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Title: Assuring a human-centred transition to Industry 4.0 in the textile-clothing sector

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Abstract

In France, the textile-clothing sector is one of the most affected by the relocation phenomenon ongoing since the 1960s and has been greatly impacted by supply disruptions due to the COVID-19 pandemic. This research proposes using 4.0 technologies to promote the relocation of textile production in France while keeping people at the heart of the industry. This paper first explains the "human vs machine" paradox by analyzing previous research on human responsiveness to Industry 4.0 technologies and then presents the study case results with a collaborative robot (cobot) within a clothing workshop. The case study allowed the understanding of human needs in Industry 4.0 and contributed to a successful improvement in productivity. The article concludes by highlighting good practices for human management to have a successful application in 4.0 projects.

Keywords

Industry 4.0, Human Factor, Cobot, Textile-clothing Industry

1. Introduction

The textile-clothing is one of the oldest industrial activities in the world [3][22]. Since the 1960s, French manufacturers have been moving their production tools to developing countries to reduce cost prices. The cost of production in these countries was much lower than in developed ones, this generated a new organizational scheme which follows a central/peripheral logic of maintaining noble value-added activities in France and moving low-value activities abroad [3][22].

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Owing to the delocalization of manufacturing and textile activities, many companies have disappeared, and many jobs have been lost, whether it be due to the partial relocation of the business or the complete cessation of this activity [3].

The textile sector has not evolved like other ones in terms of technologies due to the phenomenon of delocalization [3][9]. In the textile-clothing industry, mostly manual manufacturing significantly influences the selling price because it requires operators who are technically competent in sewing. The cost of labour was one of the main reasons that led to the delocalization of textile production. This production cost is the challenge that must be met today so that this sector can once again develop locally and offer local production [9].

To date, the problem of textile relocation in France is primarily linked to the inability of the local textile network to produce larger quantities [14]. According to INSEE data, there is a lack of resources and most industries that have partly maintained a local activity use subcontracting to obtain the finished product.

Faced with constant competitive pressure, manufacturing companies must offer productivity gains by increasing production to meet new demand or reducing direct and/or indirect costs. To do this, manufacturers seek to develop innovative products and services, or new ways of manufacturing them, requiring the teams to evolve their skills [26]. 4.0 technologies come to support manufacturers to improve the efficiency of production and maintenance operations, reduce production costs, improve the quality and customization of products, reduce hardship and Musculoskeletal Disorders (MSDs) in jobs and possibly win the challenge of competitiveness and relocation [21][28]. In this scenario, this paper presents a strategic business case that can be used by manufacturing organizations as a reference frame for a successful transition from traditional manufacturing to Industry 4.0.

2. Literature review

2.1. Industry 4.0 and cobotics

The fourth industrial revolution or Industry 4.0 is believed to offer exciting opportunities to address sustainability concerns in industrial operations [12]. As part of Industry 4.0, smart physical objects, decentralized subsystems, and even human components are seamlessly integrated into an interoperable and decentralized hyperconnected production system capable of adapting in real-time and autonomously to environmental stresses [6][12][23]. This intense focus on digitization and the implementation of technological advancements affects the structure and performance of work in industries [23]. According to Xu et al. (2018), one of the main goals of Industry 4.0 is a cooperation between machines and humans. In this context, collaborative robots, which are the origin of the term cobotics, very quickly became a technology of the 4th industrial revolution [7].

Cobots enable human-machine interactions in the manufacturing sector [17][27]. They represent a new generation of industrial robots that do not require a fence or protective enclosure, opening borders and workspace to cohabitation and collaboration with humans [2][17]. Equipped with sensors and very responsive to detections of any unexpected force, cobots can stop immediately when they encounter humans or objects [17].

Even if 4.0 technologies are often integrated to increase efficiency, competence and competitiveness against competitors [31], the associated human factor should not be neglected [2]. Longo et al. (2017) say that Industry 4.0 is most easily implemented through an incremental evolution process whose main dimensions are automation and intelligence: the product, the machine and the operator are central paradigms. For Longo et al. (2017), as Industry 4.0 takes shape, human operators must perform increasingly complex daily tasks: they must be very flexible and show adaptability in a very dynamic work environment. According to Kadir & Broberg (2020), the reaction of humans to new technologies and mainly the resistance to change are essential factors for the successful implementation of Industry 4.0.

2.1.1 Human Factors and issues related to cobotics

Robots are seen as a solution to workforce challenges in the industrialized world [7][17][27]. However, if it is to be used by human actors, it must also be accepted by them. According to Heerink et al. (2009) technology acceptance, user non-adaptability and social influences remain sensitive issues. To measure this acceptance, Heerink et al. (2009) created a questionnaire model that takes into account human feelings when using technologies.

Longo et al. (2017) advise on how to succeed in an Industry 4.0 project with the implementation of project management to secure each stage and control all its dimensions: human, organizational and technical. Longo et al. (2017) also proposed an integrative approach to enable human resources to become the centre of gravity of Industry 4.0. The considerations made by the authors served as an inspiration to create a clean way of integration adapted to the industrial environment and the human resources of the company in this study case. The objective was to support employees by providing the appropriate training on the use of a cobot and information that is not generally available: suggestions on how to increase productivity, the planned maintenance operations, and warnings on the dangers and the risks likely to happen. To do this, a questionnaire inspired by the study of Heerink et al. (2009) was developed. Following the questionnaire, a presentation of the system was made. The methodology used is presented in the next section.

3. Methodology

Since the beginning, the cobot has been brought close to everyone in the sewing workshop. This was intended to encourage operators to adopt the technology without forcing them to change their work habits. The first configurations and settings were carried out by internal staff in full view.

These implementation steps were considered the first qualitative measurement of acceptance inspired by the study by Heerink et al. (2009). The main objective was to create a social presence link when interacting with the system and to verify the interest shown by employees in using the cobot according to their level of interaction with the teams in charge of its implementation.



3.1. Definition of the priorities and implementation of an automated station

After commissioning the cobot with all the necessary tools, and having studied all its functionalities, we analysed the opportunities for automating the workshop. We first focused on low value-added or repetitive positions that do not require huge expertise. According to Biétry & Creusier (2015), the factors of well-being at work are directly linked to the feeling of personal efficacy, the satisfaction felt about the tasks performed and feelings of commitment. Positions with low added value do not fit into its definitions and have been targeted as factors of ill-being at work. We, therefore, chose the station for cutting the belts of the boxer briefs. This time-consuming and repetitive job was likely to generate longer-term MSDs (Figure 2).

Although the UR5 is a collaborative robot, we decided, as a first step, to automate the cutting operation. The objective was always to test the acceptability of this new technology, to increase user confidence (the belief that the system works by ensuring personal integrity and that it is reliable) and to demonstrate the security of the use of the cobot before proposing human-machine interaction.

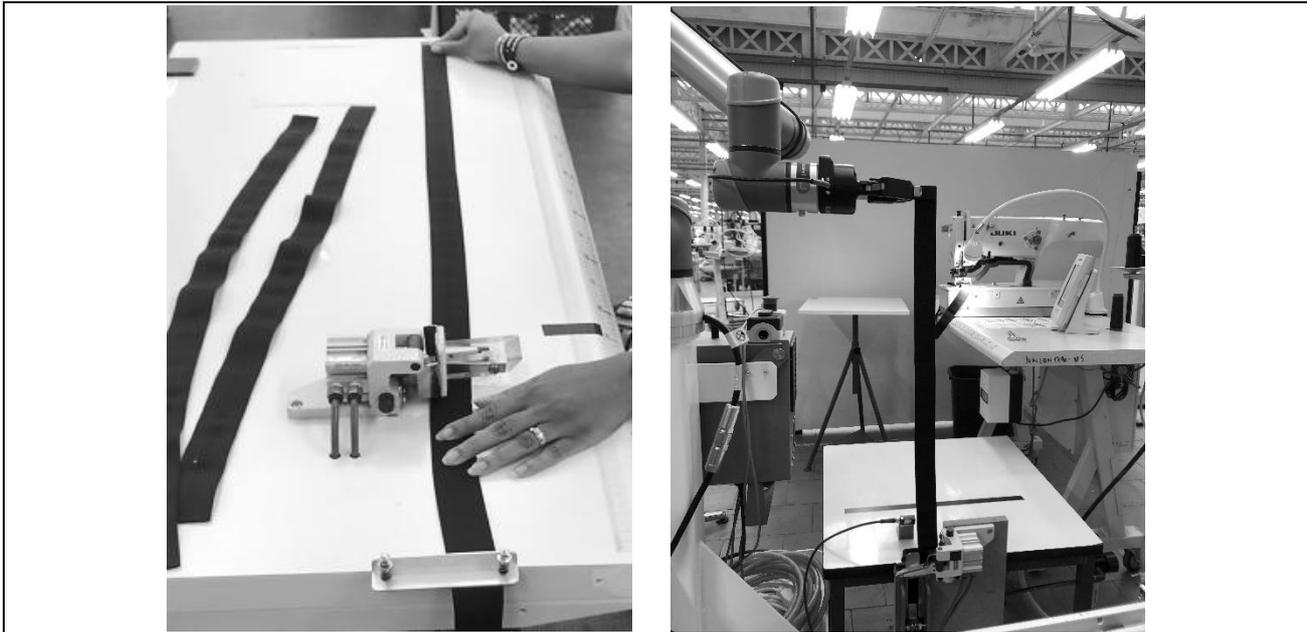


Figure 2. Old cutting station vs automatic cutting station

3.2. Acceptance questionnaire and protocol used

We were inspired by the work of Heerink et al. (2009) to develop two questionnaires (anonymous) to understand the feelings of staff on the cobot. The questions asked were considered during a brainstorming by a group of 6 people, each linked to a different department of the company to allow the most global vision possible. The desire was not only to assess anxious reactions to the use of the cobot but also to create a link between the sewing operators and the cobot. Given the fact that the French textile industry has very painfully experienced the disappearance of thousands of jobs over the years [3][22], a fear on the part of operators for the establishment of automation technologies within the clothing workshop which historically and still today is very manual, was inevitably expected. The questionnaire was therefore developed in a friendly tone, referring to the cobot as a “new colleague” and as a solution to reduce tedious and repetitive work. Precautions have been taken to not present it as a technology that is put in place to reduce jobs, which is not the case, but rather as a concrete desire to make staff aware of the potential for collaboration that could be developed with this type of technology.

The first questionnaire was applied without any prior presentation of the automatic station to know the priorities of the employees and measure their knowledge of cobotics. With these results in hand, we conducted a tailor-made presentation of the automatic station to answer questions, introduce the cobot and its systems and generate the confidence necessary for human-machine interaction in a collaborative station.

This confection workshop is divided into 8 groups, each responsible for assembling a class of products. The first stage of the event was the application of the first questionnaire, and then each group (about 15 people per group) moved to the automatic station to attend the presentation. The demonstration was followed by explanations about the new technology and the difference between cobots and industrial robots, a demonstration of the safety of the cobot in case of an

impact with a person or object and a demonstration of the automatic cutting. At the end of the presentation, the second questionnaire was applied.

4. Results

The two questionnaires were offered in paper format to all employees of the department. That day, 87 people were present. The first questionnaire was answered by 100% of the people and the second one (the feedback questionnaire) had a total of 75 answers (86.21%) of which 4 were not considered because they had a lack of precision (in single-answer questions, all alternatives have been marked, for example).

A few identical questions were asked in the first and in the second questionnaire to evaluate changes in perspective and understanding of the subject after the presentation. This is the case for the question "Do you think the cobot could physically hurt you?" which we can see in Figure 3.

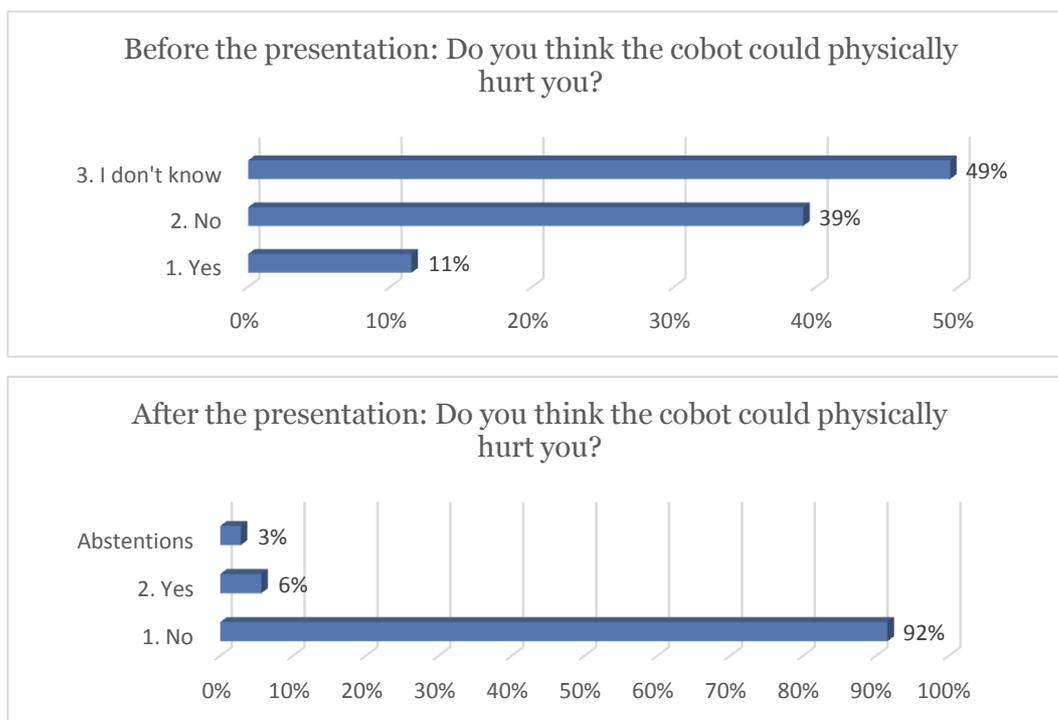


Figure 3. Results Before vs After presentation for the question "Do you think the cobot could hurt you physically?"

Before the presentation, only 39% of people answered that the cobot could not hurt them. After the presentation, the percentage of people who think the cobot cannot physically hurt them increased to 92%, which shows a gain in confidence in the system. Another question that had very satisfying results after the presentation was "Would you be willing to carry out missions where the cobot intervenes to help you?". We had barely 30% of 'Yes' answers in the first questionnaire. After the presentation, we only had two possible answers (yes or no). 76% of the operators answered that they were ready to carry out collaborative missions with this cobot (see Figure 4). This highly positive result was the determining factor for the implementation of the

collaborative workstation.

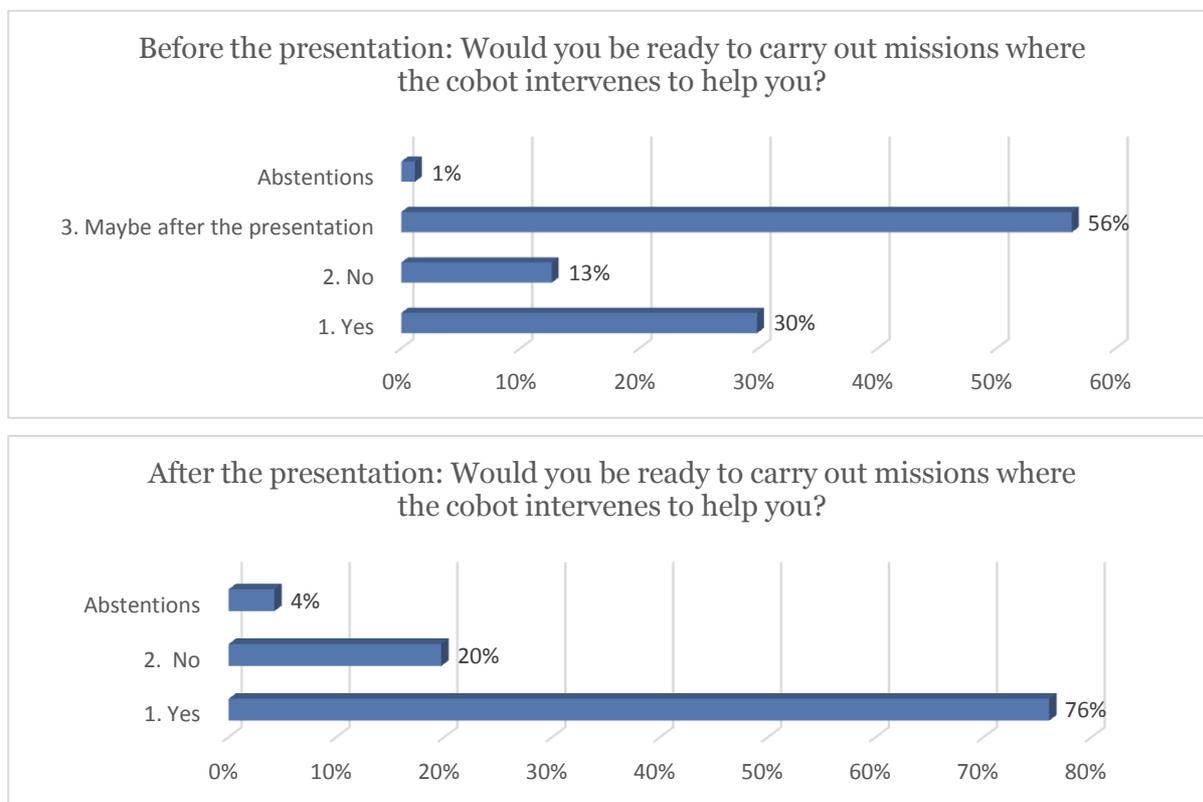


Figure 4. Results Before vs After presentation for the question "Would you be ready to carry out missions where the cobot intervenes to help you?"

It is also essential to keep in mind that the acceptability of the project by employees must be regularly assessed because it can evolve favourably or negatively. Thinking of this, we asked evaluative Industry 4.0 acceptance questions such as: "Do you think this kind of technology is important in a company like ours?" and "In your opinion, what will be the consequences if Petit Bateau does not adopt these new technologies (cobots)?", but also, technical questions such as: "What operation do you think this first cobot will be able to perform?" and "Do you have any mission ideas for a second robot or cobot?". These questions will be re-evaluated continuously throughout the use of the cobot.

According to psychiatrist Serge Tisseron, humans do not evolve as quickly as machines, but if there is a relationship of trust between the machine and the operator, acceptance is more quickly achieved. According to the psychiatrist, the more empathy you create through the robot, the more you feel confident and the more difficult it will be to undo the existing relationship [29]. Intending to create a social link and trust to facilitate the use of the collaborative workstation with an associated feeling of joy or pleasure, we asked the operators to personalize the cobot and choose a first name (male or female) for this "new employee". Among the various proposals, the most voted first name for the company's first cobot was Jorge.

4.1. The collaborative workstation and the economic results

After the good results of the questionnaires, we placed a sewing machine next to the cobot and modified its programming to offer the cut elastics directly to the operator. As expected, the collaborative workstation was well accepted by the staff, and it assured the complete production of boxer shorts for a whole confection group. Then, the profitability was calculated.

On the collaborative station, the cut is made at the same time as the sewing and there is no time transfer between the two stations, on the other hand, there is an addition of a few seconds at the start of the cycle so that the robot does its preparatory cycle (it cuts a small piece of the elastic and puts it in the trash to ensure a straight cut in production). The total time of the operation with the collaborative station was 5min20s, which means a saving of 18% of the time compared to a manual station for every 20 belts produced. In terms of monetary profitability, with this reduction in time, we manage to make a saving of 6% per product, which is verified directly in the sales margins. The productivity of this confection group also increased by 13% with the use of the cobot.

5. Discussion / Conclusion

This article presented a practical application of the deployment of a cobot, one of the technologies of Industry 4.0, while keeping humans at the centre of changes in a textile company. The acceptance questionnaire was a determining factor for the start of the collaborative workstation. From these results, we were able to identify the issues and complexities for the people who will work with the new technology daily and this knowledge will allow us to continuously check the well-being of the staff. The good results of the questionnaire allowed us to verify that the way the cobot has been presented since its arrival has influenced the open-mindedness of the employees and contributed to the success of the collaborative workstation.

The results of the collaborative workstation proved that technology acceptance, user adaptability and social influences remain fundamental issues for a successful transition to Industry 4.0. We have reduced the production time and consequently increased the profitability of the products, the efficiency and the productivity of the confection group concerned. The next steps in the deployment of this collaborative workstation are to support the well-being of staff and quantify the workload.

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