

Research Article

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Getting collaborative robots to work: A study of ethics emerging during the implementation of cobots

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Abstract: Following ethnographic studies of Danish companies, this article examines how small- and medium-sized companies are implementing cobots into their manufacturing systems and considers how this is changing the practices of technicians and operators alike. It considers how this changes human values and has ethical consequences for the companies involved. By presenting a range of dilemmas arising during emergent processes, it raises questions about the extent to which ethics can be regulated and predetermined in processes of robot implementation and the resulting reconfiguration of work.

Keywords: collaborative robots, ethics, learning, human skill, work

1 Introduction

Industrial robots have become commonplace usually placed in caged safety environments separating them from day-to-day human interaction. They are familiar in large manufacturing companies able to invest in expensive automation systems, and afford the external expertise required for their design and implementation. In contrast, the affordability and promised flexibility [1] and ease of straightforward programming offered by collaborative robots or “cobots” are moving robots into the wider workplace with the promise of sharing human and robotic skill. Their increased adoption by small- and medium-sized companies (SMEs) [2] is seen as something of a new frontier in industrial robotics [3–5]. Consequently, smaller companies are relying on their own efforts to save money and cultivate in-house competencies to take advantage of these emerging technologies.

This increasing adoption of collaborative robots in manufacturing is far from simple requiring not just the learning of new capabilities but the development of new working practices and resulting in “complex relations of appropriation and reworking” [6]. Through such processes the full consequences, technically and in terms of the human impact, are only fully understood after completion of the project. What Rittel and Webber [7] called designing for wicked problems in which the design or implementation process is not a linear progression from the idea to the final resolution of the issues. It is rather a co-evolutionary process involving cycles of ambiguity and uncertainty as solutions go on to pose new problems faced by multiple actors. Despite the ambitions of firms and the increasingly intelligent systems and off-the-shelf products developed by robot designers, these wicked problems leading to changing practices and shifts in human relations pose significant challenges [8].

Overcoming complex technical contingencies, restructuring the working routines of operators, and the challenges of learning new skills all position cobots as significantly affecting the daily experience of workers. This places cobots as ethical objects not just because they ultimately impact upon the social aspects of production but also due to the effect they have on people trying to get them to work. The focus of this article is therefore to understand the way ethical issues arise through the complex emergent processes of implementing cobots.

To achieve this the article takes an anthropological view of human-robot interaction (HRI) [9–11] to study the situational aspects of cobots upon workers in Danish SMEs. Acknowledging the aspiration of firms to continually improved productivity, the focus is rather the changing human values that emerge, and the impact upon the opportunities open to companies to consider ethics. The article highlights the discrepancies between the design of increasingly intelligent generic systems on the one side, and the need to understand the situated practices and processes of manufacturing companies on the other. In other words, a closing of the ontological gap between the

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technological resources and technological literacy [12] of firms and the solutions offered by robot designers. The article raises questions as to the extent to which ethics can be predetermined prior to the resulting mutual configuration of cobots and the jobs and social practices of workers.

The article considers first how cobots can be understood as ethical objects in manufacturing companies because of how they are employed, as well as the process through which they are employed. The methods used to gather data are explained followed by an outline of the anthropological approach taken during the analysis. The findings are presented as four areas of discussion covering aspects of learning, the ways in which values arise, the theme of human skill, and finally the reconfiguration of work. An attempt to summarise the findings is given before the conclusion as a series of conflicting issues or possible dilemmas arising from each of the thematic discussions.

considerations are situated in particular workplaces and factory settings. The changing conditions for human work are formed socially and culturally [25] and constrained locally. Localised sets of socio technical factors emerge occurring on organisational and individual levels, shaping the configurations of cobot and human work. This leads to complex issues requiring commitment by the project team if they are to be overcome. In a number of cases studied, as the complexity of the tasks became apparent, it was eventually acknowledged that cobots were in fact unsuitable for the application for which they had been considered.

Even though there exist social values and moral judgments manifest in particular practices, it is an individual's understanding, evaluation, and enactment of them, which constitutes the extent to which they play a part. Aspects shaping norms and practices are not just the consequence of local cultural factors but are influenced by individuals' subjective experiences of what they come up against, how they negotiate it, and the extent to which they participate in it.

For safety reasons, industrial robots have largely been segregated from human workers, typically in caged environments where high-speed movements and heavy loading would otherwise pose considerable hazards. To this end, and dictated by health and safety regulations, factory layouts have typically differentiated zones [26] between those allowing free movement and access for human operations, and those isolated by security barriers or other sensor activated protection devices. The long-standing separation of robot and human worker has led to a prevailing view of robots as hazardous [20].

Cobots are designed to be less harmful and overcome human-machine separation to transform work environments into places where human and robot can safely act in close proximity. Their small size, lightweight, and restricted power make them considerably cheaper than conventional industrial robots. However, as pointed out by Faccio et al. [27], due to the relative reduction in payload, this is not simply a case of comparing like with like. The resulting limitation of speed, force, and torque, alongside built-in sensors and ergonomic surfaces, render these as distinctly different robot products. It enables the possibility of direct interaction between human operators and robots in shared work spaces without the cost or challenges of constructing cages or surrounding them with guards. Their approach to programming is seen to offer a more intuitive approach [28] and allowing flexible reconfiguration [29] through approaches such as "teach pendant" programming and "walk through" programming [30]. In contrast, industrial robots have typically been commissioned within factory settings by specialist engineers

2 Cobots and ethics

The introduction of robots is increasingly influencing many areas of life [13] as people adapt their day-to-day behaviours and encounters. Accordingly, attention has been given to how ethics can be applied to the field of robotics [14–19]. Focus has typically been upon the impact of robots in environments and social spaces new to automation, rather than for example the established use of industrial robots in factories. The use of cobots in sites of manufacture represents a marked change transforming the way people are expected to interact and work [20]. These environments are far from static where ethical concerns co-evolve [21] through the introduction of new technologies. It is widely considered that manufacturing is entering the so-called fourth industrial revolution, in which prior existing technologies are being integrated in new and transformational ways [22] altering shop floor environments and significantly affecting those of the workforce who remain [20]. As such, new forms of integration and intelligent systems further develop the likelihood for greater opportunities for the introduction of robots [23,24].

The knowledge needed to assess and act ethically in a workplace is not simply a matter of applying regulations, but is developed in response to cultural and historical requirements that are themselves changing in reaction to the unfolding needs for successfully deploying technologies. Cultural influence, value judgements, and ethical

involved with programming, re-tasking, and fine-tuning installations taking as much as 2 years to complete [31].

Cobots are marketed as uncaged, safe, and human friendly, as well as being easy to install and program. Able to co-exist and cooperate with humans, shifts and confounds concerns about the replacement of human jobs by robots, to a more complex transformation of human work. As roles and tasks are modified and hybridised, rather than replaced, the need for humans to carry out only a part of a previous job becomes common. In the face of this, return of investment (ROI) calculations used to determine the economic validation of investing in cobots can become ambiguous and a matter of interpretation. Removing parts of jobs cannot be considered a direct saving in labour, leaving economic advantage to be achieved through partly freeing up workers to “do something else.”

The implementation of cobots in companies is clearly intended to change the nature of jobs. However, due to the differing contingencies and complexities of companies and applications, the manner in which this happens is not fully clear beforehand. Studying the way ethical issues arise through processes of implementation may not help to directly anticipate such things, but allow us to identify them as they arise. Are we, for example, to see the fragmentation of job functions as equally meaningful to workers? Is the restructuring of work routines to service the needs of a robot as meaningful as carrying out fabrication or assembly work, for example? Do these kinds of transformation change the kinds of relationships humans develop with their working life?

3 Methods

Taking an anthropological view of cobots goes beyond their technical understanding to consider how they become part of real-world settings involving changing human and non-human movements, relations, flows, and arrangements [32,33]. They are situated in unique real-life settings and cultures, subjected to local interpretations and adaptations. Culture referring broadly to the ways people think and act together [32]. This becomes evident in the ways that cobots are considered differently across realms of research and manufacture. From an HRI perspective for example, they are technologies under development, intended to provide opportunities for the sharing of work tasks with human operators in manufacturing and service contexts.

The study builds upon a series of semi-structured interviews carried out with 15 different Danish companies

between June and December 2019. In one case, follow-up interviews were carried out in order to talk to a number of other informants. The companies were chosen as representing a range of experiences in cobot implementation, as well as company size. Eight of the companies are characterised as having under 250 employees, three have between 250 and 500, and four having over 500. All the interviews were held at the company’s premises and were preceded by an introduction to the manufacturing process and direct observations of the cobots and/or the projected cobot installations. These initial observations and discussions provided a general basis to understand the contextual challenges faced by each company, and allowed for specific follow-up questions during the interview process. All the interviews were based upon the same interview guide initially developed through a number of pilot interviews. It comprised 24 questions organised in the following categories:

1. Introduction
2. Before purchasing the cobot/initial considerations
3. Organisation and implementation
4. Technical factors
5. Human factors
6. Closing reflections.

All the interviews were recorded and supported by taking videos and photographs of the cobot installations and relevant processes. The subsequent analysis was based on the responses to the interviews and the notes taken during the company visits.

All the companies adopted cobots as additions to the existing automated assembly systems motivated by their low cost in comparison with conventional industrial robots and the promise of flexibility [27]. All of the cobots were employed without any direct human interaction occurring with the cobot during its operational sequence. That is, human engagement occurring between or following robotic sequences. There was no attempt to define what counts as a cobot before starting the study but rather, in an anthropological vein, allowing the companies to define what they refer to as cobots themselves. In practice, this was determined by the types of robots shown, with almost all of the 28 cobots being UR series cobots produced by Universal Robots.

The analysis involved what Glaser and Strauss [34] term an iterative research design, as consideration of the data and analysis inform each other. In practice, it was achieved through detailed coding and subsequently compiling the interview responses into categories. These lead to the emergence of the aforementioned four themes and the ways they relate to the emergence of ethical issues.

4 An anthropological view of cobots

Asking managers, technicians, and operators about their experiences in overcoming issues and learning new skills is an alternative way to study cobots. Rather than a technical description with fixed characteristics and parameters, each case presented the cobot at the centre of a complex and unfolding sociotechnical system. Instead of solely technical artefacts they are more accurately seen through an anthropological lens as unique and emergent processes [35] of human and non-human reconfiguration, in which the cobot as an artefact is continually in a state of becoming. Such uncertain processes are in conflict with the planned day-to-day efficiencies and predictability of automated production systems. The general actions of technicians were characterised by iterative indeterminacy, conditional upon aspects such as managerial acceptance to spend periods away from other responsibilities. Equally, it was important for technicians to be willing to engage in often prolonged and possibly doubtful experimental cycles of trial and error. Requiring repeated attention, they often referred to “getting cobots to work successfully” as a kind of “play.” Play can be associated with the “tacit dimensions” [36] of human action, embodied knowledge and learning, and is paired with the positive engagement and creative aspects of work tasks [37]. Such humanistic attributes of engagement further the ontological challenges addressing the differences between symbolic scientific understanding of technological development and the reconstitution of technologies in social worlds where people make sense of their experience and shape meanings [38]. As well as complex social worlds manufacturing firms are complex material environments in which the building of new apparatus, jigs, assembling test assemblies and prototypes involves what Vannini [28] emphasises as instead “bodily engagements, techniques, skills, habits, and the materiality of the world of interaction.” In other words, the material practices through which things are done.

5 Learning

Having purchased a cobot for the first time, companies determine ways to organise and carry out the tasks needed to get them to work. This requires experimentation, learning processes, and a reconfiguration of jobs done by employees. These often done while also being responsible for the more familiar and primary demands of maintaining daily production. Considered in some cases

as “side projects” focus becomes intermittent and slow. Typically, the cobot becomes part of an experimental setup placed alongside the existing manufacturing system. Generally, companies find their first experience of experimental procedures far from straightforward taking many months and in a number of cases several years. The motivation to succeed is in part to learn how to do it themselves without external expertise, and then to successively introduce additional cobots to other parts of the production process. Framing manufacturing companies as complex sociotechnical systems extends the idea of the production process to that of heterogeneous assemblages of knowledge, ritual artifacts, techniques, and activity [39]. In order to work, they need to learn how to appropriate them into these assemblages in meaningful ways. Given there are complex technical difficulties to overcome alongside the indeterminate nature of experimentation, it raises questions about how and at what juncture ethical issues could or should be considered? If they are to be ethically accountable, it must be considered what competencies teams require and whether one is able to define concrete responsibilities at all [40].

Cobot projects can run from an initially estimated 2–3 months to several years. Over such periods, different personnel can be involved, and the reasons for implementing cobots change. Changing production demands or grounds for the suitability and capability of the cobot can all alter. Attempting to employ cobots often require technicians to learn, not simply new technical skills, but how to proceed amid the situated complexity of the problems involved [41]. Learning to “start things simply” and “to be able to work creatively” are common reflections. Technicians also spoke of having had to “cope with the uncertainties” of the project, the “risks” involved, and how “it is easier said than done.” Through these learning processes, experienced companies are able to reduce the time needed to employ cobots. One company, for example, developed a rule of thumb principle to call upon external expertise for programming only if it was considered to take more than 14 days to complete.

Prolonged attempts to overcome problems contribute to the development of individual capabilities. For Billet, these go beyond cognitive resources of thinking and acting, to their enactment able to “shapes and changes individuals’ capacities and ways of knowing” [42, p. 32]. Individual learning in the complex social cultural environment of the workplace remains an uncertain field of study [43]. The willingness and motivation of individuals to engage in demanding processes of self-learning are dependent upon multiple intertwined factors. It was generally recognised by companies that individual motivation was necessary to overcome the many hurdles needed to get

cobots to work. This was referred to as the need to find an “ildsjæl” meaning someone with a “fiery soul.” These are people with a high level of self-motivation and emotionally suited to persistent problem solving. An aspect of this is a self-reliant approach to learning such as turning to social media and the Internet to gain new technical knowledge outside of job hours, or operators’ intent on becoming capable of programming cobots rather than having them take over their job.

6 Determining values

The discourse through which cobots are implemented provide the basis for developing shared values and meaning. The ways people talk together determine views about the cobots, advantage to the production system, as well as their perception and understanding of human work. Before implementation, the prevailing discourse is generally that of economic benefit, often centred on the idea or preparation of a business case. This tends to stress values that are related to the economic state of the company, its stakeholders and by implication the security of its employees. The projected advantage was typically seen in human terms by improving working conditions and “removing hard and boring work.” Although these initial views were generally common, variation occurred in relation to the culture, size, and financial structure of companies.

One firm continually stressed the educational possibilities offered by cobots. They referred to the need to foster new skills in the company such as problem-solving. They saw cobots as a means to attract certain types of engaged, multi skilled employees, able to support the firm in other innovative ways. It becomes a way of facilitating new kinds of activity that in turn influence how individuals learn [44].

Purchasing a cobot to replace tasks currently done by humans goes on to influence how that work is seen and discussed. What the cobot is capable of and what the human can do are revealed in relation to one another. Consequently, human work becomes valued not in terms of say skilfulness or aptitude, but in respect to this significant other. If the cobot or indeed the human is seen as quick, the other becomes slow, if one deemed expensive the other cheap, flexible, inflexible, and so on. The capability of one becomes related to that of the other. Robots have unique cultural and historical associations with the replacement of human work. The dominant marketing image of collaborative robots is that of cobot and human becoming collaborative companions fulfilling a shared task.

In practice, the cobot is set to carry out as much of a task as is technically possible. Accordingly, they are viewed not as potentially cooperating within teams of humans, but as cheap industrial robots capable of replacing manual labour.

Gaining experience in getting cobots to work means informants can give contextual accounts that go beyond normative ideas such as intending to remove arduous and repetitive tasks. Such accounts reveal the complex relations between problem and solution discussed above. Faced with the realisation of the difficulties of replicating, let alone increasing the speed of a human operator, calls for a fresh appraisal of the benefits achievable. General benefits, such as lower cost or improved quality, give way to more valued judgements of human work, such as giving a worker more freedom to do something else, or simplifying repetitive activities. Rather than being replaced, human work is often reconfigured in ways that can lead to doubt about the best approach and the need to relearn working tasks. Reflecting upon the uncertainty, effort, and resource required to implement a cobot, one manager questioned whether it was reasonable to have started in the first place. In another example, reducing the number of workers on an assembly line to provide efficiencies of speed was seen to negatively influence the flexibility and speed of changing between different product types. The need to adapt quickly to different variants of production placed value on their human workers abilities to do this with the cobot consequently being seen as constraining and unaccommodating.

Managers make value judgements for varied and changeable reasons influencing the jobs of the workers for whom they have responsibility. What is advantageous to the firm may be viewed negatively from an individual’s perspective. Differing groups need to navigate and negotiate their values with respect to the others. While one company was considering the purchase of a cobot, a welder made his feelings known to management. If he was expected to work alongside a cobot, then he would have no hesitations in quitting his job saying “if that day comes, I won’t work here anymore.” A view of the welder at work goes some way to reveal why he might make such a pronouncement. Seated at his welding table, he was unmistakably attentive to the job in hand, self-assured and skilled. Small brackets placed neatly on one side of him with the welded ones on the other side also placed in meticulous rows. These finished parts indistinguishable from one another in their accuracy and precision of welding. The task and the welder’s skill were entwined in such a way that for him the loss of one meant he would lose the other. His strong sentiment in response to the idea of him changing job to accommodate a cobot was presented by the manager as a special case.

This was someone at odds and out of step with the inevitability of their continuing efforts towards automation. In smaller- and medium-sized companies, the opinions of the workforce are significant to their smooth day-to-day running and related to the collective welfare of workers. Assessing the workforce's reaction to the idea of introducing cobots is important for many of the companies in order to proceed. However, although such companies may wish to get a "green light" from the individuals affected, the contexts and grounds from which employees respond to such questions are complex in themselves [45].

7 Human skill

Human skill is poorly understood in any absolute terms, but becomes apparent through the close consideration of action and engagement. Determining the values of human action is central to knowing their contribution to processes of automation. As stated by Batya Friedman, "Values emerge from the tools that we build and how we choose to use them" [46]. Making the case for "value sensitive design," she draws attention to the difficulties of articulating moral values and translating these into "meaningful processes and designs." This approach together with a range of others from the field of Design Research (see [47]) offer strategies and techniques to "help researchers and designers explicitly incorporate the consideration of human values into their work" [47, p. 52]. Acknowledging that all design is enacted in a particular context and therefore local, embodied, and situated [48,49], the value-sensitive consideration of cobots in small companies offers a number of particular challenges. As a field of knowledge, design occurs in disciplines involved with the creation of products and services of all kinds. Even though design staff within manufacturing companies may well be aware of this branch of knowledge, production technicians have typically other concerns. Were they to have these competencies, it remains questionable the extent to which design principles can be applied to alter established production systems, and the emerging contingencies involved.

Consider the aspect that cobots are designed to be safe in the close proximity of humans. This is done using proximity censors and drive motors that limit the amount of force as they move. These values, embedded during their design, may be identified as useful during the implementation process. The operating speed of the cobot is typically a major factor in assessing its productivity. If running at a higher speed is the only way to make it viable, this could potentially transmit excessive force to a human

and exceed regulations or the local evaluation of whether it is harmful or not. If so, additional safety precautions, such as barriers or sensors able to stop operation if a human comes too close, are needed. Human values, therefore, become a combination of those materially embedded in the technology, those seen as pertinent by the company, such as the regulation or assessment of a limited safe speed, and the operating speed possible once the final arrangement is installed and tested. Differing companies employ different assessment criteria for deciding what counts as acceptable collision situations with humans. For some, standards were interpreted in a strict fashion by measuring the resulting forces transmitted in all the imaginable cases of human contact. For another company, a more pragmatic approach acknowledged that any worker could be susceptible to a certain amount of collision within a factory environment if they accidentally bumped into a hard object. Interpreting the cobot as being within this everyday tolerance of collision meant it was acceptable. Similarly, for one company a strict approach to all possible points of impact and possibilities for being caught or jammed by the robot were assessed. For another, they saw a distinction between likely dangers, and situations where humans would have to manipulate themselves deliberately into what they considered "excessively dangerous situations." Such flexibility in ascertaining the extent of human safety influences the usefulness and consequently the productivity of the cobot. This is seen in cases where the need for greater speed leads to the unforeseen cost of installing barriers or cages, with the further effect of reducing space on the shop floor. These kinds of value judgements impinge upon one another and are situated in the particular cultural and technical aspects of the firm.

The values that individuals place upon their work are multi-layered and subjective. For operators and manual workers, meaningful work is related to daily engagements and skills amid "myriads of real and co-working entities composed of both humans and nonhumans" [50]. Understanding human factors in order to achieve successful automation has been widely acknowledged and is evident from a number of case studies [20,51]; however, such approaches are rarely put into practice [52]. Understanding the full extent of the human element of new procedures is only evident through the processes of getting these to work, or become explicit when attempting to replace previous types of work with new ones [53]. Prototypes [54] are frequently used in design to make explicit factors that otherwise remain hidden. In a similar way, a cobot is able to reveal aspects of human engagement by trying to mimic or replace it. Difficulties in programming a cobot to replace a human worker grinding the edges of

a cut glass plate serve as an example. After several attempts, the cobot could only achieve a successful operating cycle once the programmer had physically learnt from the operator how to grind the glass properly. She had understood the principle involved but had not understood the particular arrangement of picking up the part, approaching the grinding wheel and moving it through a precise trajectory. The human skill then becomes explicit, not just to the programmers and technicians but also to the operator themselves.

Two companies in the study used hydraulically operated bending machines in their steel fabrication shops. In each case, the idea was the same. Replace the human operator with a cobot that had to pick up a steel part, hold it in the machine until bent, and then put it down afterwards. Each company faced technical challenges related to the synchronisation of cobot and the bending machine. It was however in the understanding of human factors that resulted in one company being successful and the other stopping the project after spending 6 months trying to get it to work. The difference in the two instances was in the tolerance needed to bend the part. Although the operation was similar, the first and successful company could bend their part with a low positional tolerance. The cobot did not have to be so precise with the way it held the part in the bending machine. For the second company, however, it eventually became evident that the human operator did not simply hold the part up to the edge of the bending press before bending. At a crucial moment, the operator jiggled the part almost imperceptibly and unknowingly, allowing a more precise bend to occur. This complexity in the skill of the human operator was difficult to replicate. Although they recognised that it would be achievable through continued testing, it would produce a much slower cycle of operation than the human operator could.

This understanding of human work unfolding while getting the cobot to work was commonplace among the companies studied. It meant that the initial view tended towards a normative and crude understanding compared with the detailed and varied one at the end. At the start, the cobot presents human work as reductive and technically achievable through simplified programming movements. For Zoller, it is this initially superficial understanding that leads to wanting to automate activity in the first place [55]. Companies learn what their operators do during this process. As one technician expressed it “as soon as you start to look at it, then there are issues to solve.” The cobot showing not simply the complexities of human action but ways the manufacturing system is dependent upon them.

8 Reconfiguring work

Viewed in terms of scientific management, manufacturing organisations tend to view humans as obstacles to achieving full efficiency and as a hindrance to competitive production. Seeing workers as costly, slow moving, and less reliable than automated processes, goes back to the foundations of mechanisation in industry and mass production. The consideration of human values becomes in opposition to that of technological developments leading to an economic devaluation of practical understanding and skills [56]. Some claim, however, that this desire to empty manufacturing production of direct human engagement has changed. Instead, the objective is for robot systems able to accommodate uncertain environments. The goal is for adaptable combined human–robot solutions [57,58] in which the cobot is able to be more flexible [59], and more accurate and time efficient, when working together with human capabilities.

The combination of human and robotic action upsets the lines between automation and human skill resulting in phenomena such as technological deskilling becoming contested and ambiguous [60,61]. Within small companies, the boundaries between technicians and operators skills and tasks merge as production demands, and developing new processes requires flexible approaches to work. Management choose technicians who are able to develop the new skills demanded by the cobots, with the goal of reducing the work conducted by operators. This is consistent with the view that automation has a tendency towards a polarisation of the workforce, between those benefiting through an improvement in their work situation and career chances, and those trapped in low skilled and generally disadvantaged forms of work [62]. Managers were found to portray employees as willing recipients of cobots, able to appreciate the long-term benefits to the company because of the increased competitiveness they offer. Working for progressive and competitive companies is undoubtedly important to many workers, but so too is the well-being derived from their working practice. Consequently, the movement from manual to auxiliary or supervisory roles becomes an ethical issue [20]. These changes involve workers having “to respond to new tasks, to understand new concepts and develop new procedures—all of which make the work more demanding” [44, p. 46]. The motivation and incentive to engage with these changes are individual traits and entail subjective feeling towards their work. The ethos of the craftsman, for example, and a concern for the act of doing high quality work for its own sake [63] are often associated with work requiring prolonged practical learning. A reluctance by some workers

to accept simpler tasks due to the implementation of cobots is therefore understandable, but also involves the social standing amongst employees themselves. As expressed by one informant “People who have the skill to ‘weld the tubes’ just want to ‘weld the tubes’ [...] there is more prestige than looking after a robot.”

Giving displaced workers the job of looking after the cobot or what was termed the “new employee” was commonplace. Workers typically moved from directly operating machines to preparing, servicing, and monitoring the cobot. These new tasks would involve things like filling up, and removing parts from hoppers and fixtures, as well as keeping an eye on the cobot arrangement to make sure there are no problems. In some cases, operators were asked informally by managers to see if “filling up the cobot feed tray” was something they would take on, with them responding, “do I really have to do that!”

The lengthy process of getting the cobots to work typically involves many cycles of problem solving characterised by an explorative and emergent process. The resulting level of automation and human interaction is not known at the outset. A reoccurring issue was realising that parts needed to be placed exactly in ways the cobot could then accurately “pick and place.” The precise placement and fixture of the cobot itself is crucial to prevent alignment issues but can conflict with the desire for flexibility. This might include wanting to be able to move the cobot quickly out of the way, or to move it to an operation in another location. The placement of parts in racks and waiting for the cobot operation to complete its lengthy cycle are not the free flowing harmonious and collaborative interchanges between cobot and human so often portrayed in sales and marketing literature. It was however the typical intermittent attention and action resulting from the practical need to get the cobot working properly. Coordinating this kind of work with other tasks subjects operators to hybridised and indeterminate patterns of work in which they fill “the slots” [64] in a manufacturing system.

9 Overview of conflicting issues

The above analysis provides a complex backdrop to the implementation of cobots into manufacturing companies. Each of the thematic areas outline a range of possible dilemmas that can be summarised as polarised issues that need to be negotiated and addressed if cobots are to be implemented ethically.

Learning	
Predictive planning	Contending with uncertainty
Prioritising daily production	Authorised flexibility
Justifying ROI	Experimentation
Technical opportunities	Understanding ethical issues
Fixed abilities	Experience based learning
Acceptance vs rejection	Meaningful application
Determining values	
Techno culture	Diversity of human values
Economic benefit	Multiple views of production
Normative view of robots	Situated understanding
Assumed benefit	Human effort required
Replacement of labour	Provision for new skills
Production as system	Production as workplace
Preconceptions of work	Negotiating values
Human skill	
Explicit skill	Skill through implementation
Skill as fixed	Skill learnt in practice
Skill and safety as separate	Safety as learnt ability
Reproducible skill	Skill as learnt human ability
Work as economic system	Work as aspect of well-being
Behaviour as regulated	Behaviour as responsive
Reconfiguring work	
Humans as obstacles	Humans as resources
Cobots as flexible solutions	Human adaptation
Polarised workforce skills	Diversity of workforce
Work as supportive	Direct work
Clear working objectives	Unclear hybridised work
Organisational values	Well-being
A reluctance to deskill	Appreciation of human skill

10 Conclusion

Fully understanding the ethical dimensions of adopting cobots into small- and medium-sized manufacturing companies is a difficult consideration. This article has presented an argument for a complex process of adoption affecting different groups and individuals occurring in the situated environment and material practices of the factory and workplace. Ethics have been presented as dynamic and embedded largely through the processes of getting the cobot to work, seen in separation from the

design activities of cobot producers. This article has introduced an anthropological approach to ethics through descriptions of the way technicians and operators find themselves in learning processes making sense of the new configurations of work assemblages and skills. The case has been made for cobots to be seen as a particular kind of industrial robot with the potential to reveal unanticipated ethical boundaries as they are put to work.

Four challenges facing SME's intending to implement collaborative robots have been proposed through the organisation of the article. First, understanding the implementation of cobots as involving complex learning processes. Second, that values are not given as a result of the robot or company, but emerge and are negotiated between groups and individuals. Third, that human skills are not fixed and explicit but become understood as they are replaced or altered as a consequence of how the cobot is implemented within the existing manufacturing system. Fourth, the resulting changes to human work are similarly not determined beforehand but also arise during the contingent activities occurring along the way.

The view that humans are immersed in activities that are variously situated in technological arrangements influencing the day-to-day actions of others may be far from uncommon. Understanding the ethical aspects of cobots may not simply be difficult but illusive and ambiguous. This study offers a number of reflections towards attaining more ethical adoption processes. First, the need to issue ethical responsibility and codes of practice amid the contingencies of implementation. Second, an acknowledgement that the design of robotic platforms carry with them ethical and moral consequences related to the means through which their users adopt them and get them to work. Third, that even in established robotic contexts ethics are continually being interwoven into society in new ways. Fourth, an emphasis upon new configurations of automation and human skill in the light of collaborative technologies.

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