Made in Italy 5.0. Knitwear Design within the fifth Industrial Revolution

Abstract. Starting from an examination of the fifth industrial revolution phenomenon applied to the Made in Italy clothing sector, this paper aims to investigate the present and future scenarios that Industry 5.0 opens up in the world of knitwear design. Unlike other design sectors, the convergence between physical and digital environments, which is at the center of the Fashion Industry 4.0 debate, is an established feature of the practice of knitwear, which still carries within it the craftsmanship of handmade techniques and the automation of the most up-to-date machinery and software. However, in the archetypal narrative of most Made in Italy sectors, the technological aspects tend to be neglected in favor of a communication based only on craftsmanship and manual skills, and knitwear is no exception to this phenomenon. In this scenario, craftsmanship also recalls a sustainable way of working through a savoir-faire traditionally attentive to the impact of its processes and a high-quality product that is ultimately more durable and more responsible towards the planet. Stemming from these premises, the authors of this investigation identify knitwear as an archetypal case study of Made in Italy, analyzing how far this narrative reflects reality and how the advent of Industry 5.0 can fit into this context.

1 Introduction: from Industry 4.0 to Industry 5.0[1]

It has been a decade since the concept of Industry 4.0 was born with the meaning of a highly digitalized, automated, and interconnected industry. Retracing the history of the textile and fashion sectors, it is evident how both have been fully hit by each industrial revolution: as resumed by Mattila et al. [1], the first revolution mechanized the industry, made operations faster and took away most of the reiterative and time-consuming manual work. The second introduced the assembly line, that meant high volume production and high mass consumption. The third transformed analogue information into digital, easier to be cost-effectively manipulated and transmitted. Each revolution evidently changed the processes, the numbers in production, the distribution of costs and profits, but also marked a sharp transformation in human behaviors of both workers and consumers.

If the1st, 2nd, and 3rd revolutions are considered as sharp cuts between the previously existing condition and a new one, the literature often reports and analyze the 4th industrial revolution more as a "shift", i.e., a progressive a transition from the automated production supported by telecommunication, electronics, and computers typical of the Industry 3.0 to a new paradigm where the "smart manufacturing" is a key concept [2]. The fourth industrial revolution is indeed still providing factories

[1] Author … wrote paragraphs 1, 2.1, and 4. Author … wrote paragraphs 2.2, and 3.

with robotics, artificial intelligence, augmented and virtual reality, in a transformation that is often slow and difficult, depending on the typology of companies, their dimension, their economic and human resources.
Considering the Italian fashion and textile system, it is composed – alongside the few big players – of a multitude of small and micro manufacturing companies that fit neatly in the category of the cultural and creative industries, where human creativity is the source of goods and services [3]. These businesses are based on a collaborative way of working and sharing cultural values, together with the persistent need of manual care and intervention: all elements that are hardly challenged by heavy digitalization and somehow serve as barriers to the digital shift.

Despite the Industry 4.0 is still establishing itself and manufacturers are still putting their efforts in following this transformation [4], some scholars, industry pioneers, and technology leaders started to envision the 5th industrial revolution, i.e., Industry 5.0.

Industry 5.0 is oriented towards a renewed balance between machine and human engagement. If the digital was the center of 4.0, collaboration is the center of 5.0, that uses cognitive computing and human intelligence together to create symbiotic factories [5]. Mattila et al. [1] define the key drivers of Industry 5.0 as the centrality of human, sustainability, resiliency and reduced cost and environmental control. Human action does not surrender to the digital, but is combined with "the speed, efficiency, and consistency of robots, to promote human empowerment, talent, and diversity" [1]. Human and robots will collaborate in making manufacturing more flexible and robust, and more sustainable for the people as well as for the planet by helping in monitoring environmental impacts and energy usage, preventing wastage and errors. Industry 4.0 improvements will not be neglected: Longo et al. [4] describe the envisioned future as dedicated to design and development processes that keep the technological solutions provided by Industry 4.0, but use them in a human-centric, value-oriented and ethical way.

For a decade robotics, computer-integrated manufacturing, and cyber-physical production systems have been conceived as fundamental in the evolution of industrial production [6]: technology has taken the traits of a megatrend to be exploited in a extensive way, and has been marked as an answer to difficulties in every aspect of the supply chain, from production to process management, distribution and to the relationship with the end consumer. The new production methodologies, the progressive automation of processes and the ever-increasing availability of data brought recognizable benefits, nevertheless the digital wave raised among scholars and professionals "significant ethical questions regarding the impact of technology on workers and society at large" [4]. Hence the need to rethink also the consequences on the relationships between men and technologies, on the spatial and temporal borders of production sites, on the working conditions and the autonomy of workers [7]

Today, the change of perspective is bringing together the most diverse experts like computer scientists, designers, industrial engineers, as well as philosophers and legal experts to re-think technologies as complementary to human values –rather than leaving the latter as an afterthought– [8], and to question the critical role of workers as main player of a renovated industrial system. In this way, the new paradigm will

debase the very meaning of "revolution", i.e., not just a productive transformation or a process of digitalization of industrial activities, but a full cultural, social and economic transition [9][7].

From the perspective of design, that was born as a human-centric discipline, this is in a way a return to its origins, as well as a relevant and contemporary issue to address in terms of research. The concepts of industry 5.0 are also connected with the very essence of Made in Italy: by its nature, indeed, the Italian industrial model is determined by cultural values and by the collaborative human factor. It is based on the social capital of the districts in which it is formed, namely "a set of active relationships between people" in which "trust, reciprocal understanding, shared values, and behaviors keep the members of a community firmly united and make cooperation possible" [10]. To Bertola and Colombi recalling Verganti [11], Made in Italy relies on "a special relationship with professional design communities and culture, where design moves from technological innovation, manufacturing specialization, and supply chain management to promote an innovation in product meaning": if the latest aspects gained more and more relevance in the Industry 4.0, cultural values and human relationships have been maintained and will now benefit of renewed attention, coming back as fundamental to pursue innovation in meaning and practice.

Stemming from these premises, the authors intend to frame this study within the knitwear industry, where they both have research and professional background. By identifying its distinctive features, the aim is to understand whether the specific characteristics of this industry sector will make it more or less inclined to accept the change towards Industry 5.0.

Finally, it will be discussed whether and how practices, processes and people can benefit from the ongoing transition from the 4.0 to the 5.0 model and the envisaged future.

2 Knitwear: technology and craftmanship at a balance

2.1 From an ancient manual practice to an advanced industry

The Italian knitwear industry is a case study of particular interest with reference to the paradigm shift that Industry 5.0 brings with it compared to its predecessor, 4.0. Recognizable in it is the typical expression of the Made in Italy paradigm linked to the idea of traditional craftsmanship [12] and, at the same time, a consolidated industry characterized by advanced machinery and digital technologies [13].

Originating around 1000 B.C. as a manual textile manufacturing technique requiring the mere use of a yarn and two needles, knitting is one of the oldest manual practices. Following the invention of the hand-operated knitting loom in 1589 [14], it spread over the centuries as a profitable business activity and gradually evolved from domestic work or hobby to modern industry [15], embracing the breakthroughs of the first, second and third industrial revolutions.

Knitwear is indeed of interest because, despite the revolutions, it relied entirely on the manual intervention of the human being until 1970s, when the work in the Italian industrial districts was diffused around small artisanal workshops and among people – mainly women– owning a manual machine and knitting at home [16]. Manual knitting machines brought improvements in the fastness of production, as they did not knit anymore one stitch at a time but entire rows of stitches in one single pass, and also upgraded the precision of the result, but they kept the manual aspect as they still had to be set, moved and controlled manually, and all the operations needed to shape a garment were demanded to the human hand. Manual knitting machines (Fig. 1) remained the standard for production, even industrial production, until the appearance of the first computer-controlled knitting machines in the late 1970s.

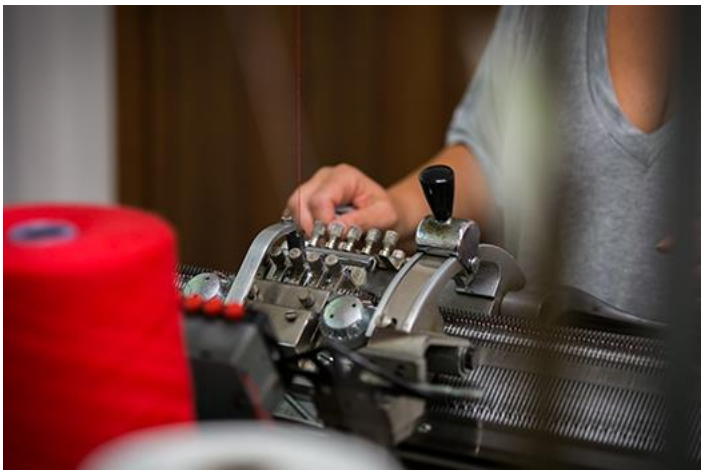


Fig. 1. The carriage of a manual knitting machine diffusely used for production until 1970s, operated by hand.

The role kept by manual machines for such a long time helped to preserve the craft aspect as an intrinsic value in all the processes of industrial knitwear, even when CNC (Computer Numerical Controlled) knitting machines (Fig. 2) marked a sudden shift from a scenario of craftsmanship made of individual producers to a prevalence of the technological element over the manual one [17].

Fig. 2. A CNC knitting machine. The protections prevent the manual intervention of the operator. The entire process is set and controlled remotely.

Indeed, despite the continuous evolution of computer controlled power knitting machines, the typical complexity of a knitted product prevents the complete automation of processes: while cutting-edge technology are fundamental in the knitting, modelling and 3D simulation departments, a large part of the conceiving and development still depends on human decisions (made by designers together with technicians), and also some steps of production like prototyping, quality control, linking and finishing can't be automated but must be completed by hand.

On the one hand, this peculiarity has sometimes made it difficult to maintain such an important manual and human component in an increasingly digital-oriented environment, causing mismatches, slowdowns and problems in design and production processes. The strong link that knitwear –and Made in Italy in general– keeps with the physical interaction with the product and with interpersonal relationships [18] suffers under the thorough digitization of processes.

On the other hand, the knitwear sector was somehow prepared to put efforts in the convergence of physical and digital environments that was at the heart of the fashion Industry 4.0 debate [19], due to the fact that knit designers, technicians, and manufacturers were already used to deal with the dichotomies around human and machine, manual and automated. This is confirmed also in previous research by the authors [13][18][19], where knitwear factories emerge as places where the seemingly opposite drives of craftmanship and Industry 4.0 technologies relate with an iterative dialogue to hold each other in constant search for balance.

Today, this advantage lays the foundations for new experiments towards the symbiosis of human and technology sought by the Industry 5.0.

2.2 The production process of knitwear: skills, workflows, humans, and machinery

As emphasized here above, the knitwear production process has always been permeated by two opposing elements: a strong technological presence linked to knitwear technology and the traditional craftsmanship derived from the sewing, finishing and embellishment processes.

It is worth clarifying here how the knitwear production process sees the alternation of various stages of work.

The various phases that make up the production cycle can be divided into three macro-categories: knitting, sewing and tailoring, and finishings[2]. Each of these phases then has related sub-phases or phases that are traditionally managed by the same company department or group of professionals. While for some of these stages technology plays a key role and knowing how to master it gives undeniable competitive advantages, on the other hand, craftsmanship and the manual element in general remain key drives for much of the process.

Typically, the knitwear production process is divided as follows:

- Software programming of the machines, in which, through strings of commands, the programming technician gives the inputs to the machine(Fig. 3);
- The software program thus created is launched into the machine and yarn-feeders and machine controls are accordingly manually set (Fig. 4);
- Electronic machine knitting;
- Quality control. The knitted panels are inspected by a specialized operator according to specifications identified on a case-by-case basis. This type of inspection does not involve the use of digital technology but is mainly a visual check;
- Washing of the knitted pieces in which the sophisticated washing technology continues to be accompanied by the craftsmanship of the individual operators who develop their personalized washing recipe;
- Ironing. The ironing phase, depending on the products, can take place either in panels or on the finished garment, or it can involve both steps;
- Embellishments application such as embroidery, prints, appliqués etc. to enrich the aesthetics of the knitwear;
- Measurements checking and tailoring of the garment. This final stage is entirely artisanal, so there is no presence of digital technologies, and the knitwear sewing machine (the so called “puntino”) (Fig. 5), unlike the knitting machine, has not undergone substantial changes since the 1960s.

[2] *Textile finishing* means all those treatments that ennoble the garment such as water or mechanical action treatments such as brushing. The most important textile finishing treatment, as it is essential for all products, is the washing phase, which is carried out by specialised facilities that are now the subject of much attention due to issues related to the sustainability of production processes and in particular to their water and chemical management policies.

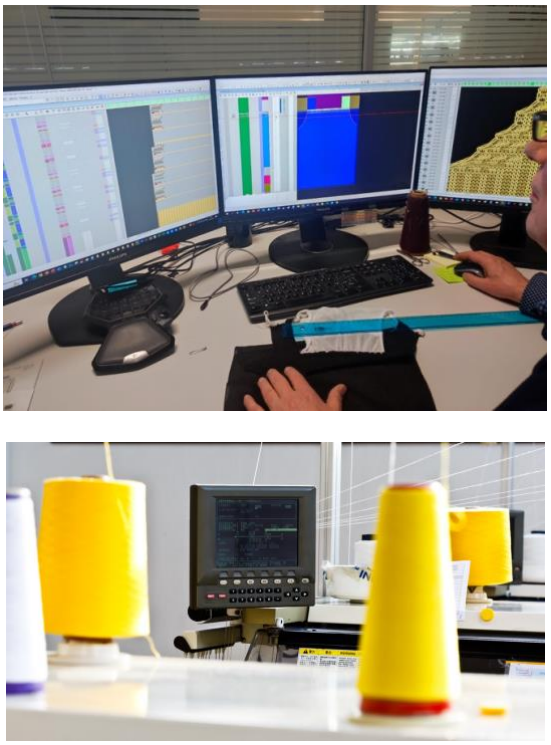
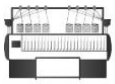


Fig. 3-4. A programming workstation operated by a programmer technician that is checking the physical result on three diverse virtual environments on the screen.

Fig. 5. The sewing phase is made with linking machines that are still entirely manually controlled.

In the table below, this process is schematized, specifying the macro phase of the individual steps and what is the degree of automation and digitization in the phase.

Table 1. The phases and macro phases of the knitwear process and their degree of automation and digitization.

PROCESS PHASE	MACRO PHASE	DEGREE OF AUTOMATION AND DIGITIZATION
 COMPUTER PROGRAMMING	KNITTING	HIGH
 YARNS & MACHINE SETTING	KNITTING	LOW
 MACHINE KNITTING	KNITTING	HIGH
 KNITTING QUALITY CHECK	KNITTING	LOW
 WASHING	FINISHING	MEDIUM
 IRONING	FINISHING	LOW
 MEASURE CHECK & TAILORING	SEWING & TAILORING	LOW
 EMBROIDERY & EMBELLISHMENTS	SEWING & TAILORING	LOW / HIGH*

* Depending on the type of embellishment selected, there are either highly automated machines that are fully part of Industry 4.0 or, on the contrary, processes still in use today that are totally done by hand.

So, to summarize, the knitting phase and all the operations connected to it have been disrupted by the advent of both analogue and digital technologies. On the other hand, the sewing and tailoring part remains largely, not to say in its entirety, an artisan activity. This is also reflected in the corporate structure of the companies offering such services. While on the one hand knitting facilities are very high-tech companies, with large amounts of capital invested in hardware and software technology, on the other hand, garment sewing companies are typically structured as craft businesses.

In knitting plants, the personnel must constantly attend refresher courses to keep up to date with innovations in the industry, requiring increasingly specific basic computer training; on the contrary in garment factories knowledge is passed on by the old artisan method of apprenticeship and quality standards are often left to the interpretation and experience of the individual worker.

The industrial laundry facilities deserve a separate mention. In fact, if they are not integrated within knitting companies (which is quite common following the weakening of the textile industrial districts in Italy), they can be described as artisan companies where sophisticated and highly digitized industrial washing technology can be found. To better understand the phenomenon, consider washing technology as state-of-the-art computerized machinery where washing recipes are saved on servers, and computers manage the parameters relating to the quality of water and the chemicals used.

So, as it emerges from the above examination, archetypes of Industry 4.0, such as the digitalization of processes and the convergence between physical and digital environments, can be envisaged as featuring elements in the knitwear industry. However, as will be examined in the following section, several aspects of the emerging Industry 5.0 are contained in the knitwear business *in nuce*.

3 The challenges of Industry 4.0 for the knitwear sector

We have seen how in the knitwear industry there is a fertile dialogue between technology (textile machinery) and craftsmanship (sewing, tailoring and finishing) that can be traced back to what Richard Sennett examined in his essay The Craftsman [12].

Sennett frames his point of view as adhering to the American Pragmatism heritage, representing the work of the craftsman in a dialogical relationship between hand and head and thus in an intimate connection between concrete practices and thought. This relationship is realized in the acquisition of supporting habits, which, according to the author, create a rhythmic movement between problem-solving and problem-finding.

It is worth noting that the term 'craftsmanship' is used by the author in the broader sense of technical work. Thus, in his view, the craftsman represents in each of us the desire to do something well, concretely, for ourselves. Today's technological developments and the resulting opportunities, far from being associated with the risk of depersonalization of work, can integrate a virtuous model of technical work similar to that which was carried out in the craft workshops of the past taken as a model by Sennett. Continuing his reasoning, Sennett also argues that all skills, even the most

abstract, originate as bodily practices. Consequently, technical craftsmanship is a practical skill obtained through practice and through the repetition of movements that enable its assimilation and refinement.

Hence the research question at the heart of this paper: how can the grafting of technology, digitization and interconnection of processes reshape the design activity of knitting and ultimately its aesthetic reach?

As previously stated, the use of certain technologies and the ongoing process of digitization bring with it the risk of abandoning craftsmanship as we have known it up to now, offering possibilities to go beyond manual activities. Consider, for example, the digitization of a product's design including 3D rendering to replace the physical prototype. These are certainly challenges facing the contemporary craftsman, who has often found himself unprepared and disoriented.

However, one should not, from these premises, demonize the presence of technology in the manufacturing sector as such. On the contrary, the aim of this paper is analyzing the phenomena underlying digitization to find new practical applications to the manufacturing sector under consideration, that of knitwear.

So, the field must be cleared of the doubt that technology is not negative in itself. However, it can take on negative connotations when it deprives its users of a manual, concrete, and repetitive apprenticeship. Some programming systems, such as CAD, entail a risk of separation between head and hand, which can result in an inhibition of the kind of learning that takes place through manual drawing. Widening the vision to computerized media and technology, we can see how these have redefined workplaces and workflows, allowing people to interact in new digital spaces and create products by acting in intangible environments. However, in the case of the manufacturing sector (in which knitwear is fully included), this integration is challenging as very concrete and restrictive production logics are followed [20].

With the advent of Industry 4.0, some of the distinctive aspects of the manufacturing sector described in the previous section have been problematized.

In particular, if we focus on knitwear, there are certain aspects in which the greatest criticalities are concentrated. There are five in particular that we can report here as having changed over these digital transformations.

a. Possible exclusion of actors traditionally active in the supply chain.

Within the organization of the Italian knitwear production districts, there are many small companies in which the artisan competence consists of a part of the whole process. These companies do not have the structure and skills to support a digital transaction and would therefore cease to exist if forced to do so.

b. Globalization as a possible element in the crisis of the traditional structure of Italian manufacturing districts.

If, on the one hand, the possibilities offered by digitization processes to delocalize and detangibleize certain phases of the production process (think, for example, of the programming and 3D rendering phases) democratize and enrich industry by involving

subjects even far removed from the production district, on the other hand they undermine the very concept of the production district.

In fact, the production district that loses the proximity of programming know-how with the subsequent phases of production would be completely devoid of sense and competitiveness.

c. Risk of less finished products, lacking craftsmanship, depersonalized, and mass-produced

As stated by many authors [21][22][12][23], the repetitiveness of the artisan gesture is a method to assimilate the technique, enter into dialogue with the creative process and ultimately create better, more refined, and long-lasting products. In the knitwear industry, the use of digital design technologies, while allowing a pattern to be modified on screen in a much quicker and more accessible way (and with less material waste) than a traditional physical model, carries the risk of less attention and thought. The image on the screen is often inconsistent with reality; it is a simulation that often deludes a result in terms of fit but, above all, feel. In addition, the separation of head and hand also risks having a social impact, as workers who have the task of putting their hands on the design have no way of using their experience to highlight critical points on computer-generated boards.

d. The availability and speed of digital has facilitated plagiarism and diminished efforts towards innovation.

Through digital technologies, it becomes much easier to copy products, and therefore there is a risk of market standardization. Furthermore, if we ask ourselves what drives innovation in the textile sector, we certainly encounter the creativity of the craftsman, the archetype of Made in Italy. This is often expressed as the need to find new solutions, to innovate products through their improved manufacture.

It is therefore evident that there is a risk that this capacity, which has always been recognized in Italian knitwear above that produced in other countries, will be diminished as a result of the digitization processes described above.

e. Knitting programming technology as a potential barrier to design.

As mentioned in section 2, technology has become a predominant part of knitwear companies, and the professional figure of the knitter has changed from that of a craftsman with manual skills to that of a software programmer [17]. This process of digitization makes it possible to produce highly refined and creative products that would have been unthinkable using manual production techniques or mechanical looms. However, this phenomenon has also introduced a technological 'barrier' between the designer and his request that can only be realized through a software programmer, with whom there is a distance of visual, cultural and technical languages. The creation of this barrier has led to the creation of a new professional figure, that of the product developer who stands between the designer and the programmer in order to bring their prerogatives into an effective dialogue.

This working approach, therefore, implies a dialogical distance between the actors in the chain, who will have to operate according to common languages that have yet to be defined and are, consequently, not easy to implement.

In the light of these considerations, it cannot be overlooked that also in knitwear, the skills to be possessed include both tangible and intangible aspects.

This is the case in the development of the first phase of prototypes where the ability to operate in a digital environment and at the same time to model garments on a mannequin (so-called moulage) is required for the programming part of the textile machines. Another explicative example of the coexistence of these two souls is the ability, essential in knitwear, to build a reciprocal relationship with materials and their physical properties - tactile and visual. very important in the world of knitwear and textiles in general is to imagine both the aplomb of a garment to model its wearability, but also its tactile aspect, possibly by putting the two components in relation to each other.

From all the above, it emerges that it is crucial to maintain a relationship of mutual collaboration and influence between craftsmanship and technology, a balance that also underpins the transition to Industry 5.0.

4 Conclusions: the balancing factors of Industry 5.0

On behalf of the above considerations on the critical issues that the knitwear industry is facing with the Industry 4.0 and on the envisioned features that will characterize the upcoming Industry 5.0, the authors tried to hypnotize a balancing factor for each one of the exposed problems.

Table 2. Critical factors of Industry 4.0 and the respective balancing factors foreseen with Industry 5.0.

Knitwear Industry 4.0	**Knitwear Industry 5.0**
Effort in implementing digital-programming tools and advanced machinery to automate the most of the process.	Return to value human engagement and to enhance human skills in controlling digital environments and relate with power machines.
The most competitive asset for companies was a strong economic investment in technologies with consequent suffering of smallest artisanal realities.	The most competitive assets will be innovative solutions for a effective collaboration between people and technologies that creates new space for small artisanal realities.
Effort in fully transferring the physical objects in digital environments with virtual prototyping, 3D modeling, digitization of yarns to anticipate the final result.	Return to value the human physical interaction with the material in the real world as a support for and with the support of software and machines.

Debasement of personnel intervention due to the progressive reliance on the autonomy of smart technologies.	Return to value the expertise of people in controlling machines and creation of new professional figures able to mediate between the digital and the physical world.
The complexity of knitwear advanced technology created a barrier between the moment of creation and the moment of making, that prevent dialogue between designers and technicians.	A stronger human presence together with shared digital skills can reconnect designers and technicians, bringing benefits to knowledge exchange and innovation processes.
Loss of the manual reiterative gesture that refine the product, loss of the opportunity to personalize or customize product.	Perfection, personalization, and customization are available, allowing each product to be improved and tailored by manual interaction with the machines.
Delocalization and detangibleization of some production phases that jeopardized the processes of knowledge exchange within the industrial district.	Return to value proximity and presence as channels through which human expertise can be shared, and at the same time exploit digital channels to enhance and systematize cultural exchanges.

It must be said that each of these balancing factors cannot be addressed with an approach that is exclusively utopistic and optimistic. They are not ready-made solutions, but goals to reach with renewed efforts: the challenge today is indeed represented by the "how" each challenge will be addressed and by the "what" should be the updated approach to address them.

One of the possible answers is anticipated by [24], when he recalls the concept of responsibility towards the work, which is today disintegrated by the overcoming of technology on human thinking. Technological updating must not be aimed at replacing people, but at integrating them into the activity, allowing them to reacquire that responsibility. In this regard, knitwear is a privileged context, as human intervention remained fundamental even with the most up-to-date technologies: the variables of a knitted product are so many that it is still impossible to delegate choices entirely to computers and machines, and consequently human responsibility have kept its importance –even if it lost its centrality–, maintaining an advantage when we envision its return.

Moreover, in creative and cultural industries this responsibility takes the unique trait of being shared, as the value of the project is not individual but collective, and results from personal interactions. When industrial changes happen in such fields, they always modify not only processes but also the relationships, spaces and skills required for workers who progressively revolutionize their way of operating and relating to other people and with the equipment [7]. In knitwear, we have seen how the dramatic advancements in software and machinery have brought to an excessive specialization of the technical roles and has blocked the dialogue among professionals, who found themselves deprived of the benefits coming from the sharing of a common language. If Industry 4.0 jeopardized the connecting nodes

between people, environments, and technologies, today the human factor, the interrelation between humans, and their collaborative work in dialoguing with technologies represent the most desirable and valuable solution for the future but also one of the greatest challenges for the sector.

Another element to consider is the relevance of craftmanship, in a context where the craftsmen action is the one that activate decision making when touching the yarn, checking the fabric, feeling its thickness, controlling every single stitch, monitoring the progressive creation, often in a physical and reiterated contact with the garment that make the actions dense and meditative. Therefore, the manual experience in the physical environment should resume its role as the basis of learning processes and, once on the workplace, should be enhanced as a complementary moment to the use of technologies.

The renewed approach should thus include human responsibility towards the work, collaboration and dialogue, direct relationship with the physical dimension of projects, and critical thinking as a fourth element: being this another ability that is exclusively human and that lost some relevance under the enthusiasm for technology and artificial intelligence, we must go back in training and nurturing it, to preserve human problem-solving skills and value-adding human creativity.

These are the levers that can help the knitwear sector to preserve its heritage of human craftmanship and to get the most out of the speed, productivity, and efficiency of robots. This reflection, even when transferred from the specific case of knitwear to a wider context, opens a wide space for research in preparing a fertile ground for people and for companies to welcome the upcoming change, and in studying the balanced set of skills that should constitute the cultural and professional baggage of future workers.

Once overcome the idea of a pervasive technology and the coincidence of the concept of future with the one of automation [24], the Industry 5.0 will find new space for human, artisanal, and manual culture to create a new way of thinking and making that moves transversally between the two worlds by combining their diverging strengths.

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