"Meet Your Personal Cobot: Will It Change You? Can You Resist It?" Appropriating Collaborative Industrial Robots in Makerspaces as a Trading Zone

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Introduction

Collaborative robots (cobots) were first introduced in automotive factories as devices capable of manipulating objects in collaboration with human workers (Colgate et al., 1996). For safety, these devices embodied the principle of passive mechanical support, which—combined with existing robotic technology—brought about the now stabilized image of a cobot as an anthropomorphic robotic arm, endowed with strength and sensitivity. Some *Industry-4.0* visions promote cobots and human-robot collaboration as an alternative to the unsuccessful "Computer Integrated Manufacturing" paradigm of total automation from the early 1980s. Yet, in spite of the positive image they enjoy, due to safety concerns and path dependencies, cobots have found relatively few industrial use cases. As a result, some vendors are targeting the consumer market as well. Today, (personal) cobots can be ordered, installed and operated by anyone willing to invest 5000€ in a handy universal helper; and, recently, they also started figuring in makerspaces.

The appropriation of cobots in non-industrial contexts made crowdsourcing new applications in makerspaces interesting for human-machine interaction (HMI) and robotics researchers. The creativity of makers and hackers—so their argument goes—might eventually be channelled towards industrial applications. Driven by this rationale, an Austrian consortium consisting of two research institutes, a manufacturing company and a makerspace successfully developed this idea into a publicly-funded research project called "Cobot Meets Makerspace: Democratizing Collaborative Robot Technology in Public Work Shops"[1], on which this paper is focused.

My preliminary analysis of the data collected through surveys, interviews and participant observation of various project activities suggests that the appropriation of cobots in the studied makerspace may be conceived of as a *trading zone* (Galison, 1997), within which unrestricted access to cobots and "reliable" expertise are traded for crowdsourced cobot applications and lay expertise between the individual and institutional actors involved in the project.

Previous research revealed numerous tensions and contradictions between the ideal of democratizing technology and "neoliberal business-as-usual" amidst DIY locales (Braybrooke & Smith, 2018). My aim in this paper is to go beyond the realisation that idealized democratic institutional models may be misappropriated by business interests. Instead, I will ask whether and how mutually-beneficial exchanges centred on manufacturing technologies "in the making" are possible between individual and institutional actors even in "makerspaces defined by institutional encounters" (Braybrooke & Smith, 2018). In this sense, the proposed trading zone model complements that of makerspaces as "real-life laboratories" (Dickel et al., 2014) by suggesting that the collaboration between technoscientists and lay experts (including makerspace members), and between research institutes and DIY locales are inherent to the *co-construction* of technologies and their users (Oudshoorn & Pinch, 2003) in post-automation —*as process* rather than experiment.

[1] Project website: http://www.comemak.at

After introducing the case and the theoretical framing, the focus in this paper will be on the first encounters between researchers, cobots and makers, and on how the actors approached the safety issue in the studied project; followed by a short and open discussion of the case.

Case Study

The “Cobot Meets Makerspace” project aims to install cobots in the “GRAND GARAGE” (GG) makerspace in Linz with the technical support of HMI and robotics researchers to the end of crowdsourcing new assembly applications, which might also be of interest in industrial contexts. In addition, the project set out to develop a new cobot safety concept and a more intuitive and versatile web-based human-programmable interface.

Driven by various interests, a robotics institute called JOANNEUM, the HMI group of the Vienna Technical University (a member of which I am myself) and the training centre of an engine maker, called RIC, partnered with the GG in the project. During the project’s kick-off meeting, the JOANNEUM representatives expressed their interest in how makerspaces would go about safety issues and how their members would interact with cobots in a non-industrial context. RIC had hopes that the applicable safety norms and standards could be made more flexible and permissive without increasing risk on the part of application integrators (i.e., factories). The representative of the makerspace (a roboticist especially hired for the project) expressed hope “for the unexpected to happen” in terms of exploring and improving the modes of interaction between humans and robots. As an example, he recounted how a member of the GG “hacked” the software of a laser-cutter and then showed the engineer from the vendor company what else the machine could do. Also, the makerspace hoped to capitalize on the open source project results by offering trainings, technical support and consultancy around cobots to interested companies. Finally, the representatives of the HMI group were interested in crowdsourcing cobot applications in makerspaces, perceived by some members of the group as being more creative than conventional research labs and factories.

Besides providing its paying members with access to a wide range of industrial tools and machines, the GG is part of a holding company, which owns the former tobacco factory in Linz (the “Tabakfabrik”). With the support of the city of Linz, this company turned the former factory into a business hub, hosting co-working spaces, company offices and the GG. One of the makerspace’s role is to “attract talent” into the Tabakfabrik ecosystem. Nevertheless, the GG does not lure its members into business relations and not every company is allowed to join the hub, so the director tells us during one of the first project meetings. Instead, the GG occasionally offers freelance contracts and other incentives to its members for various purposes.

Appropriating Cobots as a Trading Zone

Galison (1997) coined the term *trading zone*, representing "[a] site—partly symbolic and partly spatial—at which the local coordination between beliefs and action takes place " (p. 784). Such coordination is made possible through interlanguages (trading languages, pidgins, creoles), which facilitate the communication between different epistemic subcultures (e.g., theoretical and experimental physics) sharing a common goal (e.g., to build a radar system). Drawing on Galison’s work, Collins et al. (2007) note that there might be several types of trading zones, which do not necessarily build on interlanguages alone but also on what Collins and Evans (2002) call *interactional expertise*—expertise that, for example, is sufficient to interact with participants and carry out a sociological study; or boundary objects (Start & Griesemer, 1989)—“objects which are both plastic enough to adapt to local needs and constraints of the several parties employing them, yet robust enough to maintain a common identity across sites” (p.393). In addition, Collins et al. (2007) propose a two-dimensional system for classifying trading zones, along the axes of collaboration-coercion and homogeneity-heterogeneity.

The trading zone concept has also been applied to exchanges between non-scientific communities (Balducci & Mäntysalo, 2013; Gorman, 2010). In these examples, the different groups involved in the trade seem to have had sufficient epistemic, political or other kinds of authority to act as approximately equal partners in the trade. The balance of power relations between trading partners determine whether a trading zone tends to be collaborative, coercive or subversive (Galison, 2010; Collins et al., 2007).

Having triggered common interests with the members of different technical cultures, I would argue that cobots may be regarded as *boundary objects*, which stimulate and justify exchanges between researchers and members of the GG—as two different "user-developer" groups—and between different kinds of institutions. The sociotechnical configuration of the studied project thus appears to resemble a trading zone, centred on a manufacturing technology in the making. This configuration is interesting because it creates the premises for the co-construction of cobots and their (un)projected[2] users (Oudshoorn & Pinch, 2003; Akrich, 1992). In processes of co-construction, users play a determinant long-term role in the design, development, and application of technologies. Such modes of interaction may yield unexpected, mutually-beneficial results for technoscience and society. This, of course, is an optimistic scenario, which needs to be validated empirically from case to case.

As Galison (2010) notes, one way to determine whether a particular sociotechnical configuration may be conceived of as a trading zone is to look into *what is being traded, by whom, and how power is distributed among the partners of the trade*. I will now turn to an account on the empirical material to provide situated answers to these questions.

First Encounters Between Makers, Researchers and Cobots

The first big question in the project concerned which cobot to install in the makerspace. While the roboticists pushed for a Universal Robot, the HMI researchers preferred a Franka Emika Panda, which comes with a more intuitive human-programmable interface (HPI). By contrast, the Universal Robot provides a relatively open application-programmable interface (API), which—unlike Panda's HMI—can only be mastered by people having programming skills. To ease the decision, the partners decided to organize a free two-day workshop with interested members of the GG, featuring the Panda robot in a first attempt to evaluate the intuitiveness and versatility of its HPI. To ensure safety, one of the two trainers would keep one hand on the robot's safety-stop button at all times.

The first day consisted of a presentation of the goals and methodology of the project, followed by a safety briefing. Then, in the hands-on part, participants implemented a simple pick-and-place application (a wood block puzzle). For the second day, participants were asked to think of an application of their own. The 11 participants were also asked to fill out a feedback form with questions concerning their perception of the cobot's safety, usability and potential real-life use cases.

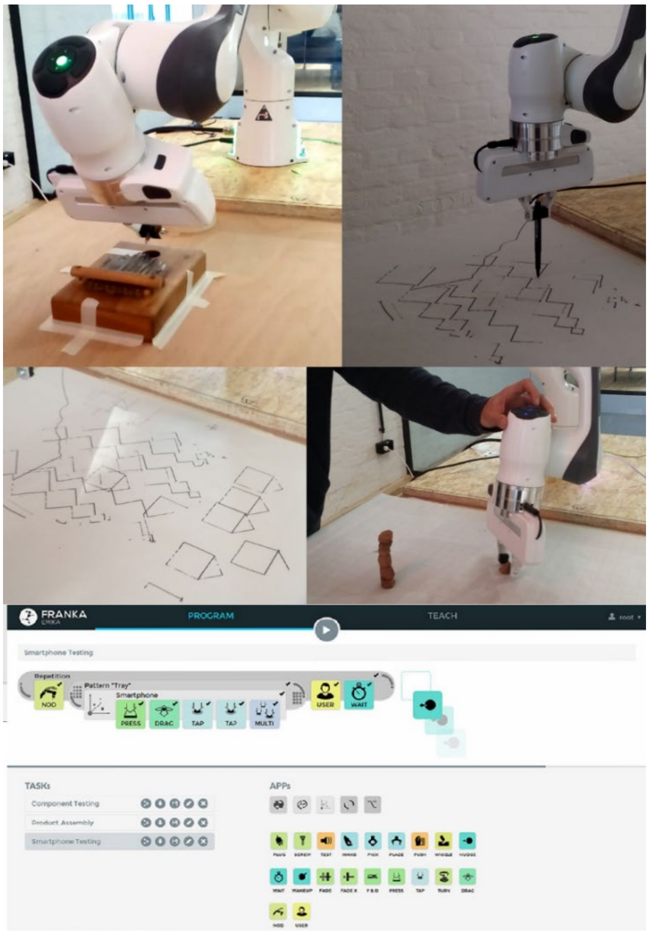
All participants indicated that they were there in their free time out of different curiosities, ranging from philosophical questions (e.g., "will we remain framers or be framed?") to technical and practical interests (e.g., potential cobot applications in fashion design and museums). More than half of the participants were well-known to the employees of the makerspace, who referred to them as "regulars." Only 3 participants had previous experiences with robots or programming skills.

The figure below illustrates some of the cobot applications attempted by the participants as well as Panda's programming interface. A museum curator and musician thought of teaching the robot how to play the kalimba. A graphic designer and another participant wanted to try out its drawing abilities. Two

[2] Akrich (1992) coined the term *projected users* (as opposed to real users) referring to those user images (or profiles) for which inventors and designers conceive technologies.

other participants wished to test the sensitivity of the robot by programming it to build a tower of asymmetric stones.

Being used to industrial applications, the trainers were puzzled by these ideas. And, after countless, repetitive rounds of testing, only playing a simple melody on the kalimba seemed to work. Owing to its limited programming interface, the cobot was clearly unfit for most of these tasks. Currently, Panda's capabilities can only be extended by acquiring additional apps from Franka Emika's app store. In this store, a single app costs 800-2000€; and, besides Franka Emika, only carefully screened companies are allowed to develop and sell new apps.



During this exercise, one type of "good" being traded between the trainers and the participants appeared to be in the form of "demystifying truths" about the potential and limits of cobots. The difficulty to implement any kind of unscripted idea suggested that robots are still unfit to replace humans in various work settings. The HMI researchers also confirmed their hypothesis that the sparsity of industrial cobot use cases is not only due to safety concerns but also to the current limitations of cobot programming interfaces.

Although the trainers did not realize this right away, all of the participants' ideas had isomorphic equivalents in the world of manufacturing. For example, building a stone tower is an actual assembly application; and playing the kalimba is similar to pressing switches or clamps. I would argue that, for the researchers, the interpretation of these application ideas in terms of their own research interests represented a first step towards developing the interactional expertise necessary to collect and re-specify new cobot use cases in the GG. Also, the workshop generated a series of new requirements to the future generation of cobots, especially concerning their versatility and sensitivity. Such requirements are expected outcomes in processes of co-construction, like user-driven development.

The feedback of the workshop participants indicated that they also learned something about the potential uses of this kind of robot; for example, at work. For some, this experience was important as part of their professional development; whilst for others, it was just a new and interesting experience, which provided them with a feeling of success when something actually worked. 30% of the respondents indicated that they saw potential in using a cobot in everyday activities, for example as a "third hand" or a display of what people and robots are and aren't able to do. Finally, 6 out of the 11 participants expressed their wish to take part in other activities related to the project.

The Social Construction of Cobot Safety

A cobot is any industrial robot, which is not operated behind a safety fence. Current industrial safety norms require a separate certification process for each cobot application. This means that any change to the application code, its physical layout or the robot's physical structure will require a new certification process. In Austria, the certification process itself does not directly involve a state authority.

Instead, the safety of an application is “negotiated” between the integrator (i.e., factory) and a certified safety consultant. These consultants have a profound understanding of the multitude of applicable norms, and perform the necessary measurements and calculations for each application. The goal of the process is to minimize the risk of injury due to unforeseen contacts between humans and cobots. Reasonable risks, which can be identified but not eliminated using technical means, are called *residual risk*. The certification process seeks to minimize residual risk and to make it explicit using highly visible safety warnings.

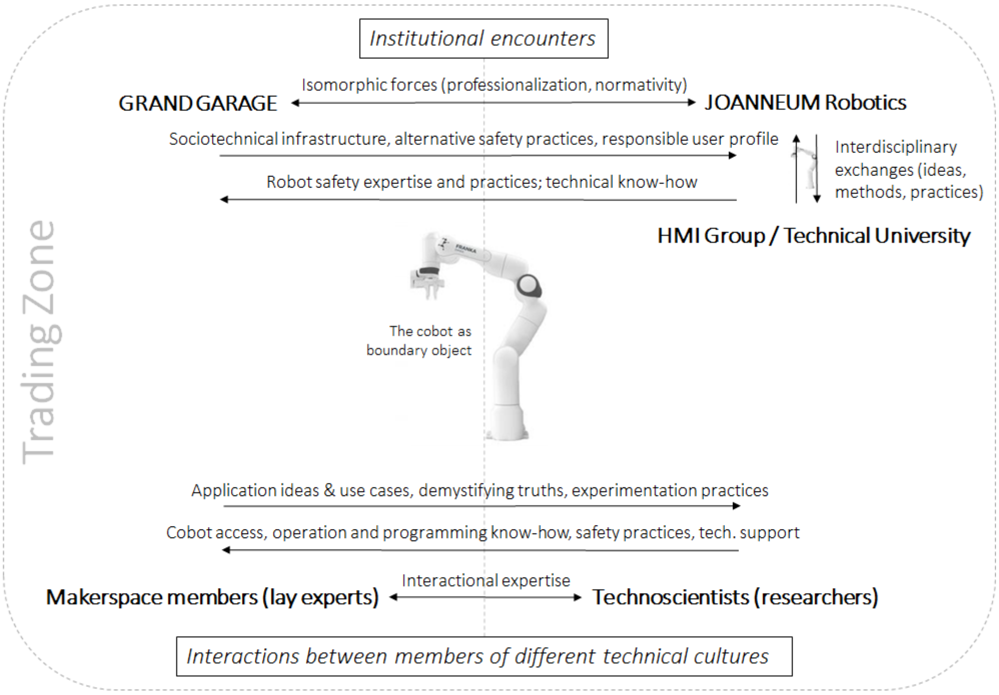
These cobot safety norms and practices, however, only apply in industrial contexts. As soon as a cobot is operated outside of a factory, it falls into a grey area. It may, for example, be regarded as a service robot, like an autonomous vacuum cleaner; or not. Installing a cobot in a makerspace thus breaks the norms and categories used in industrial safety practice by simply not being in a factory. Moreover, since in makerspaces applications cannot be known in advance, the existing industrial safety standards, which focus on predefined applications, are inapplicable. This represents a research challenge in the project.

Makerspaces have their own safety principles and systems, which basically aim to ascertain the identity of the person working with a particular machine at any given time; hence, responsibility is deferred to individual members. In technical terms, makerspaces simply treat all risks as being residual. With immobile machines, like 3D-printers and laser cutters, the principle of self-responsibility seems to work well. In the case of cobots, however, the issue is posed in a qualitatively different manner because these are potentially unpredictable “metal contortionists” animated by software. To mitigate the risk of gross negligence accusations in case of an accident, the GG decided to consult an inspector from the Austrian work protection agency before allowing members to work with cobots on their own, regardless of the safety concept resulting from the project.

With the project team still debating about potential safety hazards and ways to mitigate them, one researcher found out that another makerspace in Berlin, called the HappyLab, had already installed a Panda cobot and allowed members to use it at their own risk. The roboticists on the team were intrigued: “What kind of safety concept was in place in the HappyLab?” The answer came over the phone: “a sane human mind.” This unexpected development generated peer pressure upon the GG. As a result, the project team agreed to speed up the development of a safety concept by seeking trade-offs and alternative methods to ensure safety and flexibility at once. And, since there were no documented experiences with this kind of problem, the JOANNEUM researchers had no other choice but to observe what and how the members of the GG would do with the cobot in order to better understand the potential safety hazards arising from those interactions. Faced with the reality of makerspaces, the roboticists “discovered” the value of participant observation as a research method.

Another traded good in the process of understanding the safety issue consisted in a new image of cobot users. Whereas industrial safety norms project cobot users as people who cannot be made responsible for their own safety, cobot users in makerspaces could be characterized as curious individuals whom organizations can trust to be responsible for their own interactions with technologies. Peer pressure from the HappyLab thus mitigated the normative impulse to implement industrial safety norms and systems in the GG, which also affected the epistemic authority of the JOANNEUM researchers. As a result, the distribution of power between the actors involved in the project seems to have found a new balance.

By hiring a trained roboticist for the project, the GG seized the opportunity of collaborating with Austria’s biggest robotics institute to the end of acquiring know-how and expertise in a new technical domain. In exchange, the robotics institute gained access to a completely new sociotechnical infrastructure. By deferring safety to experts, the GG also took action towards minimizing the risk of accidents at the expense of disciplining their customers. In doing so, it traded some of its freedoms for safety. This suggests that, introducing a new technology in makerspaces may—under certain conditions—cause some degree of institutional isomorphism (DiMaggio & Powell, 1983) through professionalization and normativity.



Open Discussion

These empirical observations suggest that, in the studied case, "goods" in the form of know-how, expertise, practices and artefacts are being exchanged between the members of different technical cultures and institutions. These exchanges are motivated by the shared goal of "democratizing" cobot technology, which bears different meanings in each of the involved technical cultures and institutions. Yet, rhetorically, the call for democratizing a manufacturing technology in the making seems both generic and enticing enough to stimulate participation and collaboration around cobots as boundary objects. The resulting sociotechnical configuration resembles a collaborative, heterogeneous trading zone, tentatively illustrated in the figure above.

Nevertheless, the current balance of power and interests between the actors involved in the trade seems fragile. Further developments in the project might, for example, determine the GG to seek more aggressive ways to capitalize on the outcomes of the project by prioritizing the interests of the businesses in the Tabakfabrik over those of individuals. This would push the trading zone into a subversive mode. The JOANNEUM researchers might also re-evaluate whether it is more worthwhile to challenge industrial safety norms and practices or to coerce the makerspace into implementing them, considering the business interests of their employer. And, with the members of the GG becoming co-constructors of cobot technology, an expert culture might emerge in the GG itself.

The fact that other makerspaces simply choose to short-circuit the safety issue, thus dropping an important barrier to the appropriation of cobots by their members, raises the additional question of which model of appropriation (i.e., with or without the involvement of technoscientists) is more likely to serve the ideal of democratizing cobot technology in a sustainable way. Or perhaps this is the wrong question to ask; because, in post-automation, different models of appropriation may well co-exist and jointly contribute to a shared goal.

I would like to leave these and other possible scenarios and questions open for discussions during the symposium.

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