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THE ROLE OF UNIVERSITIES OF APPLIED SCIENCES IN THE TRANSITION OF THE TEXTILE INDUSTRY.

A Saxion Perspective

Inaugural lecture by Dr. Jens Oelerich on 28 May 2026 in Enschede, Netherlands

Content

About this publication

This publication is written as part of the inaugural lecture of Dr. Jens Oelerich, Professor of Applied Sciences in Sustainable & Functional Textiles at Saxion University of Applied Sciences in Enschede, the Netherlands.

Textiles are everywhere

Textiles are an indispensable part of our daily lives. We touch them at night in our beds, walk on them on our floors, dress in them when we leave our homes, and sit on them in our cars or offices. Textiles improve the acoustics of our rooms, enable us to pay with fibre-based banknotes, and allow us to express our lifestyle, attitude, respect, and emotions.

Beyond comfort and aesthetics, textiles also serve critical functions in many other products. They protect us from infection as face masks, support medical treatments as textile-based heart valves, and provide safety in applications such as anti-ballistic vests and high-performance composite structures. Lightweight and flexible, textile materials enhance comfort and sustainability while functioning either independently or in combination with other materials (Xie et al., 2023). They operate across scales, from nanometre-scale electrospun fibres used in filtration (Podgórski et al., 2006) to structural reinforcements in large-scale structures such as wind turbines (Mishnaevsky et al., 2017) and precast architectural elements.

Textiles are an essential part of the Dutch industry. Beyond their traditional role as garments, textiles are a strategically important material across sectors, including manufacturing, logistics, healthcare, construction, agriculture, mobility, defence and security. The European textile industry contributes significantly to employment, regional economic resilience, and export capacity (EURATEX, 2024) and serves as a critical platform for circularity and sustainability transitions (EU Textiles Ecosystem Platform, 2024).

About the author

“Everything is chemistry” was my firm belief when I started my PhD in bio-inspired catalysis in water in 2009. I grew up in a small town in Germany near the Dutch border. Because my parents had never studied at university and my secondary school did not prepare students for academic study, my path initially pointed towards vocational education. Chemistry was already my favourite subject, so I completed a vocational programme in the beautiful city of Münster to become a Chemical Technical Assistant. The programme provided an excellent foundation and broadened my view of the possibilities higher education could offer.

Because personal circumstances kept me in the region where I grew up, I had to choose between two universities of applied sciences, one in Germany and the other in the Netherlands. The Dutch were, and still are, exceptionally good at study information sessions, so I chose a general chemistry bachelor’s programme at Saxion UAS. This turned out to be an excellent decision, not only academically but also personally: during one of the programme’s first official components, a Dutch-language course, I met my wife, Jacqueline, and we have been a couple ever since.

After completing our bachelor’s degrees, we moved to Groningen, where I pursued a master’s in molecular science at the University of Groningen. During my studies, I met Prof. Dr. Ben Feringa, who later won the Nobel Prize in Chemistry for the design and synthesis of molecular machines, and Prof. Dr. Gerard Roelfes, my future PhD supervisor, both of whom are exceptionally knowledgeable and inspiring. I am deeply grateful to Gerard; he offered me the opportunity to conduct my doctoral research under his supervision and supported me wholeheartedly at every stage of the journey.

Before I started working as a researcher at Saxion, I had never seen textiles as a special material or a fascinating field of research. I was used to thinking in terms of molecules, connecting atoms, and conducting experiments in fume hoods or oxygen-free glove boxes. In 2013, I entered a completely new world, one where I could finally apply my knowledge of chemistry to real challenges companies face in their daily operations and processes. Learning about the materials, machinery, and production methods used in the textile industry opened my eyes to this fascinating field. I quickly knew that I wanted to utilise my deep chemistry background, combine it with the new knowledge I was gaining, and apply it to help innovate, strengthen, and preserve the textile industry in the Netherlands.

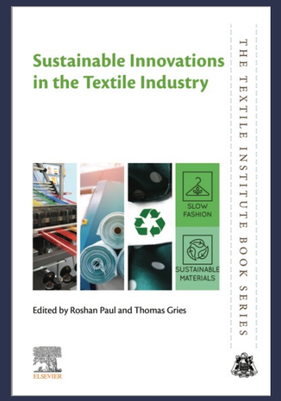
Currently, Jacqueline and I live again with our two amazing girls, Felien and Clara, in my childhood home, about 20 minutes by train or car from Saxion. We both enjoy the benefits of knowing and living in two countries that sometimes feel like one and sometimes like two very different worlds.

Motivation for the topic

The field of textiles is highly diverse, spanning materials science, process engineering, and fashion design. Given this breadth, I was unable to cover every aspect of this fascinating research domain in a single publication. At the same time, I did not want to produce a work that focuses solely on one dimension of the research group's activities or relies primarily on literature on a narrowly defined topic.

For this reason, I chose a topic relevant not only to the academic community and textile experts but also to other groups, such as students, policymakers and the public. By providing an overview of the work conducted at Universities of Applied Sciences (UAS) in Europe on textile education and research, and by examining how this work contributes to the transition of the textile industry at the European, national, and regional levels, I aim to produce a publication that is accessible to a broad audience while still offering valuable insights for those seeking answers in this field.

Our research group conducts applied research in response to the questions, challenges, and innovation needs of our partners. Without their contributions, this research would not be possible. Because all contributions are equally important, and to avoid overlooking a partner or undervaluing anyone's contribution, I chose not to mention any of the companies our research group works with in this publication. If you are interested in learning more about our incredible partners, their contributions to our research, and our research group's work in general, please visit our recently updated magazine. If you would like an overview of one of the research fields I worked on as an associate professor of applied sciences in Sustainable Textiles, you are invited to read our book chapter on closed-loop post-consumer textile recycling (Oelerich & Mahy, 2024).




Closed-loop postconsumer textile recycling 18

Jens Oelerich and Jan W.G. Mahy
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18.1 Introduction

Because the production of textiles needs raw materials such as fibres, process chemicals, energy and water, this has an impact on the environment. However, the trend of overconsumption that has outgrown the logical use of textiles has led to a tremendous increase in production and an associated impact. The doubling of production in only 15 years, between 2000 and 2015 (Ellen MacArthur Foundation, 2017), was partly initiated by the growth in ambition of fashion retailers and brands to produce inexpensive and lower-quality textiles and fulfil the wishes of the market for fast and fashionable clothing. This is called the 'fast fashion' trend, and it catalysed the unsustainable behaviour of consumers to buy many more textiles than were needed for protection and comfort, such as those that were used only a few times before being discarded. This trend causes an enormous amount of textile waste. Approximately 11 kg of textiles are discarded per person every year in the European Union (EU), which adds up to 5.8 million tons of annual textile waste (EEA, 2019).

Looking at the increasing frequency of new seasonal collections launched by the fashion industry and the decreasing quality of textile materials used and presented, clothing is worn and washed less often before it is discarded. This accelerates the consumption of clothing and creates unsustainable systems of overproduction and overconsumption, which directly conflict with Sustainable Development Goal 12 in ensuring sustainable consumption and production patterns (European Commission, 2022a). Fast fashion trends, the growing world population and the low rates of use, reuse, repair, and closed-loop recycling of textiles lead to the ever-increasing demand for primary raw materials from natural and fossil resources, especially from outside Europe (European Environmental Agency, 2022).

The dumping of postconsumer textile waste is a huge urban waste problem. There is a common practice of commercial and charity organisations collecting discarded textiles. Thus, a small portion is recovered, but the rest is normally discarded as solid urban waste. There is a huge untapped potential for discarded postconsumer textile waste, and the recycling possibilities are unlimited. To recycle on an industrial scale, collected clothes should first be sorted. Several systems are available for sorting textile waste according to colour, fibre type and chemical composition. The sorted textile waste can be collected separately to develop different high-added value products (Paul, 2012).

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Introduction to the Sustainable & Functional Textiles research group

The research group Sustainable & Functional Textiles (S&FT) at Saxion is an interdisciplinary team that collaborates with regional industry and education partners in an international context. The group currently undertakes projects across two research lines: Sustainable Textiles and Functional Textiles. These lines operate both independently and collaboratively within a broad stakeholder network.

The Twente region, where the research group is based, has a strong textile heritage and hosts many small and medium-sized companies that work with textile materials, develop textile processes, or produce textiles for diverse markets. Saxion and the Twente region are well established as a textile hub within the Dutch landscape of initiatives focused on sustainable (bio-based and circular) and functional (technical and medical) textiles.

The textile industry is inherently international, and the Netherlands has long played a significant role in global textile trade, fostering the growth of several major textile retailers and producers. The Sustainable & Functional Textiles research group is likewise embedded in the European research and innovation ecosystem, maintaining a broad network across the European textile landscape.

A University of Applied Sciences (UAS) is a higher-education institution that offers bachelor's and master's programmes to prepare students for professional careers. These programmes integrate academic theory with practical training, emphasising industry collaboration, internships, and applied research addressing real-world challenges. UAS are particularly known for their practice-oriented curricula and strong international networks (Deutschland.de, 2023).

This publication will elaborate on the role of Universities of Applied Sciences in the transition of the textile industry at the regional, national and European level.

To provide a broader dataset for my inaugural lecture and beyond, a cross-sectional online survey was conducted among employees at European Universities of Applied Sciences (UAS) offering textile education and/or research. The survey was distributed to 64 contacts identified through the Sustainable & Functional Textile (S&FT) research group network and professional recommendations. Recipients were encouraged to forward the invitation within their institutions. Data were collected between 6 February and 1 March 2026. The instrument comprised 21 questions: eight multiple-choice items, seven open-ended questions, three slider-scale items, and three ranking questions.

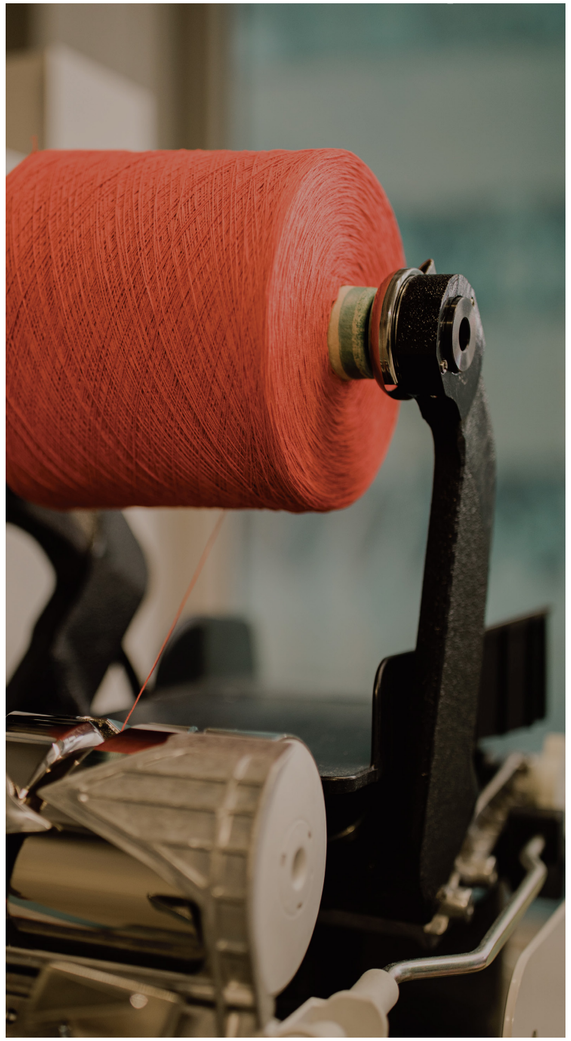
Quantitative items (multiple-choice, slider-scale, and ranking questions) were analysed using descriptive statistics where appropriate. Ranking responses were converted to weighted rank scores to determine priority patterns. Open-ended responses were analysed qualitatively using thematic analysis to identify recurring themes and illustrative examples.

In total, 38 employees from 16 UASs across 10 countries completed the questionnaire. Of these, 25 were involved in both textile education and research, 10 in textile research only, and 3 in textile education only. Half of the participants (19) held a leading position as a professor and/or manager/team leader at their UAS.

The survey

The responses:

• Saxion University of Applied Sciences (Saxion)	The Netherlands	11
• Amsterdam University of Applied Sciences (AUAS)	The Netherlands	5
• Avans University of Applied Sciences (Avans)	The Netherlands	4
• University of Borås (Borås)	Sweden	3
• Niederrhein University of Applied Sciences (NUAS)	Germany	2
• Berlin University of Applied Sciences (HTW)	Germany	2
• Lucerne University of Applied Sciences (Lucerne)	Switzerland	2
• Hof University of Applied Sciences (Hof)	Germany	1
• ArtEZ University of the Arts (ArtEZ)	The Netherlands	1
• Polytechnic University of Tirana (Tirana)	Albania	1
• VIA University College (VIA)	Denmark	1
• HOGent University of Applied Sciences & Arts (HOGent)	Belgium	1
• Tampere University of Applied Sciences (Tampere)	Finland	1
• TTK University of Applied Sciences (TTK)	Estonia	1
• Vilnius University of Applied Sciences (Vilnius)	Lithuania	1
• HAN University of Applied Sciences (HAN)	The Netherlands	1



Introduction

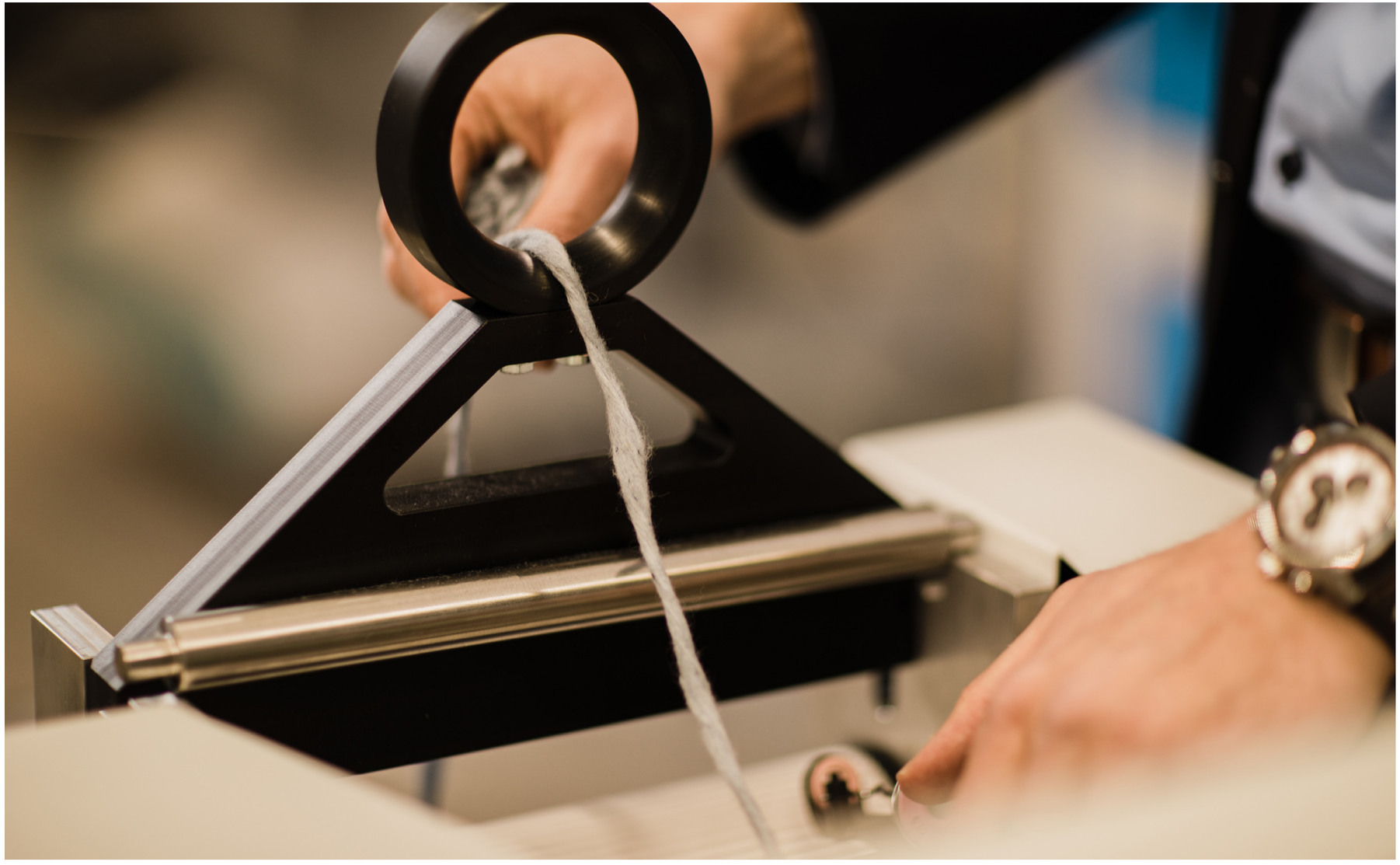
Over the course of its history, the textile industry has undergone a series of structural and technological transitions that have reshaped material use, production methods, and labour systems, as well as the nature and approaches to research and education.

Textile production has been central to Europe's economic and cultural development. In early European history, household spinning and weaving of wool and linen were the dominant textile activities. During the medieval period, textile manufacturing shifted towards organised urban workshops and guild systems, in which high-quality wool and silk became major export commodities (Munro, 1999). These industries drove innovation, wealth, and long-distance trade.

By the early modern era, mechanisation had begun to transform production. European countries emerged as hubs for cotton spinning and weaving, and textile mills became a feature of the industrial landscape (Riello, 2013). This shift marked the transition from craft-based to factory-based manufacturing, laying the groundwork for the broader Industrial Revolution and permanently altering Europe's labour systems, urban growth, and global trade relationships (Brugger & Gehrke, 2018).

In the twentieth and twenty-first centuries, the industry transformed again through globalisation and advances in synthetic fibre technology. Production is dispersed across international supply chains, while materials such as nylon and polyester reduce reliance on traditional wool and cotton (Kroschwitz, 2004). These changes reflect the textile sector's continual adaptation to new technologies, markets, and economic pressures, evolving from craft-based, local production to a highly mechanised, globally integrated industry.

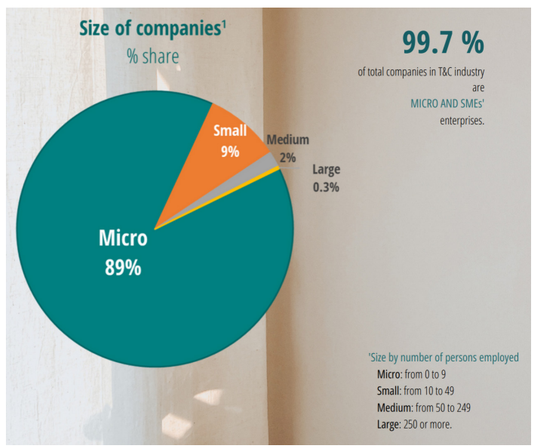
However, production-driven business models built on cheap, fast manufacturing of constantly changing collections, largely made from fossil-fuel-derived synthetic materials, have significantly contributed to severe environmental impacts and enormous waste streams (Niinimäki et al., 2020).



The current state of the textile industry in Europe

Today, the European textile industry remains an important industrial sector, not only for traditional products such as clothing, home and interior textiles, but also for the design and production of essential materials used across industries, including healthcare, agriculture, construction, and the automotive sector. With around 197,000 companies, of which 99.7% are small and medium-sized enterprises, and 1.7 million employees, the European textile industry generated an annual turnover of €170 billion in 2024 (EURATEX, 2024).

At the same time, the textile industry is undergoing another significant structural transition, driven by environmental, technological, regulatory, and economic pressures. This transition reflects a broader shift from traditional manufacturing towards a more sustainable, digitalised, and local value chain. Additionally, novel strategic demands have emerged in the European textile industry, driven by Europe's strong desire to become more competitive, resilient, and less dependent on fossil fuels and foreign resources.



The European textile industry is currently undergoing a major transformation driven by sustainability, regulation, digitalisation, and workforce adaptation. Key elements include:

Green and circular economy imperatives:
EU policies, including the European Green Deal, the Ecodesign for Sustainable Products Regulation, and the EU Bio-based Industries Strategy, set requirements for durable, repairable, and recyclable textiles, while extended producer responsibility (EPR) schemes and waste management reforms push companies towards circular business models (Circular Bio-based Europe 2021; European Commission, 2019, 2022, 2023a).

Regulatory compliance and competitiveness:
New obligations under EU eco-design rules and waste legislation require companies to redesign products, improve material efficiency, and document environmental performance, while maintaining competitiveness in global markets (European Commission, 2022).

Digitalisation of production and data:
Automation, IoT systems, digital product passports (DPPs), and AI are increasingly integrated into manufacturing and supply chain processes, improving transparency and traceability while demanding significant investment and new digital capabilities (European Commission, 2023b).

Skills and workforce adaptation:
As production becomes more technology-driven and the workforce ages, the sector faces a widening skills gap. EU initiatives such as Skills for the Green and Digital Transition support upskilling and reskilling in areas such as circular design, data analytics, and sustainability management (European Commission, 2023c).

Overall, companies must navigate this transition while maintaining daily operations, creating a complex environment in which transformation and business continuity occur simultaneously (EU Textiles Ecosystem Platform, 2024).

"The European textile industry is currently undergoing a major transformation driven by sustainability, regulation, digitalisation, and workforce adaptation."

Universities of Applied Sciences

Modern Universities of Applied Sciences (UAS) emerged in the 1960s in countries such as the Netherlands, Great Britain, and Germany.

They were established to provide practice-oriented higher education closely linked to industry and professional fields. In Germany, Fachhochschulen were formally created between 1968 and 1971 through the consolidation of engineering schools and technical academies. In the Netherlands, the hogeschool system evolved from higher professional education (HBO) and expanded rapidly during the 1960s and 1970s, followed by major mergers in the 1980s that formed today's multidisciplinary UAS. Great Britain developed polytechnics with a strong technical and professional focus, which later influenced the European UAS model. Over time, these institutions evolved from vocational schools into higher education institutions that combine professional education, applied research, innovation, and strong cooperation with industry and society (Hochschulkompass, n.d.).

Research at UAS

Applied research at Dutch Universities of Applied Sciences (UASs) is a relatively recent development, beginning with the establishment of the first lectorates (research groups led by a lector) in 2001, when UASs received structural funding to conduct practice-oriented research (Griffioen & De Jong, 2000–2006). The Netherlands Association of Universities of Applied Sciences (Vereniging Hogescholen) and the national funding body Regieorgaan SIA have played central roles in shaping the identity, structure, and quality standards of applied and practice-based research in the Netherlands (Regieorgaan SIA, n.d.; Vereniging Hogescholen, n.d.).

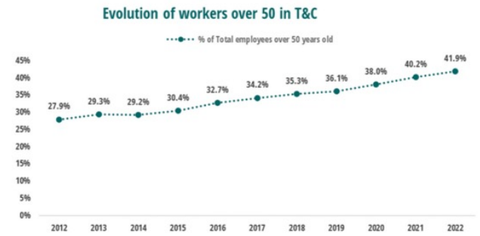
The role of research within UASs has been the subject of ongoing public and academic debate, particularly regarding its legitimacy, quality assurance, and its relationship to higher professional education. This debate continues today, for example, in discussions about the development and positioning of the Professional Doctorate (PD) as a new practice-based doctoral qualification in the Netherlands (Overheid.nl, 2026).

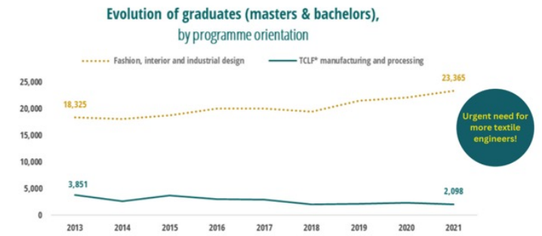
Today, research at Universities of Applied Sciences (UAS) is generally regarded as complementary to that at academic research universities. University research is typically characterised as fundamental and theory-driven, contributing primarily to scientific knowledge and disciplinary development. In contrast, UAS research is practice-based, often interdisciplinary and applied, and conducted in close collaboration with local and regional communities, commercial partners, and society (Regieorgaan SIA, n.d.).

Many UAS research groups also distinguish their work from that of traditional universities by using maturity scales such as the Technology Readiness Level (TRL) and the Societal Readiness Level (SRL). The TRL scale was originally developed by NASA to assess how close a technology is to operational deployment, ranging from level 1 (basic principles observed) to level 9 (system proven in operational environment) (Heder, 2017). This framework has since been adapted to evaluate the maturity of research outputs in applied contexts. Building on this, the SRL scale was introduced to assess the societal readiness of innovations, with a focus on social acceptance, adaptation, and integration (Innovation Fund Denmark, 2018). The next chapter presents an analysis of the TRL or SRL used by UAS researchers for their work at UAS.

Education at UAS

Over the past decade, employment in the textile sector has declined by more than 10%, while the share of workers aged 50 and over has risen sharply from 27.9% in 2012 to 41.9% in 2022. At the same time, the number of bachelor's- and master's-educated professionals in manufacturing and processing has fallen by more than 45%. Together, these trends underscore an urgent need for more textile engineers (EURATEX, 2024).





European UAS offering textile education provide a broad spectrum of programmes, ranging from technology-oriented curricula covering textile materials, chemistry, and machinery to business-focused programmes and design-oriented study tracks. In recent years, however, a clear shift has been observed: students increasingly choose design-focused programmes, while technologically demanding study paths attract significantly fewer applicants. As a result, many technology-oriented programmes rely heavily on students with prior experience or educational backgrounds from major textile-producing regions, where technical textile knowledge is more widespread. A comparison of the current main educational topics with the needs of the textile industry is presented in the next chapter.

The role of UAS in the textile transition at the European level

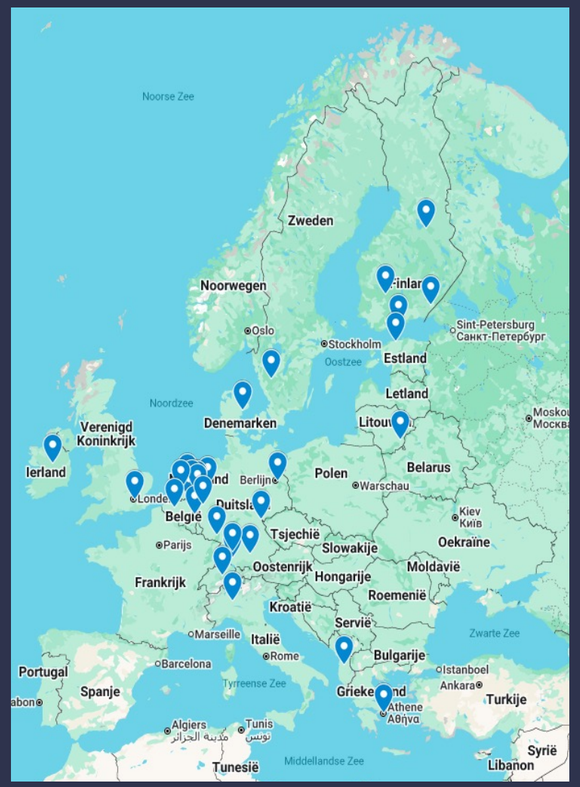
The higher education system in Europe is not unified.

Many countries have a binary system comprising traditional, academically oriented universities and a more practice-based alternative. However, not all countries refer to these practice-based institutions as Universities of Applied Sciences (UAS).

For this publication, 29 universities were identified as offering some form of textile-related education and/or research and as being able to classify themselves as UAS. To exclude other types of universities from the questionnaire, the first item was a screening question asking whether the respondent's institution identifies itself as a UAS.

UAS often differ in their position within national education systems. While all UAS with textile programmes offer bachelor's degrees and most provide some form of textile-related master's education, the majority do not offer their own PhD programmes. Instead, they collaborate with traditional, academically oriented universities to host PhD candidates. Some UAS, such as VIA University College in Denmark, emphasise vocational education and do not offer master's degrees or PhD programmes. In contrast, institutions such as the University of Borås, the Niederrhein University of Applied Sciences, and the Polytechnic University of Tirana can award PhD degrees independently of traditional research universities.

Some European countries lack UAS and instead rely on art and design academies or on practice-oriented research



conducted at polytechnic universities that focus on the technical sciences. This is particularly true of Italy, France, Spain, and Portugal, which together account for more than 50% of the European textile industry's total turnover (Euratex, 2024).

The role of UAS in textile education

A considerable share of textile education in Europe is delivered by Universities of Applied Sciences (UAS), whose programmes are designed to meet the practical and technological needs of the textile and fashion industries.

The size of textile education at UAS in Europe

There are significant differences in the size of the staff involved in textile education across the UAS institutions that participated in the questionnaire. The largest textile education-related staff are at the University of Borås in Sweden (HB), the VIA University College in Denmark (VIA), the Niederrhein University of Applied Sciences (NUAS), and the Amsterdam University of Applied Sciences (AUAS), each with more than 45 FTE dedicated to textile education. Next, there is a group of UAS institutions with between 10 and 20 FTE of educational staff, namely Hof University of Applied Sciences (Hof), Saxion University of Applied Sciences (Saxion), the Polytechnic University of Tirana (Tirana), and TTK University of Applied Sciences (TTK). Between 3 and 10 FTE of textile-related staff can be found at Berlin University of Applied Sciences (HTW), Lucerne University of Applied Sciences and Arts (HSLU), HOGent University of Applied Sciences and Arts (HoGent), Vilnius University of Applied Sciences (VIKO), and Tampere University of Applied Sciences (TAMK). Avans University of Applied Sciences (Avans) and HAN University of Applied Sciences (HAN) do not offer direct textile-related education but do conduct textile-related research at their UASs. There are many more UAS in Europe that participate in textile-related research but do not offer their own textile education programmes.

Main educational topics at UAS in Europe

When asked about the **main textile-related educational topics** taught at their UAS, most survey participants identified sustainability in textiles and textile product development, followed by textile production and processes. Notably, relatively little attention has yet been given to digital textile innovations, societal and cultural perspectives on textiles, and consumer behaviour related to textiles.

Future skills for workers in the textile industry

When participants in the questionnaire were asked **what skills future employees in the textile industry should have**, transformational and problem-solving skills were most frequently mentioned. These were closely followed by digital and green skills. Critical thinking and creativity were also frequently highlighted. This aligns with the findings of a study conducted for the Skills4Circularity project, which included company interviews, a questionnaire, and an analysis of a large number of job vacancies in textile companies (Skills4Circularity). These companies were seeking employees with expertise in deep digitalisation across the value chain, eco-design principles for circularity, sustainable material sourcing and traceability, waste management and resource minimisation, and emerging technologies such as AI, robotics, and advanced recycling.

The textile research capacity at UAS in Europe

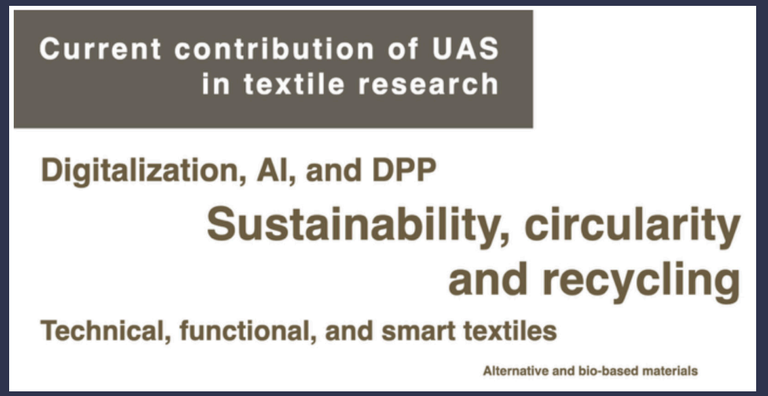
In research, the University of Borås stands out for its **textile research staff capacity**. The University of Borås employs more than 40 FTE dedicated to textile research, making it by far the largest research capacity among the European UAS institutions that participated in the questionnaire. At a considerable distance, NUAS, VIA, Saxion, Tirana, and HOGent follow, with between 10 and 20 FTE of textile research capacity. All other UAS represented in the questionnaire have fewer than 10 FTE of textile-related research staff. Notably, based on the questionnaire data, the total textile research capacity across all participating UAS, approximately 160 FTE, is still lower than the reported number of permanent staff employed at the Belgian textile research institute Centexbel alone, which was 174 FTE in 2024 (Centexbel, 2024). For a fair comparison, it should be noted that not all Centexbel staff members will be permanently involved in textile-related research.

The role of UAS in textile research

Because textile research is highly interdisciplinary, many UAS contribute to textile-related innovation even without offering a dedicated textile education programme. In the Netherlands, for example, Avans University of Applied Sciences (Avans) and HAN University of Applied Sciences (HAN) contribute to textile research through expertise in ecosystems, sustainable business models, and molecular science, despite not providing textile-specific study programmes at their institutions.

Current and future research areas of UAS

When asked about current research areas at their UAS, the questionnaire respondents most frequently cited sustainability, circularity, and recycling, followed by digitalisation, AI, and DPP. Research on technical, functional, and smart textiles was also highlighted.



When asked which **research topics they expect to gain importance** in the future, participants indicated that themes related to digitalisation, AI, and DPP would become significantly more relevant. Sustainability, circularity, and recycling remain important but receive slightly less emphasis and are now considered equally relevant to research on technical, functional, and smart textiles, as well as to safe and transparent supply chains. This shift reflects the industry's strong need for digitalisation, automation, and effective management of regulatory requirements.

European networks for UAS in textile research and education

The Network of European Textile and Fashion Universities of Applied Sciences (NETFAS) is a European association of higher-education institutions specialising in textiles and fashion, with a focus on education and research . The organisation operates as a cooperative network under Dutch law, bringing together more than 20 textile and fashion UAS to exchange knowledge, strengthen links with industry, and support applied research and innovation across Europe. NETFAS holds a seat on the board of the European Technology Platform for Textiles (Textile-ETP), thereby bringing UAS closer to the European textile innovation agenda and to the European textile industry partners, represented by the European Apparel and Textile Confederation (EURATEX).

The European Technology Platform for the Future of Textiles and Clothing (Textile ETP) aligns the research and innovation priorities of the European textile and clothing industry with the scientific, technological, and knowledge capabilities of universities, research organisations, and technology developers. By fostering collaboration between industry and research partners, the platform aims to strengthen the sector's competitiveness through coordinated research, innovation, and technology development. It currently represents 92 research and development institutes and universities, 73 industry partners, and 70 associations from across Europe.

An analysis of the 93 ongoing partner projects within the Ecosystex community, coordinated by the Textile ETP, shows that Universities of Applied Sciences (UAS) participate as consortium members in fewer than 20 of these Horizon Europe, Interreg, and Erasmus+ projects. A review of these projects reveals that UAS are more strongly represented in regional Interreg initiatives and education-oriented Erasmus projects, and significantly less represented in larger, research-intensive Horizon Europe projects.

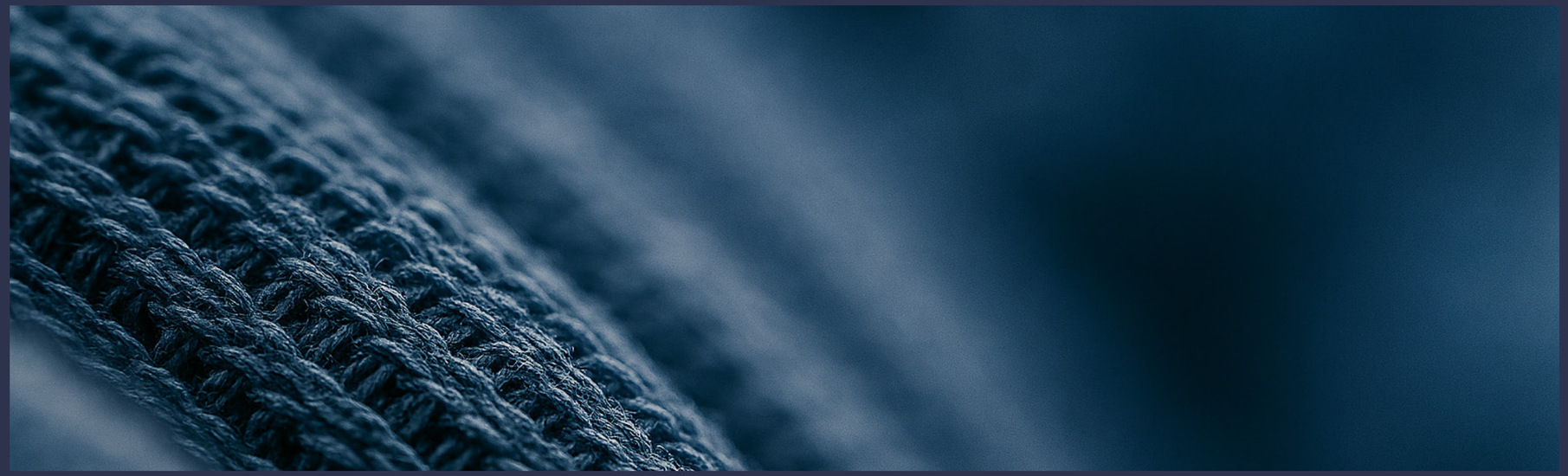
A closer examination of UAS projects also indicates that, in several European textile-related consortia, UAS contribute primarily through cross-disciplinary expertise rather than textile-specific research. Examples include roles in construction-related innovation, life-cycle assessment (LCA), or sustainability evaluation, rather than in core textile technology development (Textile ETP, 2024).

According to the survey results, research groups at Universities of Applied Sciences (UAS) identify small and medium-sized enterprises (SMEs) and the academic community (including other universities and UAS) as their primary research stakeholders. These are followed, at a considerable distance, by governmental institutions and the general public.

Interestingly, responses from Dutch UAS differ significantly from the overall results. Dutch UAS regard the general public and governmental institutions as more important stakeholders than large companies, after small and medium-sized enterprises (SMEs) and the academic community. By contrast, across all UAS, large companies are regarded as more important stakeholders than the general public and governmental institutions.

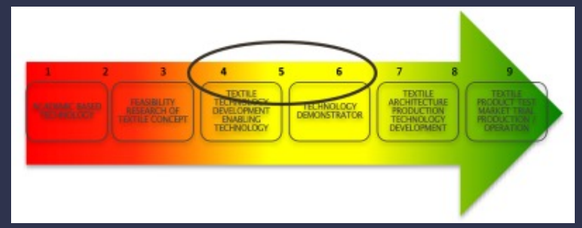
Next to that, the participants indicated that most funding for textile research at their institutions comes from national funds dedicated to applied research, with other national and regional funding sources following. European funding for education and research appears to be the least significant source for UAS.

This, together with the observation that collaborations with national and regional stakeholders are more important for most UAS than international collaborations, reflects the traditionally strong national and regional focus of UAS and suggests that European research programmes such as Horizon Europe currently support only a limited share of UAS research activities.



The **Technology Readiness Level (TRL)** and the **Societal Readiness Level (SRL)** can be used to describe the maturity of a development (Heder, 2017). Both scales are currently used by the European Commission to indicate the maturity of technological or societal developments in European research projects. Therefore, it was relevant to understand whether researchers at UAS engaged in textile research use any of these maturity scales, which scale they prefer to describe their work, and how they position their research within the chosen scale.

Interestingly, 83% of respondents to the questionnaire use one of the two maturity scales to describe their research, with TRL preferred by 64% and SRL by 19%. When asked about the range of TRL or SRL levels that best describe their research, the average responses indicate a minimum level of 4 and a maximum of 6. This strongly emphasises the applied character of textile research at UAS and aligns with the requirements of European Horizon research calls, including the Research and Innovation Actions (RIA 3–6) and Innovation Actions (IA 4–7).



Technology readiness levels for textile research.

The rol of UAS in the textile transition at the national level – a Dutch perspective

The Dutch textile industry is relatively small in manufacturing terms but remains economically relevant through its broader ecosystem of trade, retail, and design activities. In total, there are more than 11,000 registered businesses with textile-related activities in the Netherlands. Nearly half of these operate in retail and wholesale, highlighting the country's strong role as a distribution and trade hub rather than a production centre. The sector is also highly fragmented: over 95% of textile businesses have fewer than 10 employees, and more than 99% employ fewer than 50 people. This indicates that the industry is dominated by small and medium-sized enterprises, with only a very limited number of large businesses. Overall, the Dutch textile sector is characterised by small-scale entrepreneurship and a strong focus on commerce and supply chain coordination rather than large-scale manufacturing (TELL 2026).

Map of textile companies in the Netherlands based on Textile Ecosystem Living Lab (TELL, 2026)

The Dutch policy perspective

The Netherlands has become one of Europe's most active countries in addressing the environmental and social impacts of the textile industry. Dutch textile policy aligns closely with European sustainability goals and emphasises circular-economy development, waste reduction, corporate responsibility, and innovation in sustainable materials. A central priority is the transition towards a fully circular textile economy, with the Dutch government setting the national objective of becoming 100% circular by 2050 (Government of the Netherlands, n.d.). Policies therefore promote reduced use of virgin raw materials, longer product lifespans, repair and reuse, and improved recycling systems.

To support this shift, the Beleidsprogramma Circulair Textiel 2025–2030 sets out measures to reduce the use of virgin raw materials, extend product lifespans, encourage repair and reuse, and improve high-quality recycling systems (Rijksoverheid, 2024). These policies promote circular design, sustainable material substitution, and the development of new business models that reduce environmental pressures across the textile value chain.

Extended Producer Responsibility (EPR) is an important policy instrument that makes textile producers and importers responsible for the collection, reuse, and recycling of discarded textiles. Since 1 July 2023, producers must ensure appropriate collection systems, finance recycling processes, and report annually on the volumes placed on the market, reused, and recycled. The aim is to shift environmental responsibility back to industry and to stimulate more durable, repairable, and sustainable product design (Government of the Netherlands, 2023a, 2023b).

Despite these developments, policy attention to the strategic and economic importance of maintaining a strong domestic textile industry remains limited. Recent Dutch circular economy and textile policies rarely emphasise the need for a resilient national textile sector capable of supplying essential materials for construction, healthcare, defence, and other critical industries without heavy reliance on volatile global supply chains or foreign technological expertise.

The structure of textile research in the Netherlands

Structured research at Universities of Applied Sciences (UAS) in the Netherlands emerged only in the early 2000s, so it is not yet as firmly established as research at academic universities. Lectoraten (applied research groups) form the foundation of applied research at Dutch UAS. Each group is organised around a specific theme and led by one or more professors of applied sciences. These groups work closely with lecturers to integrate research into education and with industry partners. Together, they create a research environment in which innovation, practice-based inquiry, and education reinforce one another (Regieorgaan SIA, n.d.).

Applied research plays a central role in many Dutch UAS. By participating in research projects, students develop a curious, analytical, and critical mindset that prepares them for the complex challenges of their future professions. This research culture enhances the overall quality of higher professional education: students gain access to the most up-to-date knowledge, and through their work, that knowledge flows directly back into professional practice (Regieorgaan SIA, n.d.).

Collaboration with small and medium sized enterprises (SMEs) has grown rapidly in recent years. This trend strengthens regional innovation ecosystems and highlights the increasingly important role of UAS in supporting practice driven knowledge development. Recent analyses by the Vereniging Hogescholen show that cooperation between SMEs and Dutch Universities of Applied Sciences is expanding significantly (Vereniging Hogescholen, 2026).

At the national level in the Netherlands, textile research within universities of applied sciences is mainly concentrated at three institutions: the Amsterdam University of Applied Sciences (AUAS), ArtEZ University of the Arts in Arnhem (ArtEZ) and Saxion University of Applied Sciences (Saxion) in Enschede. In addition, other UAS conduct textile-related research within broader research domains in which textiles is one of the application areas. Examples include Digital Product Passports research at the HAN UAS, circular textile supply chain research at Avans UAS, and textile-related consumer studies at Rotterdam UAS and Fontis UAS.

"Lectorates connect research, education, and practice within Universities of Applied Sciences."

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The research community New Textile Ecosystem (NewTexEco)

The three UAS, AUAS, ArtEZ and Saxion, together with a large number of industry partners, are part of the New Textile Ecosystems (NewTexEco) research community, which was established through an eight-year SPRONG grant from NWO/SIA to enable research towards a sustainable and regenerative textile sector (https://newtexeco.nl).

The core of **NewTexEco** comprises five research groups from ArtEZ (Fashion and Design), AUAS (Fashion Research & Technology and Fashion Identity), and Saxion (Sustainable & Functional Textiles).

The Fashion Professorship at ArtEZ, led by Prof.Dr. Daniëlle Bruggeman, conducts design-led research into how fashion operates within social, cultural, environmental and economic systems. It explores alternatives to mainstream practices by examining values, identities, materials and ecosystems through cultural theory and practice-based experimentation (Bruggeman, 2018).

The Design Professorship at ArtEZ conducts practice-based research that positions design as a transformative approach, connecting art, technology, science and society. Led by Dr. Perica Savanović, it explores how designers can address societal challenges through prototyping, co-creation and alternative systems thinking.

The Fashion Research & Technology group at HvA, led by Dr.ir. Troy Nachtigal, conducts practice-oriented research at the intersection of fashion, technology, sustainability, and digital innovation. It examines how emerging tools and systems can improve design, production, and consumption across the textile and apparel sector. Through collaborations with industry, educators, and research partners, the group develops insights and tools that support a more resilient fashion ecosystem. (Nachtigal, 2021)

The Fashion Design and Identity research group at HvA, led by José Teunissen, studies fashion as a cultural phenomenon shaped by globalisation and digital transformation. From a practice-based design perspective, it examines how developments such as digitalisation, diversity, de-westernisation and sustainability influence values, identities and industry practices (Teunissen, 2024)

The Sustainable & Functional Textiles research group at Saxion, led by Dr. Jens Oelerich

Drawing on the diverse expertise of these groups and the involvement of around thirty partners from the textile practice, NewTexEco aims to strengthen circular textile research across the three institutions, integrate research outcomes into education, and build a strong national stakeholder network in circular textiles. This collaboration supports innovation across the entire textile value chain, from production and design to use, reuse, and beyond. The NewTexEco research community also helped develop concrete research projects, including the Care and Repair project, realised by ArtEZ and HvA, and the two DPP projects, Digital product passports for circular denim (DPP4CD, and The Molecular Digital Physical Digital Product Passport project (M-DPP).

Contact with public and governmental institutions

The abovementioned UAS maintain close contacts and strong working relationships with several Dutch government institutions, including ministries and executive agencies. The Amsterdam University of Applied Sciences is part of the core team of the Circular Textile Action Plan (ACT), developed under the mandate of the Ministries of Infrastructure and Water Management (IenW), Education, Culture and Science (OCW), and Economic Affairs and Climate Policy (EZK) (ACT, n.d.). ACT aims to position the Netherlands as a leading, knowledge- and innovation-driven economy within the European circular textile sector.

The research group Sustainable & Functional Textiles (S&FT) at Saxion University of Applied Sciences has a long-standing collaboration with Rijkswaterstaat, the executive agency of the Ministry of Infrastructure and Water Management responsible for overseeing Dutch textile waste streams. At Rijkswaterstaat's request, Saxion investigated contaminants in polycotton textiles that hinder recycling (Temmink, 2025) and examined how more refined sorting processes can improve the quality of recycling streams (Askanian, 2026).

In addition, Saxion collaborates closely with the Ministry of Defence, particularly the KPU-bedrijf, which manages all textile flows for the Dutch armed forces and related ministries. Together, they have initiated several research projects, including work on natural and circular fibres within the Going Circular – Going Cellulose (GC2) project (SIA, n.d.) and the development of analytical tools to detect and quantify recycled fibres in textile products (Ten Berge, 2026).

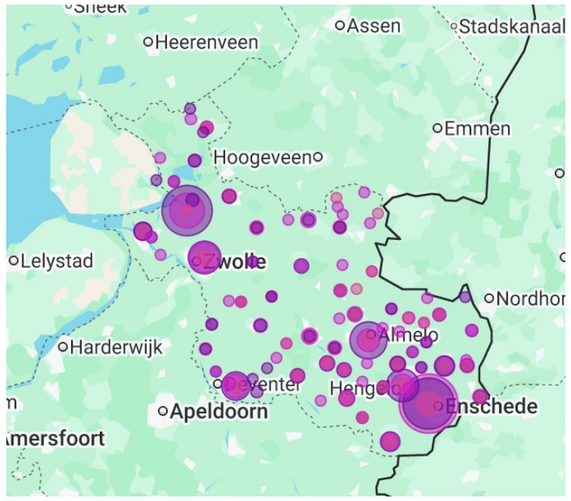
The Dutch Circular Textile Valley

The Dutch Circular Textile Valley (DCTV) https://www.dutchcirculartextile.org/ is a collaborative ecosystem that brings together frontrunners across the circular textile industry. The initiative curates, stimulates, guides, and accelerates the most promising circular textile innovations. By fostering knowledge exchange, enabling new partnerships, and supporting measurable impact, it contributes to the transition towards a fully circular textile industry.

The role of UAS in the textile transition at the regional level – an Overijssel perspective

Saxion's role in Overijssel

Saxion University of Applied Sciences is the only UAS in the province of Overijssel offering textile-related research and education. As the sole University of Applied Sciences in the Twente region, Saxion, together with the University of Twente, plays an essential role in the regional knowledge infrastructure in the Netherlands and the German border regions. Since the University of Twente no longer offers dedicated textile research or education, Saxion is the only institution in Overijssel that maintains this expertise and continues to develop applied research and educational programmes in the textile domain.

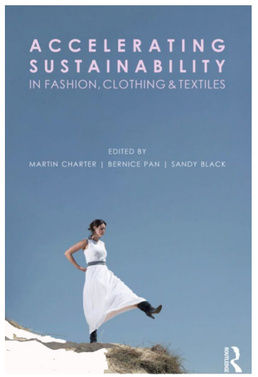


Map of textile companies in Overijssel based on Textile ecosystem living lab (TELL, 2026)

Foundation TexPlus

Stichting TexPlus is a collaborative partnership that brings together key organisations active in the circular textile sector. The consortium spans the entire value chain, from textile collection and sorting to material processing and the production of new end products. Through this integrated collaboration, TexPlus strengthens regional innovation capacity and accelerates the transition towards circular textile systems.

The goal of the foundation TexPlus is to connect the chain from collection to reuse. It does this by stimulating the reuse of textile products and, through innovative techniques, recycling non-reusable textile products to the highest possible quality, while actively involving the market in the development and application of recycled textile materials (Mahy & Oelerich, 2024).




22 Accelerating circularity in textiles: lessons learned from a regional perspective

Jan Mahy and Jens Oelerich

INTRODUCTION

The "low countries", roughly extending from northern France (region "Hauts de France"), Belgium (mainly "Flanders" region) and the Netherlands (mainly eastern part centred around region "Twente") have a centuries-old tradition in yarn spinning and textile weaving. Materials of bio-origin such as wool, hemp, flax and increasing production capacity in cotton weaving have led to world-famous interior (curtains, carpets) and clothing textile manufacturing and related crafts. These regions, among others, have been frontrunners in the transition from a "craft" to an "industry" in the 19th century, with large-scale spinning and weaving mills. After World War II, increasing labour costs and a shift to manmade cellulosic fibres (rayon, viscose), synthetic fibres (polyester, polyamide) and cotton have caused an accelerated transfer of textile production outside Western Europe.

The legacy of this industry has led to excellent vocational and academic education centres and a network of industries in the low countries founded on fibre and polymer technology, including commercially successful products of high performance fibres such as aramid (Twaron®), carbon (Tenax®) and ultra-high molecular weight polyethylene (UHMWPE, Dyneema®) from large industrial conglomerates such as Akzo Nobel and DSM (Teijin, 2019). While a dwindling

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As the knowledge partner within TexPlus, Saxion initiated and co-led the application process for the Regiodeal Circular Textile Twente project, which formed the basis of the TexPlus foundation. Within this project, the Circular Textile Lab at Saxion was financed and built, opened in 2021, and has since served as laboratory facilities for numerous research projects and as shared facilities for start-up companies. Currently, TexPlus is redefining its role as a catalyst for circular textile initiatives and businesses in the eastern Netherlands.

Textile research at Saxion

Textile research at Saxion began in 2004 with the appointment of Dr. Michiel Scheffer, the current President of the Board of the European Innovation Council, as Professor of Applied Sciences in Textile Economics and Fashion Management at Saxion. In 2009, ir. Ger Brinks joined Saxion and later succeeded Dr. Michiel Scheffer as research group leader. Under Ger Brinks's leadership, the research group at Saxion grew significantly, from fewer than 3 FTE to more than 10 FTE. The group's name "Smart Functional Materials" reflected the reduced focus on textile research in the European flagship programmes FP7 and Horizon 2020. With the launch of the new programme, Horizon Europe, textile research gained renewed attention. This shift, combined with the increasing focus on green solutions, was reflected in the group's new name. When Dr. Jan Mahy took over the research group in 2019, it was renamed Sustainable & Functional Textiles, representing the two research lines within the team. Since 2024, Dr. Jens Oelerich (link) has been the Professor of Applied Sciences and head of the research group Sustainable & Functional Textiles. Today, more than 20 researchers, lecturers, and technicians work on textile-related research and innovation projects within Saxion.

Past and current projects

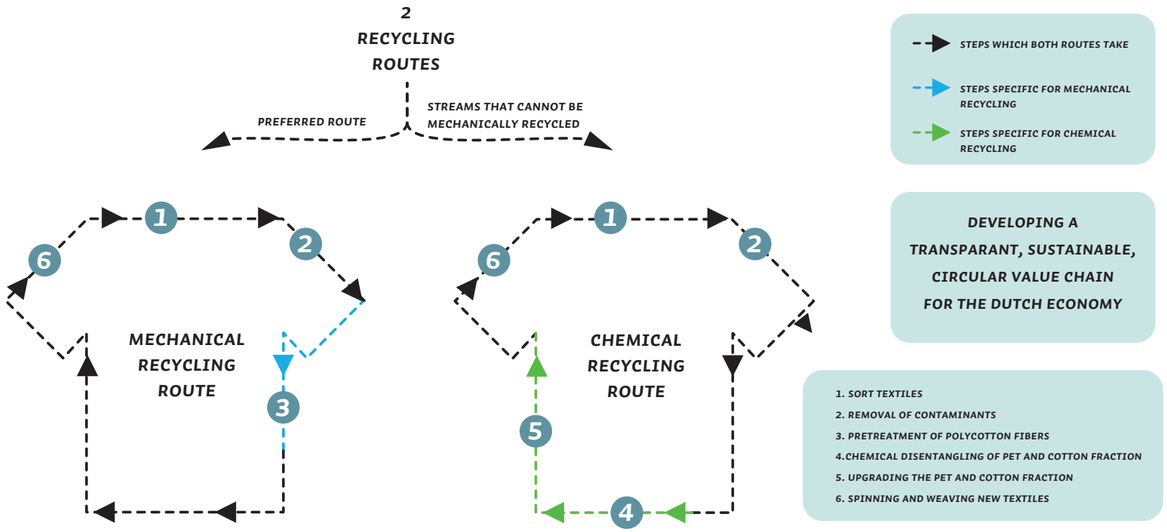
Since the start of textile research at Saxion, the Sustainable & Functional Textile research group and its predecessors have worked on more than 50 research projects with countless partners from education, industry, government and society. This work was initially organised within the Knowledge Centre Design & Technology and later under the umbrella of the School of Creative Technology at Saxion (ACT). Together with our colleague research groups Ambient Intelligence and Smart Cities at ACT, and with many other research groups within the focus areas Circular Innovations and Energy Transitions; Health, Wellbeing and Technology; and Key Enabling Technologies, we have built multi- and interdisciplinary applied research projects and strive for real industrial or societal impact.

These research projects were mostly clustered around our two research lines, sustainable textiles and functional textiles, in which we continually strive to integrate both aspects as effectively as possible.

Within the framework of sustainable textiles, the Regiodeal Circular Textile Twente project stands out. In this project, we established the Texplus Foundation together with five regional partners to work towards a future circular textile economy built on regional innovations, materials, and partnerships. As part of this initiative, the Circular Textile Lab was established to support SMEs through innovative research and up-to-date laboratory equipment, helping them meet the growing demand for more circular materials in textile products.

In this laboratory, we optimised recycling technologies, analysed novel recycled materials, bio-based materials (Dutch cotton), and circular materials (link to Wolkat project). We also developed real textile prototypes that integrate newly gained knowledge with unique materials.

A concrete follow-up initiative is the Dutch Growth Fund project Textile Polycotton Waste Evaluation & Recycling The consortium aims to establish a transparent, circular polycotton textile value chain in the Netherlands. This covers the entire process, from the collection and sorting of polycotton waste, through multiple recycling pathways, to the development of new products incorporating recycled polycotton. A strong emphasis is placed on increasing the market uptake of recycled materials, an aspect often overlooked in existing initiatives.

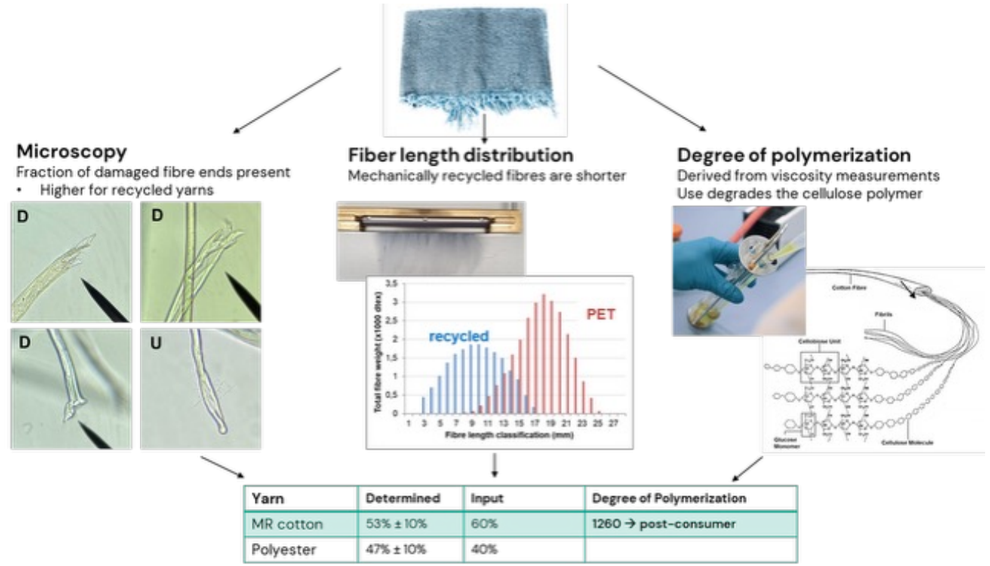


Texpower

In collaboration with the KPU-bedrijf of the Ministry of Defence, which coordinates textile streams across Dutch government agencies, a series of projects titled “Recycling Content Analysis” (Recan I–III) was initiated. These projects were funded by companies across the textile value chain and supported by TechForFuture.
Their aim was to develop reliable methods for verifying the presence, quantity, and origin of recycled fibres.

The projects produced a toolbox of analytical techniques for detecting recycled cotton in polycotton textiles, including microscopy (qualitative detection), fibre length distribution (semi-quantitative analysis), and degree of polymerisation measurements (to distinguish pre- and post-consumer origins). This work resulted in a publication in Scientific Reports (ten Berge, 2026).

Based on these results, the Interreg D-NL FiberFact project was launched. FiberFact focuses on scaling and standardising these verification methods across the Dutch-German textile value chain and integrating them with digital traceability solutions to improve transparency and support circular textile systems.



Building on earlier work in recycled fibre verification and traceability, the project “Digital Product Passport(s) for Circular Denim: From Pilot to Practice” (DPP4CD) focuses on implementing scalable Digital Product Passports (DPPs) across the circular denim value chain. In line with upcoming EU regulations—such as the Ecodesign for Sustainable Products Regulation (ESPR) (link), will make DPPs mandatory for textiles from 2027, as well as the Corporate Sustainability Reporting Directive (CSRD) and the European Sustainability Reporting Standards (ESRS), the project develops standardised, interoperable systems to capture product lifecycle data, including material composition, production processes, repair history, and recycling pathways. This improves traceability, reduces administrative burdens (especially for SMEs), and supports circular business models.

The project defines legal, environmental, technical, and user requirements for circular denim DPPs and develops a modular, data-driven system that integrates physical and digital components. A pilot with a circular blue-jeans manufacturer will demonstrate end-to-end lifecycle tracking, from production to recycling, and serve as a scalable model for wider adoption. Overall, DPP4CD aims to accelerate the transition towards transparent, compliant, and circular textile systems by combining digital infrastructure with circular-economy principles.

To create a mattress system that is easier to recycle and reuse while improving patient comfort and support in real-world healthcare settings, the research group initiated two SIA-funded projects, Re-Mat and Re-Mat II. A central concept is the development of a mono-material mattress, which simplifies material composition, facilitates more efficient recycling, and enhances functionality.

In the initial Re-Mat project, which won third prize for the best RAAK project of SIA in 2025, we explored key concepts and demonstrated the mattress's feasibility at full scale. ReMat II advances this work by emphasising implementation and validation. The focus has shifted from conceptual exploration to developing full-scale prototypes, optimising shorter supply chains, and testing in real-world care settings. Patients and healthcare professionals are actively involved in evaluating sleep quality, comfort, usability, and practical applicability. In parallel, the project integrates circular strategies, such as eco-design, life cycle assessment, and recyclability, alongside a safe-by-design approach that addresses both environmental and human health considerations.

Remat


Texenergie


XO-Soft

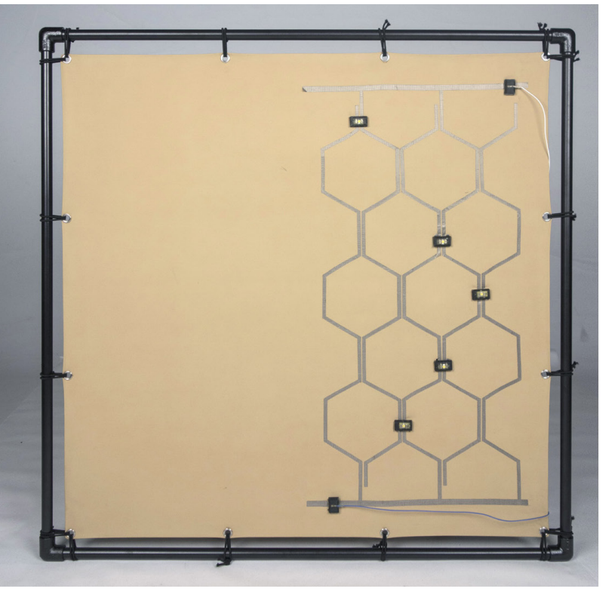
Saxion's multidisciplinary applied research capabilities are widely regarded as valuable contributions to complex research projects, particularly those bridging the gap between lower and higher TRL levels. One example is the XoSoft project, a European Horizon 2020 initiative that developed a modular soft-robotic exoskeleton to support individuals with mild-to-moderate lower-limb mobility impairments (Xiloyannis et al., 2020). Within this consortium, the S&FT research group collaborated with the materials research institute to design and realise a textile-based wearable that integrates sensors and robotic components while preserving user comfort.

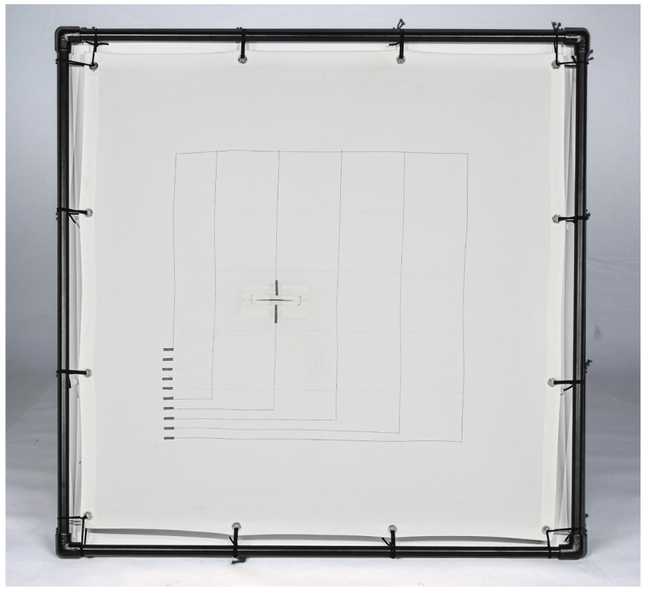
The DigiSmartTech Erasmus+ project was a collaborative higher-education partnership focused on developing training courses at the Bachelor's and Master's levels for digital printing of smart textiles. In addition to Saxion's SFT research group, academic peers such as the University of Borås (Sweden) and TTK University of Applied Sciences (Estonia), as well as industrial partners, formed the consortium. Together, these institutions bridge the gap between textile engineering and digital technology to train the next generation of European textile professionals.

The national Holland Hybrid Heart programme highlights the multifaceted nature of Saxion's research, with S&FT collaborating with several other applied research groups within a broad consortium of medical and academic partners. Saxion contributed textile-driven innovations essential to soft-robotic and bio-inspired heart prototypes, including 3D seamless knitted pneumatic actuators, origami-inspired foldable textiles, and 3D-woven cardiac structures. Additional work included biomimetic valve designs, textile-based mechanical tissue characterisation, durable ultrasonic weld seams, and fibre-reinforced soft-robotic bladders, all of which contributed to the development of next-generation artificial heart systems.

Within the four-year RAAK-PRO HITEX project, Saxion's S&FT and Ambient Intelligence groups collaborated with Fontys UAS and a consortium of ten companies across the textile and electronics value chain. The project focused on embedded textiles, specifically the precise and durable integration of electronics into technical textiles using methods such as inkjet printing, 3D weaving, technical embroidery, laminating, and nano-coating.

Together with the consortium, we developed four smart-textile prototypes: a multifunctional disaster-relief shelter with integrated solar cells and lighting; an anti-theft cargo canvas that detects cuts and triggers alerts; emergency escape curtains with embroidered LED guidance; and heated roller blinds designed to improve comfort in heritage buildings where double glazing is not feasible.





Our partnerships with the Dutch Ministry of Defence, the Ministry of Economic Affairs and Climate Policy, and the Ministry of Infrastructure and Water Management, through its executive agency, Rijkswaterstaat (RWS), have produced several key publications that inform public bodies, industry stakeholders, and the wider public about the current challenges facing the Dutch textile ecosystem.

The Ministry of Defence initiated our publications analysing recycled textile fibres in textile products, which may serve as a prelude to future standardisation of analytical methods within the textile industry (ten Berge, 2026). For the Denim Deal, financed by the former Ministry of Economic Affairs, we produced a technical report on the state of the art in the use of post-consumer recycled cotton in denim (Kuppen, 2024). This report provides a clear overview of the industrial opportunities and challenges associated with integrating post-consumer recycled materials into new denim production. RWS commissioned us to map contaminants in polycotton textiles on the Dutch market (Temmink et al., 2025) and to quantitatively assess the recycling quality of textile waste streams for fibre-to-fibre recycling (Askanian, 2026). These studies are essential for understanding the characteristics of available textile recycling streams in the Netherlands, their contamination levels, and their potential for high-quality textile-to-textile recycling.
Our research group also collaborated with the Ministry of Defence on Smart and Functional Textiles. One example is the development of a textile-based remote identification system to prevent “friendly fire” in combat situations (Kuhlmann et al., 2019).

The textile research laboratories at Saxion

Saxion provides comprehensive infrastructure for applied textile research, spanning the full chain from material characterisation and chemical analysis to circular fibre processing, advanced knitting and weaving, and prototyping. Together, these laboratories enable interdisciplinary innovation across sustainable, functional, and smart textiles.

Circularity and sustainability in textiles are supported by the Circular Textile Lab, which houses the full mechanical recycling chain, from old fabric to new yarn. Here, fabrics are chemically recycled and spun into Lyocell-type fibres on a FET wetspinning line, or mechanically opened into fibres, analysed for length and strength, and processed into small batches of yarn using carding, drawing, roving, and ring spinning equipment. Research focuses on recycled fibre processability, fibre blending, and the use of innovative bio-based materials.

The Knitwear Laboratory provides advanced capabilities for producing elastic, comfortable, and highly functional knitted structures, ideal for integrating sensors and actuators. Equipped with state-of-the-art circular and flatbed knitting machines, including a fine-gauge Santoni circular knitter and Stoll ADF and CMS systems, the lab supports both metre-made fabrics and 3D knitted forms. Its technology enables stitch-by-stitch control, complex textures, and the programming of mechanical properties directly into the textile microstructure.

The Pilot Production Laboratory bridges the gap to small-scale manufacturing with a digital weaving loom, an industrial embroidery machine, and seam-welding equipment. The integration of conductive yarns enables the creation of functional textiles, including heating elements and hybrid soft-rigid systems. For product development, the Design & Prototyping Lab provides industrial sewing machines and dedicated workspaces for pattern cutting and garment assembly, enabling rapid translation of concepts into functional prototypes.

The Mechanical Textile Laboratory provides precise measurements of key material properties, including tensile strength, tear resistance, wear behaviour such as abrasion and pilling, and tactile feel, supporting objective evaluation of textile performance. Complementing this, the Chemical Textile Laboratory provides infrastructure for dyeing and washing tests, raw-material identification, and assessments of colourfastness, lightfastness, water and oil repellency, and breathability, all of which are critical for understanding and improving textile functionality.
Together, these laboratories create a unique and versatile research environment that fosters innovation across the entire textile value chain, from fibre to final product.

S&FT's role in Education

The research group has a broad and meaningful impact on education by enriching academic programmes, strengthening collaboration, and linking education to real-world challenges. Through close collaboration with the bachelor's programmes in Fashion & Textile Technologies (F&TT), Chemistry, Chemical Engineering, and Forensic Sciences, and with the master's programme in Innovative Textile Development (ITD), the research group ensures that students across disciplines engage with the latest developments in sustainable and functional textiles. This collaboration brings cutting-edge research directly into the classroom, enabling students to explore emerging materials, technologies, and societal issues from multiple technological and design perspectives.

Students participate in research projects addressing urgent challenges, including the award-winning bachelor's thesis by Louise Kirsten on the influence of washing on fibre properties and the master's thesis by Irina Ratiu-Teodora on the effects of mechanical and chemical recycling of polycotton textiles in 2024. Both received the De Maere Foundation Thesis Prize. Additional examples include the 2024 master's group project on e-textile waste, which won the best student project award at the E-textiles conference, and the 2025 master's thesis award received by Charlotte Wohlmeiner for her research on 3D knitting for an artificial heart.

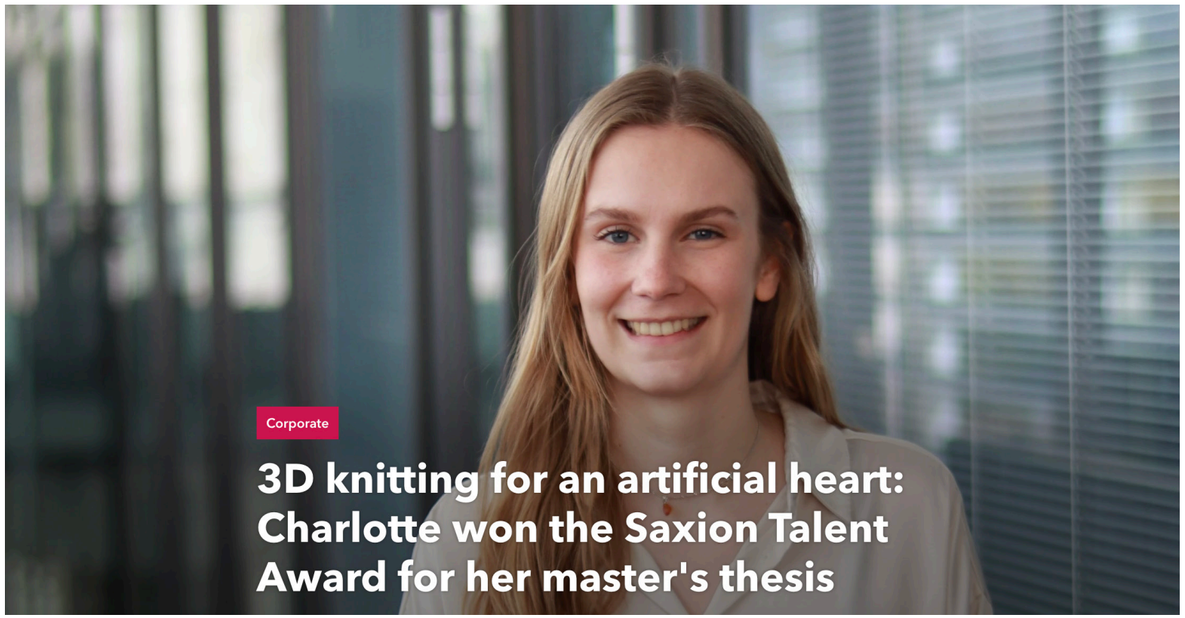
Across these projects, students explore new technologies, conduct field tests, and collaborate with industry and societal partners. These experiences help them develop practical skills, critical thinking, and the confidence to apply their knowledge in real-world contexts. Working alongside researchers and professionals also exposes them to interdisciplinary approaches, strengthening their ability to innovate across the boundaries of design, technology, and science.

By integrating research outcomes into curricula, supporting student-led inquiry, and fostering collaboration across programmes, the research group Sustainable & Functional Textiles enhances the overall educational experience. It prepares students to become forward-thinking professionals and contributes to the ongoing evolution of education in the textile, design, and applied sciences domains.

The vocational education provider ROC van Twente and the higher education provider Saxion University of Applied Sciences are located next to each other in Enschede and both offer textile-related education programmes that together span almost all eight levels of the European Qualifications Framework (EQF) (Europass, n.d.).

The ROC van Twente offers several vocational programmes, including Process Operator (specialisation in textile machinery, EQF 2), Assistant Fashion Tailor (EQF 3), Fashion Product Coordinator (EQF 4), Fashion Designer (EQF 4), and Fashion Tailor (EQF 4) (ROC van Twente, n.d.). Saxion offers higher education programmes in the textile domain, including the bachelor's degree in Fashion & Textile Technologies (F&TT) at EQF level 6 and the master's degree Innovative Textile Development (ITD) at EQF level 7.

Together with the University of Twente, the ROC and Saxion could build on a continuous learning pathway offering EQF levels 2-8 for textile education in the Twente region. For more information, please read the Outlook chapter.



Discussion and conclusion

Research at Universities of Applied Sciences (UAS) are still comparatively young within the European higher education landscape, particularly when set against long-established research universities.

Their role as centres of applied knowledge is evolving, shaped by strong regional embedding and close alignment with industry and societal needs.

UAS with textile education and research in Europe are typically located in historic and/or current textile hubs, where they hold a strong position within regional education and industry ecosystems. They frequently act as founders or key drivers of regional and national initiatives, such as Textile Factory 7.0 in Mönchengladbach, NewTexEco, or the Texplus foundation in the Twente region.

This regional anchoring is not a limitation but a structural strength: it positions UAS as ideal partners for European research frameworks, particularly where interdisciplinary research, application-oriented outcomes and regional impact are required. Additionally, the clear focus on research at higher Technology and Societal Readiness Levels (TRLs and SRLs) aligns closely with the requirements of EU Horizon calls, including Research and Innovation Actions (RIA 3–6) and Innovation Actions (IA 4–7).

To fully realise this potential, UAS should consolidate and expand their strategic regional positioning by building strong connections with local stakeholders from industry, (local) government and society, and, where possible, with national and European policymakers. This remains essential to ensure relevance and impact. At the same time, UAS need to strengthen their influence in national decision-making processes through more structured engagement with governmental bodies.

At the European level, greater visibility and strategic participation are essential. UAS with textile education and research should maintain their leading role in Erasmus projects while expanding their involvement in cross-border collaborations and large-scale EU research initiatives. A stronger position within these frameworks will enable them to accelerate the transfer of textile innovations to industry, particularly to SMEs, and to contribute effectively to closing the skills gap in key transition areas, especially where new competencies and applied expertise are urgently needed. To achieve this, UAS must continue to strengthen their structures and capacity for EU advisory services, project acquisition and funding support.

Future textile professionals will need digital fluency, sustainability-driven design capabilities, and systems-oriented creative problem-solving to lead the industry's technological and circular transformation. As automation and digitalisation advance, competition with other sectors for highly skilled employees will intensify. Because many of these sectors have traditionally been more closely connected to key ICT and AI resources, the textile industry must proactively develop strategies to equip its workforce with these essential competencies. UAS, with their strong links to other knowledge domains, SMEs, and education, are well-positioned to serve as crucial partners for the European

textile sector in this transition.
The Netherlands has five strong research groups in textiles, which are clustered within NewTexEco to build on strong facilities and align their research agendas and networks. This provides a strong foundation for interdisciplinary research to deliver hands-on solutions to Dutch textile companies.

Saxion's research group S&FT provides technical textile research with deep expertise in materials, chemistry, and processing. Its cutting-edge research facilities, close collaboration with education, and practice-based research approach generate valuable knowledge for mostly local and national SMEs. Through an increasing focus on European collaborations, S&FT is currently strengthening its reputation and impact beyond the Netherlands.

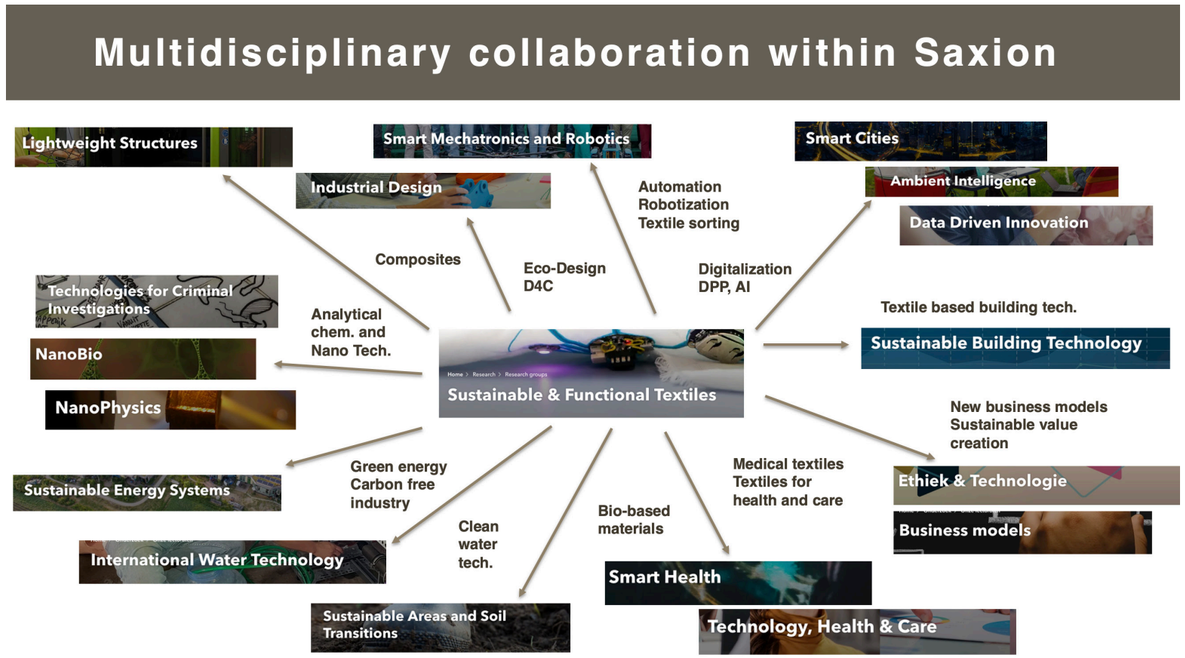
In conclusion, it can be emphasised that the concept of UAS aligns strongly with the challenges arising from the current transition of the textile industry, and that UASs should claim a more prominent role in addressing them.

Outlook

Our research group, Sustainable & Functional Textiles (S&FT), holds a unique position within the Dutch textile education and research ecosystem.

With a dedicated and skilled team bringing deep expertise in textile materials science and design, chemistry, and processing, and with outstanding laboratory facilities and a close connection to the textile industry, Saxion has all the essential conditions to serve as the textile knowledge centre in the eastern Netherlands.

To meet the demands of the industry's ongoing transition, both our research group and Saxion's textile education must continue to evolve. In the following section, I would like to outline the future collaborations, projects, and structures I envision for the research group S&FT in the coming years. Because our research group is built on co-determination and a strong team spirit, and because our research approach is driven by industry questions, these changes will not be imposed but will be thoroughly discussed and weighed to ensure they align with the needs of our partners, the expertise within our group, our core values, and our way of working.



Strengthening internal collaborations to maximise external impact

Looking at Saxion's broad knowledge base, S&FT is well positioned to play a crucial role in collaborations across multiple research domains and with various other Saxion research groups, supporting regional, national, and European textile companies and related industries. One collaboration I aim to strengthen is with Saxion's SMART Mechatronics and Robotics research group. For applications such as textile sorting, their expertise in automation and robotisation can significantly enhance the competitiveness of the Dutch textile sorting industry. Together with the data and AI expertise of our research groups, Ambient Intelligence and Data Driven Innovations, we can develop systems that sort used textiles stepwise: first by defects and stains, then by their value in the second-hand market, and finally by their suitability for recycling streams when needed. S&FT's expertise in analytical chemistry for detecting contaminations and unwanted chemicals, combined with our knowledge of textile materials, recycling technologies, and their specific requirements, can further strengthen this approach. In combination with the above-mentioned know-how, these capabilities could dramatically increase the volume of textiles that can be reused in second-hand markets and processed for recycling applications.

Additionally, together with the same research groups, the Industrial Design group, and our NewTexEco partners, I would really appreciate integrating S&FT's expertise in circular textile materials with the unique design approaches for circular denim and knitwear demonstrated in Amy Kerr's master's thesis and the Knit2Last project. My goal is to embed these circular design principles into digitalised and automated weaving and knitting practices. Through these research and innovation efforts, we can help strengthen the circular textile market's currently challenging financial position and provide it with a much-needed boost in innovation.

Given the growing importance of a European defence and security industry amid geopolitical tensions and shifting international roles, Saxion UAS's combined expertise in textiles (fibres), lightweight structures (composites), and mechatronics (including drones) uniquely positions it to support this sector in the Netherlands. Advanced process technologies, such as Additive Manufacturing, thermoplastic composites, and sustainable defence-oriented production methods, are increasingly vital to European defence initiatives. These opportunities for internal collaboration and the experience of S&FT in defence-related projects will make Saxion a highly suitable knowledge partner for defence applications.

A stronger collaboration with Saxion's research groups, Smart Health and Technology and Health and Care, would also be highly valuable, enabling us to apply our expertise in integrating electronics into textiles and our user-centred design approach for Smart Textiles to

practical applications. I am convinced that many important opportunities are emerging across sport, rehabilitation, and the ageing population.

Additionally, I would like to explore the connection between the circular textile transition and the energy transition. Many textile processes still rely on steam generated from fossil fuels. Electrifying these processes would significantly reduce greenhouse-gas emissions. Even after electrification, textile sorting, recycling, and local production remain energy-intensive, and the energy required is not always available in the Netherlands due to grid congestion. It would be highly beneficial if these processes could be synchronised with periods of energy surplus. If energy-intensive textile processes could store surplus energy as steam, hot water, or electricity in batteries during periods of lower energy market prices, this could help stabilise the energy grid and make circular processes economically viable.

In addition to these collaborations, I would like the group to continue increasing its visibility through peer-reviewed and professional publications, as well as through strategic engagement with ministries, network organisations, academic partners, and the general public.

However, all of this is only possible with a stable financial foundation and state-of-the-art laboratory facilities. The current housing situation at Saxion, in particular, raises concerns for our research group. Our laboratories are used extensively by researchers, our own interns, students from several educational programmes, and external companies. It is therefore essential that our facilities remain continuously accessible and serve as a highly visible, vibrant environment. We also require the flexibility to invest in new machinery, rearrange and rebuild laboratory spaces, and offer our services to our partners. This is crucial for textile education and research at Saxion and for the industry we support.

Textile Academy Twente

Together with our partners at the ROC of Twente, Saxion's educational programmes, including the bachelor's Fashion & Textile Technology and the master's Innovative Textile Development, and the University of Twente, I aim to develop a continuous learning pathway that enables students to pursue vocational, higher, and academic education in textiles throughout the Twente region.

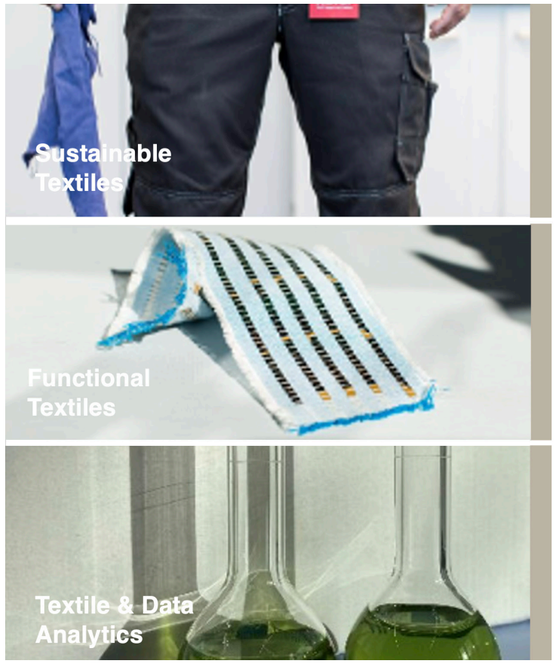
Such an integrated and well-aligned educational route would offer young talent a clear professional trajectory and provide lecturers with a coherent framework for drawing on each other's expertise.

To the outside world, such a Textile Academy Twente would demonstrate a strong commitment to textile education and research in the region and present a clear, recognisable profile of these activities to students, other education providers, industry partners, regional and national governments, and society at large.

Structure of S&FT

Within our group, research is organised into research lines, through which projects are coordinated, and knowledge lines, where knowledge is collected, analysed, and disseminated. At present, our research group consists of two research lines: Sustainable Textiles and Functional Textiles. In recent years, we have seen growing demand for our analytical expertise in textiles and data. For this reason, it could be beneficial to expand the group with a third research line, Textile & Data Analytics, which would bring together the knowledge lines on physical and chemical textile analysis and on data collection and analytics.

Additionally, our knowledge lines Innovations in Textile Processing, Human-Centred and Ecological Design, and the newly proposed line Automation, Robotisation, and Decarbonisation are relevant to all three research lines. Their cross-cutting nature strengthens the coherence of the research group and supports innovation across the full spectrum of our research.



Future research of S&FT

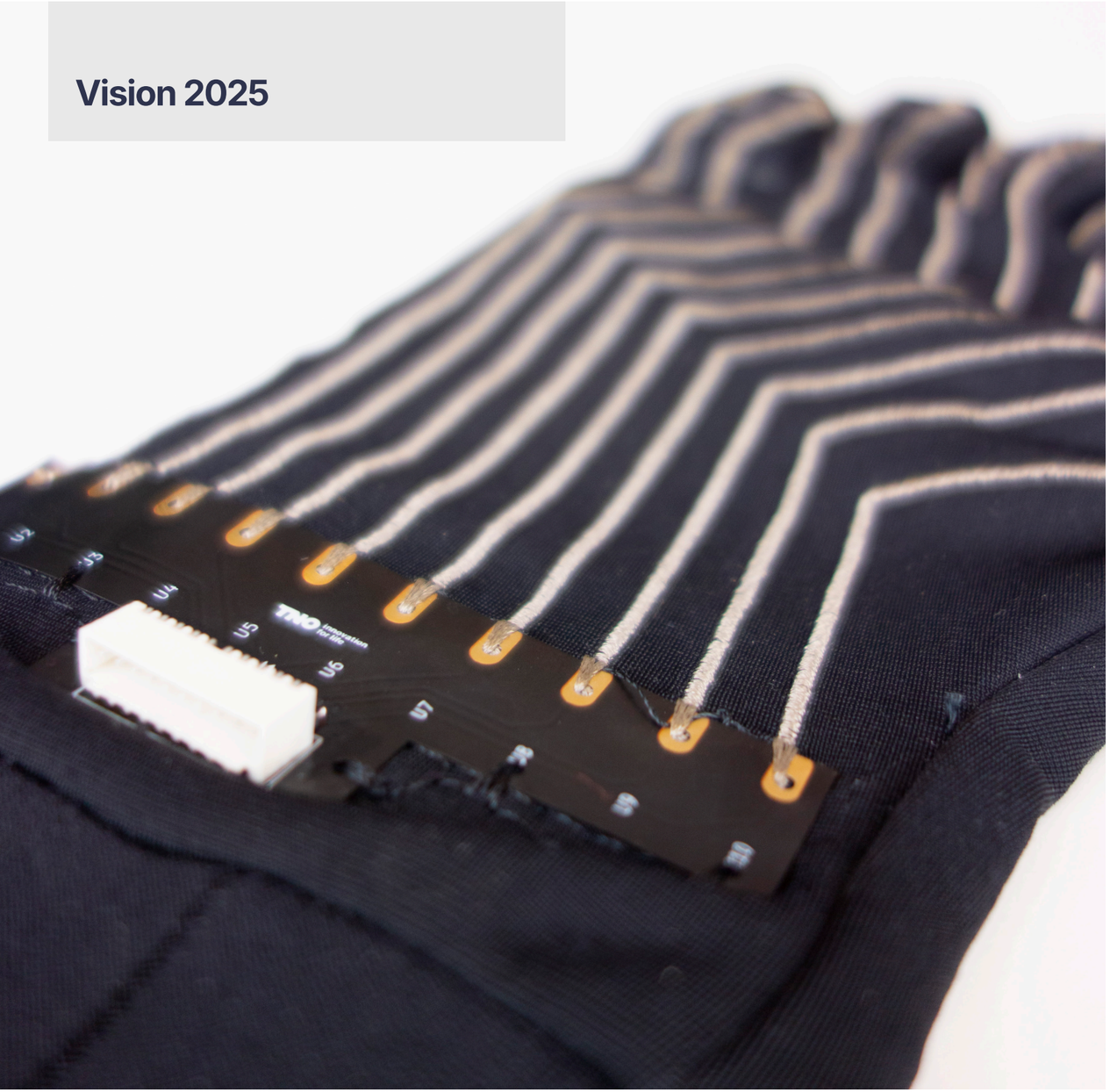
- Chemical and mechanical recycling of textile materials
- Processing of recycled and next generation fibres
- Advanced textile construction technologies
- Integration of electronics into textiles
- Physical and chemical textile analysis
- Data collection and processing

Innovations in textile processing

Human-centered and ecological design

Automation, robotization and decarbonization

Vision 2025



At the end of this publication, I would like to outline my ideal scenario for the textile industry, education, and research landscape in Europe by 2050. This vision represents a state in which all elements align. I am fully aware that the future cannot be predicted, but this vision should serve as a point on the horizon, providing direction and illustrating a possible path forward.

In this ideal future, fashion has moved beyond the need for rapidly changing trends, and clothing is regarded as a high-value good, worn with care and for long periods. Textiles are high-quality and designed for durability and longevity. Dynamic DPP systems embedded in textiles track and optimise (household) laundry processes, providing essential data for end-of-life scenarios.

The textile industry's strategic importance is reflected in substantial investment. The most relevant materials, ranging from high-performance fibres such as aramids and carbon fibres to volume materials for clothing and home textiles, are produced within the EU. Natural fibres such as hemp and flax are cultivated locally. Bio-based and waste feedstocks are converted into cellulose fibres such as Lyocell, and existing textile streams are recycled into high-quality fibres using advanced mechanical and chemical processes. Synthetic fibres, including polyesters and polyamides, are produced exclusively from bio-based feedstocks and recycled raw materials. Retaining materials in circulation is valued as much as producing new ones.

All textiles used in Europe are collected, sorted, and recycled within the EU. Sophisticated sorting centres, equipped with AI-powered vision systems, first identify second-hand quality, detect damage or stains, and assess value. Combined with information from fully implemented Digital Product Passports (DPPs), the system determines the highest-value retention pathway. Damaged or stained textiles are repaired or cleaned using automated robotic processes. The second-hand commercialisation of suitable garments is facilitated by automated photography and online marketing systems.

Designers know the properties of the materials they work with, use eco-design principles, and construct textiles with end-of-life options in mind. Local micro-factories produce individualised, made-to-measure garments, strengthening the emotional bond between textile and user and reducing overproduction. Local repair and remanufacturing workshops help increase the lifetime of textile goods.

The textile industry is recognised as a value-adding partner for markets such as defence, construction, mobility, and healthcare, providing essential textile materials produced in Europe, guided by strategic considerations rather than price alone. The industry also delivers solutions for an ageing society through smart, comfortable sensing technologies and high-tech medical textiles. As a result, the textile sector is deeply integrated into manufacturing processes across Europe.

The province of Overijssel is an important hub for textile innovation, hosting significant sorting, recycling, and production facilities that are increasingly digitally connected through data, technology, and trust-based collaboration.
The strong connections with the IT sector, automation and robotisation, and the interdisciplinary character of the work attract young talent to the textile industry, who are fascinated by the complexity and characteristics of the materials and processes they work with.

Textile research and education at Saxion take place in close cooperation with our partners within the proposed Textile Academy Twente structure. Together, we work in well equipped, visible, and vibrant facilities, closely connected to the needs and developments of the textile sector. With this in place, we place the Twente region firmly on the European map.

Appeal

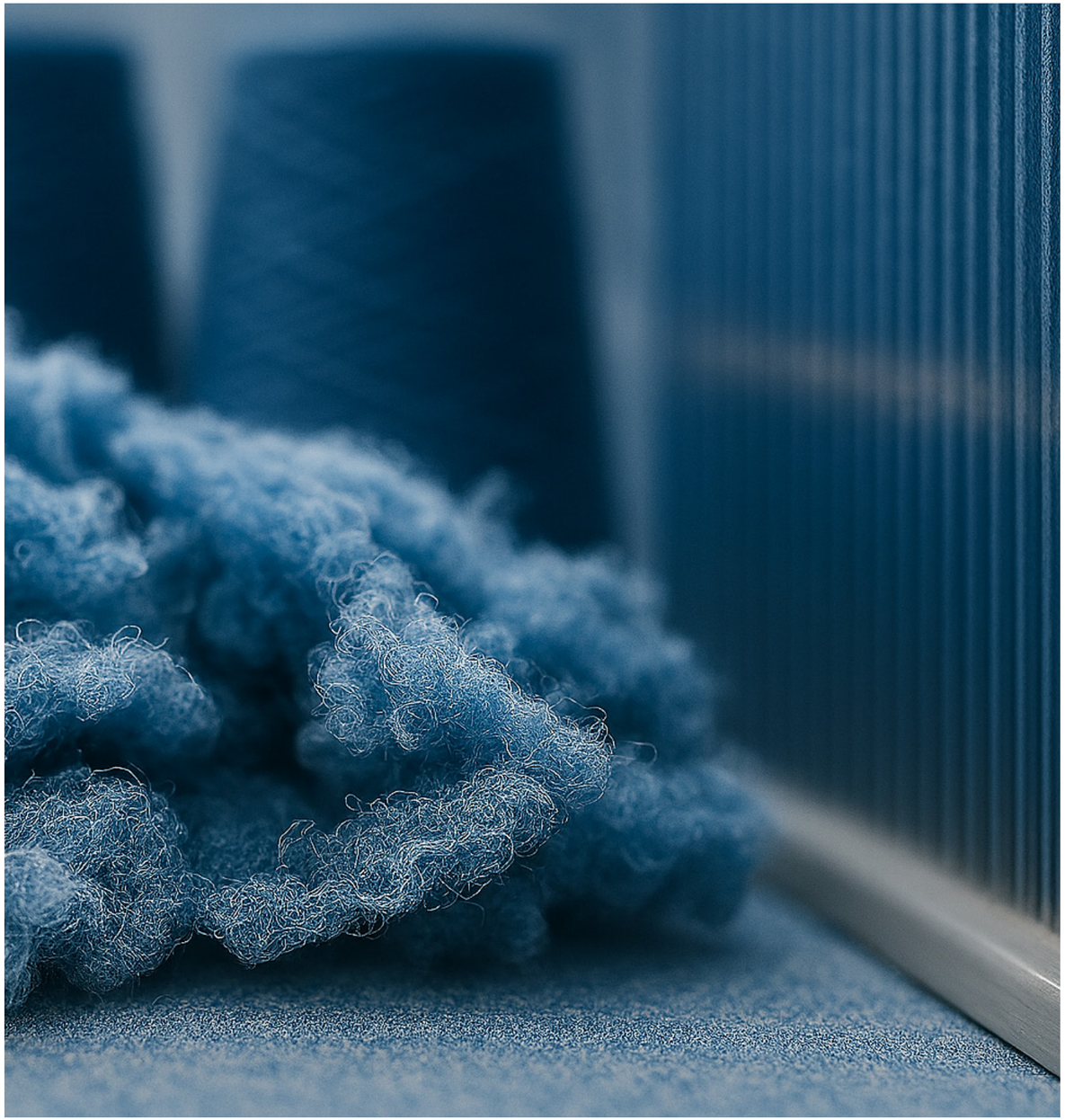
The Dutch textile industry is not only economically valuable but also strategically essential, and it is up to us to shape its future.

The industry is a driving force behind the circular economy in the Netherlands, providing secure access to raw materials and enabling the country to recover, reuse, and retain critical resources rather than relying on volatile global supply chains. Textiles are vital for crisis and defence: from protective gear and medical textiles to advanced fibre-based materials for safety, mobility, and national resilience. A strong textile industry strengthens our autonomy.

But such strength does not arise on its own. It grows where research is bold, where education empowers new generations, and where industry and academia collaborate with shared ambition. Without sustained investment in startups, scale-ups, established companies, and the knowledge and talent that fuel them, we risk losing not only competitiveness but also expertise, creativity, and the innovative capacity that keeps the Netherlands at the forefront.

Our research group is committed to preventing that. By uniting cutting-edge research with embedded education and deep industry partnerships, we work to keep knowledge anchored here, where it can spark new ideas, strengthen companies, and inspire the next generation of makers and innovators. With the right support, the Dutch textile industry can lead with confidence, building a resilient, circular, and high-value future.

“A strong Dutch textile industry can contribute to raw-material independence, resilience, and value creation.”



Acknowledgment

Good applied textile research requires the experience and perspectives of many people. I'm very proud to be part of an amazing team of experienced and young researchers, with a strong set of knowledge and skills, but, even more importantly for me, a dedicated drive to deliver excellent work and always offer a helping hand. It is a privilege to work with you, and I look forward to many more years filled with exciting projects, insightful research, and a lot of fun at work. Thank you: Amy, Anke, Carlos, Eliza, Ezra, Floor, Harout, Hellen, Jan, Jirka, Karin, Laura, Maud, Melissa, Pramod, Richard, Robin, Sarah, Sven. And our former colleagues: Bertram Henk, Iñaki, Jorrit, Marijke, Theresia, Young Suk,

I would like to thank all the students who contributed to our research, whether as interns, final-thesis students, or through project assignments. Your dedication, creativity, and hard work have been invaluable to the progress we have made.

Special thanks go to my predecessors, Ger Brinks, Gerrit Bouwhuis and Jan Mahy. Ger, you started and supported my career at Saxion by hiring me in November 2013 to work on the chemical recycling of cotton. This was under Gerrit's supervision. Gerrit, you always gave me the freedom to explore my own path while teaching me the art of building consortia with textile companies. Jan, you have been a great promoter of my personal development in recent years. From the moment I started as an associate professor of applied sciences to my promotion to research group leader, you consistently gave me a deep sense of trust and appreciation, which supported me enormously in my growth.
Thank you all very much.

I would also like to thank the people behind the scenes, our financial, research, marketing and management support: Dorien, Ezra, Susan, Christien, and Mariël. You have been a tremendous help over the past years, especially in recent months, in making my inaugural lecture possible.

Saxion is a great place to work and conduct research. This comes from a clear ambition to position Saxion not only as an education provider but also as a broader knowledge institute, where research and education are valued equally. This ambition has been, and continues to be, driven by both the former and current Executive Board of Saxion. For this, I would like to express my gratitude to Anka Mulder and Inge Grimm, in their representative capacity.

I would also like to thank my colleagues, Professors of Applied Sciences at Saxion, especially those who work with us in multidisciplinary projects, and our cluster of research groups within the School of Creative Technology.

This inaugural lecture was part of a larger event at Saxion and an ETP on Tour programme to Enschede for ETP members who had attended the annual ETP conference in Amsterdam beforehand. Thank you very much, Lutz Walter, Beatrice Manzini, and the entire ETP team, for organising the ETP on Tour and the event at Saxion together with us. It is wonderful to celebrate this special occasion with our partners from across our European network.

The regional circular textile industry cluster, TexPlus, has provided an opportunity to test ideas from the research community in real-world settings. Whether in textile waste collection and sorting, recycled-content spinning and weaving, or economies of scale, many concepts were adopted and implemented, thanks to a dedicated team of entrepreneurs. I would like to thank all partners of TexPlus.

The research community NewTexEco is a great example of collaboration within textiles. Depending on their expertise, each research group brings unique characteristics, knowledge, and networks. These collaborations help build a common understanding and bridge the gap between different research disciplines within a single industry. I hope we can continue to build the research infrastructure. I would like to thank everybody who is involved in this exciting programme.

The textile domain within Saxion is often cited as an example of the excellent collaboration between research and education. This is not a given and always depends on people. My special gratitude goes to Paula van Veen, Jurrie Barkel, Jan-Chris Hullegie and all other colleagues from the bachelor programme Fashion & Textile Technology and the master programme Innovative Textile Development who make this possible for us.

Starting my first position with HR responsibilities in a group of 20 people was quite a challenge. Luckily, I had a dean who always had an open ear, was supportive, and enabled our research team's steady growth. I'm very grateful, Arjan, for your invaluable support during the first two years of my position as research group leader. Sometimes work and home feel like two completely different worlds to me. Every morning and evening, I cross country borders, switch languages, and move between meetings about textiles, project acquisition and lab facilities, topics that rarely come up at home. At work, I speak mostly English and Dutch; at home, German, except during the bedtime routine, when our daughters insist we switch languages, mostly to stall for time. At work, I'm the one in charge, and I'm expected to make decisions. At home, it often feels like the kids are the ones setting the tone, and honestly, that's exactly how I want it to be. These two worlds are different, yes, but they're beautifully connected. And even though they sometimes influence each other, it's almost always in the best possible way. Ich möchte dir, Jacqueline, und euch, Felien und Clara, sehr dafür danken, dass ihr mir immer wieder zeigt, was im Leben wichtig ist und mir den Raum gebt, den ich benötige. Ich liebe euch!

I would also like to express my gratitude to Ludovico Einaudi, whose immersive music accompanied and supported me while writing, whether in a crowded office or at home.

At the end, I would like to thank our incredible partners who contribute their questions, experience, facilities, and time to our research. I know that it is becoming increasingly difficult for the textile industry to engage in research, which is why I value your contributions so highly. Without your support, our research would not be possible. I hope we can continue our valuable collaboration, preserve existing industry and skills in the region, and introduce innovations that help us transition together toward a strong, green, and digital industry.

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On the use of AI in this publication: Microsoft Copilot was used exclusively for linguistic refinement of the manuscript. No personal data was uploaded to the system. The tool did not contribute to conceptualisation, questionnaire development, data analysis, or interpretation of the findings.

Thank you.