L. F. (2022). A framework of circular business models for fashion and textiles: The role of business-model, technical, and social innovation. *Sustainability: Science, Practice and Policy, 18*(1), 451–462. https://doi.org/10.1080/15487733.2022.2083792

Cooklin, G. (1997). *Garment Technology for Fashion Designers.* Blackwell Science.

Drews, J.-A. (2019). *The Gap and How to Bridge It: Attempts at Reconciling Weaving and Garment-Making.* (MA Thesis, Paris: École nationale supérieure des Arts Décoratifs, 2019).

Drews, J.-A. (in press). L'enjeu des finitions dans le projet de tissage zéro-chute No Cuts No Seams. In A. Castres, F. Cousin, & C. Duroselle (Eds.), *Rubans, galons, franges, lisières. Finitions textiles*. Les Indes savantes, Association française pour l'etude du textile.

Drews, J.-A., McQuillan, H., & Mosse, A. (in press). Methods for Designing Woven Textile-forms. Examples from a pedagogical textile design workshop. *Proceedings of the Textile Intersections Conference 2023*. Design Research Society.

Earley, R., & Forst, L. (2019). *Everything That Went Wrong: challenges and opportunities in designing and prototyping long-life garments in a circular economy.*

Ellen MacArthur Foundation. (2021). *Circular Design for Fashion*. Ellen MacArthur Publishing.

Eppinger, E. (2022). Recycling technologies for enabling sustainability transitions of the fashion industry: Status quo and avenues for increasing post-consumer waste recycling. *Sustainability: Science, Practice and Policy*, *18*(1), 114–128. https://doi.org/10.1080/15487733.2022.2027122

Fashionary. (2020). *Textilepedia*. Fashionary International Limited.

Fletcher, Kate. 2014. *Sustainable Fashion and Textiles: Design Journeys*. Earthscan.

Forst, L. (2020). *Textile Design for Disassembly: A creative textile design methodology for designing detachable connections for material combinations*. (PhD Thesis, London: University of the Arts, 2020).

Ghezzo, P., & Vannucci, R. (2018). Processi di riciclo nell'industria tessile. In *EcoDesign nel settore del tessile* (Vol. 8).

Gries, T., Bettermann, I, Blaurock, C., Bündgens, A., Dittel, G., Emonts, C., Gesché, V. et al. (2022). Aachen Technology Overview of 3D Textile Materials and Recent Innovation and Applications. *Applied Composite Materials, 29* (1), 43–64. https://doi.org/10.1007/s10443-022-10011-w.

Harvey, C., Holtzman, E., Ko, J., Hagan, B., Wu, R., Marschner, S., & Kessler, D. (2019). Weaving Objects: Spatial Design and Functionality of 3D-Woven Textiles. *Leonardo*, *52*(4), 381-388.

Iñiguez Flores, R., Hernandis Ortuño, B., Holliger, C., & Monterrubio Soto, J. C. (2014). Advanced Design as a Process for Knowledge Creation. Delivering Knowledge to Stakeholders and Fostering Future Skills for Innovation. In *The Shapes of the Future as the Front End of Design Driven Innovation* (pp. 151-156). PorruaPrint.

Karana, E., Rognoli, V., & Giaccardi, E. (2017). Materially Yours. In J. Chapman, *Routledge Handbook of Sustainable Product Design*. Routledge.

Karell, E. (2021). *Closing the Loop through Clothing Design: Wishful Thinking or Achievable Practice?* Aalto University.

Koskinen, I., Zimmerman, J., Binder, T., Redstrom, J., & Wensveen, S. (2012). *Design Research Through Practice: From the Lab, Field, and Showroom*. Morgan Kaufmann.

LaPointe, D. J. E., Vincent, L. J., & Wright, L.T. (1988). *Tapered, tubular polyester fabric* (U.S. Patent No. 4,771,518). U.S. Patent and Trademark Office. https://ntrs.nasa.gov/api/citations/20080012393/downloads/20080012393.pdf

Lewis, H., Gertsakis, J., Grant, T., Morelli, N., & Sweatman, A. (2017/2001). *Design + Environment. A Global Guide to Designing Greener Goods*. Routledge.

McKinsey & Company. (2022). *Scaling textile recycling in Europe–turning waste into value*.

McQuillan, H. (2020). Zero waste systems thinking: Multiphormic textile-forms. [University of Borås]. http://hb.diva-portal.org/smash/record.jsf?pid=diva2%3A1478307&d-swid=-2664

Mitchell, A., & McLoughlin, J. (2014). Joining fabrics: Fastenings. In R. Sinclair, *Textiles and Fashion: Materials, Design and Technology*. Elsevier Science & Technology. https://ebookcentral.proquest.com/lib/unibo/reader.action?docID=1838431

Mossé, A., & Bassereau, J. (2019). *Soft Matters*: en quête d'une pratique plus résiliente du design textile et matière. [*Soft Matters*: in search of a more resilient practice of textile and material design]. *Sciences du Design*, *9*, 50-63. https://doi.org/10.3917/sdd.009.0050

Nawaz, N., & Nayak, R. (2015). 'Seamless Garments'. In R. Nayak, & R. Padhye (Eds.), *Garment Manufacturing Technology. Woodhead Publishing Series in Textiles* (pp. 373-383). Woodhead Publishing.

Ng, F., Hu, J., Szeto, Y., & Wang, X. (2007). Integrated design of seamless fashion in woven textile with multilayer. *Research Journal of Textile and Apparel*, *11*(2), 67-74.

Niinimäki, K. (A c. Di). (2017). *Sustainable Fashion in a Circular Economy*. Springer International Publishing. https://doi.org/10.1007/978-3-319-51253-2_8

Piper, A. (2019). *Material Relationships: The Textile and the Garment, the Maker and the Machine.* Developing a Composite Pattern Weaving System. (PhD Thesis, Nottingham: Nottingham Trent University, 2019). http://irep.ntu.ac.uk/id/eprint/39927/.

Rissanen, T., & McQuillan, H., (2016). *Zero Waste Fashion Design.* Bloomsbury, Fairchild Books.

Rana, S., Pichandi, S., Parveen, S., & Fangueiro, R. (2014). 'Natural Plant Fibers: Production, Processing, Properties and Their Sustainability Parameters'. In Ss. Muthu (Ed.), *Roadmap to Sustainable Textiles and Clothing, Textile Science and Clothing Technology* (pp. 1-35). Springer.

Rau, T., & Oberhuber, S. (2019). Material matters. L'importanza della materia. Un'alternativa al sovrasfruttamento. [Material Matters. The Importance of Matter - An Alternative to Overexploitation]. Edizioni Ambiente.

Riemens, J., Lemieux, A. Lamouri, S., & Garnier, L. (2021). A Delphi-Régnier Study Addressing the Challenges of Textile Recycling in Europe for the Fashion and Apparel Industry. *Sustainability*, *13*(21), 11700. https://doi.org/10.3390/su132111700.

Stappers, P. J. (2013). Prototypes as a Central Vein for Knowledge Development. In L. Valentine (Ed.), *Prototype: Design and Craft in the 21st Century* (pp. 85–98). Bloomsbury Publishing Plc. https://doi.org/10.5040/9781350036031

Thomas, L. (2009). Woven Structures and Their Impact on the Function and Performance of Smart Clothing Technology. In J. McCann, & D. Bisson (Eds.), Smart Clothes and Wearable Technology (pp. 131-55). Woodhead Publishing. https://doi.org/10.1533/9781845695668.2.131.

Vicerial, J. (2019). *Clinique vestimentaire: Pour un nouveau paradigme de la création & réalisation vestimentaire sur-mesure.* [Clinique vestimentaire: For a new paradigm of tailor-made clothing design & production]. PhD thesis, École nationale supérieure des Arts Décoratifs, Paris.

Wang, X., Ng, F., Hu, J., & Seto, Y. (2009). Shapeable stretch textiles via simple weaves for seamless woven fashion. *Textile Research Journal*, *79*(18), 1715-1724.

diid No. 80 — 2023
Doi: 10.30682/diid8023j