Exploring the implementation of Industry 4.0 technologies in the manufacturing industry: a qualitative study about the effect of collaborative robots on manual laborers' jobs

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June, 2024

ABSTRACT: Integrating collaborative robots in manufacturing settings can have repercussions on traditional manual labor tasks. This research explores the impact of cobots on manual laborers' tasks and roles, seeking to understand the role that HR can play to ensure a smooth implementation of cobots. Using a qualitative study approach, the data was gathered through interviews with industry experts and academic automation researchers. The findings indicated that introducing cobots in the workplace can bring many benefits for both the organization and employees, including improving efficiency and safety conditions, however, they lead to a crucial need for reskilling, upskilling, and deskilling of the manual workers. Moreover, despite the many motives mentioned to adopt these robots, there are several factors stopping companies from acquiring this technology, including change resistance, and lack of awareness of the benefits. This study confirms existing theories, contradicts others, and contributes new theories to the existing literature, by providing insights into the practical challenges and benefits that cobots can offer in the manufacturing industry. Recommendations for practitioners are provided, discussing HR strategies that facilitate a smoother implementation cycle.

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Keywords: Cobots, Industry 4.0, Manual laborers, Human Resources, Collaborative work

1. INTRODUCTION

1.1. Problem Statement

With the beginning of Industry 4.0, new methods of organizing production emerged, including technologies such as Internet of Things (IoT), AI, and machine learning, which results in a new manufacturing transformation era through digitalization. This transformation derives from seeking to increase automation in production processes as a way to enhance productivity and increase flexibility, amongst other things. With this industrial revolution, new technologies central to advanced automation are introduced, such as advanced sensors, embedded software and robotics, however, these are also capable of impacting the employment of workers (Mindell & Reynolds, 2023). Nevertheless, human work remains indispensable, leaving space for the opportunity to enhance and support the labor force through the use of these technologies (De Assis Dornelles, Ayala, & Frank, 2023).

The implementation of collaborative robots or "cobots" illustrates the fundamental principles of technology supporting workers in the context of Industry 4.0. As their name depicts, cobots are advanced robots designed for direct human-robot interaction within a shared space. These offer several benefits, including great mobility due to their light weight, flexibility to perform a variety of tasks, and great computing capabilities attributable to their user-friendly programming interface (Collaborative Robots And Industrial Revolution 4.0 (IR 4.0), 2020). Additionally, in contrast with industrial robots, which can often be heavy, rigid, and possess an isolated workplace, cobots can safely share a physical space with human workers, while also assisting them in their tasks.

Nonetheless, existing literature mainly focuses on the acquisition and development of said technologies, meanwhile, only a select few studies touch upon the impact of collaborative robots on the traditional tasks of manual laborers (Neumann et al., 2021). As the nature of industrial manufacturing work follows a different paradigm, from that of knowledge work, the transformation of work when previously mentioned technologies are implemented, varies from the changes in corporate knowledge work. In other words, the transition for manual laborers departs from working with machinery to working with information technology (Hullman, van Vuuren, & Bondarouk, 2023). Additionally, most of the existing literature has focused on knowledge workers, hence most theories relate to the effect that these technologies have on said type of workers, making it unclear if these apply to manual laborers, as jobs, tasks and norms in manufacturing are different from those of knowledge work. Consequently, it is hard to understand the organizational implications of this transformation, creating a knowledge gap for Human Resources practices when it comes to ensuring a successful implementation of collaborative robots in manufacturing settings.

1.2 Research Objective

This research aims to explore the implementation of collaborative robots in the manufacturing industry, focusing on the impact this technology has on manual laborers and their job roles and tasks. Seeking to understand how Human Resources (HR) departments can ensure the smooth implementation of collaborative robots, through understanding what resources are essential for laborers' adaptation to and adoption of cobots.

1.3 Research Question

-How does the integration of collaborative robots impact the traditional roles and tasks of manual laborers?

2. THEORETICAL FRAMEWORK

2.1 Human Resources and Industry 4.0

Industry 4.0 has been defined in many ways, but essentially, it refers to the transformation of manufacturing through digitalization. This revolution, also called "smart industry", combines interoperable software, hardware, and connectivity technologies, aiming to create new methods that increase the automation of processes, and consequently lower production costs. The start of the fourth industry means a change in both the "product", and the production processes, therefore causing modifications to the business model of organizations (Erro-Garcés & Aramendia-Muneta, 2023).

Put differently, this industrial revolution brings the integration, interactivity, and interconnection of production processes in the manufacturing industry, all made possible by previous industrial revolutions, and the Internet of Things (IoT) (Beauchemin et al, 2022). In this context, it becomes critical for organizations to adopt these technologies as a means to meet their market demands. However, this industrial revolution also introduces the need for human-machine cooperation, in this way affecting organizations' human resources, and their leadership style (Erro-Garcés & Aramendia-Muneta, 2023).

That being so, organizations not only need physical and virtual resources to transition to Industry 4.0, but digital skills relevant to the new technologies should also be present. This highlights the importance of upskilling workers, unveiling a need to implement skill development strategies that enable workers to interact with and learn about said technologies (Marinas et al, 2021).

2.2 Collaborative Robots

With the introduction of Industry 4.0, and an increasingly dynamic market requiring rapid and timely responses from organizations, flexibility became a key factor in production processes and manufacturing. This is where robotization emerges as a crucial development for the manufacturing industry (Liu et al, 2022). Nonetheless, human workers continue to be relevant for traditionally manual activities such as order picking or quality control, hence, it becomes vital to redesign these work tasks into collaborative human-robot tasks, symbolizing the transition towards a more human-centric industry revolution, also known as Industry 5.0 (Pasparakis, De Vries, & De Koster, 2023).

Collaborative robots or "cobots" emerged as the technological development designed to support human operators in a shared workspace. These robots aim to help their human counterparts perform dull, dangerous, or dirty jobs by utilizing the productivity robot automation offers, along with the flexibility humans offer when it comes to decision-making processes (Zhu et al, 2021). The workload of a task can be broken down into sub-tasks, which in turn can be allocated to the human operator or a cobot, depending on the requirements and capabilities needed to complete the task successfully. For example, humans thrive on cognitive capacities and adaptability, whereas, cobots are great at repetitive activities, precision, and heavy lifting, making them useful for tedious and less ergonomically sound tasks, including rapid heavy pick-and-place operations, material handling, quality assurance, and verification processes (Salunkhe et al., 2023).

In contrast with industrial robots, cobots are light in weight, offering great mobility in factories, they can be used to perform multiple tasks, and they are easily programmable, which results in a user-friendly interface even for users who do not possess a programming background.

Amongst the benefits of cobots, enhanced productivity is one of the most important, as these robots can take on small tasks that add to the overall speed of a process, and that were previously not considered when automating job tasks. Additionally, cobots decrease the large concern that robotization might replace human labor, as they add value to existing jobs instead of demoralizing the workforce (F. Sherwani, Asad & Ibrahim, 2020).

2.3 Changes In Job Tasks Due To Advanced Technology Implementation

As digitalization and automation of processes continue to spread across the manufacturing industry, the nature and organization of human work are also reshaped by this. With the introduction of Industry 4.0-related technologies, traditional job roles are redefined due to tasks becoming more highly automated, which consequently, creates a new wave of jobs with new skill sets and evolved competencies (Marlapudi & Lenka, 2023). For organizations, this is a disruptive change in their business models, thus also impacting every job's efficiency, skill requirements, and day-to-day content (Mourtzis, Angelopoulos & Panopoulos, 2023).

Essentially, machines cannot do the full range of tasks humans can do, which contradicts the belief that automated systems are replacing workers. On the other hand, digitalization can make certain tasks obsolete, but it can also redefine existing tasks, and create new tasks for human labor (Waschull et al., 2022). In other words, the implementation of cobots can have side effects on workers' skills, such as deskilling, reskilling and upskilling.

Deskilling is defined as reducing the level of skill required to carry out a job, in this case, the ability of cobots to perform repetitive efforts and movements can alleviate ergonomic issues for workers, as well as allow them to serve multiple stations simultaneously, leading to a reduced cycle time, and decreased number of tasks carried out by humans. On the contrary, the introduction of cobots can lead to the enhancement of workers' qualifications by teaching them new skills, also known as reskilling. This technology pushes workers through a transition towards more cognitive tasks, such as programming, control, and supervision of cobots, involving higher levels of complexity, decision-making, and creativity (De Assis Dornelles, Ayala & Frank, 2023). In other cases, creating a work environment, where cobots support workers in executing manufacturing activities more effectively, can push the need for learning additional skills, leading to upskilling as a side effect of automation.

This industry shift requires technological skills, as well as an organizational assessment of the tasks being affected by automation. Therefore, organizations need to elaborate training and development programs for their workforce, to embrace Industry 4.0 in a socially sustainable way (Romero et al., 2016). As technological change often brings positive and/or negative effects on work design, human work sees a shift to more complex jobs, strongly affecting the skills and knowledge requirements of jobs, hence, upskilling is needed, making training and learning key elements in the transition to more automated workplaces (Waschull et al., 2020). This makes it possible for organizations to benefit from the smart machines' strengths and capabilities, in addition to empowering their employees with new skills and knowledge, that can capitalize on the opportunities offered by the fourth industrial revolution.

As a consequence, it becomes crucial to design a vision and strategy to approach the implementation of Industry 4.0 technologies. Veile (2022) emphasizes the importance of a favorable company culture and management support as a requirement for the successful adoption of said technologies. Furthermore, he categorizes building up sufficient resources and, guaranteeing the presence of capabilities needed, as fundamental strategic aspects needed, which aligns with the widely used dynamic capabilities theory in organizational theory, and that often leads to the utilization of the resource-based view framework, both concepts strongly focused on investigating the resources and capabilities existing within a firm.

3. METHODOLOGY

3.1 Research Design

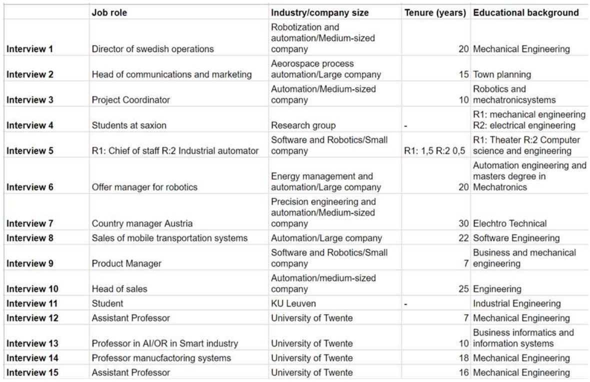
This research uses a qualitative study design, as it focuses on the exploration of phenomena, namely, the effect that cobots can have on manual laborers; through understanding how individuals experience said phenomena (Malterud, 2001). Qualitative research involves gathering and analyzing non-numerical data, focusing on experiences, perceptions, and attitudes (Patton, 2014).

This is study in interview-based, and the method used for data gathering was semi-structured interviews, as means to seek views on a focused topic (Hammarberg et al., 2016), while fostering a comfortable environment for open dialogue. The interviews explore essential aspects for the successful implementation of cobots, and were performed with individuals close to the research topic.

3.2 Data Collection

The interviews were conducted with 17 individuals with a total of 11 professional backgrounds (see Table 1). The respondents were chosen from different environments, 13 of them were found through professional networking at the Hannover Messe of 2024, which is a prominent industrial technology trade fair; the other 4 respondents were academic researchers at the University of Twente. Consequently, the interviews provided a diverse set of perspectives, from both industry practitioners and academic experts. Additionally, according to Hennink et al. (2016), nine to seventeen individual interviews are needed to reach the point at which no new information is identified, or also called saturation, which was used to lead the conclusion of the interviews.

Table 1. List of interviewees



	Job role	Industry/company size	Tenure (years)	Educational background
Interview 1	Director of swedish operations	Robotization and automation/Medium-sized company	20	Mechanical Engineering
Interview 2	Head of communications and marketing	Aerospace process automation/Large company	15	Town planning
Interview 3	Project Coordinator	Automation/Medium-sized company	10	Robotics and mechatronicsystems
Interview 4	Students at saxion	Research group	-	R1: mechanical engineering R2: electrical engineering
Interview 5	R1: Chief of staff R:2 Industrial automator	Software and Robotics/Small company	R1: 1,5 R:2 0,5	R1: Theater R:2 Computer science and engineering
Interview 6	Offer manager for robotics	Energy management and automation/Large company	20	Automation engineering and masters degree in Mechatronics
Interview 7	Country manager Austria	Precision engineering and automation/Medium-sized company	30	Elechtro Technical
Interview 8	Sales of mobile transportation systems	Automation/Large company	22	Software Engineering
Interview 9	Product Manager	Software and Robotics/Small company	7	Business and mechanical engineering
Interview 10	Head of sales	Automation/medium-sized company	25	Engineering
Interview 11	Student	KU Leuven	-	Industrial Engineering
Interview 12	Assistant Professor	University of Twente	7	Mechanical Engineering
Interview 13	Professor in AI/OR in Smart industry	University of Twente	10	Business informatics and information systems
Interview 14	Professor manucfactoring systems	University of Twente	18	Mechanical Engineering
Interview 15	Assistant Professor	University of Twente	16	Mechanical Engineering

The 15 interviews were guided by an interview guideline of 10 questions related to cobot development and implementation. The questions were obtained and tailored from a previously established set of questions found in an article by De Assis Dornelles et al. (2023) that investigated a topic closely related to the focus of this study. The original article provided a comprehensive framework that effectively addressed key aspects relevant to the impact of collaborative robots on manual laborers' skills.

Lastly, participants were informed about the research purpose behind the interviews, and how their statements were going to be used to complement this study. Moreover, all participants were asked for verbal consent to audio record the interviews.

3.3 Data Analysis

The data collected through the interviews was transcribed and analyzed with a thematic analysis approach. This method is used to analyze qualitative data, with the goal to identify, analyze, and report repeated patterns (Braun and Clarke, 2006). The goal was to provide a full picture of the topic, not focusing only on the effect of collaborative robots on manual laborers, but also on what can be done to ensure a smooth implementation of such technology.

The data analysis tool ATLAS.ti, was used to generate the codes used to create the relevant themes. The themes were: Cobot characteristics, Cobot development, Motivation for adopting cobots, Implementing cobots, Cobot's consequences, Cobots and humans, and Changes in skills. These were then aggregated in 2 dimensions: Cobot design and characteristics, and Cobot implementation (see Figure 1 and Figure 2).

4. FINDINGS

These findings are the culmination of a careful investigation into Collaborative Robots' implementation and the effect it can have on manual laborer's jobs. The findings will be divided per second-order theme to investigate the results, providing a detailed explanation of the key assumptions found. Together, it will help answer the research questions formulated in this paper.

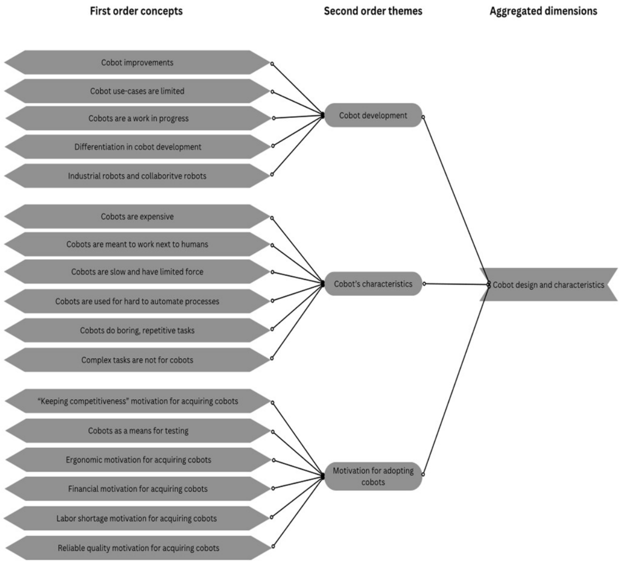


Figure 1. Cobot Design and Characteristics dimension

4.1 Cobot Design and Characteristics

4.1.1 Cobot's characteristics

Cobots have features that ensure no collisions with the operators, meaning that they can work next to humans in the same workspace. It "[...] is really a robot that is tailored to work with an operator more as a colleague, so in that case, it eliminates the use of safety fences and it's tailored for collaborative work." (R12). Additionally, cobots were created to handle mundane tasks as one of their primary applications. As humans are often too intelligent to be doing these tasks daily, "[...] there's a saying, if you hate it, you automate it." (R3). Therefore, they are implemented in tasks that can be boring and of no value to humans, so it is "[...] not necessarily the human assisting the cobot in its work, but more like the cobot assists the human in their simple, repetitive, tedious tasks." (R4.2)

Another expert expressed that: "you use co-bots where you have to automate or guide a process that is actually inherently very hard to automate." (R3), meaning that cobots are often chosen as a flexible option for automation. Some processes are too complex to be fully automated or need the supervision of a human to ensure that the process is being carried out properly, hence, cobots are a good option, as their " [...] design is different from standard industrial robots. It doesn't have any sharp edges, it's lightweight, and also has integrated safety functions like collision detection, limited speed, limited force, and hand-guided operations. Such kinds of things make it possible to work in the same environment -with humans-." (R6).

On the contrary, collaborative robots also have some disadvantages. The interviews revealed two primary problems. First, collaborative robots are not useful in every type of task, one expert gave an example: "if you have a task where you need to pick a piece, decide where it has to be put, put it there, then get a screw, drill a hole, put the screw inside, then measure the screw and paint it, this is something a cobot can't easily do, it's way too complex." (R2). This shows that the scope of work that can be done by a cobot is still limited.

Second, cobots themselves are not necessarily expensive, however, they "[...] need to equip it with a lot of sensors so they can keep a safe distance from humans, and they need more advanced AI technologies to detect the object" (R13), as well as how it was expressed by another specialist: "the cobot needs eyes, what do we do? We have a laser system, we have a camera system, we have a software in between, sometimes we may even need some AR (Augmented Reality) to detect things, so this is a lot of cost that makes the cobot suddenly more expensive again, the cobot arm itself might be cheap but the whole system that works in the industrial process can become very quick very expensive." (R2).

4.1.2 Cobot development

The reasoning behind developing cobots seems to stem from the need for flexibility in certain processes, which full automation does not always allow for. "[...] For example, for precision assembly, you still need the flexibility of humans. Then the industrial robot doesn't fit in this environment. You really need something that could support with more flexible capability and in a very safe way" (R15). However, as these robots have to be safe enough to work in the same environment as humans, their use cases can be limited, one expert explained: "Much manual work is done fast and needs sometimes a certain amount of more force -more than cobots have-. The human can do it because he recognizes that it can do it in a way that it won't hurt anybody, the cobot cannot because it's restricted, and this is something that prevents us to apply it in many processes." (R2).

Fortunately, "the payload for cobots and their reach are getting bigger" (R1), so there is hope that in the future, many more manufacturing processes could benefit from this technology. Additionally, the interviews revealed that the hardware development for these robots is quite mature, having a lot of improvements in robot programming as well, however, it "[...] is still a bit of a challenge how they can be applied, and also the ethics around it." (R12)

Lastly, one of the experts commented that cobot development does not move as fast as wanted, and this is due to a lack of differentiation between competitors, where most companies follow almost the same model when manufacturing collaborative robots. "[...] The main difference is going to be weight, how much they can carry. You can see … tiny co-bots and others have big co-bots. I would say, maybe end effectors as well. How do you attach an end effector to a co-bot, what kind of end effector do you attach, and for what reason" (R5.1).

4.1.3 Motivation for adopting cobots

The interviews revealed that companies decide to adopt collaborative robots due to 6 main reasons. First, one factor was spoken about by almost all experts, namely, the shortage of skilled workers. "[...] companies are not able to find skilled labor anymore and then they go to cobots, then the economic side of things goes more in the background, because if I cannot do it at all, then I rather spend the money." (R9). Most agree that is a matter of better resource management, "[...] and this time, the resources are people, we are facing a lack of people, and we need to increase their value, so, the efficiency of their work." (R8).

Second, a lot of companies are choosing to adopt cobots as a means to improve work ergonomics. As cobots offer the best of both worlds, automation, and human labor, they can be useful in processes that put a burden on the human and their overall well-being. For example, "[...] in palletizing, it can handle the heavy weights instead of a human picking and placing heavy weights like 10 kilograms or 5 kilograms" (R6). In addition, "[...] it cannot just replace work which is not ergonomic. It, of course, can also actively improve the ergonomics" (R14), this can be done in cases where the cobot takes over tasks like handling tools or positioning objects for the manual laborer to work on, and in this way, saving them from having to engage in physically straining movements.

Third, every business investment goes down to its financial benefits, hence, many companies base their decision on the benefits that cobots can bring in this area. Most of the experts agreed that despite cobots being pricey, most companies look for the "[...] return on investment and decide on that. They're like 'oh yeah, having a robot is much cheaper, in a year, you know, it's as if we had three people' -workers-" (R5.2), which, "[...] if you look in The Netherlands and in the west in general, labor costs are quite high and especially for technical skills" (R12), hence, cobots are presented as an option to reduce costs, not only labor costs but also those that come from safety regulations. One respondent explained that: "when they buy a cobot, it is certified for use, for being used as a cobot. They don't need fences, safety switches and so on, so they can open the work area and maybe get more productivity by using the open space" (R7).

Fourth, some of the tasks performed in manufacturing settings tend to be repetitive, this is something that humans do not excel at, where factors such as tiredness or changing workers can result in some deviation when it comes to the overall quality of the results. "[...] Reproducibility is an issue that comes to the quality, of course. The robot doesn't care for 8 hours doing the same thing, it will always more or less be the same quality in terms of, if you position something, the currency will always be the same" (R14). This pushes companies to opt for cobots as a way to improve the reliability and consistency of their product quality.

Fifth, as cobots are considerably safer than industrial robots, they are often used to test project feasibility. "[...] Mostly anything that needs to happen quickly because you can very easily, quickly test things. You don't need to worry about any safety features. You don't need to worry about remote programming. You can just get hands-on with them" (R4.2). Another expert also mentioned: "The second form is for prototypes. if you want to do some new development, then you can use cobots because they're very flexible. So you can program a cobot and cooperate with the operator to facilitate your testing process, testing a batch or prove your concept" (R15).

Finally, as most companies coexist in a rapidly changing business environment, they must keep up with the competition. Cobots are slowly becoming part of the automation trend, so "[...] it's actually the goal for companies to say "OK, you need to implement the cobots and then make your processes more efficient, so you can get a more competitive position in the market" (R13).

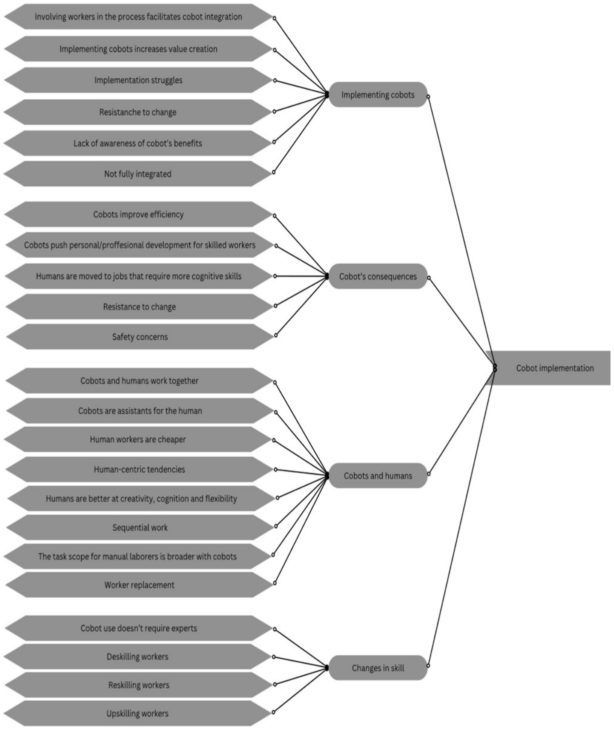


Figure 2. Cobot Implementation dimension

4.2 Cobot Implementation

4.2.1 Implementing cobots

When it comes to implementing cobots, a series of obstacles were mentioned. The lack of knowledge about the advantages of cobots was addressed as a foundational issue that stops many companies from acquiring them. The difficulty to see benefits in cobots was mentioned, as most companies are used to operating in certain ways, such as using industrial robots or traditional manufacturing, "[...] and they don't see the benefits in the newer ways" (R1). "[...] If you just roll that out on the shop floor and you don't inform the people about the benefits or maybe possible risks or challenges, then it will not work." (R3). This lack of awareness leads to change resistance, as companies were successful with the ways they have chosen before, it is "[...] what they're used to and people don't like change, so they try to continue with that." (R3). Additionally, it can cause resistance to change in workers, as it often can create "[...] the perception that is leading to job replacement, then you also have this cultural resistance in companies." (R12).

Then, a good implementation plan becomes crucial for successfully adopting cobots. Acquiring cobots is easy, "[...] however, the cheapest robot is worthless if it is not implemented in the right place and way" (R7). These robots can be a "[...] a nice solution for collaborative work, but the integration is a bit more challenging because there is a safety factor, so you really have to guarantee that this system is safe, and then also there is the trust issue, because as much as you tell an operator that a robot is safe it's still a machine" (R12). Consequently, there are still many cases where the cobot is still not fully integrated "[...] So, usually the robot still works autonomously without human workers, but maybe the worker is able to jump into the process and the robot will stop during some interactions" (R9).

It was also discovered that often times "[...] The people that are responsible for the processes or what machines are being acquired are not the ones that are in the shop floor. Especially in bigger companies, there is no real exchange there." (R3), which makes the integration of cobots difficult. Thus, the importance of worker involvement in the designing and implementation process was stressed, as it "[...] helps them with learning how to work together with the cobot" (R4.2). Additionally, another expert explained that: "it's important to create good use-cases, meaning something where from a practical and financial side, but also the work side, just makes everyone, company included, think "Oh yeah, that makes sense". In that moment, it's not just a cobot being there because it's a cobot, it just really makes sense to have it. So, I think that creates certain acceptance and awareness by itself and also makes the people realize "Oh yeah, that could be beneficial for me as a worker as well" (R14).

Finally, on a more positive note, a respondent mentioned that: "by applying the robot, you'll increase your value creation and profits, therefore you have more stable jobs, you don't have less jobs, you'll normally have more jobs." (R2), which could possibly minimize the fear and resistance to implement cobots.

4.2.2 Cobot's consequences

Implementing cobots can lead to several consequences. On one side, cobots are becoming more popular and a lot of companies are interested in adopting them with the aim to stay competitive in their industries, as a result "[...] some of them don't know how to implement it and make it safe for humans." (R6).

On the other side, three main consequences were mentioned. First, manual laborers get more value added to their jobs, "[...] so, this means that we take out of their responsibility in the repetitive tasks and tasks with less added value, then they can concentrate on something else" (R8). This often leads to shifting their roles to jobs that require more cognitive skills, in other words, the "[...] worker can concentrate on those knowledge-intensive tasks, whereas the more repetitive and easy things are done by the robot" (R14), in this way pushing them to focus on complex and more extensive skills.

Second, this shift also pushes personal and professional development for said workers, as it gives them the chance to learn new things. One respondent explained that after implementing cobots he experienced a shift in the mindset of skilled workers: "the first reaction of workers is "oh no we are losing our jobs", but during working with it, they became proud of it, because they were not a simple worker, they were robot operators, which also has a higher value." (R2).

Third, efficiency gains is one of the biggest benefits of implementing cobots. One of the respondents mentioned: "This is in the way of resource management. Time is a resource. So they -workers- don't spend time on those repetitive tasks, and the robot helps them do their job faster." (R8). Adopting cobots can ultimately improve the efficiency in production processes.

4.2.3 Cobots and humans

The main idea behind developing collaborative robots is that they work together with the human, so it becomes possible to "[...] merge the benefits of human skills and automated skills, to bring them together because they are very complimentary" (R3). Merging their skills can go in two ways according to the experts. One way is sequential work, where both the human and cobot are in charge of a different part of the task, "[...] the worker will put the piece where the cobot can then use it and pick it up and do something with it. So they're kind of working alongside one another." (R5.1). The other way gives cobots an assistant role, "so a collaborative robot will be supporting the associate with this work," (R10). In this way, the cobot takes over the work that the human is overqualified for, helping them to be more efficient and productive. As one of the specialists said: "we also do not look to -build- more humanoid robots, the robot is a tool for the human, this is basically how we see it." R2.

"The human has superior properties. Technically speaking, when it comes to some flexibility, the skills adaptation and things like that." (R14) This emphasizes that humans are still needed in these processes, as one respondent said: "human beings are really good at doing cognitive tasks, so think about holding tiny screws and positioning them, where you have to really think along while your doing it, complex cognitive tasks, so that's where humans are really good at." (R12). Consequently, when cobots are introduced, there is often a shift in roles for workers, where they become operators of the robots and are able to take on more tasks or responsibilities. So: "if you are a robot operator you have the skill to operate, you can not only drill holes but you can also do other processes, and previously, you would have to be trained in the other processes, and now you are trained in robotic operation, and the processes in the machine." (R2).

On the other hand, introducing cobots is not always economically smart, as the technology is still quite expensive, and beyond that, cobots need to be slow in order to be safe for humans which can affect the cycle time of processes. This can often make it difficult to justify the costs incurred when adopting cobots, as it's "[...] oftentimes not economically feasible for the company anymore because the worker is just as fast by doing manual labor." (R9). Another expert also said: "if you have an experienced worker, he will almost always be cheaper with the same results, and very often is also faster, because it's hard to beat the complexity of our visual system, our motoring system, our sensors that we have in our fingerprints and eyes" R2.

On a negative note, despite of humans still being better skilled for these jobs, cobots can take on bigger workloads: " one robot will work all day long, all night long, so they replace like three people. So, I believe out of the three people, maybe they keep one, but I'm not sure they keep the three, you know." (R5.2). Therefore, some cobot developers advocate for worker replacement: "our goal in the future is that we hand over the manual work completely to the robot. This is what we are thinking and what we're working on" (R10). In the contrary, other developers do not look forward to replace humans: "They are cobots because they are collaborating together with humans. So, yeah, they really are going to take the most heavy tasks from humans, but they still have to be working in combination with humans." (R11).

Additionally, it is important to mention that 10 years ago, most companies were focused on fully automating processes, which is the reason why many developers were, and still are working towards this goal. However "[...] 3-4 years ago that changed and then we're saying we need to cooperate the humans with the automation." (R13). This brings other topics on the table, such as "[...] ethics, which is something that was not considered before when people wanted to introduce robots in the shopfloor." (R12).

4.2.4 Changes in skills

As cobots are different from industrial robots, working in close proximity to skilled workers being one of the main differences, their integration affects said workers. One of the things mentioned by many of the experts was cobot's intuitive and flexible design, which often means that "[...] there should not be a robot programmer, but just the worker themselves that it's executing that" (R14). One of the respondents mentioned how it is not needed: " to hire someone with a certain expertise about the cobot, or knowing how to program a robot, because the features of the cobot we have created are for a really intuitive application. So, you can just take the cobot by hand, you can place it down, teach it how to take such a part, and the software is guiding you through the learning process of teaching the robots" R11.

Nevertheless, it was discovered through the interviews that the integration of cobots has implications for the manual laborers' skills. Some experts mentioned that a consequence of cobots taking over certain job tasks is deskilling. The skills needed for those tasks will not be needed anymore due to automation replacing them, however, those sets of skills are already decreasing: "Much less people are learning those kinds of things because there are way more other types of jobs available now. So, I think it goes hand in hand, one thing may lead to a bit of a decrease in people with a specific skill set. On the other hand, I think the decrease of people with a specific skill set will also improve development for these kinds of things -cobots-." R4.2
Another consequence mentioned is reskilling of the workers. "[...] It is not often that you see the robots replacing the personnel, I think they will get [sent] to different or other tasks in the company," R1; this indicates that there is "[...] going to be a change in jobs because people will go from a factory worker to an operator and It's a very different way of working." R4.2. Thus, workers will need to be trained on different skills that aids them through this role transition.

Lastly, when cobots are introduced in the workplace, teaching manual laborers new skills becomes crucial "[...] because they extend their scope of task." (R8). These new skills come from knowing how to operate these robots, an expert explained: "if you think of a drilling cobot, this is a highly manual task, you do not have special skills, you only have to train in how to apply the material in the right way, so, if you use the cobot, you need to have somebody who is able to control a robot, program a robot, solve a problem of a robot, maybe to clean it, so the worker has to have a different skill set, and it is definitely upskilling." (R2).

5. DISCUSSION

5.1 Theoretical Implications

The findings of this study confirmed some of the assumptions previously established by the literature. The research corroborates Zhu et al (2021) assumption that cobots were created to support humans in a shared workspace, improving productivity by combining the efficiency of robotics and the flexibility of humans, which often are complementary.

The findings showed that cobots are taking over dull, tedious, and dangerous tasks, as a result of their excellent capabilities for repetitive tasks, precision, and consistency. On the contrary, humans thrive on cognitive skills and adaptability. As a result, tasks can be broken down and shared between cobots and humans. Altogether it supports the beliefs of Salunkhe et al. (2023). Further confirming that this division of tasks often pushes workers to more cognitive tasks, such as programming, supervising, and controlling the robots, adding higher levels of complexity, creativity, and decision-making to their job roles. In turn, more value is added to the existing jobs due to cobots, which aligns with F. Sherwani, Asad & Ibrahim (2020), and their theory that cobots are not meant to demoralize the workforce.

As Waschull et al. (2022) assumed, reskilling, deskilling, and upskilling emerge as side effects that are needed to adapt workers to this shift. Therefore, it becomes crucial for organizations to create skill trainings, and design a good implementation strategy that matches their case; which aligns with the hypotheses made by Marinas et al, (2021). Additionally, investigating the existing resources and capabilities present in a firm, as well as fostering a favorable organizational culture can facilitate the adoption of technology.

On the other hand, some theories were challenged. While prior studies by Pasparakis, De Vries, & De Koster (2023) thought that cobots fall under a human-centric approach to technology, some developers still prove to have human work replacement as one of their goals, which contradicts this belief. Moreover, De Assis Dornelles, Ayala & Frank (2023) thought that humans would be doing fewer tasks than before due to cobots' introduction, however, the findings revealed that humans' task scope is broader with cobots, as they can take on more tasks with more complexity, including taking over tasks that would require additional training, as cobots allow workers to do these tasks through them, in a role of robot operator. Finally, contrary to their belief that cobots will add to the overall speed of processes, the interviews revealed that cobots might add to the cycle-time, due to their slow nature attributed to safety features.

This research also uncovered new insights that contribute to the literature. Firstly, it was discovered that cobots have limited use cases. Due to their safety features, they have to be slow, furthermore, it is still not possible to mimic the complexity of humans' capabilities, which results in cobots not performing well at complex tasks. Moreover, cobots were found to be an expensive technology development due to all the added systems needed. Despite that, they seem to be a flexible option for automation, as they prove effective for tasks that are hard to automate.

Their flexibility combined with the current labor shortage, motivates companies to acquire cobots, as well as a necessity to lower their costs related to labor and safety measures, while improving quality consistency, both being the result of collaborative work, where the cobot can also take the role of assistant to the worker.

All these benefits make cobots attractive to companies, nevertheless, it was found that there is a lack of awareness when it comes to cobots benefits and safe implementation. As a consequence, resistance to change can arise amongst workers, and occasionally all the members of a company.

Lastly, it is imperative to create good cases for cobots that make sense to all stakeholders, as this facilitates cobot implementation, as well as involving workers throughout the entire cycle, giving them a voice and an opportunity to adapt to the new technologies.

5.2 Practical Implications

Implementing cobots in a manufacturing setting can be quite disruptive for workers if not done correctly. Therefore, different factors should be thought of when helping workers adapting to the changes expected. A number of suggestions were made by the experts interviewed, these could be used by HR departments as resources to potentially aid a company through the implementation process.

First, it is imperative to create good use-cases for collaborative robots. This means that companies should analyze the reasons behind wanting collaborative robots, in a way that it shows a clear need behind acquiring them. It is necessary that the decision of integrating cobots makes logical sense to all stakeholders, as this would raise awareness of the benefits behind collaborative work, and in turn, it will decrease the chances for technological resistance from manual laborers.

Second, involving the workers from the beginning can have positive effects during the implementation cycle. This includes developing technologies based on the needs of the users, in this case, the manual laborers; as well as giving them a voice throughout the process of cobot integration. Failing to involve manual laborers in such decisions can be detrimental to the overall implementation success.

Third, companies should create trainings that aid workers in learning the new skills needed for their role transitions. This can include skills trainings, safety workshops, cobot awareness talks, in other words, any resource that can facilitate a smooth adoption of collaborative robots.

5.3 Limitations

The results presented in this paper must be interpreted with caution, in consideration that is subject to limitations that should be kept in mind.

The findings of this study are based on the perception of cobot's developers, and academics researching these technologies, hence, the opinions portrayed are biased toward what these groups of people think. As a result, the understanding of cobots' effect on manual laborers jobs could be limited, the opinion of these laborers are not included in the research, posing sampling limitations.

Additionally, due to the methods used in this research, namely, thematic analysis, the data was collected and analyzed from the viewpoint of one researcher, hence, the conclusions obtained are based on a singular perspective. Furthermore, the interviews were done with a selected group that might not cover the entire scope of the topic, as not all companies operate the same way, and not all researchers focus on the same viewpoints. These together affect the generalization ability of the present study, making it unclear whether the findings apply to all emerging cases in the topic.

Finally, this research can be considered as a cross-sectional study, meaning that the findings presented are the result of data analyzed at a single point in time. Consequently, the results might not continue to be relevant over time, as technology continues to evolve and change over the years.

5.4 Future Research

This section outlines recommendations for future research informed by the limitations found, inviting future researchers to make new discoveries in the field.

A suggestion is to include the perspective of manual laborers by collecting data from them, as this can provide a more complete picture of what effect collaborative robots can have when being implemented. Additionally, if the qualitative nature of this research is kept, it can be useful to include more researchers in the effort to decrease viewpoint biases.

On the contrary, it could be valuable to include a quantitative method in the research, as it can provide different results, which will be based on metrics instead of perspectives and opinions.

5.5 Conclusion

5.5.1 How does the integration of collaborative robots impact the traditional roles and tasks of manual laborers?

The integration of cobots in manufacturing settings has several repercussions on manual laborers' roles and tasks. These can be divided in three side effects, which ultimately change the way of working of these laborers.

The first effect relates to deskilling. Introducing cobots could mean the end of certain skills belonging to manual labor, as these activities are now being automated. Those skills can be as simple as drilling holes or handling materials in the shopfloor. Additionally, cobots are saving laborers from tasks that are not ergonomic, in this way changing their task scope as well as improving the conditions of their job roles.

The second effect relates to reskilling. Previous automation methods did not necessarily allow for interaction between robots and humans, hence, as humans are starting to work next to cobots, a new set of skills is required. The need for teaching workers new skills becomes crucial as they are transitioning to new roles, namely, robot operators. This transition means that the job roles of skilled workers are often shifting from simple non-value added tasks to more cognitive and knowledge extensive tasks, which necessitate more complex skills such as technological skills.

The third effect relates to upskilling. As it was discovered in the findings, cobots can't work alone, they need supervising and maintenance, which creates new roles or tasks added to the manual laborers agenda. Unlike with reskilling, workers are not fully transitioning to a different role, however, they are taking on extra responsibilities, namely, supervising and maintaining the cobots, with tasks like making sure the program is running well, or troubleshoot.

In conclusion, the introduction of collaborative robots is affecting manual laborers by making their task scope broader, as well as providing them with a chance to develop themselves professionally through learning new skills.

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