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The Inhumanity of the Human Factor - A Scoping Study of the Language in Cobot Introduction Methodologies in Manufacturing

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Abstract

The study dissects a trend in the literature on collaborative robots (cobots) within Industry 4.0. By examining 16 articles from 2017 to 2023, this scoping study lays bare the dehumanizing language used to describe the human workforce — terms like "worker," "user," and "operator" reduce people to cogs in the machine. The author exposes the underlying agenda in these articles: a collective pursuit of efficiency with cobots as the spearhead. The study questions the practice of quantifying human experience, arguing that such reductionist views fail to account for the value of human expertise and context in the increasingly robotic manufacturing environment.

Keywords: Human Factor; Cobots; Collaborative Robot; Automation;

1. Introduction

My friend Benny works for the Danish furniture producer Carl Hansen and Son. They produce some of the Danish furniture classics like the Wishbone Chair, originally designed by architect Hans J. Wegner in 1949. The Wishbone Chair has a hand-woven seat, which according to their website “takes a skilled craftsman about an hour to create, using approximately 120 meters of paper cord” *[1]*. Benny is one of these skilled craftsmen. He has been flown around the world by Carl Hansen & Son to demonstrate his skills at fairs and in shops. Benny is hearing impaired, using lip reading and hearings aids. Reading and writing are not his strongest forte. But when it comes to his craft, he is superior surpassing his peers in speed and accuracy. A seat woven by him has the top quality that guarantees the company’s brand. Now the company is investing in robots, to handle “heavy loads more efficiently” *[2]*. How can Benny use this new technology to lighten him of repetitive tasks and heavy loads? According to Benny “it lies in his hands”. He knows with his hands. To learn his craft he has embodied knowing [*3*], that enable*s* him to know exactly what type of pull the paper cord needs to sit perfectly in the seat. How can he be able to teach a robot to help him with this?

2. An emerging research area

In the landscape of modern manufacturing, the convergence of cutting-edge technologies has ushered in a new era known as Industry 4.0 *[4]*. This fourth industrial revolution is characterized by the seamless integration of digitalization, automation, data analytics, and artificial intelligence into the manufacturing processes *[5]*. Since 2006 at the forefront of this transformation stands the introduction of collaborative robots *[6]*, also known as cobots, as an enabler of Industry 4.0's vision for efficient, flexible, and intelligent manufacturing systems. Historically, industrial robots have been a cornerstone of mass production, automating repetitive and labor-intensive tasks in manufacturing facilities. However, these conventional robots were often large, immobile, and isolated from human workers due to safety concerns. The emergence of collaborative robots

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has revolutionized this paradigm by facilitating safe and efficient human-robot interaction on the factory floor. Benny can literally share a space with a cobot and show it his craft.

For the past eight years literature on cobot implementation has focused largely on safety issues as described in *[7]* and *[8]*. Certainly, one would want Benny to be safe when collaborating with the cobot. Less focus seems to be given to how the collaboration with cobots might impact Benny – though *[7]* conclude that "For these reasons, future developments should focus on … operator well-being and related human-centered design, social and psychophysical aspects of collaboration *[7, p. 24]*. This is agreed upon by Weiss, Wortmeier & Kubicek *[9]* when concluding that "There is a need to explore in more detail which subaspects of workflows can be usefully automated; how much depth and complexity collaboration can and should achieve; and how this will ultimately affect people's (cognitive) workloads, required skills and training, and perceptions of the quality of work performed by humans" *[9, p. 343]*.

The current study reviews an exemplary number of articles on introducing collaborative robots as part of automation of manufacturing in industry with the purpose of analysing how this revolutionary cohabitation of the working space is addressing user involvement.

3. Methods: a scoping study of articles on introducing cobots in manufacturing

The articles were reviewed by conducting a scoping study *[10, 11, 12, 13]*. Researchers may undertake a scoping study to examine the extent, range and nature of a research area, determine the value of undertaking a full systematic review, synthesize and disseminate findings, or identify gaps in existing literature *[10]*. This study is based on a literature search performed in the spring and summer of 2023. Using both block search and snowballing the study compiles 16 research papers published between 2017 and 2023 relating to methods for cobot introduction that somehow focus on user involvement.

The scoping study allowed the mapping and summarizing of the articles and is particularly suitable for emerging research areas *[11]*. The study should, as such, not be confused with a systematical literature review. Scoping studies are particularly well-suited for emerging research areas because they help map out the breadth and scope of a field that may be in its early stages or lacks clear direction. Particularly in relation to clarifying concepts and terminology they are useful. In new or evolving areas of research, there may be confusion around terminology, definitions, or conceptual frameworks. Scoping studies can help clarify these by mapping out how different researchers are using certain terms or concepts, and how those ideas have evolved over time *[12]*.

This methodology was, therefore, suitable for my purpose of reviewing the available literature in relation to the relatively unexplored topic of user involvement in cobot introduction methodologies. As advised by Levac, Colquhoun and O'Brien, the analysis comprises both a descriptive summary and a thematic content analysis, as described below.

3.1. Literature search: article selection and inclusion criteria

The relatively small number of articles found as well as the relative recentness of publishing dates also points to the field as an emerging one. Inclusion criteria included articles published after 2008, because this was when the first collaborative robot was produced *[14]*. Articles in English and Danish were another inclusion criteria, as well as articles from book chapters, journal articles and proceedings from conferences.

3.2. Analytical framework and strategy

The articles were read and analysed comparing the language of the described overall intention of the paper with the language used to describe the solution with special emphasis on the language used to describe the actors. The analysed articles share a structure which is common in scientific papers. An introduction is followed by a literature review or a research background. Following this is a section on the development of the research framework and a section on methodology. Lastly a description of results is followed by a conclusion and or discussion ending of with a list of references. The intention or aim of the articles we find is described in the Introduction, whereas we found that the solution is described partly in Methodology and partly in Results. One of the focal areas is the vocabulary used for the person standing next to the cobot in each article. This analytical theme will be expanded by comparing the description of the intention of each article with the description of its results. The purpose of this approach is to analyse how (and if) the results are consistent with the overall intention of the study. Further details relating to the included studies are available in this summary *[15]*.

4. Results

4.1. Language used for the person next to the cobot

The articles were searched in relation to the precise wording for the person next to the cobot to find out which words were most common and to analyse what the implications of using these words might be.

Table 1. Naming the person next to the cobot

Word for person next to cobot	Mentioned in number of articles	Mentions in total	Range in number of mentions in each article	Average number of mentions
Human	16	1388	240 times -> 4 times	86,75
Worker	14	231	77 times -> 1 time	16,50
User	13	268	99 times -> 1 time	20,61

Operator	11	448	99 times -> 7 times	40,72

As shown in table 1 calling the person next to the cobot *human* is common in all articles with a total of 1388 mentions. This includes talking about the person as "human factor", and referring to the person in both singular and plural as the "human" or "humans". The range of use varies a great deal between the 16 articles, with the average of mentions 86,75 times. Two articles are outliers with less than 10 mentions. The word "human" or "human factor" is often used in the dichotomy human versus the robot/cobot. The person is thus not being described in any meaningful way other than being referred to as a member of homo sapiens. The human is rarely described with more if any characteristics, such as e.g. competences or even sex. The abstractness of the word places the difference from the cobot as the only important denominator of the person.

The second most used word for the person next to the robot/cobot is *worker*. It is mentioned in 14 out of 16 articles with a total of 231 mentions. This includes "workers" and has an average of 16.50 mentions pr article. 7 articles mention worker less than 10 times, whereas 4 articles mention it 10-20 times. Only 3 articles mention it more than 30 times. An outlier article uses it 77 times. The term "worker" refers to the social hierarchy in industry, where the worker is different from factory owner or management, who pays the worker to do specific work for them. The worker is in this regard not the decision maker. Using the word "worker" only describes the terms of employment not the individual characteristics, or competences. The term does, however, describe the person as someone, who is not defined by the relation to the robot/cobot.

User is the third most used word for the person next to the robot/cobot. It is mentioned in 13 out of 16 articles with a total of 268 mentions. This includes "users" and "user experience". Again, the range of use varies with an average of mentions of 20,61 pr article. 7 articles mention user less than 10 times, whereas 6 articles mention it more than 10 times. An outlier article use it 99 times. The term "user" refers to a person using something. It is often used in interaction design particularly as a user of an interface. In this regard the person next to the cobot is by the term "user" defined by his or her relation to the robot/cobot. He or she has no other characteristics than as paired with the robot/cobot often through an interface. A smaller number of articles (2) use this pairing in words like human/robot team or describes the robot as a team member. Two other articles talk of the robot as a colleague in this way equalizing the cobot with the person.

10 articles use the word *operator* for the person standing next to the cobot. It is mentioned in total 448 times. Two articles use it less than 10 times, whereas the rest use it between 24 and 99 times. This includes "operators". An operator is someone who uses equipment or machine. The person next to the cobot is in this sense defined by the cobot, not by the work process he or she is part of or the manufacturing process.

4.2. Aim of the articles

The four most common words used for the person next to the cobot in the articles all in this sense *dehumanizes* the human in some way or other, even if all articles aim to help the introduction of the cobot to lighten the burden of the person next to the robot. The most quoted article suggests that in the smart factory "people could be seen as "things" to be monitored and connected with each another and with machines" *[16, p. 308]*. The purpose and aim of the articles, which is common in the introductions of the articles, is to achieve "a highly effective state (and outcome)" as suggested by *[17, p. 204]*. The abstractness of words used for the person standing next to the robot is perhaps caused by this look for effectiveness of the process.

The aim of efficiency is described in various ways. Sometimes it is described as easy implementation *[18]* or sometimes as the goal of achieving interaction fluency *[19]*. Another expressed goal is improvement of production processes *[20]*, where the purpose is to analyse "… how generated data may be used to predict and account for the uncertainty caused by human beings" *[20, p. 1602]*. Essentially, the person next to the cobot is causing uncertainty, which can be "alleviated" through data processed through an equation. The same strategy can be found in *[21],* where the title of the article is mentioning the inclusion of User experience in the design of human-robot interaction. In another article the same authors suggest including user experience "based on human physiological response monitoring in order to objectify the Operator 4.0 experience" *[22, p. 16]*. So even if the authors started out wanting to analyse worker's perceived experience the result is interpreting perception as monitorable physical responses.

The point of view expressed in the articles can be interpreted as what Star in her 1990 article "Power, technology and the phenomenology of conventions: on being allergic to onions" calls "managerial" *[23]*. Basing her work on Latour's Actor Network Theory *[24]* she regards networks as comprised of many kinds of actors, human as well as technological. In this sense the person beside the cobot is an actor as well as the cobot in the network of manufacturing, but so is the management and the end-customer. Star argues that technological changes can be seen as destabilizing of networks. "When standards change, it is easier to see the invisible work and the invisible memberships that have anchored them in place. But until then it may be difficult, at least from the managerial perspective" *[23, p. 44]*.

She challenges David's discussion of the "productivity paradox" *[25],* which formulates the paradox that for many companies the introduction of (often very expensive) new technology leads to a decline in productivity. Star on the other hand claims that "If much work, practice, and membership goes unrepresented in analyses of technology and socio-technical networks, then the invisible work that keeps many of them stabilized will go unaccounted for, but appear as a decline" *[23, p. 44]*. From a managerial point of view the person next to the cobot is more effective, if their effort, stress and cognitive overload can be counted and calculated through an equation, because the clutter of human actions, perceptions and emotions relevant for the job is "invisible". Some of the articles suggest that the monitoring could be done if the person next to the cobot wears biometric equipment producing data *[22, 26]* – others that video or other surveillance equipment should be used to measure the work *[27]*.

4.3. Context boundness

My friend Benny's craftmanship is monitorable as shown in *[28]*, but is it measurable? The right tug on the papercord, the right dance around the frame of the chair is learned over time and has been taught to new colleagues by demonstration and feeling. Not by repeating exactly what Benny does, but by adapting the craft to another network, another practice, another context. Several of the articles does address this context boundness of the work. Kadir et al. *[29]* interview four factory workers and three managers to find challenges and opportunities in successful adoption of cobots. A very interesting finding is expressed by a manager: "We want to use the cobot as intended, so it is important to create tasks with the right flow, so it becomes a collaboration and not the cobot doing all of the tasks while the worker is sitting simply observing on the side." *[29, p. 605]*. This at least implies that the worker is central to the work and that the cobot should adapt to the context.

Khamaisi et al *[30]* describe the human needs as "the real needs of the operators in a specific context of use, focusing not only on safety and ergonomics issues, but on the overall UX aspects (e.g. usability, intuitiveness, satisfaction, cognitive load and emotional response)" *[30, p. 10448]*. They propose to analyse UX by use of both quantitative and qualitative measurements combined with physiological through "non-intrusive sensors" *[30, p. 10448]*. So, the emotional response is still only addressed if it can be measured by equipment and quantified.

The most recently published articles discuss competence development needed for the implementation of industry 4.0. The point of view is in these articles not centered on the factory equipment (including cobots) but on the persons in the factories. The theme is competence development and learning. Successful learning depends "on the extent to which the workplace is designed not only for the production of certain goods, but also for supporting learning …" *[31, p. 394]*. Analysing 128 statements from 31 manufacturing SMEs participating in workshops and follow-up sparring interviews the authors conclude: "From this first coarse analysis it is apparent that at least part of the answer to the question on how the workforce is prepared to the future of manufacturing is that this does not take place in an organized and strategic manner" *[31, p. 397]*, which leads the authors to suggest: "the results may also provide explanations as to why we are experiencing a slow-paced digital transformation amongst SMEs in particular." *[31, p. 401]*. They particularly point towards a cluster of companies, which are characterized by a constraining learning environment, as "companies with high degree of highly specialized manual labour, which would be difficult to automate or digitalize." *[31, p. 400]*. The same authors in a second article discuss competences needed for Industry 4.0 because they have detected a discrepancy "Human workers remain crucial to the continued operation of smart manufacturing environments, and yet, the stakeholders affected by the digital change are not properly prepared nor seriously considered in the decisions surrounding the digital technologies." *[32, p. 380]*. They use a typology of competences needed, used in software development, dividing them into management, backend (technical backbone), and frontend (end users). Digitalisation only happens, if the initial push comes from management *[32, p. 383]*, but "stakeholders from different areas such as management, administration, shopfloor workers, customers, and suppliers should be asked and involved in the design process of proposed Industry 4.0 technologies" *[32, p. 384]*.

5. Conclusion and perspectives

Asking and involving different stakeholders is not a strategy suggested by most authors in the articles in the current scoping study. Where the different solutions are tested, it is often on university students or users with engineering backgrounds. User experience is in most of the articles addressed via quantification, sometimes by monitoring the person.

Star describes the point of departure for feminist and interactionist analyses of power and technology that which is omitted by the dominant view. How this creates multiplicity – several simultaneous forms of being within the same self. "Our selves are thus ... monstrous selves, cyborgs, impure, ... in the sense of being that which goes unrepresented in encounters with technology." *[23, p. 29]*. She recommends strategies which imply listening, rather than talking on behalf of. Following Latour she calls this talking on behalf of "translation" and underlines the importance of involving all actors. "We know how to discuss the process of translation from the point of view of the scientist, but much less from that of the laboratory technician, still less from that of the lab's janitor, much as we agree in principle that all points of view are important." *[23, p. 33]*.

In line with Star, I find it interesting that the translation of human factor into something measurable is predominant in the articles, because the shared purpose of the articles is to use robots to help the person next to the robot or maybe humankind in general. The shared aim is as mentioned to achieve effectiveness. But it is questionable if viewing the human factor as a sum of measurements is, in fact, effective. At the very least it is perceivable that listening to and involving Benny in digital transformation could be more effective. He is after all the one in which hands the weaving lies and who knows into every tiny detail how a well woven seat looks and feels.

Thus I have to agree with Weiss, Wortmeier & Kubicek *[9]* that further research is needed focusing on how cobot introduction affect people's (cognitive) workloads, required skills and training, and perceptions of the quality of work – lest we lose the knowing resting in Benny's hands.

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