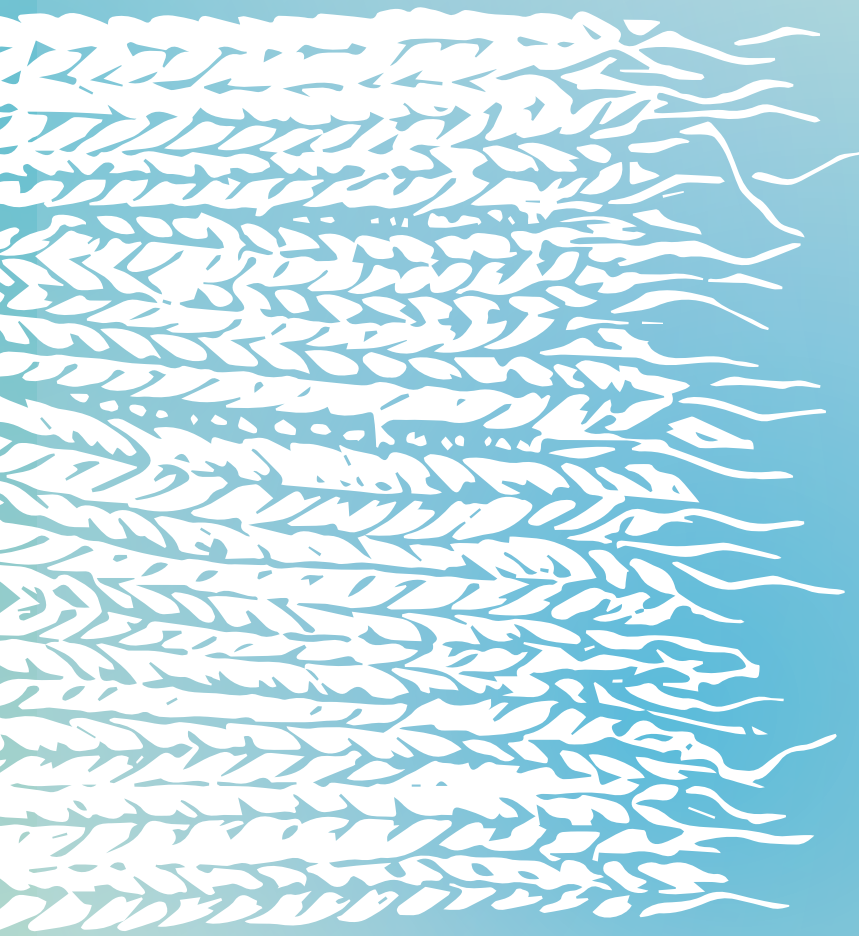


the untapped potential of digital knitting as a counter-concept to fast fashion



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The creative case studies of PACESETTERS are investigating the current and potential interdependencies between stakeholders, networks and their collaborations. Supported by cross-disciplinary, collaborative co-research methodology, these case studies make explicit links between the status of resources or services and the impact of potentially disruptive innovation.

Specifically, the topic of this investigation focused on Decentralised Architecture: SUSTAINABLE RE-INDUSTRIALIZATION BY TRANSLATING AVANT-GARDE STRATEGIES INTO MAIN-STREAM PRODUCTION

Driving the climate transition requires a shift from centrally planned and implemented to decentralized architectures distributed among federated nodes operating in a relative autonomy with respect to central authorities. Regenerative and renewable modes of production rely on distributed networks that operate in an interconnected but independent fashion. The result is not only greater resilience but a multiplication of creative business opportunities and realistic scenarios for the sustainable scaling of creative business models. Cases included investigations into circular aesthetics of new materials in artificial biology systems; repurposing place in post-conceptual art and design; digital knitting as a counter-concept to "fast fashion"; fermentation and metabolic processes across disciplines.

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EXPLORE THE INTERVIEWS

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We see the opening up of new scenarios that encourage a radically different re-industrialisation strategy based on decentralised and circular modes of on-demand production.

The concept of technique outlines a practical and specifically human relationship to the world. There is perhaps no better example than knitting to illustrate Walter Benjamin's approach to the non- technological concept of technique as an emancipatory project and a liberation from the instrumental, exploitative and extractive relationship between humans and nature. Up until the 17th century, knitting was a handmade activity mainly focused on producing socks and stockings, caps and gloves organised as a cottage industry in which the work was done by people in their homes. Later on it became an industry based on industrial machines able to produce

garments and accessories in an automated way. Digital technologies have had a huge impact on the knitwear industry since the early 1980s but the concept of digital textile microfactories is emerging as one of the approaches which could better face the challenges of the climate transition. Their potential to transform the industry toward more economically sustainable and community-centric practices is significantly connectable to local traditions, motifs, patterns and heritage. From digitally hacked home-knitting machines to industrially automated machines the contexts of knitting spans widely and allows experimental design with complex patterns both in avant-garde fashion and grassroots street-wear. We therefore see the opening up of new scenarios that encourage a radically different re-industrialisation strategy based on decentralised and circular modes of on-demand production. This creative case study explores and analyses the potential of digital knitting as a counter-concept to fast fashion, deeply entangled with reflections around the supply chain and sustainability of materials used in the knitting process and the biases of contemporary craft canon embedded in the hierarchical nature of traditional craft.

The discussions came to highlight the importance of collective, knowledge-sharing approaches to manufacturing and design, moving beyond the notion of the solitary creative.

The collected interviews focus on the intersection of digital knitting technology, sustainability, and innovative fashion business models. We opened up these conversations with practitioners to explore how digital knitting machines, particularly those capable of wholegarment production, offer a low-waste alternative to fast fashion, enabling on-demand and short-supply chain manufacturing. The main area of discussion is the challenges of breaking away from traditional industry structures, such as the pressure of infinite growth and the difficulty of promoting quality, ethically produced goods over cheap, mass-market items. Furthermore, the discussions came to

highlight the importance of collective, knowledge-sharing approaches to manufacturing and design, moving beyond the notion of the solitary creative, and the potential for knitting technologies to be applied in other fields like architecture and interior design, particularly when using locally sourced materials like coarse wool. Several barriers though, are preventing a new ecosystem of production based on “create - sell - produce” (instead of create-produce-sell) from becoming more widespread even if the technologies are available. It’s a chain of small gaps that add up.

Taken together, these interviews reveal a constellation of situated experiments that position local contexts as critical sites for rethinking knitted manufacturing. Rather than proposing a single model, they articulate a plurality of practices in which innovation is primarily procedural, embedded in how tools are shared, workflows are adapted, and value is generated in relation to place and community. Echoing Ezio Manzini’s notion of cosmopolitan localism and Ernst Friedrich Schumacher’s call for human-scale economies, these approaches gain renewed relevance through digital fabrication technologies that allow advanced manufacturing to operate beyond metropolitan centres. In such contexts, digital knitting and related tools support the re-valorisation of local skills and material knowledge while enabling new forms of economic viability.

By making these practices more visible, this series aims to open space for dialogue, collaboration, and mutual recognition, while signalling to policy makers the importance of supporting forms of innovation that may seem peripheral yet play a decisive role in countering rural depopulation and fostering more sustainable local economies. Finally, these interviews seek to offer young designers concrete evidence that alternatives are not only conceivable but already being tested, while allowing practitioners to recognise shared challenges, and perhaps feel less isolated in navigating them.

diletta cancellato

Milan-based cU, whose name is an acronym for cancellato Uniform, is a new knitwear clothing line launched in 2022 by the designer Diletta Cancellato who aims to create a contemporary wardrobe, with progressive 3D knitwear design and a new size system based on height. The brand proposes four different sizes that uniquely refer to height, so that every item can fit as many people as possible, from 1.30 m to 1.90 m.



Tell us a bit about your approach and the idea behind your brand. In simple words, what is cU | cancellato Uniform?

cU is a knitwear brand that brings together Italian artisanal know-how with new 3D knitting technologies to create every-day garments that can adapt to a wide range of bodies, ages, genders

and physical abilities. Two distinctive features define cU: a body-driven approach with a very generous fit that led us to a sizing system based only on height, and a focus on production processes, largely based on 3D knitting technologies.

How did you come to knitting machines along your path, and what led you to see them as the manufacturing technology best suited to express your creative ideas and to initiate cU?

My path started with studying fashion product design at “Politecnico di Milano” for my bachelor’s. It was the first time that, for the third year, you could choose to specialize in jewelry, ready-to-wear or knitwear. I chose knitwear.

Back then Politecnico already had a big lab, now it’s amazing and full of manual knitting machines, later electronic ones too, and I fell in love with knitwear. I then continued with a master’s at Parsons in New York titled Fashion Design and Society, where everyone could choose their own theme, and I kept going with knitwear; it became my way of expressing myself. The extreme versatility of knitting, starting from a single yarn and being able to create three-dimensional forms, to make the fabric, even to develop your own yarn, offers endless possibilities and maximum creative freedom. For me there’s nothing else. As I went on, I had the chance to train as a programmer on CNC knitting machines, and that’s when the idea of cU | cancellato Uniform was born, as we realized how much potential knitwear still had left unexplored.

Even though knitting machines capable of creating three-dimensional forms have been on the market for years, only now are we seeing more advanced uses that really leverage their potential. Why do you think it’s been so slow?

The real issue is the complexity of programming and of understanding how to design for those machines. Unlike panel machines, they have many limitations. They do let you make a whole garment—something you can’t do with other machines—but there are many other constraints,

and that often dampens interest in using them. In a fashion system that has to invent something completely new two, four, even six times a year, you eventually run into friction. And there aren’t many people who can program them at a very high level to produce more complex pieces. In the end they were used to make classic jumpers in lots of colors without really pushing the potential of these machines. We, by contrast, work on the complete garment, the total look.

In various articles about your brand there’s a lot of attention on the new sizing system that adapts to different bodies, but little interest in your production model, which is on-demand and in small batches. Would you tell us how it works and how you decided to produce this way?

Our business model goes a bit against the grain, somewhat anti-capitalist. When we approach B2B clients, because now we also sell to stores, the question is, “But is this even profitable for you?!” They’re referring to the fact that, since we don’t have all the traditional sizes, the number of orders is reduced. Of course you always have to

consider your end goal, and for us it’s to offer a different way of approaching both dressing and making fashion. Our aim is to create garments that, as we said, adapt to as many bodies as possible and to the changes in a person’s body over time, because once you’ve found your height size, a garment will fit your body from XS to XL. A simple example from my own experience: during my pregnancy, up to the ninth month I kept wearing this trousers day after day and they always fit the same. It’s a piece designed to last, really last, because even with a drastic change in your body the garment continues to fit. There are no seams, the weakest points

of a garment, the first to give over time. It's extremely comfortable and, thanks to an aesthetic that makes it versatile for different occasions, it's something that can endure over time. Being one-size also means that, because we've optimized our processes, we can produce without stock, on-demand. Right now, since we're a start-up, it takes a few weeks while we schedule time on the subcontractors' machines we rely on; in the future it could be just a few days from the order. On the other hand, a shop that buys our pieces purchases far fewer sizes, and the same garments work for many more people, so there's much less risk of stock sitting unsold, going on sale, or—worst case scenario—being burned. It's in our interest that this doesn't happen, so we believe we'll be rewarded for this choice, and the skeptics will realize we were right. Letting shops buy less from us may mean earning less in one sense, but it lets us build something that changes the approach and the impact on the fashion system.



Was this choice strongly driven by your refusal to contribute to the climate crisis, where the fashion industry has a major impact?

Absolutely. When you set out to create a new brand, you can't avoid finding a different way of doing things, otherwise you fall back into a system that doesn't work. The current sizing system is totally exclusionary and creates a lot of waste. The prevailing production model doesn't work either: it drives ever-greater consumption, larger leftovers, and garments with very short lives. Our idea was to think differently and build a new model, a new way of making clothing. Our approach is always evolving, we don't think we've arrived or found the final solution to everything. It's continuous R&D. For example, our garments are mainly made of natural fibers. We do have a small elastic component that's synthetic, and every choice, on the sustainability side, has to be weighed. Those elastic bands, the result of years of research, let us use them only in some areas, the bare minimum, to achieve great fit and adaptability; they're always kept separate, never blended with other fibers. Thinking about the end of life of the product, you simply cut off the elastic band and the rest is fully biodegradable. We've already set a path to make even those elastics more sustainable, it's our journey. The key, in our view, is to build everything into a process of self-critique and improvement, weighing every decision and accepting compromises, because we're still in an industry: we consume energy, use materials, and make new things. Anyone who claims 100% sustainability isn't being truthful. It's more: "We do our best with what's possible today," and we remain in a logic of continuous improvement. As Bruce Mau says in his latest book, my kind of bible: "today's solutions are

tomorrow's problems." you have to keep revisiting what might have been a good solution at first as new innovations arrive. My view of sustainability is that the approach has to be fluid, always a bit in motion. Our aim is to create garments that, as we said, adapt to as many bodies as possible and to the changes in a person's body over time, because once you've found your height size, a garment will fit your body from XS to XL. A simple example from my own experience: during my pregnancy, up to the ninth month I kept wearing this trousers day after day and they always fit the same. It's a piece designed to last, really last, because even with a drastic change.

After all these years, we've learned that sustainability isn't a switch but a journey. Even when you draft very innovative ideas on paper, new brands struggle to find subcontractors willing to experiment with these production modes. In the end, with a traditional supply chain it's hard to be understood and accepted. How did you build that virtuous relationship?

At the beginning it was very hard. We spent the first year explaining the idea just to get started with the first samples and prototypes, and many told us we were crazy and would never make it. Having been trained as a programmer helped, it gave people some confidence on my vision. They knew I was aware of what I was talking about; sharing technical language certainly helped. But we kept knocking on doors until we found someone who gave us a chance.

Beyond the production challenge, how did you tackle distribution? Because once you find a manufacturing ally, shops often don't have the language to explain a new approach to their customers and prefer not to take risks. Do you mainly sell online?

For the first two years we focused on testing the product, especially our new sizing system. So we sold directly to people, mainly through pop-up stores, to meet them face to face. At the beginning we had three sizes, then we moved to four to improve fit. Once we were fully confident in the product we started approaching wholesale, really only in the last two seasons, and this season has been the first real wholesale season. Because of that we paused direct sales a bit, since timelines are different and we needed to realign with wholesale seasonality, even though we work on continuous collections that we gradually expand, changing seasonal colours. Now, from September 2025, we'll have the first proper deliveries to stores and we'll also reopen the e-commerce for direct sales.

In an interview you said that with your brand you want to build integrated inclusivity, meaning not adding people at the end of the process but putting them first. Were you referring only to how you design the garments, or, as I sense, does this also include material choices and the production-distribution model?

When we say integrated inclusivity, we mean an inclusivity so embedded in the development process that it isn't even perceived from the outside. It's something we no longer 'announce', because we realized it risked becoming a label for the brand, as if its value depended only on that. People tend to notice that before aesthetics, comfort, or fit; at that point inclusivity is no longer integrated, it's just a tag, and that wasn't what we wanted. Paradoxically, in fashion and apparel the only way to change course and get out of the Anthropocene that's disrupting the planet's balance is to put people first. Fashion has forgotten that its primary purpose is to dress human bodies. There's a standard sizing system used as a base template and then it becomes a show, a collection after another, forgetting that first of all we have to dress bodies. So the focus has to return to the person, their well-being, and what actually makes sense for them. When you apply that

thinking to every choice, to every decision and all R&D work, it ends up touching everything. Our first official presentation was during Milan Design Week in 2022. As a small start-up, the first thought was to rely on existing shops as partners. But we realized, for example, that truly accessible shops were basically nonexistent. Our research includes many different people already in the design phase, and among them there are people with disabilities. We've collaborated with individuals and associations; many of them wouldn't have had autonomy in typical retail spaces, some couldn't even enter or move freely, which would have gone against what we're building. So we found a large empty space and, together with an architect, we created racks at different heights, with higher ones fitted with extendable arms so that someone using a wheelchair could take garments in their size independently. We built an accessible fitting room with a series of details so that anyone entering the space wouldn't immediately think, 'this is for people with disabilities'. It was simply a beautiful space, with a set designer we made an installation of dried flowers, and there were pink metal racks. Those with specific needs could move autonomously and enjoy what we were offering just like everyone else.

| Would you call that a design-for-all approach?

Yes, design-for-all, or human-centred design. In the same spirit we designed magnetic buttons.

For someone without mobility issues in their hands they're just cool, magnetic, neat, black, an elegant detail. For others they make life much easier. Our logo is knitted directly into the garments, so there are no scratchy labels that irritate the skin or add extra materials. There are many such details that you might not notice unless we explain them, but together they make our pieces much more inclusive and accessible, and everyone benefits, because they're more comfortable and better to use.

| In terms of positioning within the fashion industry, the usual success story for a new brand is to grow demand and numbers. How would you like to grow?

From the start our goal has been to reach significant volumes, we hope to get there. There are many beautiful niche or craft projects that do things differently, and I admire them. But to truly

contribute to change you need numbers. So the challenge was to find a system that let us industrialise a product that works at scale and still preserve our approach as we grow. If I hand-make three ultra-sustainable pieces a year, it's possible, but maintaining that approach, with all the features we've discussed, at scale is something else. That's why we talk so much about process optimisation, industrialisation, and on-demand production that also works at scale. Our goal is to have impact, and impact comes with numbers. We want to grow internationally, expand R&D into different product categories, and carry our approach into those categories. We also want to share our sizing system eventually. I say 'eventually' because we have to establish ourselves first, otherwise it wouldn't work. The sizing system is currently being patented, not to keep it to ourselves, but to protect us as a small independent start-up before we release and expand it.

We're not interested in endless growth in the classic capitalist sense, selling more and more just to earn more and constantly launching new things as an end in itself. Absolutely not. Even now, when we speak with stores, we always say our product needs explaining. We've also done a lot of work on pricing, which we haven't talked about yet, but it's fundamental. We're talking about a made-in-Italy product with very high-quality yarns. It isn't 'cheap', but today the value of clothing is distorted by fast fashion. At the same time, our prices are far from the absurd levels of today's luxury. We aim to offer a product that, once explained, becomes an investment in quality and comfort, something that can truly last a lifetime, even if your body changes. A piece you can share and pass on because it adapts

to different builds. Perceiving that quality involves educating the end customer. Our goal isn't growth for its own sake but growth that replaces a different kind of product and helps people get used to a new approach to clothing, dressing, comfort and quality, and, hopefully, to less waste.

With 3D knitting machines you control quality at a higher level than cut-and-sew and once you send the project, set the yarn and tweak the settings, is it a bit like sending a file to a 3D printer anywhere in the world?

Exactly. Once you make a sample to verify machine settings and the first result, you're set. With process optimisation and 3D knitting, once the structure is in place, we can produce and ship within a few days. We often mention these four pieces that represent our four sizes: one day a

prominent person we'd been speaking to for a long time told us, with very short notice, they would stop by the next day. At that moment our four outfits were away for a competition. We called the knitwear factory and, by 2 p.m. the following day, without anyone working overtime, just the machine running after hours, we had the pieces washed, pressed and ready. For us that was proof the model works, and that it can overcome the usual hurdles of on-demand seen as purely hand-made, with weeks of waiting and high costs, which inevitably remains a small niche without real impact at scale. We're not interested in endless growth in the classic capitalist sense, selling more and more just to earn more and constantly launching new things as an end in itself. Absolutely not. Even now, when we speak with stores, we always say our product needs explaining. We've also done a lot of work on pricing, which we haven't talked about yet, but it's fundamental. We're talking about a made-in-Italy product with very high-quality yarns. It isn't 'cheap', but today the value of clothing is distorted by fast fashion. At the same time, our prices are far from the absurd levels of today's luxury. We aim to offer a product that, once explained, becomes an investment in quality and comfort, something that can truly last a lifetime, even if your body changes. A piece you can share and pass on because it adapts to different builds. Perceiving that quality involves educating the end customer. Our goal isn't growth for its own sake but growth that replaces a different kind of product and helps people get used to a new approach to clothing, dressing, comfort and quality, and, hopefully, to less waste.

What do you think is the most complex part of your work? It's one thing to be creative; it's another to run a business and imagine new models of production and distribution.

The hardest part is convincing the people who work with or for us that things considered impossible can actually be done. Our motto is one of the basic rules of statistics: events with zero

probability are not impossible. It's true. It's very hard to get external partners to invest time in what is, in fact, a shared investment to support small brands. Maybe the toughest thing is that sometimes it's frustrating, but little by little we move forward. We're stubborn enough to keep going with our vision.

luca laurini

Label Under Construction (LUC) is an Italian knitwear brand founded in Perugia (IT) in 2003 by designer Luca Laurini, building on his family's long-standing tradition in the knitwear industry and his experience with Maurizio Altieri's Carpe Diem. LUC is known for its experimental approach to materials and manufacturing, merging architectural precision with avant-garde techniques like advanced laser-dyeing and complex seams, resulting in unique, timelessly elegant, and often monochromatic garments with a focus on meticulous craftsmanship and high-quality natural fabrics.



<https://www.labelunderconstruction.com/>
IG: @labelunderconstruction_luc

Would you tell us how you first got into digital knitwear.

I come from a family of knitwear manufacturers. My father, already in the early '60s, started working with a small workshop, and at that time shaped knitwear didn't exist. But by the '80s he

began to change the production setup and moved towards fully fashioned knitwear. At the same time, I always had a strong passion for architecture. When I was 20, I had a bit of a crisis because I wanted to study architecture, but I decided my architecture would be textiles. The way you build a garment, I considered that a kind of architecture, the very first architecture we live in every day. So I studied in Florence and later in the United States at FIT, the Fashion Institute of Technology. After a three-year course, I worked in a few research studios before starting my own path. Having had the chance to train in my father's company, knitwear immediately became very interesting for me, also because of its potential compared to woven fabrics. Being able to create shape with digital machines, giving direct form to knitwear, was really what pushed me in this direction.

At the beginning of our chat you asked me why we call it generically digital knitwear, since in the production world other terms are used. Can you go more into details?

The word 'loom' tends to generalize everything, both woven and knitted fabrics. In the '60s and '70s, industrial knitting machines appeared that produced flat panels, which were then sewn together. From what I know, these machines

evolved from the first stocking machines. At that time, you couldn't make shaped garments. Shaped knitwear only came with what are called 'fully fashioned flat knitting machines.' With electronics and programming, they can make decreases, increases, suspensions, all very technical operations that allow you to create two- or three-dimensional forms directly from a digital file. The potential is enormous. It's also really fun to work with these machines together with the programmer. Going back to the architecture analogy: the architect does the drawing, but then you also need the engineer, the surveyor, the geologist, it's a team work. Knitwear is the same: you have the programmer, the knitwear technician who does calculations like a surveyor, and the person who sews the knitwear. Sewing knitwear is totally different from sewing woven fabrics, it's a different profession altogether. So you get this beautiful teamwork.

Unlike woven fabrics that use warp and weft, knitwear uses a continuous yarn in the structure of the garment, which in theory could even be unraveled, right?

In our facility, we have a machine specifically to recover garments or fabrics with small defects, especially when they're made from high-quality yarns. Nothing is wasted. We unravel the garment, rewind the yarn onto cones, and reuse it.

Talking about sustainability, sometimes the fabric can't be saved—if the holes are too big or defects too severe. In those cases, we sort natural and animal fibers, and at the end of the season organizations take them and, through a specific process, recreate fiber.

After your studies, and also thanks to the 'gym' of your family's company, how did the brand LUC - Label Under Construction come about? What's the concept behind it?

The name of the brand comes from the architectural idea—something that's always under construction. I liked the idea that design never really ends; there's always a model to improve or rethink. The acronym LUC also fit because my

name is Luca, and people were already calling me that. Another detail: since the brand is 'under construction,' I didn't want a fixed label. Instead, every garment

has a small hole with a metal wire running through it—that's the label, removable with a tiny screwdriver. There was another reason too: 80% of our garments are reversible, and a normal label would have been a problem. I also liked the idea of no-logo. In the '80s and '90s logos were everywhere, and people often bought clothes just for the logo. For me, it was a provocation not to have a logo. In the end, the hole became more distinctive than a logo, it's a signature. What I really wanted was for people to choose a garment for its craftsmanship, its beauty, its content.

When you started, was your family's knitwear company still active? Do you still produce there with digital machines, or do you now work with external services?

When I started, I created a separate structure with my older sister, because we knew we'd need other partners beyond our father's workshop. We set up a company to take care of everything for the brand—from materials research to design to sales. Of course, we used our father's company for knitwear prototyping, but we also worked with other partners, producing woven pieces and even testing footwear. Sadly, our parents have since passed away, and now we also continue their business, producing for third parties, brands like Brunello Cucinelli, Dior, Prada. But LUC remains an incubator of ideas, where we experiment in a broader sense. We also use our space for art exhibitions, concerts, small theater performances.



Many designers and students complain that it's hard to interact with manufacturers, because it's difficult to convince a company to stop their machines for creative prototyping. How do you see the birth of new brands using this technology compared to when you started?

This is an interesting topic, because I know I was privileged. But you also have to prove you're resourceful and creative. Still, it's tough to get started. For example, in the beginning, when I was sourcing woven fabrics (since LUC isn't only knitwear), one person told me they weren't interested in startups, meaning orders below a certain quantity. That kind of closure felt ridiculous. Ten years later, a client told me that the owner of that same fabric company was now a collector of my work. When I met him, I told him how one of his employees had shut me out years earlier. These things happen. My sister and I, instead, have always tried to give opportunities. Of course, the economics matter, but we always start with the idea, the project, and then figure out the challenges along the way. We really enjoy collaborating with new designers. These kinds of closures are frustrating, because the world doesn't only run on economics. It's ideas that bring results. Closing the door to new people with projects is a disappointing attitude.

Interest in these machines is growing, because they allow new business models. Instead of creating a whole collection, producing, distributing, and waiting for sales, young people today are experimenting with catalogs that evolve continuously. They sell directly, showing prototypes, letting clients try them, even customizing. They often skip stores, focusing on quality and sustainability. How do you see this shift compared to the traditional fashion market, which is in crisis?

Given my age, I'm a bit old-school. For me, the tactile component is essential. Selling online or through catalogs has limits. It's true that cutting out physical stores shortens the supply chain and avoids huge markups. But I'd be sad to see stores disappear. Choosing a store is about creating an experience, like buying a book in a bookstore versus online. Both are valid. Still, it's tricky for high-level products. For mass-market items, returns and shipping are easy. But with quality design, customization can be risky if the

client doesn't like the result. These days, we do a lot of customization, but in a very tailored way: the client must touch the fabric, try on a garment with the right fit. Some steps are essential to meet expectations. For design products, this path is harder, while for mass products it's easier, but that's not our world.

We've also seen a middle ground emerging, not mass-market, not pure luxury. Like jeans, but high-quality, not cheap, not overpriced either. Brands with strong concepts that balance sustainability and quality, often sold through events or hybrid models. How do you see these new approaches?

Yes, I see that. With LUC, we've also dedicated part of our work to a modular approach. We start from the same base and build variations, different necklines, materials, or colors. This modularity helps us reach more reasonable prices. Of course, materials are still medium-high quality. Costs today are sometimes immoral. I often design with-

out thinking about price. I don't like compromises because I want a pure design idea. But I know the market has other needs. Recently I've done many projects I'm happy with. To use an architecture metaphor, it's like being asked to fit the comforts of 200 square meters into 30. It's fun. The danger is when companies cut costs by underpaying workers. That's the one thing I'm very sensitive about.

Thanks for that point. It connects to another theme: new business models like on-demand or small-batch attract creatives who want to follow the whole product, but not be stuck in a factory all day. It's about balancing life and work. How do you experience this in your company?

Yes, that's a hot topic. First, some professions in manufacturing are disappearing. Partly because education has changed a lot in the last 40 years. Before, even in elementary school, kids would apprentice and learn trades. Today, most people study until university or beyond. Of course,

some young people still want to start working at 16 or 18, but in general the gap has widened. On top of that, many manufacturing workplaces are not healthy or pleasant. Working eight hours with loud noise or in poor conditions is tough. In our company, we've moved to part-time, about six hours a day. For creatives, that means more space to experiment. For workers, more life balance. This wasn't accidental, it came from the needs of our collaborators. We saw it as important: happier people are more efficient. For me, it's vital to understand and value the people around you, to give them trust and space. I don't want a collaborator doing repetitive work for 8 hours that crushes their personality. That would make me feel bad. As for trades, I think we need more awareness. In Umbria, for example, new trade schools are opening to help kids at 14 or 15 decide if they want to study

long-term or learn a trade, from electrician to plumber to textiles and knitwear. This problem isn't only in textiles, it's everywhere. That's the one thing I'm very sensitive about.

Europe is preparing green policies to specify the Green Deal approach and reduce the ecological impact of mass production. Even though you don't do mass production, you'll still be affected: end of life, circularity, digital passports for garments. How are you dealing with this topic?

From the start, LUC has always been sensitive to sustainability. For example, we've often chosen to use leftover materials, like military fabrics from the '60s and '70s. We even bought 300 hemp bread sacks from 1951, with stamps still on them, and turned them into jeans. Partly for the image, partly because deadstock lying abandoned in a warehouse seemed so sad. We've always reused, rethought. If we overproduce, we make sure materials are recycled or given to people who put them back in circulation. When we have leftovers, we make limited editions, sold at a lower price, not higher. We always worked with certified fabrics and yarns, unless it's a very small producer doing beautiful things but not yet certified. Since we mainly export, we're often asked for full certification. We've also had fun making patchworks, manipulating materials to give them a new identity. So yes, we've always been sustainable, and now we're adapting to the new rules too.



marte hentschel

Entrepreneur, educator and expert in sustainability, responsible production and digital technologies applied to fashion She serves as professor of Sustainable Fashion at BSP Berlin and co-CEO of VORN, The Berlin Fashion Hub. Trained as a menswear tailor and educated in Fashion & Apparel Design, Marte has become a recognized voice for design, social innovation and systemic change in the textile and fashion sector.



<https://vorn-hub.com>
<https://www.shift.vorn-hub.com>
IG: @vornfashionhub

What is Vorn Hub and how's exploring new trajectories of fashion making?

Vorn is a project commissioned by the government of Berlin at the end of 2021 with the goal to provide a go-to space for the very fragmented community of Berlin fashion brands, impact

startups, research organizations and grassroots initiatives. Just to give an example, there are more than 1,000 independent brands in Berlin, and there are a couple of bigger organizations like Zalando's headquarters with more than 6000 people in the Staff, along with 3 Fraunhofer Institutes with textile related research. Additionally in Berlin you can find a dozen research institutes and 11 universities and colleges with fashion related higher education. It's extremely fragmented and Berlin tries to strategically establish itself as a hub for sustainable innovations in fashion, and a learning was that hubs is where you can cluster and bundle knowledge activities, support programs and create a safe space for this very fragmented sector and community. This approach showed already very beneficial results with the media hub and the games hub. We applied to develop this idea with a consortium composed of 3 founding organizations and got commissioned, and now we are now supported in our 4th year of support with the biggest investment into fashion by the Berlin Government ever. It's really a lighthouse project that receives a lot of political support and a lot of recognition. Vorn is a registered cooperative which is also rare. It's a kind of co-ownership based model that is very committed to social and environmental but also economical sustainability. We have to date about 250 member organizations of all kinds and sizes, of which I'd say roughly, 25% are Berlin based. We have a co-working space, community activities and event space, a retail pop-up space. Because we are also located in Bikini, Berlin, which is a concept mall really in the heart of the city at Kudam, close to all the luxury stores and the big department stores, and we have a couple of activities and programs.

How do professionals and practitioners interact and collaborate with the hub?

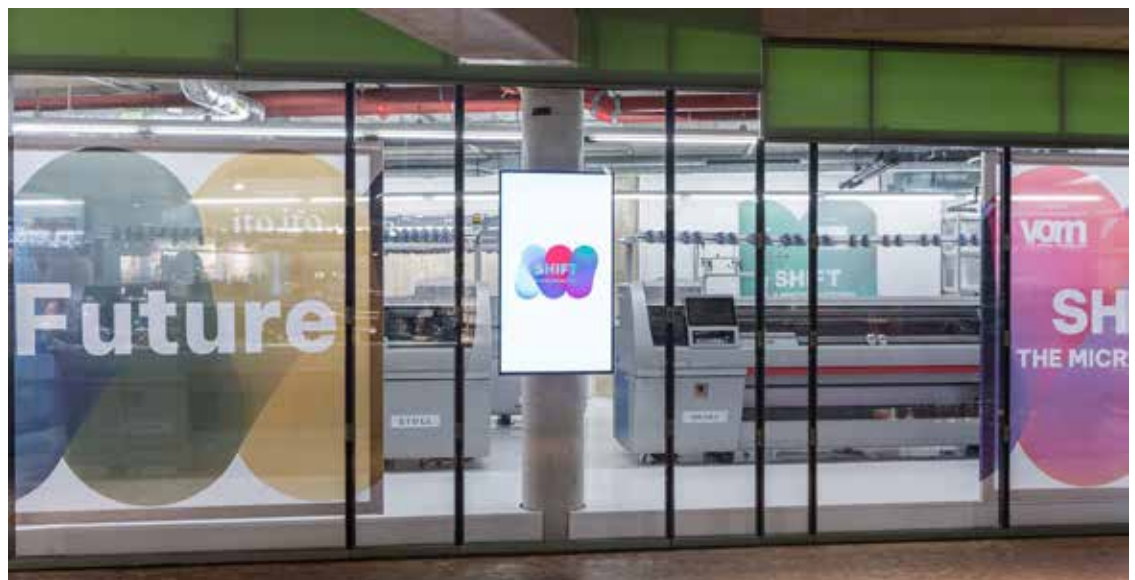
Our latest addition to our family of infrastructure facilities and activities is the Shift microfactory, which is a living lab or a demonstration factory of industrial knitting machinery, equipment materi-

als, software solutions and different partners and experts that we work with. So if you think about Vorn, it's like a journey where you can just become a member and exchange and start collaboration with others. You can apply for programs like research designer or researcher in residence or collaborative R&D programs or the design Academy that we run now for the 4th year and scaling program activities. You can join if you have a strong solution with a high internationalization potential. For example, you can apply for an internationalization program that we run with partners and come to the US or to Japan or to Korea. We always identify certain markets that come with a high potential for our community members. Our big goal is to support the fashion industry to become net positive, which is, of course, ambitious. But everyone who is with us and supports us and partners with us signs a code of honor and commits to contribute to that very, very big goal. That also means our activities are really value chain stage agnostic. So we have retail innovations. We have new ways of consumer education. We have very, technical, specific and engineering-focused members and activities, but also kind of broad community or customer engagement programs. Our job is actually to identify gaps, identify opportunities or identify needs for change. For example, legislation kicks in, then we reach out to our community and see what are the state of the art solutions we have in the community and how can we support these to provide their solutions to the needs of brands and retailers in our community and then it's either just a matchmaking or it takes a little more to close this gap and then we organize a research program, design or development sprint or in multiple years, multi-stakeholder program. So it can be from very small to long-term projects.

You mentioned the concept of microfactory that is actually been around for almost 20 years, not specifically in the fashion sector, but in other manufacturing contexts. That is the way to efficiently customize products or bridge the gap between artisanal and mass production. What is the vision that you are bringing on the microfactory at Shift?

Something that we really learned is that business models in fashion are broken, which is a big issue and one of the systemic flaws that are incredibly hard to redesign. As a retailer, a designer, or a brand, you do a forecast, and try to estimate what your customer or your future customer might

need urgently in their closet, or how you can outperform or kick out competition whatsoever. Then you create something based ideally on that, with hopefully a little creative twist and then you produce something in low- living, low-cost countries compromising on your own values because you pollute soil, water, air, and so on and so forth. After a couple of weeks, but more realistically a couple of months, you receive the goods back, and then you try to push it in a saturated market, and the results, depending on the statistics that you read, are something between 40 to 60% of sales. And the rest is the rest. So it's an incredibly resourceful, inefficient, and stupid process that results in business models that don't work anymore. They can be optimized, surely, and there will be companies that do a very good job in optimization. But it's outdated. And it's very risky, just from a commercial perspective. So we have overconsumption, overproduction, and incredible amounts of waste.



What if one could design first, then sell and produce after. And this is something that we work on in different constellations since I've been in this field, more than 20 years. The topic is very close to my heart and something that annoys me a lot. So I worked on this issue from different angles. Obviously not very successfully because it's still ongoing. But in the past years there's very exciting technology and of course, also pressure from the consumer side and pressure from the legislative side. We feel like there's a new momentum that we're in, and we've seen other changes in consumption culture like the rise of vintage, whereas 20 years ago used clothes were still stigmatized, and only for poor people. We believe you know, there has to be certain ingredients like technology readiness, demand and regulation and a couple of other things, and if you cook it in a soup, then there might be an opportunity for an evolutionary step in development. And that is also the case for on demand production. And it's probably not only interesting for mass customization or bespoke tailoring if you wish. It's also interesting for a no-inventory future of fashion because of 3 things from our perspective. The first is the strength and the power of 3D that has evolved over the past 5

years with incredible development. If you're not a super expert, you can't identify if that visual is a photograph, or a 3D rendering which has upsides and downsides. You can put a product into an online shop and the customer has enough trust to actually press the buy button even if this item possibly does not exist materialized. The second is that you have to localize your supply chain because time is key. This vision is shared by many of our community members but it's incredibly hard to accomplish. You need to have very powerful 3D design and local but also automated manufacturing technology because the cost of labor is very different depending on the location. And the third is that you need to include circularity concepts because if you depend on global material streams that would prolong this supply chain and the lead times. Ideally you could make use of the resources that are looping around in your core markets like the metropolitan areas. You could make use of industrial waste or post consumer waste to create products that you've just sold and are not yet existing. Long story short, we did an investigation and understood that this does not exist. There are microfactory-like projects but they are not as developed as we thought.



The idea of a closed loop micro factory is not there yet, so we probably have to build it ourselves to provide access to that type of technology so that our community members can innovate their business models. Through the support of many partners like Stoll which donated or lent machines, which is incredible. Milestone and Zalando invested in this endeavor which is quite remarkable because we're a registered cooperative and it's like "communism" for German business ears. I'm exaggerating a bit but it's quite remarkable that we succeeded in this quite an impossible undertaking. That's also why we're a bit proud that we could make it happen and Adidas piloted their store microfactory in the same location in 2016 and building on that we had a little bit of trust from previous projects. Shift is a pixel product microfactory that works with a flatbed knitting machine and a dozen software solutions that frame clo3D as a software partner of ours, but also others so we don't have an exclusive take on it. At the moment, that's also where the Knitink project comes into play, because we are piloting a collaboration with them in a R&D project. We explore ways to unravel and re-knit not only the prototypes and products that are designed and manufactured in our facility, but also we explore ways to work with post-consumer waste to

unravel and then unravel post-consumer knitted textiles, to make recycled yarns available for new projects for our customers like brands and retailers. Additionally we collaborate with a number of material innovators because we believe that knitting can partially replace cut and sew. It's not only that we want to give access to industrial knitting technology because it's zero-waste, short term, it can be unraveled and re-knitted, which is a very unique opportunity. Garment to garment recycling technology involves many more steps and we believe that partially knitting can replace cut and sew to some extent. But of course our offering will not replace fast fashion, but it will potentially be a pretty desirable alternative to some product groups, to some categories. Our job now is to lower the barrier to access that technology through learning. We do a lot of workshops, we educate programmers. 3D designers, machine operators not only trigger the demand for that technology, but also lower the barrier to work with these methodologies and these technologies.

You published a white paper in 2023, exploring the concept of microfactory and called it pixel-to-product manufacturing. You mentioned it previously and highlighted the commitment to driving systemic change and ensuring a more sustainable, equitable future of the fashion industry. What are the major gaps you see in the system to reach this goal?

One big hinderer of circularity that only can happen in collaboration, and can truly happen very localized, very locally. So if you have to send around materials, whether it's recycling inputs or outputs or processed products whatsoever, there are numerous risks involved, and those risks might be big hurdles for circularity.

So our understanding of circular supply chains is to enable more local supply chains, where industrial waste or post-consumer waste is used and recycled and turned into new products with least quality, loss with least material loss with least energy consumption. So the dependency on global material streams is one of the big gaps and the limitation of both efficiency and availability of recycling infrastructures. If you notice, a recycled fiber based material is on average 5 times more expensive compared to virgin material. If this is the market logic, it doesn't make sense. Virgin materials could also be more expensive because they are externalising emissions and social sustainability, and so on. That's still a long way to go, and we try to explore ways to close that gap by using an alternative recycling methodology. We're imagining a perfect future when the design, the manufacturing, and the recycling can happen at the point of sale, together with the consumer. So long story short, the dependency of global material streams is one of the big gaps. The other big gap is the lack of competency. After 40 years of outsourcing textile manufacturing there are no people with the know-how. We accumulated two generations of knowledge loss. You can of course create new manufacturing facilities in Europe but the knowledge isn't there anymore, plus one would have to drastically innovate the way garments are manufactured. I'm a seamstress by education and if you look into clothing assembly lines, you still find very basic machinery and unskilled labor women, mainly young women, because you can't do this job for very long. There's very little innovation in those machines and their very flexible nature makes it very tough to be managed by robots. That's why you need to look into other manufacturing technologies and that's why knitting is interesting. So, lack of educated people, lack of innovation and lack of valid business models in collection, sorting and recycling of textiles.

In the last years the debate on sustainability focused on the fact that many people fell on the illusion recycling could be a

business instead of an effort to be financed by those making profit with mass production. The only possible and realistic way seems to consume less and produce long-lasting garments. Do you agree?

Yes, thanks for bringing this up. And I could talk about this forever. Because recycling and second-hand is actually fighting the symptom of a toxic and dated industry and consumption culture and you have to get rid of their waste.

But this does not replace other parallel and complementary activities that ideally are a result of an action plan that is part of a strong strategy for systemic change. So ideally the reason that we still have to deal with textile waste is a symptom of that systemic flaw. At the same time you have to redesign products that never become waste because they last long, they can be fixed and resold, remanufactured, and so on. Recycling should really be the last option, and then, of course, it also has to be designed for cyclability.

So we know there's a reason why only 1% of garments are actually recycled to new garments: it's because they are not recyclable. They have trims and they are multimaterial blends. New design strategies should be implemented. There has to be incentives for companies to do differently. There has to be really strong regulations, and there has to be consumer education, all of it at once. If you only focus on reducing the vast emissions that you do as a brand or as a material supplier but don't look at the long run of selling toxic products to your customer, it's not very clever. At the same time there should be orchestrated support programs for infrastructure that need to be available because a systemic change is extremely expensive, and takes a long time to eventually achieve a critical mass of customers that request circular products, not only sustainable products. That's also why I could really become furious when we talk about ocean plastics, for example. Of course it's better to have clean beaches, free from plastic waste instead of polluted beaches. The solution is not just cleaning the beaches though. Yes please, let's clean the beaches, but also prepare a change in the system that generates tons of plastic waste on those beaches and in the oceans. Why is it a good idea to create products that emit microfibers? There's just no need for any product that pollutes whoever. So designers and businesses and retailers have to do a better job. And we, as supporters and researchers and organizers of infrastructure, we have to support them with low barrier access to knowledge and infrastructure and programs and resources to be able to do that.

Recently, you've been starting this collaboration with the Knitink project which I interviewed in the past days because they developed a protocol to facilitate the unravelling of knitwear. Would you tell us a bit about it?

What I love about Knitink is that its concept is really one of the oldest methodologies and the result comes from a time when these resources were still precious. The concept of waste is something very contemporary. The idea that we

extract resources, and then we just discard them is something that does not exist in nature, and it hasn't been existing in society over many, many years. It's kind of ridiculous that we invented the concept of waste. The moment people started to weave and knit, stitch and embroider things they also found ways to undo because of the precious resources. The only problem is that it's very resourceful, and it's not available yet on an industrial scale. The collaboration with Knitink is a great example on how we approach R&D and approach collaboration. We don't exist just for the purpose of research, because we have to feed our researchers. We identify a gap or an opportunity or a demand and then we do try to understand who has the best knowledge and who developed the best outcomes to date on a problem. And if these solutions or services are perfectly meeting the needs that we identified we try to onboard them and say:

“Hey, look, you have something that is really needed by our community” and do the matchmaking. Basically, sometimes we understand the solutions are there, but they’re probably at the laboratory stage, and there’s a couple of things that hinder them. Many times it’s too expensive compared to what the market really needs. And here with the market, I don’t necessarily talk about fast fashion, I also talk about smaller independent brands with, you know, premium price points. But even for them it’s not said that these quite manual or lab stage solutions are really applicable. So sometimes our role is trying to find ways to further develop it. So here, with Knitink we figured out that this is one of the most advanced solutions therefore we invited them to collaborate with us and together we created a design guide to make this technique available to designers. And this can then be done manually with mechanical knitting machines, with industrial knitting machines, with circular knitting and with flatbed knitting machines because it’s a more generalized approach. It’s a freely downloadable guide, shared and open source. Then we tried to understand what it takes to implement it into our facility because we have specific machines, materials, components and then in each region we have different products and different materials and different needs and techniques that one would have to apply. We try to understand what we can do with that partnership to apply to our very specific setting and the products that we have looping around Berlin and the needs of the brands and retailers we work with. And then what can we do to scale it? How can we make this very specific protocol applicable to hotels or kids wear, or shoe uppers you name it. With our collaboration, we try to expand the solution, but we also try to apply it to our specific setting in the microfactory.

Yes, one of the things that you’ve just mentioned is that there are so many sectors in which you can create a lot of garments that are not mainstream fashion but are super interesting to design on. All the world of uniforms, for example. All the areas where you use textile that is not fashion, but needs to be shaped in a certain way to become more sustainable. What do you think about it?

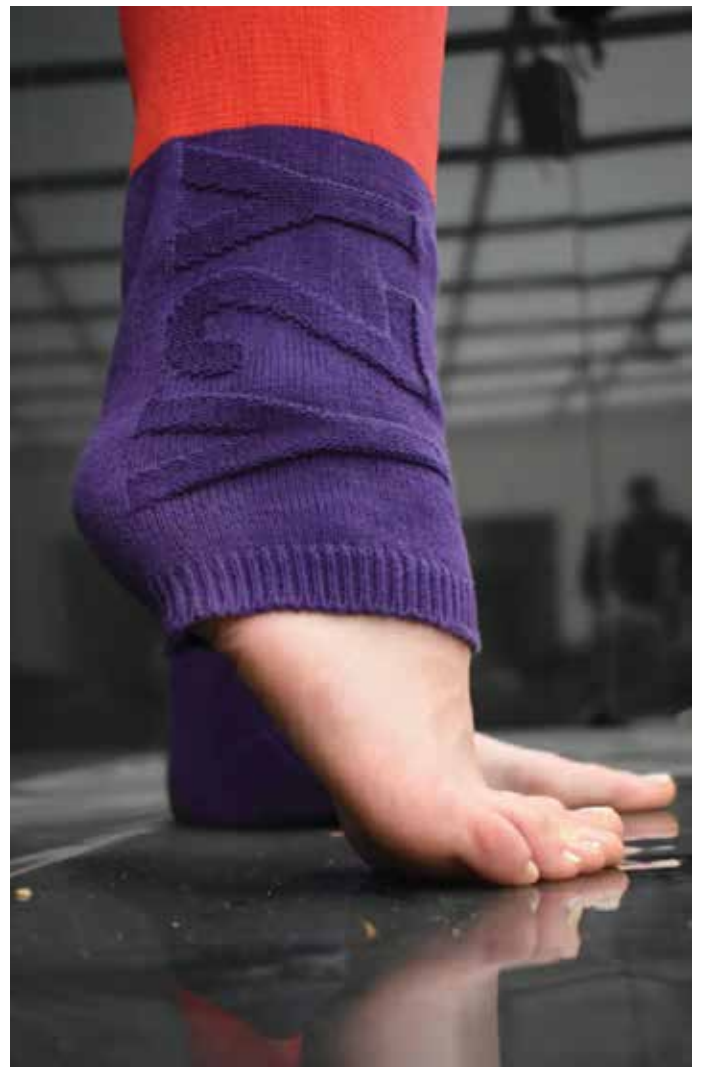
Absolutely. I’m very much with you, and I believe we should be more modest because I believe we can learn from these other verticals, and from these other sectors, and that would even include corporate wear workwear, but also technical textile and functional textile. There’s so much that we can learn from interior and from construction textiles and some geotextiles. Work where workwear has decades of experience

with circular economy, because it makes total sense that you provide clothing as a service and not sell a uniform to an employee of the Postal Service, because they change their positions so often that it makes total sense that this is provided as a service, because the Deutsche Post, one of the biggest employers in Germany and also powerful buyer in terms of public procurement. So really an organization that could be a change agent for the entire industry alone with more than 100,000 employees or something like that. It’s ridiculous numbers. And of course their core job is shipping so it makes total sense that the service provider keeps ownership so the longer they circulate, the longer lifespan of this particular product, the more commercially feasible this business model is. In fashion we intentionally shortened the life cycle or half the life cycle of garments over the past 20 years. There’s a lot that we can learn from these sectors. And probably it’s a good one to start an alliance to reach a critical mass and prove sustainable business models aren’t only cooler, and they’re also commercially more feasible in the long run. Before you start convincing all the fast fashion players, one would have to identify an alliance of the willing by looking into these sectors and really team up with them to prove that it’s actually possible because it’s been practiced for many decades over there.



knitink

A knitwear project from the Prato district that developed a process to design garments to be unravelled back into yarn and re-knitted, even when fibre blends are used, cutting energy and water versus classic recycling. It's led by three founders: knitwear designer Brenda Cecchi - also founder of Patafisic), Cristina Bellandi - knitwear designer & development consultant, owner of +MATER+, and Claudio Marenco Mores - marketing and international brand manager. Together they pair Italian know-how with process innovation to keep yarns in circulation longer.



Would you like to explain, in simple words, what the Knitink project is about and how you are proposing a new vision to recycling knitwear which is more sustainable and attentive to the environment?

Claudio >> Thank you for this invitation and for giving us the chance to share a bit of our project and our story. We're three former colleagues who've been working in the fashion sector, Brenda and Cristina specifically in knitwear for

many years. Knitink starts first of all from observing and engaging with our context. We work in the area between Florence and Prato, where recycling has always been part of the local product's *genius loci*. What we've observed is, by now, well known: the fashion industry is among the most polluting and the most involved in exhausting the planet's resources. So we imagined methods, starting from what we know, to try to invent a new approach to recycling knitwear. Existing methods for recycling knitwear are mechanical and chemical, and they mostly have limits in terms of the re-usability of fibres. That's part of the history and know-how of the territory. What we focused on, and one of the strongest selling propositions of our idea, is finding a method that would also allow the recycling of mixed fibres, putting back into circulation all those products that basically end up in landfill at the end of their use. We began the project calling it Y2Y, Yarn to Yarn; over time we won grants, evolved, and the project took the new name Knitink. The idea was to test a great many yarns, so first carry out a broad laboratory research phase, and then work on a sort of protocol so that we don't intervene only on the finished product, but restart the cycle from design. The garments can therefore be returned to their primary component, the yarn, so we go back to a composed yarn, not to lose fibre, and then re-assemble it. On top of that, our method saves a great deal of energy and water otherwise used by other methods, shredding and the rest. We don't use chemicals either, which is another big plus.

Cristina >> Claudio was extremely thorough; I'll add something about Prato's heritage, which I'm part of personally as a native. Prato's recycling tradition is founded on the production of carded yarn, whose distinctive feature is a thread made of very short fibres. That matters for recycling because when you recover a garment at the end of its use, the fabric is shredded and the fibres become extremely short. I say this because one advantage of the Knitink process is not only what Claudio mentioned, recovering mixed compositions, but also allowing yarns a longer life so they don't have to reach the shredding stage. Shredding leads to short fibres and therefore to carded yarn only. Yet there are many other types of yarn, some very fine, that concern long-fibre spinning which is simply impossible once the material has been shredded. So if we're dealing with a particularly valuable yarn, we think it makes more sense to preserve it in its nature rather than send it to shredding.

From how you describe it, it reminds me of when I was little and saw my grandmother: when a sweater wasn't used anymore but was still good, she would pull specific points to undo it and wind the yarn into balls. The resulting yarn was wavy; she would wash it and, while drying, stretch a skein to relax the fibres, then rewind the balls to be knitted into something new. Is this the kind of process you're optimising?

Brenda >> Yes, the concept is simple and old, widely used in the past. What we add, our goal, is to bring this concept to an industrial level. To do that we also asked ourselves what kind of design would be optimal: we need to start from re-de-

signing a sweater so it can be undone back to yarn, because at scale that's not feasible today even if it's a known artisanal practice.

In new eco-design approaches, people often talk about cradle to cradle: the need to design an object so it can be disassembled at end of life and each part reused. Can we say Knitink is a kind of cradle to cradle applied to knitwear?

Claudio >> Yes. Our process unfolds in four phases, starting from design, because garments must have specific characteristics, both in how the piece is built and in pattern shapes, and certain technical tricks must be included. Cristina

and Brenda have developed these into a kind of abacus which, however, allows endless combinations; it isn't limiting. Then comes assembly, and finally the option to recover the yarn. This cycle works on the small scale on which we tested it, we have unraveled and remade garments multiple times with excellent results. Ideally, we'd bring it to a critical mass, collaborating especially on those garments we're less attached to: functional pieces. Those are the ones that more easily end up in landfill. If we could work at that scale it would be perfect, because that's where our method can express its greatest positive impact.

When you buy a knitted sweater you typically see two product types: one where the pattern pieces are made on industrial machines and then sewn together, and another that comes off the machine already three-dimensional, ready to wear. I imagine your method only works on the second type?

Cristina >> The first mode is called cut-and-sew. Then there's 3D, called WholeGarment, 'Capo completo', or 'Capo integrale', there are different terms, which is what you were referring to: you feed yarn into the machine and the finished

sweater comes out. In between there is what's called 'Capo Calato' or Fully Fashion: the pieces that make up the garment come off the machine already in their predetermined shapes, those defined by the pattern, and they're assembled using specific machines called 'rimaglio' in Italian, which make a chain-like stitch that joins the edges. We have tested and refined both of the options we mentioned, except cut-and-sew, which doesn't make this kind of recovery possible. Both are important and interesting. In fact, we haven't overlooked classic Fully Fashion, the shaped or 'calato' garment, because industrially it's still used, more than its more evolved 3D WholeGarment counterpart. Despite incredible progress since 1992, the year it was invented, 3D still imposes a series of design limits; so industry still often relies on shaped Fully Fashion. That's also for cost reasons: you have to program the machine set-up before mass production. Programming a 3D garment costs more, so depending on the production type, companies will prefer one option or the other.

Your approach is very interesting, and you developed it thanks, above all, to your training and early careers in Tuscany. Yet you're sparking more interest and activating more collaborations abroad than in Italy. Is that a cultural issue or a lack of technological interest in your local context?

Claudio >> I don't think it's just cultural; it's more about economies of scale. The Italian market and production are particularly focused on luxury, meaning extreme complexity, craftsmanship and value. We don't want to become just a

storytelling element for a luxury brand that makes a recyclable capsule collection. We've had contact, even personal, with the big luxury maisons, but we'd rather take the longer route that is likely more effective. I have sweaters by great designers I've owned for years; before I give them away they practically have to fall apart. That's not the issue, their longevity is fine. I own 30-year-old

sweaters I still wear with great pleasure: extremely beautiful pieces, designed and made in Italy. We're more interested in working at a scale that has impact. That's the philosophy behind the project.

Let's look at how the market has changed. You're saying that in Italy knitwear production has remained mostly high-end, whereas large-scale production has moved to other countries?

Brenda >> Today Italy serves the luxury market when it comes to knitwear, and since the '90s mass-scale production has largely moved to countries that produce at much lower costs than in Italy. Claudio>> One interesting thing about

this moment, setting aside all the drama that may come with tariffs and import-export issues, is that the middle segment, the premium segment, has been expanding a lot. That may give us space to experiment at a scale large enough to have a qualitative impact on the planet. We're not interested in making ten 'sustainable' little sweaters; we want to work on production that really allows recirculation. And now, perhaps, with premium segments strengthening, because luxury has become the preserve of a very small slice of the market, not economically irrelevant, but irrelevant in global impact, we may see more attention to our project.

What present and future plans are you developing within the project? Recently you mentioned starting a collaboration with Vorn Hub in Berlin...

Cristina >> We started a collaboration that we presented in March 2025, within VORN Hub, which focuses on sustainability for fashion in Berlin, where they opened a microfactory to support designers who want to develop collections with

knitting machines. It's a collaboration that's just getting started, because we sensed an openness especially from institutions. Our goal there is to bring the project to TRL-10, to reach, as Claudio said, a more substantial critical mass of experimentation. Through them, we hope to get to that level.

It's pretty clear: we talk about a 'fashion system' because a system is made of actors who collaborate to build a vision. If that vision doesn't align with the goals and ethics you're pursuing, you go where there's an ecosystem able to bring out the value of your proposal, because alone you go nowhere. Over these years developing the project, which actors or contexts helped you the most to make it concrete?

Brenda >> Certainly for us the European Union had a key role. Thanks to the funds made available with grants, we were able to do most of the experimentation, both through the S4Fashion call and the second call of the WORTH project.

Within those two successful applications we also met a network of other organisations and mentors we compared notes with. There we found an ecosystem where we could experiment and carry the idea forward. We're absolutely thankful to the EU Commission.

steph linn

Artist and knitwear design-er-programmer trained in knitwear at Central Saint Martins and with an MFA from the Slade (UCL). Their publication *Factory of One* explores a studio model where a single practitioner designs, programs, and produces end-to-end with digital knitting tools, enabling rapid iteration and on-demand making without large supply chains. Linn's artwork spans sound, installation, and knitted sculpture, often using hacked Brother machines to probe the histories and futures of industrial knitting.



<https://shl-index.neocities.org/order>
IG: @reduce_productivity

I stumbled upon your publication *Factory of One* while I was exploring an independent publishers' and artists' fair in Milan. Browsing in a booth my gaze recognised a knitting machine punch card on a book cover. I got the book, read it and decided to contact you. Would you tell us how this publication came to existence?

I studied fashion design with knitwear at St. Martin's in my undergrad and that's when I first started using knitting machines. I really didn't enjoy using them for a long time because we didn't have any digital knitting machines. When

I was in my final year, I bought a Brother KH-910, which is one of those you can hack, and using open-source software and tutorials I was basically able to hack it. Drawing with Illustrator was a huge part of my practice and so I wanted to knit out my drawings without having to use punch cards because they have so many limitations on the size and details you can get. And I didn't want to use fully digitized machines because access to them was really limited at the school. They would choose two people per year who could use the Stoll machine, which is what they had. Since I didn't get chosen, I had to figure out my own way to do that. I think it was probably around 2015/2016 I got this knitting machine off eBay, hacked it and then have been using it ever since. I then transitioned from doing fashion more into doing art. I started using the knitting machine to do more quilts and tapestries, which is what I use it for now. Later I went to Slade, which is an art school in London for my two-year master program because I wanted to figure out how I could take myself seriously as an artist and figure out what my work is about. During my last year, a bunch of friends and me, we all wanted to make publications for our degrees and we started a weekly meeting to work on it. I decided to focus on the history of the knitting machine because when I was working in a factory in Portland, doing sewing, I got interested in the combination of textile and labor history. When I looked into it a bit more I discovered Luddites and realized some of them were actually smashing knitting machines as a protest towards their bosses not against the technology, which I found super interesting. I spent most of my master researching that and then also finding out how it really connects to the history of computing because the punch cards can have many different uses and initially were used in a lot of military operations and governmental census projects. My publication became a way to bring all this disparate research together, and find a way to use all this research I've been doing that you can't always see in the outcome of an art project.

In which way the history of knitting machines inspired your artistic work?

A lot of what I think about right now is the human relationship to technology and the very specific decisions which have shaped the way technology has been developed. For example, I

see my knitting machine as a collaborator rather than an enemy. And the Luddites as well, they didn't hate technological progress, they hated the boss using this technology as a way to suppress them rather than make their lives better. I see the knitting machine as a case study of a machine because it's a technology which escaped the industrialized setting and allowed people to make stuff themselves at home. It's a way of showing that the machine could be a special friend if we had more power over how technology and machinery was developed rather than a tool of oppression, as historically it has been.

How did you start to feel more comfortable in using this tool for art rather than fashion?

I got really disenchanted with fashion and with having to do production. So I've worked as a freelance knit designer for a few people and

done some production for them. Then I've also worked as a seamstress and done production and doing all those different jobs, and I just didn't enjoy it. I have a lot of friends who use the knitting machine, the domestic knitting machine and do production on them. But for me, I want to use it more to create art rather than manufacture a medium or small scale production. I just find it nice to re-appropriate something that's made for production and try to show the range of stuff that this machine can produce, being complicated and artistic rather than crafty and homemade.

In your book, you had many conversations with friends, collaborators, hobbyist designers, who are using home knitting machines for self production and also producing for others. Do you think it's more a political or environmental trigger implicated in this choice of people going back to old style knitting machines?

It's a good question because obviously the environmental implications are also political ones. The way production exists now with fashion is complicated, especially if you're a small designer, and getting high quality knit produced gets finan-

cially impossible for most people because you have to go to Italy to source the yarn and then ship it to a factory in Turkey, which apparently has high quality knit production at lower fees, as Italy is too expensive for small designers. You could also get production in China, but the numbers you have to have is quite high. And so I think a lot of people who are still really dedicated to knitwear - which in itself has a really high entry point for the amount of labor and the materials and just how long it takes to make stuff - people are basically forced into doing all the production themselves or finding some local producers. One of the people I interviewed, she's worked with a couple local factories, but the reality is there's not that many, even in England, a place famous for knitwear. There's not that many factories left that do complicated knit production and so just by means of the environment, you're forced into taking it into your own hands doing the production yourself. I have a lot of friends who will do all their trims themselves and link everything together themselves, but maybe order fabric in from one specialty place or you have this mix of DIY and production that you have to figure out. But I don't think people start necessarily from a political standpoint. I come from a DIY background, so for me it's been political to always make my own stuff and always have my own hand in the work I make. A lot of people are just forced into it because of how expensive production is and also how people have become quite detached from understanding how things are made and the value things have and people are very used to the prices that come with fast fashion. If you look at an aesthetically pretty jumper, it's going to cost a lot more than anything from fast fashion, but it will also last your whole life. People don't necessarily have an understanding of the costs behind it. So I think the choice of producing with a DIY approach is more environmental and then the political aspect comes in when you start analyzing why you are forced to work this way, or why you feel you have to do everything yourself.

What often happens in creative professionals is that they quit working for a big company because of the lack of creativity and decide to embrace an entrepreneurial path which often leads to burnout. What is happening in the professional life of people around you?

Having gone to fashion school, it's very interesting to see where people have ended up. There's a few of us who still work at big companies, but a lot of my friends have worked at big companies

and had a similar experience because the work is just so uncreative and unfulfilling, you're basically sitting on a computer all day. And that's not what you

envision when you learn a really practical skill like knitwear: you want to be at a knitting machine, you want to be making samples yourself, but realistically that's not the most productive way of doing things. So I've had a lot of friends leave those jobs and become exactly a 'factory of one' business. Web 2.0 and stuff like social media became such a double edged sword because in some ways it's helpful to make your own money and be able to set your own hours and set your own prices, but the reality is you're still living within the larger production and fashion system that you can't really decouple yourself from. My friends who have their own brands organised this way, I rarely see them, they're always working, constantly working because, you have to embody all these different parts of the production line. Basically in one person you have to design, you also have to think from the perspective of production, asking questions like "how am I going to make this?", "What am I going to make this with? Oh, this yarn I want is too expensive. How can I mitigate that cost?" and then you also have to market it yourself. Taking photos trying to get interesting to the people looking at your stuff or to get stores to buy it. And then you also have to sell stuff yourself and package things yourself, go to the post office: embodying all of those different roles can really drive you crazy and it often goes into self-exploitation. I used to do some small scale production of things or sell online the stuff I made, but I want to get away from it as much as I can, because even there you can't be purely creative, you also have to be in the production mindset and the sales mindset at the same time, it really hampers the creative side of it where you're thinking through all these things at once, it can be really challenging to get through. Additionally, as the economy is going down, people have less expendable income to spend on things that are considered a luxury, which knitwear often is. These professional paths receive so little support from the government or from any kind of social support nets for creatives that it's incredibly challenging to stay afloat even as a 'factory of one', even if you're living outside of the city. It's a really complicated issue, on one side it seems like a liberation, but you're still tied to this economic system and stuff that really puts a lot of pressure on people without much safety nets and without any actual power.

The fact you need to take care of all the aspects from sourcing the supplies to communication and shipment can be overwhelming. What could be collectively managed and nurtured to make this approach more sustainable from the point of view of lifestyle? Where do you see a collective dimension that goes beyond just the fact of sharing knowledge and knitting tutorials?

I think about this a lot. I don't know if I have a good proof answer, but one thing it could support many practical challenges, could be a cooperative or collectivised operation, rather than having all of our disparate studios far apart, being able to actually organise a collective studio thinking more cooperatively because a lot of

people I know they work part-time in their own production, but they also work for other people. They get commissioned to do knitwear stuff like sampling and my dream for the future is to have a place where it's operating under more of a cooperative where you can be a creative professional, but you also share the means of production as well. And you can switch between working on your own personal projects and also working with your friends on some commission work, on some design work, or on some work for larger firms that are in the city

that need network specialists. I could see that working, but it's hard because a lot of people are used to working on their own and having this singular vision of what they want their knitwear to look like. And I think what could save us from this kind of exploitation is working with each other and sharing resources and knowledge about knitting machines and about practical knowledge and sharing yarn. Getting over this idea of there being the sole designer and the sole artist and thinking more cooperatively and more collectively.

But you've been trained to be a creative solo, so probably we should also think in which way should the training change according to this vision, because I realize that a lot of design and fashion schools are really forging this personality of the creative solo...

Totally. It's so prevalent in art school as well. I would love for fashion and art schools to divest a bit of the ego from it, especially because you're going to be working with other people and you're going to be having to collaborate on a

vision. And it would be very useful to focus more on learning to work in collective ways. There's a fine balance you can make because obviously I still want to do the work I want to make, but I also think sometimes the best outcomes come from when you have to shift things around and collaborate with other people, definitely it's the best way to avoid burnout. I also see that technology, especially social media and digital technology, has really split people apart in ways that have made us all become very independent. That's the dream for everyone to just have independence. Now what we would really need to do is shift back the opposite way and really band together because it's much easier to individually exploit people. But when everyone is talking together and working together, it's going to be a lot harder to take advantage.

You talked about various challenges, like the choice of purchasing good yarn, what is your relationship with materials that you use for your art production?

I definitely started out using more acrylics because I didn't know any better. As I got more experienced, now I have a strong aversion to acrylic and anything plastic-based. I use mostly wool. I

use lots of mohair, cashmere, wool, cotton, linen sometimes. But it's a combination. I love these materials and I would love to work with them forever. I also feel it's nice to use things from near where you're from. I am living in England right now and using English wool feels really exciting to me because it's nearby, thinking I can go and look at the sheep. But again, I realised it's hard because nowadays raising wool sheep isn't very common as it used to be because you don't get a lot of money out of it, so most people in the UK and Europe raise sheep for meat.

Something else came up as I discovered a really great wool shop in London called Denier Studio. They get big shipments in from Italy and from designers and factories. It's basically their extra, the wool that they haven't managed to sell, wool that's left over from projects and productions. She basically has connections to different factories, brings in this wool and winds them off onto smaller cones that you can buy. It's amazing because you can get really high quality, amazing yarns like from Loro Piana, without the necessity to have the connection to factories because she opens up a huge level of accessibility to good yarn that I don't think I had when I was a student. In a way this is a nice example of ways that you can find these loopholes in the production line and make them work for small designers to find your little scraps, find little weasily ways to exist. A lot of the ways that people I know have worked out sustainability is through finding deadstock, finding yarn that's not being used and

making do with that, rather than being able to go and find places that produce sustainably from the very beginning because then, again, the cost is so challenging. And because small designers pay for everything, the brunt of the cost is put on us. So, yeah, it's a challenging topic.



gerard rubio

Designer and entrepreneur, best known as the founder and CEO of Kniterate, a company creating compact digital knitting machines aimed at designers, makers, and small-scale manufacturers. Trained in design and with access to textile workshops during his studies, he developed an early interest in combining craft and technology. In 2014 he launched OpenKnit, an open-source DIY digital knitting machine that sparked global attention in the maker community. Building on that experience, he co-founded Kniterate to bring industrial knitting capabilities into an accessible format, making digital fabrication in textiles available beyond large factories.



<https://kniterate.com>
IG: @kniterate

More than 10 years have passed since we first met, and you've gone through various evolutions. Let's start with your latest project. How do you position Kniterate knitting machine in the market?

I see Kniterate filling a gap in the market. It sits between domestic knitting machines, older manual models from the eighties, or even before, that people are still using, and industrial machines

that require big budgets, space, and expertise. We designed Kniterate to be an accessible option between those two worlds. It automates most processes, offering around 80% of the capabilities of an industrial machine, but with simpler hardware and software. This way, both users of domestic machines and professionals familiar with industrial machines can enjoy working with it.

From your perspective, how does that "in-between" tier featured by Kniterate, change fashion manufacturing in practice?

I'd love to say it will have a big impact, but it's difficult because we live in a world of abundance where fashion has become so cheap. We got to

this point because companies got super efficient in externalising. It's almost impossible to compete with garments produced offshore in low-wage countries. We're not trying to compete with that system. We're providing a new product. I mean, it's not a new product as knitwear has been existing for centuries. Italy and Spain, for example, used to have a very strong manufacturing ecosystem. It all went away, or most of it. We offer a different model, a new production and consumption method: on-demand and customized production in which the user as the consumer has more to say. This brings us closer to the pre-industrial model where clothing was made locally, sometimes even at home or in small workshops. We imagine a decentralized future of micro-factories where people can order garments made locally on demand.

You launched Kniterate some years ago through a Kickstarter campaign. Who are your main customers today, and where are they located?

Our main customers are small businesses companies with just a few people producing small runs or tailored products. In the past two years, we've

also seen strong demand from universities. Today, about half our sales go to universities, not only fashion schools but also product design, architecture, and computer science departments. They use Kniterate for research with textiles, an area that was closed or difficult to access before. Now these machines and technologies are opening up these processes so researchers can now repeatedly make experiments with knitted fabric, make tweaks like using a digital fabrication tool and develop lots of interesting stuff such as sensors and shapes for architecture. Most of our machines are in the US, but we also sell in Germany, the UK, Canada, and increasingly in Australia and New Zealand.

That makes sense, since universities can now provide students with more accessible machines. What about the learning curve, is Kniterate easier to use than industrial machines?

Industrial machines are very sophisticated machines, once you master them they're amazing.

But it takes years. So, at the beginning to experiment you need a technician, which is a big expense. And it's also a bottleneck because everything needs to go through this technician. With Kniterate, we kind of want to get rid of this middleman and let the designer, the architect, the programmer, to interact directly with the machine and develop a workflow. It's

more streamlined if you can directly use the machine and understand what the machine is making for you. There's definitely an advantage if you already know domestic machines, because you understand yarn, tension, and how all these parameters have an effect on your fabric. But we also have users who started from zero and built successful businesses. What helps most is being tech-savvy, attentive to detail, and willing to experiment. It's not an easy technology, you need time and patience, but it's more approachable than traditional industrial machines.

How did you evolve from OpenKnit, the maker-oriented, open-source project, into Kniterate, a company producing hardware and software?

OpenKnit was meant to be an open-source tool anyone could replicate, but it was more of a proof of concept. It wasn't reliable enough for real production, you had to spend a lot of time on it, and what you were able to produce with it was quite limited. Knitting machines need to be extremely precise because if a few stitches drop, the piece is ruined. With OpenKnit's 3D-printed and laser-cut parts, I couldn't achieve the necessary consistency. The project stalled because you also need to have knowledge about textile production, electronics and mechanically, it's pretty complex. For me it was too much, until an investor approached me. At first, I hesitated, but I realized that starting a company was the best way to bring this technology to more people. I joined an accelerator in China, where we redesigned the prototype in steel and built a reliable semi-industrial machine. It was a big leap, but a natural evolution, providing not low-cost, but a cheaper than industrial option.



When you launched Openknit, you made a video which became viral of you manufacturing a jumper and bringing it into a fast-fashion shop as a provocation to show an alternative landscape to production. How does Kniterate propose an alternative to fast fashion?

Kniterate isn't a hardware revolution, the technology has existed for decades. We made it smaller, more compact and more accessible. What changes things is software. By making knitting software easier to use and by building a community for sharing designs, we can do for knitting what 3D printing communities did for digital fabrication. We're not fighting fast fashion, but we can offer an alternative model that's more sustainable and locally connected.

And do you see examples of community use, where local producers share machines?

Yes. One of our most active customers is in London. They run their own brand but also use their machine for on-demand production for other companies. Their machine runs almost 24/7. That's what we'd like to encourage: not everyone owning a machine, but building networks where skilled operators can produce for designers and brands nearby. At the moment it's slow and inefficient, people exchange emails and PDFs back and forward, but we're working on a platform to streamline these connections.

Working with materials is also central. How does Kniterate approach sustainability in yarns?

We're beginning to sell yarns ourselves, because many customers struggle to find the right ones. Not only in terms of composition, but also regarding thickness, strength and colors. We want to focus on natural fibers like wool and cotton. Every material has an environmental impact, but we believe these are more planet-friendly than synthetics. We've used acrylics and polyesters in the past, but we're transitioning toward natural yarns, which also make production easier when you stick to consistent, reliable materials because you can identify the right parameters and save time.

Looking ahead, how do you see Kniterate in ten years?

I'd like to see a global distributed manufacturing network, with many micro-factories connected online. Designers could share ideas and patterns, and anyone could get a garment made without being a fashion expert. Building this community, both of people and of knowledge, is the future I'd like to work toward. I look forward to seeing what we can build together.

matilda noreberg

Textile designer and lecturer in the design education at KMD, Universitetet i Bergen. She is educated at the Royal College of Art, London in knitwear and was previously the creative director of the Norwegian brand Oleana, where she pushed through an æsthetic new direction, based on local production and sustainability. It was at Oleana that Matilda came into contact with 3D knitting for the first time and with both design, product development and production in the same place, Matilda could have total creative control from idea to execution. Her first collection was purchased by Norway's National Museum, she then co-founded RSKA (Research Studio for Knit and Architecture) with Joel Persson and Edvin Bylander.



How did you begin working with knitting machines? Was it a family tradition, or something you discovered in your education?

I started out working in fashion, mainly styling for brands, but eventually I grew tired of it. I decided to study textiles and enrolled in practical courses, then a bachelor's in textiles. I kept seeing potential in the fabrics I created for fashion and thought knitwear might be the perfect combination: you're in control from yarn to finished product, working with both the textile itself and the fashion aspect. I then pursued a master's at the Royal College of Art, where I came into contact with semi-industrial knitting machines and digital knitting. Later, I worked in the industry and eventually moved to Norway to join a knitwear brand. There, I became deeply involved in production and machinery. We transitioned from only flatbed knitting to also doing 3D knitting, which is how I got into that area.

At university, did you start with home knitting machines, like the domestic ones often used in labs in Italy, and then move on to industrial flatbeds?

Yes. During my bachelor's, I worked with domestic machines. In my master's, we used Dubied flatbeds, which gave me a deeper understanding of knitting. We also had opportunities to collaborate with industry and use machines like the Shima Seiki flatbeds at the RCA, though only briefly.

How was your learning curve with computerized industrial knitting? Did you find the coding complex and do you think it requires a special mindset?

Actually, I don't program. When I worked in the factory for five years as creative director and designer, I made a conscious decision: I couldn't be both a great designer and a great programmer. Programming is highly complex, and you can achieve far more when working with a top-level programmer. So I've always collaborated with programmers rather than coding myself. I understand what it looks like and how it works, but I've never gone deep into it, I don't think the outcome would be strong if I tried.

We've noticed that innovation often comes from people who get hands-on with machines. What do you think is the best model for collaboration between designers, programmers, and manufacturers?

I think long-term relationships are crucial. When you work closely with a programmer and get to know each other, it creates space for real exchange. I've experienced the traditional way—sending off specs and getting responses like “impossible” or “too expensive”, and it was frustrating. At the factory, I started asking questions: “What happens if we turn this the other way?” or “Can I try linking it myself?” That unlocked a lot of new possibilities. Being present in the factory, collaborating long-term with a programmer, and having ongoing conversations is, I think, the best approach.

Where did you find this conversation? Because when companies do manufacturing, they

don't want to spend time in conversations so, you should have the specs and also be explicit about the numbers of your order. Where did you find this openness in having a dialogue?

I found it when I was creative director at the knitwear factory. Because I was part of the factory itself, we could rethink how we used machines. Of course, time and money pressures

limited us, so most of the time we had to work "the normal way" just to get collections out. But each season we set aside a couple of weeks to experiment. Eventually, I resigned to focus on more research-based knitting. Now I collaborate with two architects. For each project, we pay for development time, say, two weeks of programming, so we can explore freely without production constraints. It's not easy to secure funding, but if you can, it's a great way to experiment.

Do you also own a machine to experiment on this type of research?

No. We collaborate with factories that have the machines. I usually travel there, work with a programmer full-time for a week or two, and together we develop and test ideas. At this stage, we're not thinking about mass production, only experimentation.

Even though these machines could enable on-demand production, the practice hasn't spread much. Why do you think that is?

I'd split it into two parts. On-demand production of pre-designed styles could work, and we actually did that at the factory with minimums as low

as five garments. But for customization, where customers choose from dozens of colors or details, I don't think people really want it. They like the idea, but in reality they rely on designers to make decisions, provide context, and create the whole world around a garment. Limited options could work, like choosing between two or three colors, but I don't think broad customization fits most fashion brands.

You've also expanded knitting into architecture and upholstery. How did you identify this potential use of knitting and how did that transition happen?

It started during the pandemic. Fashion was rushing to digitalize, showing 3D visualizations that didn't look convincing. Meanwhile, I had seen how architecture had already gone through

a long digital shift. Working with architects, we asked: now that we can knit in 3D, what should we use it for beyond sweaters? We began experimenting for both the body and for space, and realized architecture offered huge unexplored potential. Textiles can have many benefits in architecture, and with experimentation, there's no reason knitting machines couldn't scale up. We've been making installations, doubling machine widths, and working on projects such as temporary wall systems for a gallery in Malmö. We're also exploring outdoor applications and molds from knitted forms. After 3-4 years, we're still in an exploratory phase.

And do you face limitations from the software side?

Not so much. We don't use standard designer software. The main issue we've faced is data ca-

capacity when working on very large projects, but not significant software constraints.

The choice of materials is a key aspect to implement high standards of sustainability. How is your team dealing with this topic?

In Norway, wool is a natural choice because of tradition and availability, and I'm glad for that. Once mass production slows, I think acrylic and cheap materials will naturally lose ground. Wool has incredible properties, durability, fire resistance, insulation, and fits both fashion and architecture. In research, we're exploring recycled fibers, such as short-fiber recycled wool, especially for architectural applications where wear and tear isn't as critical. I think small projects should also be able to work with these materials, though right now funding often favors bigger players.

How do we shift the perception of wool and knitting as "old-fashioned" to being seen as futuristic?

That's a really good question. Often, when architects see knitting, they dismiss it as "baby clothes," not realizing how complex it really is. Bringing in different perspectives helps, for example, when my two architect colleagues talk about knitting, people react differently. We're also working on a project for the Technical Museum in Stockholm: building a large, simplified knitting machine for children to understand programming concepts. It's a way to show that what's often coded as "women's work" is actually advanced technology.

That's fascinating. Any closing thoughts on sustainability and the future of knitting?

Yes. I think we shouldn't underestimate hand knitting either. Local, small-scale production adds value to garments, encouraging people to care for them and pass them on. As long as the quality is high, it's a strong alternative to mass production. The key is keeping product development knowledge alive and integrated.

stefanie everærts

Designer-programmer specialised in the technical artistry of industrial knitting. Rooted in hands-on exploration of machines, yarns and techniques, she pushes the boundaries of knitting technology to create innovative 3D forms. By integrating design with machine programming, she refines each piece through constant testing and iteration to ensure it's both striking and feasible. As a programmer technician for a Belgium-based manufacturer, she applies advanced techniques responsibly, helping preserve Belgium's knitting heritage and bridge design with industrial production.



How did you start working within the knitting machine world? Was it something you had as a family tradition, or did you encounter it during your educational path?

By education, I'm actually a product developer. And the first 4 years of my education I had no experience with textiles or knitting at all, and then my school purchased a Kniterate knitting machine. It was my last year and I had to write my thesis and they also published a subject about knitting and quite impulsively I applied to it, because in my free time I worked with textiles, and I thought it would be nice to incorporate it in my final thesis. And then it really was just a loophole for me, because there was nobody in the school who could work with Kniterate, or who could knit at all. So it was really exciting for me to learn how to make it work, because, in my opinion, you cannot work with the Kniterate if you don't know anything about knitting. It was really like a long full year of learning, and afterwards I couldn't imagine not knitting anymore. So ever since I've just been knitting and the Kniterate was the 1st step for me. Later I couldn't have access to automatic machines anymore so I purchased some domestic machines. I also followed a different education, applying for a BA in Textile Technology at Hogent and there I learned how to work with weaving machines, knitting machines. and now I'm working professionally as knitwear developer at a knitting factory on Stoll machines.

You said it took one year to learn the Kniterate machine without knowing anything about knitting, but I guess you knew how to knit by hand, is that correct?

I very basically knew how to knit by hand. I once knitted a scarf, but that's it. And then, learning how to work with the Kniterate, in the 1st half year of my thesis I was barely able to knit anything, and then I also went to a lady who works with the domestic knitting machines to have, like, a bit more insight. Then I could start to implement that knowledge into working with Kniterate and the software. And then, by the middle of the year, in January, I had my successful samples. But still really, really basic, let's say. And then by the end of that year I was able to produce a full garment, but still with the knowledge that I had, it was fine, but if I think of it now it's like I should have had this and that. I think knitting on a knitting machine, depending on how complex you can go, if I will be doing this for the next 10 years, I would still have a lot to learn. There are so many possibilities, not only with the stitches, but also with the flatbed machines, you can knit a full 3D object out of it. You need a year to know the basics, but then you can continue your knowledge so much afterwards.

And what about moving from the Kniterate to the Stoll? How would you see a nice trajectory if someone would start from scratch now, what would you recommend?

It depends a little bit on what you are willing to make, because there are some things that you can do on the domestic machine that you cannot do on an Kniterate. I think definitely to have the insights of what your machine can offer you and how it works. And it's really important, I would say, to learn on the domestic machine maybe first, or maybe do it on the side, because with the Kniterate you think it's automatic, and it just starts running but you actually don't know or don't understand what's happening. It's really good to have that connection with both the domestic one and the Kniterate to sort of be able to evaluate. When I studied textile technology, I had a class in industrial knitting, and we also learned how to knit on the regular machines first because it makes you really understand what

the needles need to do in order to produce fabric. And then you go to the software and it just depends what type of things you want to do. If you want to make only 1 or 2 things, it's maybe a lot of effort to program something, test it out, program it again and test it out again whilst if you're busy on the hand-knitting machine, you can make a pattern just as you go and try something out. It depends a little bit on what scale you want to operate, and I think for the learning process to really understand it it's always valuable to work with domestic knitting machines or like hand industrial knitting machines to really create. It's crucial to figure out what you're doing because if you run a program through an industrial machine, and you don't know exactly what you're doing, there's a very big chance that you will break all of your needles or something else which can be really dangerous. So it's very important that you get to know each step well.

There is a sort of transparent barrier between the potential of this machine and the complexity of translating this potential into manufacturing ideas. Meaning that you have creative people without the skills to code. And then the knit programmers on the other side that have not been trained to be creative on the machines. What's the right mix for you in this field?

There's a good example at the TextileLab in Tilburg. There you have programmers, and they work together with artists. So the artists come up with the ideas, the designs and the developers do the technical development. In this way you really

get to see products that you would otherwise never get, because the designer can think about the shape and the texture but it technically has to be able to be manufactured by the machine. So you need a technical person to translate it. It's very interesting if somebody is both a designer and a knitter and you can see a lot of people emerging, who are already designers and then become developers. At this moment, for example, the people at the textile lab also often are already doing some work on their own. Because, yeah, you also have to be a little bit creative to come up with these structures. I work in production, and often things that are possible are closed off because it's not practical, or you cannot get your profit out of it. In order to research something though, you sometimes don't have to think about what is profitable, and you can really get the extremes out of the machine and then go and evaluate: what can we now take from this experiment and use it for in production. If you have a technical person together with a creative one, it's the best solution, I would say or both the qualities in one person.

We've been discussing distributed manufacturing and short supply chains, especially imagining local infrastructures where you can share machines and use other facilities to empower, especially independent creators in rural areas. If starting a lab or this type of infrastructure in what knitting technology would you want to invest in?

I think it's really nice that something like Kniterate exists because it's the only machine that has accessible software that you can use from anywhere for free. You can prepare your work at home, and then, indeed, find the working space

that you have available close to you and go knit something out without having to do the investments of both software and machines. There are a lot of people who are interested in experimenting with something like industrial knitting, or maybe close to it, but they just don't have the access to it. And then also a lot of factories or workplaces with industrial machines are not around anymore in

Western Europe like they used to, so often the jobs are not available and they will not take orders if it's not big enough, because they won't get profit out of it. There is indeed something missing in between, to allow research and development. I also must say that I haven't used the Kniterate software in quite a long time and with its 1st release you really had to think a lot because there was not much automation in the software. Maybe now it's better because sometimes it was a little bit harder than programming Stoll machines, because the Stoll machines have a lot of what they call modules or color arrangements. Basically, that's a way of really easily being able to apply a structure without having to think about the transfers and other more complex stuff. With Kniterate you really had to program stitch by stitch, conversely with the Stoll machine you have simulators which will tell you if you do something wrong or on which row there is an error. It's kind of easier to find your mistakes. Kniterate is a good step in between and if they improve it in some aspects, it could open so many doors. It would be really interesting what it could provoke, especially for its accessibility in terms of price.

Kniterate is in continuous improvement, especially with community feedback. The open approach of building a community of users around it and listening to it brings many insights. I guess the more people use it the more its software and the machine are going to improve. It's hard to find this approach in the industrial machines which are very complex, very expensive, and there isn't so much interaction between the user and the company. There is a different culture of getting in touch with the end user and I think for Kniterate is a competitive advantage, do you agree?

Definitely. And also, it can be quite nice in-between stuff. Because right now, just from my own personal experience and working in a knitting factory, the development time often has not enough room to experiment, or really focus on development because we often want to skip to the production quite fast. And it would be really

cool if designers or creatives could maybe experiment a little bit with a Kniterate machine, figure a bit more to really develop and make things. And then, if they would want to industrialize it's interesting for production companies if creatives could come and present their work with something really concrete and things can go into production also quite easily. Right now with these production companies if they don't see the financial benefits they will not focus on the development, that's why it's nice that designers can do it in their own independent time.

In your latest project you've been exploring 3D shapes on knitting objects. Can you tell us a bit about your experimentation?

When I started working more with the industrial machines, I often found that there is still a lot of cut-and-sew approach while there are so many possibilities for 3D objects to be made with the machine. And I asked myself why it was not

used more with its great potential. Then I realised that the development time of a product made with this machine is quite intensive and additionally, if you'd, for example, have a product and you'd want to change yarn the effort is always like starting back from zero, because your material being different means behaving differently, your shape will change, so often companies prefer to just make the knitted fabric and then cut-and-sew it, because they can control it better. That's why I started thinking that maybe we should design

objects in a different way because if I design objects in a way that I know that it's more convenient to program in a future iteration, how would that look? So I started working with a sort of a building block that repeats itself, and then depending on the size and the number of repetitions, if it goes from small to big, you have different product possibilities. In this way you would limit your development time and knitting would be a more suitable option for 3D objects and then it's really nice to work with 2 qualities of yarn, at the same time, one providing consistency and the other more for the functionality. The elastic yarn in my work really makes it possible that if I use a different one for the touchable parts my shape doesn't change that much. So the elastic is a constant material that I use, and then depending on the function, on my handbags, for example, I made in cotton and on my poofs I used wool, because it's nice for an interior object. If I would once want to make a lamp for it, it would be possible and because of the elastic, my shape will not change that much, I will not have to make such big programming adjustments. So that's a little bit of the idea behind it.

You mention the fact the choice of the materials has a lot of impact on the fashion industry especially on how long a garment would last. What is your reflection about materials?

I find it sometimes a bit tricky, because, of course, I use a lot of elastic in my work, and that's not necessarily very sustainable especially if you mix 2 qualities and with the knitting structure that I use it's not separable anymore. But

if I make products on demand I don't make any stock because I only go into production if I actually have an order. That's also a way of thinking sustainable. My material choice isn't optimal, and I really would like to explore a more sustainable option for the elastic yarn in the future that can give me the same consistency that I'm looking for, but by personalizing designs it's also less likely for people to get rid of it easily because it's very specific for the client and very likely I hope it will last for a long time.

You talked about production on demand. I've been discussing this topic with various designers and there's no foolproof method. What is the approach for you to make it work?

I would say that I'm still searching for my formula. Definitely. I think I'm a bit lucky in the way that the place where I work is connected to the work that I do in my spare time. So I can use those connections to produce on demand and I think

that's a big advantage that a lot of people don't have. If you'd ask to produce on demand to a knitting company, they will often say no, and it's also understandable, because it's really hard to get a profit out of it if you're just used to produce in big numbers. That's a bit of an advantage that I have that I'm able to do the programming myself, and I only need machine time. But then still, I'm still searching for the right marketing strategy. That's why it would be really nice if you can take the production into your own hands and, for example, do it in shared infrastructure equipped with a Kniterate because right now, even if the factories with the industrial machines can do a lot more than the Kniterate, designers can't really have access to it.

And how do you sell your knitted production?

I've heard from other designers that often online retailers prefer to sell design products without sharing the identity of the designers because they

don't want people to be able to find their website to get a better price on it. I've been fortunate enough not to encounter the need for a bigger distribution because I'm working on a really small scale at the moment and I'm also still really dependent on my job as a programmer, because I also still just really want to learn from the industry.

Actually, we were discussing how it could make sense nowadays to have different price tags according to where you buy the product from. It could be possible if we had some kind of transparency on the price and the fact that keeping a shop has its costs but it's also an easier experience for the client: you're walking on the street then you find a shop, with a curation of the product exposed, you can touch it and buy it immediately. Differently, if you buy it online to be produced on-demand, directly from the creator, you put trust in the producer and wait for the object to be manufactured and shipped, why should it have the same price?

I think it's definitely nice to be able to work with shops, because even if you can see my things online and on Instagram I can also imagine that people would like to interact with the product before buying it, and especially if it's on demand and customizable there is no way of seeing the product until it's made in that color combination. I can make a small swatch so you have a little bit of an idea of what it will look like, but you will not be able to see the full object until I've made

it, because that's the whole purpose of it: having no stock and no waste of material. It would be nice if you could have some samples in a sort of a shop then people can go, test the product and ask questions so the designer could focus more on making. And, of course, the people from the shop will be paid for this service. We should think about some new guidelines to protect both the designer and the shop displaying the products.

Do you see the future of knitting really like a technology that could be supportive into providing a more sustainable and ecological fashion industry?

In my opinion, knitting machines are the only production technology that can really make something to size without the waste of cutouts that you have with garments made in the traditional way starting from rectangular shapes. With

knitting you have all that freedom in creating shapes.

Although it's not reaching its potential right now, and the reason, in my own personal experience of working at a knitting company, is because the margins in fashion are very low. Until there is this opportunity of fast fashion, and they are still allowed to do manufacturing with that impact on the environment there won't be so much space for knitting. The main issue is that knitting is relatively slow in comparison to producing a weave. You can manufacture a long piece of a weave, but with knitting, if you want to do it to the shape it takes a lot of machine time. If you take, for example, a t-shirt in comparison to a knitted t-shirt. Well, you have the same functionality, they're both a t-shirt but one is more expensive to make, and people are not willing to pay a different price for it.

In general, people are not aware that a lot of cut-and-sew clothes are also made out of knits, or people are not aware of the kind of fabrics that they wear. If it's a fast production method or not, or a lot of people think that everything is woven. A lot of it is knitting all the T-shirts that people wear, they think it's woven, but it's knitted and usually more durable. Definitely, education could have a big part in raising awareness because people now know more about the fibers and are starting to choose natural fibers over synthetic

fibers but not many people know the difference between weaving and knitting, and it's a huge difference. I really wanted to educate myself on manufacturing methods but it's so hard to find literature on how the industry works. So I really had to find this educational path and it's the only education that is left in Belgium that teaches at the industry level on textiles. But then, again, I sometimes wonder, where did the teachers get their knowledge from? Because what they teach in their lectures is not referring to specific books, it's just really hard to find the right literature to educate yourself and find written sources. And if you find a source, a good book then it usually costs so much money and I don't end up purchasing it or reading it.

The company where I work is a family run business in its 4th generation. I also heard from other friends working in the industry in Belgium who had the same experience. There are so many family companies who have been doing it for generations, and they didn't learn weaving or knitting from going to school, they learned it from the generation before. They've been in the knitting business for over 30 years and there's so much to learn from them. I'm learning more than I've learned in school, and there wasn't really a way for me to know more about knitting before I started working there. Especially the programmers who have been in the business for so long, they know things without knowing that they know them, it's so automatic for them to do this or that, and only by observing them I can ask them, why do you do this? Or why do you do that? Why is this happening? You really need people who have been in the business for years and have witnessed and solved specific problems. It's something that you cannot learn in a short time. It's really there where you see the experience building up in years, that's why it is really important to be surrounded by people who have been through that process because there is a lot of tacit knowledge involved which is not in books.

Back in the day it was more easy to find young people who wanted to work in the technician role. You have the knitting programmer. but you also need a person standing with the machine and treading the yards and fixing if something is broken. Young people are not motivated to do that sort of work yet, but it's really unfortunate, because right now, a lot of those people who have been really good knitters, in managing the technical part, are retiring and there's just so much knowledge that is disappearing that we have to be really careful about that. We need to transfer this knowledge onto new people before it's too late, and I think with some cases it is even already too late.

When I was doing my internship at the TextileLab there were some of those old weaving machines and they didn't have people there anymore who knew how to work on them. They have a nice passmenterie machine, to make cords and tessels, and they are unable to work with it, and don't know where the machine was produced. So if this machine breaks, they will not be able to make or find a replacement.

Going back to the 3D knit and knit-and-wear, is it more expensive to manufacture, because you need more programming capacity or else?

The programming is definitely one aspect. But definitely, also because your knitting time increases because you're knitting a tube, that's how

you get that 3D shape. But then, if you want to make a pattern onto it, you will have to transfer the whole time to the different beds. This process really increases your time a lot. That's kind of the same reason why, for example, a single jersey is way less expensive than an azure pattern, because you need those transfers. It takes more time and therefore money. But then, again, you can also save in cut-and-sew time.

Nowadays cut-and-sew is done on such a large scale and with experienced people working very fast, it gets cheaper for us to do it with cut-and-sew than

knit-and-wear, especially if something fails in production, you have to throw away a full sweater. That's why companies and designers should think more about simplifying their products to have less failures in production, because that's also both economically and ecologically sustainable. There are many other ways to make things interesting rather than to complicate them by a cut-and-sew approach.

| What's coming up in your future?

I'm really focused on learning at the moment, because I've only been programming full time since October, so there is still a lot for me to catch up.

And I'm also really excited because the more I know, the more innovative stuff I can make or think of, and then at the same time. The products that I make are objects you can buy but for me they're also a way to show people what these machines are capable of. I hope I can inspire people to start working with knitting if they can see the benefits of making something in 3D right out of the machine. I would like to work more on this 3D aspect of the machine and hopefully start collaborating on some cool 3D stuff.

