# Collaborative Robotics and Industry 4.0: an Engineering, Sociology and Activity-Centered Ergonomics Cross-Experience

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**Abstract.** This communication aims to present a cross-perspective – robotics, industrial engineering, sociology and ergonomics – research project experience dealing with development of collaborative robotics in SMEs. Our conviction is that Industry 4.0 must imply : (1) "departinionning" of disciplines involved in the design of work situations and (2) construction of hybrid approaches for understanding and transforming work. In this communication, we propose to relate such an experience on the basis of a research project - funded by the French National Agency for Reseach (ANR) , and focused on transformation of French Small and Middle Companies (SMC's) in relation to introduction of Collaborative Robotics. Collaborative Robotics is of particular interest for us as it embeds promises and pitfalls of articulation between technologies and work. However, these promises may be discussed and tempered by confronting them to actual design issues, work organization and transformation of work management.

**Keywords:** Collaborative robotics – Industry 4.0 - Ergonomics – Sociology – industrial engineering

## 1 Problem statement

This paper aims at present a cross-perspective – robotics, industrial engineering, sociology and ergonomics – research project experience dealing with development of collaborative robotics in Small and Medium French Companies (SME). Our research is set in the following context: according to "the factory of the future" – or Industry 4.0 - program in France, the globalisation of competition, coupled with the ageing of the working population and industrial facilities, makes it necessary for France to im-

prove its production tool and competitiveness. Moreover, the COVID 19 crisis has increased awareness of the importance of preserving and developing a strong, innovative industrial activity that generates wealth and jobs. In order to achieve this, it would be necessary, again according to claims of the French Industry 4.0 program, to continue the modernisation of the production tool, in particular through the integration of collaborative robotics. In this context, our conviction is that an effective Industry 4.0 transition must overtake a pure techno-centered perspective and must imply : (1) “departinionning” of disciplines involved in the design of work situations and (2) construction of hybrid approaches for understanding and transforming work. In this communication, we propose to relate such an experience on the basis of a research project - funded by the French National Agency for Reseach (ANR), and focused on transformation of French Small and Middle Companies (SMC’s) in relation to introduction of Collaborative Robotics. Collaborative Robotics is of particular interest for us as it embeds promises but also pitfalls of articulation between technologies and work. Among the "promises" made by proponents of this technology, we particularly note that :

- This technology is presented as "easy to implement and maintain"; "favouring productivity gains";
- It is also presented as virtuous on a societal level, by making certain workstations more attractive, or by contributing to the prevention of musculoskeletal disorders through the cobot's taking over repetitive or strenuous tasks;
- It is a model of potential non-substitutive technologies that may lead to a strong reification of what could/should be actual collaboration between workers and technologies [1].

However, it seems to us important and topical to confront these promises with real situations of design, work organisation and the transformation of work management.

## 2 OBJECTIVE/QUESTION

In this context, the main objectives of our interdisciplinary research project are to propose :

(1) An analysis of what is covered by the polysemic terminology of the research object "cobot".

(2) A work and activity approach related to organizational and socio-cultural transformation of work and activities of SMC's executive coping with the transformation of their companies;

(3) A socio-political and historical analysis of the French and German programmes related to the so-called "industry of the future" since the mid-70s in order to identify the evolution (or not) of the place of collaborative robotics in the history of robotics ;

(4) Finally, based on the 3 previous points, a multidisciplinary approach to the management of design projects of companies engaged in the modernisation of their production tool (tools in the broad sense of the term, including: technical, organisational, social devices)

# 3 METHODOLOGY

This multidisciplinary research, carried out by 11 researchers, is based on the articulation between different research modalities specific to this project:
- a hybrid thesis in industrial engineering and ergonomics
- an action-research conducted in an SME by a researcher in sociology and a doctoral student in ergonomics.
- more than ten days of seminars between project researchers dealing with the exploration of cross concepts (collaboration/cooperation, work situation...) based on socio-political and historical work.

In addition, specific methods were developed for each of the sub-objectives. More specifically, a state of the art on the evolution of robotics for (1), a multiple case study based on observations, interviews and analysis of company documents for (2) and the analysis of more than 400 documents and reports on "The industry 4.0" for (3).

# 4 Results

In order to meet the objectives announced above, we will present our results in 3 parts.

## 4.1 "Cobot", a concept that is still under debate and still evolving

If the definition of the industrial robot is precise and well framed in the robotics community, the notions of cobot and collaborative robot, frequently used when talking about Industry 4.0, are less so. It thus seems useful to go back over the history of this neologism: at the end of the 20th century, the word "cobot" designated mechanically compliant devices (COmpliantroBOT), intended to be used within the framework of haptic interfaces ([8], [9], [10]). Later, the term "cobot" was used by robot manufacturers and industrialists to designate a new type of robot with sufficient safety features (mechanical and/or electronic properties) to be able to operate in the same workspace as humans. The word "cobot" has thus taken the other meaning of COllaborative-roBOT, cooperative or collaborative robots [9], cooperation or collaboration meaning, without further theoretical and/or practical details, the possibility to share the same workspace. Finally, the idea of co-manipulation, which refers to specific uses within the field of industrial robotics, has known in the last few years significant advances in order to increase the handling performances of workers. Cobots can interact (or not), with workers (perform movements in autonomy, share tasks, operate in the same workspace) but would no longer replace the human gesture in the strict sense of the word. Their function would rather be to guide or accompany it [3].

Thus, the meaning of "co" in cobot and the promise of collaboration, potential or actual, real or truncated, give rise to debates on two complementary levels:
- The notion of cooperation/collaboration between humans and robots is all the more difficult to stabilise as the notions of cooperation and collaboration between humans

or between humans and machines [4] are controversial in the Social and Human Sciences.
- among specialists in technology, labour and industry in general, especially on the occasion of the (ongoing) revision of ISO 8373:2012, as some definitions are often outdated [8].
Faced with an evolving, sometimes protean definition, resulting both from the history of the development of so-called "manipulation" robotic systems and the conceptual evolutions produced by the interactions between Human and Social Sciences and Engineering Sciences, it seems reasonable to be on the lookout for new literature, to take a nuanced approach and to provide support to companies likely to be attracted by these tools.

### 4.2 SME managers, both interested and cautious about cobots

The difficulties in stabilizing the functions covered by the "Cobot" tool described in the previous section raise questions about its actual integration in work situations. But more generally, in order to think about and carry out transformations likely to redraw the contours of the industrial landscape, executives and managers find themselves in the front line. And moreover, they are the guarantors of the decisions and methods of change management which will ultimately guarantee healthy and high-performance work. Thus, we were interested in the point of view of SME managers on the integration of cobots in their production facilities. We identified a contradiction on: on the one hand, the French “Industry 4.0” program presents collaborative robotics as a solution that is relatively easy to integrate and which would solve, among other things, problems related to physical wear and tear and work-related joint pain. We can add to this political will the strong technical progress making the cobots more and more easy to integrate, but also the rhetoric and marketing around these technologies which are pushing hard to seduce company managers. But on the other hand, a first exploratory part of our research showed that very few SMEs were really equipped with a working cobot (at least at the time of this research, 2018). Faced with this contradiction (large developments in the supply of cobots, but few SMEs equipped), we sought to understand through interviews with the managers of five volunteer SMEs, what are the expectations, the hopes, but also the points of vigilance or the obstacles to the integration of a cobot in a workstation.

**The managers interviewed see the cobot as a potential solution to production and occupational health problems.**
The table below (tab. 1) presents a summary of the results obtained. It should be noted in particular that the managers of 4 of the 5 SMEs surveyed are interested in cobot in order to limit biomechanical constraints, physical wear and tear, and the risk of occupational accidents or illness.

**Table 1.** Managers' interests in cobots

| | SME1 | SME2 | SME3 | SME4 | SME5 |
|---|---|---|---|---|---|
| ...limit biomechanical stress, physical strain and wear and tear, the risk of accidents at work or occupational illness | | | **X** | **X** | **X** |
| ...to alleviate the difficulties of recruiting for positions recognised as difficult | | **X** | | | |
| ...enriching the content of workers' work; mobilising them on "high added value" tasks | **X** | | | **X** | |
| ...improve productivity, quality, better control of our production process | **X** | | | **X** | **X** |
| ...to develop and offer new products | | | **X** | **X** | |
| ...to convey the image of a company at the cutting edge of technology | **X** | **X** | **X** | **X** | |

**But managers measured against the promises conveyed by the cobots**

The table below (tab. 2) presents a summary of the results obtained. It should be noted in particular that the managers are particularly concerned about the technical complexity of the cobot, and their ability to maintain it, and to protect themselves legally in the event of an accident. Several authors have already pointed out in the past [5] that the difficulties of designing cooperative systems are largely underestimated and that the promise of effective human-machine cooperation is not always kept.

There is also the question (line 4) of the capacity of this new technology to fit into the history, dynamics and know-how of the company. For the intention of managers is shaped by the history of the company, by the experience of past successes and failures, and one of the challenges of change management is a compromise between rupture and continuity in strategic choices.

**Table 2.** Managers' points of vigilance toward cobots

| | SME1 | SME2 | SME3 | SME4 | SME5 |
|---|---|---|---|---|---|
| Lack of information on the potential and limits of the cobot, its integration process in production, solid experience feedback | | | **X** | **X** | |
| Complex and expensive tool to program and maintain (with liability issues in case of accident). Uncertainties about the | | | **X** | **X** | **X** |

| | | | | | |
|---|---|---|---|---|---|
| time frame for the return on investment | | | | | |
| The first studies of the workstation targeted in the company have revealed that the work is more complex than the managers imagined, and the cobot will not be able to do as well as the operator. | | | **X** | **X** | |
| Fear of a break with the core business, with the company's culture | **X** | **X** | | | |
| ...to develop and offer new products | | | **X** | **X** | |
| The operators concerned put on the brakes, arguing that by leaving the simple tasks to the cobot, the work for them will be intensified by only carrying out complex or unplanned tasks. | | | | | **X** |

To conclude on this part of the results, despite the interest of the managers for the cobots, we noted a weak effective integration of this technology. This can be explained by technical difficulties in integrating a cobot into work situations (a simple technology, but one that reveals the complexity of work situations), but also by a certain vigilance on the part of managers, faced with "turnkey" technical solutions that would instantly respond to local health and productivity issues. This observation therefore calls for the techno-deterministic discourse as a solution to the current problems of work, which we will analyse in the following section.

### 4.3 Industry 4.0, both in continuity with and a break from the major industrial projects of the 1980s

Analysis of the literature describing the Industry 4.0 program [11] reveals elements of language very close to those used in the major plans of the 1980s in France, whose limits had already been identified [7]. The 1990s were marked by a relative discretion in the place of robots in industry reports. The rhetorical use of the robot in discourses on the industry of the future reappears in the 2010's in the form of the "collaborative robot" or "cobot". Continuity with past discourse is ensured by the place of the cobot in industrialisation (i.e. the cobot of 2019 is rhetorically part of the same discursive device as the robot of the 1980s: the idea is to make it a link between man and the automatic industrial process). The break with the past is ensured by "the passage from substitution to collaboration, which leads to the presentation of an industry using technical innovation to put man "*back at the heart*" ([11], p. 15).

Moreover, beyond these elements of language, the semantic analysis of the "Industry 4.0" program reveals a set of essentially techno-centric tools and methods and little room is left for real "engineering" of work transformations. In fact, it can be seen that in the program's promotional institutions in France, representatives of the human and labour sciences (ergonomics, occupational psychology, sociology of work, management and organisational sciences, adult education) occupy an extremely limited place. Technical rationality and political communication are predominant.
In order to lift this scientific lock, the doctoral work between robotics - industrial engineering and ergonomics carried out within the framework of our research project aims on the one hand to clarify the model of real collaboration between workers and robots and on the other hand to develop a hybrid management of the design process of collaborative robotics by articulating scientific and technical questions with a proposal of activity-centred management of the ergonomic design process [2]. We will come back to it in conclusion.

## 5 DISCUSSION CONCLUSION

The ambition of our multidisciplinary project is to use developments in collaborative robotics to question and improve existing change management systems in industrial environments (and more specifically in SMEs). This project allows us on the one hand to re-discuss what is meant by "cobot" and to catch the issues of worker-machine-environment coupling (1), to understand the external (3) and internal context but also the stakes that weigh on SME managers (2).
Due to the multiplicity of issues (health, safety, work, employment, productivity, etc.) linked to the management of collaborative robotics projects, our research provides an opportunity for multidisciplinary discussions in order to co-develop new design methodologies, to remove certain identified obstacles: projects for the introduction of new technologies are driven by decision-making processes in which different logics (economic, production efficiency, quality, human resources management, safety, health, etc.) are confronted and therefore result from trade-offs between these different logics. However, the primacy of techno-deterministic approaches implies that technologies are often thought of as "remedies" to economic, competitiveness, production or risk factor problems, without questioning the "root causes", particularly the organisational causes of these problems, and the relevance of the technological solution alone. In the current context of strong political pressure to modernise, there is a potential risk of introducing heterogeneous technologies everywhere (cobotics and exoskeleton, additive manufacturing, big data and cloud, Internet of Things and RFID, augmented reality and virtual reality, etc.), without questioning their possible interactions (synergies or contradictions) or their consequences on real work.
These pitfalls reinforce the need to propose, upstream and throughout the projects accompanying the transformations of work towards an Industry 4.0, a model for change management:
- Participatory; between stakeholders (decision-makers, management, production, maintenance, designers, workers concerned, etc.) with different logics (economic,

organisational, HR, health, safety, quality, production, work activities, staff representative bodies, etc.);
- Multiscalar: integrating micro, meso and macro issues, short, medium and long term temporalities, and different hierarchical levels;
- Based on real work in all its complexity and variability;
- Relying on methodological devices enabling stakeholders to draw on the experience of past successes and failures in order to understand the present and think about the future (for example, through projective methods of simulating future work and/or organisation) [4]. However, this model will have to be refined and replicated in other contexts in order to strengthen its methodological soundness.

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