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Factory fieldwork informing the design research process

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FACTORY FIELDWORK INFORMING THE DESIGN RESEARCH PROCESS

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ABSTRACT

Engaging with manufacturing operators in design research poses a myriad of challenges ranging from ethics to logistics. We describe a process of qualitative, mixed-methods, non-participant fieldwork user research involving 10 garment factory workers created to inform the design of technology to support operators' physical and mental health. The resulting data were subjected to thematic analysis which identified themes that informed not only the design of technology, but also the co-design process itself. In this paper, we explore the latter as a contribution to design research methods, discussing the implications of analysing user research data towards informing design researchers' behaviour in their interactions with research participants and how these might help collect ecologically valid data.

INTRODUCTION

Manufacturing jobs are often associated with occupational injuries, a phenomenon which has been studied for long to develop preventive strategies, and which is growing along with an ageing workforce (Peng and Chan, 2019). There has also been an increase in research on psychosocial aspects of such jobs, as well as on the interplay between physical and mental health at work (Wixted, Shevlin and O'Sullivan, 2018). In Europe, depression and anxiety account for up to 50% of chronic sick leaves (World Health Organization - Regional Office for Europe, 2021). Digital technology has the potential to prevent physical and mental complications at work through active and passive data collection, communication, and information (Romero *et al.*, 2016). However, to increase chances of usefulness and meaningfulness, it requires workers to be involved in the design (Béguin, 2007). User research and codesign methods are used today in a variety of contexts, including factory shopfloors. However, these are usually highly controlled environments which challenge design researchers in attaining expected intense researcher-participant contact. Such level of contact is critical to establish *rapport* (Erete, Israni and Dillahunt, 2018; Groeneveld *et al.*, 2018).

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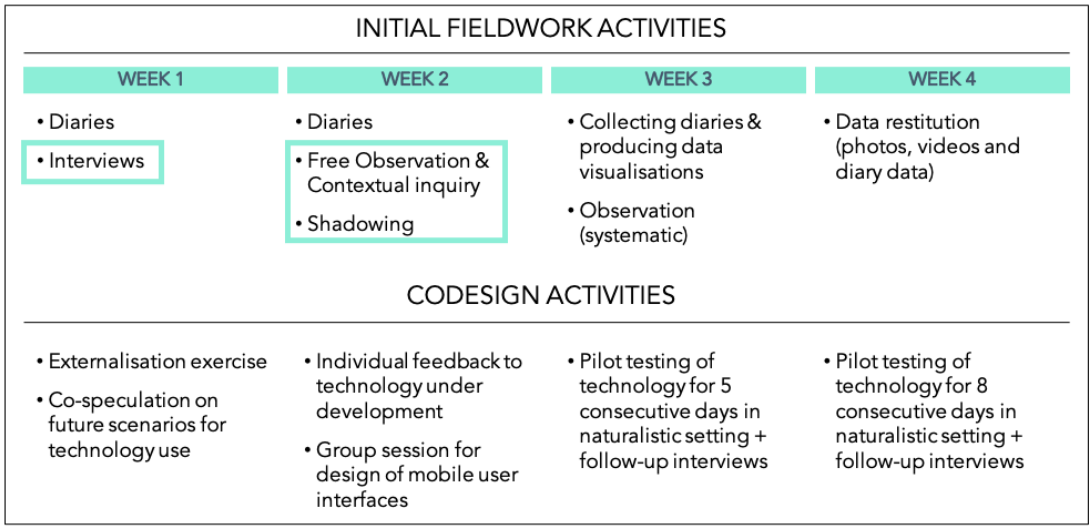

Figure 1: Outline of user research and co-design activities throughout project OPERATOR. This paper reports on the interviews and free observation, outlined in the image above in light green.

Factory shopfloors are challenging environments for user research and codesign for various reasons, such as participant recruitment, safety issues, confidentiality, work schedules, or agreements with worker unions (Ardito *et al.*, 2014). There are reports of workers being suspicious of new technology being presented to them by designers (Heikkilä, Honka and Kaasinen, 2018) as well as reports of difficulties in conducting pilot studies, especially at scale (Mattsson, Fast-Berglund and Åkerman, 2017; Peruzzini and Pellicciari, 2017; Heikkilä, Honka and Kaasinen, 2018).

Ethnographies of work have described communities of practice among members of a certain profession (Orr, 1996), aspects of gender performance (Cross, 2012), and group behaviour (Chakravarti, 2011). These are examples of aspects which are relevant for design researchers to be aware of in the process of establishing rapport and to improve likelihood of collecting ecologically valid data. However, not always is this generic information about user groups available to design researchers prior to fieldwork. Furthermore, each worker group has conditions and dynamics which are unique, requiring fieldwork researchers to build their presence (Daniellou and Rabardel, 2005; Barcellini, Belleghem and Daniellou, 2014; Schwartz, 2021).

In the process of doing user research to inform technology that could support manufacturing workers' physical and mental wellbeing, we collected data that were, in itself, relevant to establish rapport and to inform user research and codesign as a process in this particular setting. In this paper, we present it as a case study (Breslin and Buchanan, 2008) with an approach to data analysis that we expect may be replicated by other design researchers in similar circumstances. To illustrate this possibility, we conclude with an account of how the lessons learned were applied to another research setting.

FIELDWORK CONTEXT

The research was held in a garment factory, a partner of the R&D project OPERATOR, with just under 300 workers, most of whom women. The shopfloor has several sectors (e.g., cutting, pre-assembly…), each led by a line manager. The factory produces high-end garment pieces with very low fault tolerances. Garments are produced by moving from one sector to the next, making sectors interdependent. Inside each sector, the pieces also move unidirectionally, therefore, operators' work is also interdependent.

The factory has general work orders by clients, which are distributed chronologically through the sectors. Therefore, each sector has daily and weekly objectives. Before deciding on closing a deal for a work order, clients need to see prototypes (also called samples) of the pieces, therefore, some operators' workflow may be interrupted with a request to produce a sample for a client.

MATERIALS AND METHODS

To inform the design of technology to support physical and mental wellbeing, we sought to understand operators' practices, aspirations, and concerns, as well as the context in which a future design could be used. The study received approval by the ethics committee of the Faculty of Psychology and Educational Sciences of the University of Porto (Ref.2020.09-6). To conduct the study, the garment manufacturer in the project was asked to announce the study and invite operators, seeking to achieve variability in terms of age, professional experience and type of operations. Gender-balance was not sought since only women worked in the sewing operations.

Ten operators volunteered to take part in the study. The study involved ten female operators (average age 40.6 years (SD=9.7)). All performed sewing operations, but belonged to three different sectors, which stood at different phases of the process of building a garment piece.

A multidisciplinary team of design and work psychology researchers took part in non-participant fieldwork, during which we used the following methods individually with each participant: a diary study, interviews, free and systematic observations, an externalisation exercise, and a speculative design exercise, which happened in the course of four weeks of fieldwork.

In this paper we report on data collected through the interviews and free observation with contextual inquiry (Figure 1). Interviews were audio-recorded and transcribed verbatim. Observations were further documented with photographs, video, and drawings. The data were analysed using Thematic Analysis (Braun and Clarke, 2006) to find implications for design.

As we reflected on four themes that emerged and how they could be translated into *designed products*, we examined how they could inform our *design process*: they informed design research behaviour in the field.

RESULTS

In this section, we describe each theme, along with fieldwork pictures and operators' quotes when relevant.

SEEKING PERFECTION

In operators' eyes, perfection is conceptualised differently depending on the stakeholder: to the company (employer), perfection is associated with innovation, following rules of conduct (e.g., workstations nice and clean) and improving efficiency, namely through training flexible workers, i.e., those who work on multiple operations and machines. Each client is also associated with a certain level of perfection:

Interviewer*: You say these clients are more demanding. How is that felt on the production line?*

O7*: The chief [line manager] lets us know. Several times a day, I guarantee you. And we know by the brand, right? We also associate brand to client.*

Operators understand that they are requested to produce a certain number of pieces per hour to meet the company's commitments to clients, but they also understand that they work for high-end clients and under very low fault tolerances. At times, this forces operators into a debate of values (Schwartz, 2021) to choose between meeting production goals, meeting personal life demands (e.g., avoiding overtime) or staying true to their work values. Perfect is what operators report they need to be.

There are situations which are more prone to defects (Figure 2). Producing samples is one of them, because it is a new, one-time job, which carries with it the pressure of delivering a high-quality piece to show to potential clients. Furthermore, there is often one person looking over operators' shoulder when preparing the samples. Being observed during work is stressful for operators, especially if the observer knows the trade.

Figure 2: Piece with defect.

Other situations prone to defects are working with difficult (e.g., slippery) fabric or working with striped/checkers patterns. However, even though their work might be made harder because of faults in prior phases of the production process, operators think of defects as being their own fault.

Operators can be confronted with defects that they themselves notice or they can be faced with one or more pieces to fix at the end of the day. In the first case, they have a bit more control, but it can also be highly frustrating when they keep trying to fix the same piece and it does not come out well time and again. The second case is a common reason to determine a bad day at work. Operators will much rather do a new piece than fix a defective one sent back by the quality control department. The second case also has the effect of surprise, which, here, intensifies the feeling of frustration (Ortony, Clore and Collins, 1988).

O8: *What makes me suffer the most is really the job coming back with defects. No doubt about it. No doubt about it. It's really bad. It's bad internally, because there's no one there pestering us, not at all. But, internally, it's really bad. It's feeling we're not being able to.*

Operators report experiencing flow (Csikszentmihalyi, 2008) when work is coming out at a good rhythm and with no defects. The feeling of flow is influenced by the operation, by the fabric, by the machine and by whether operators are being pressured to get the job done quickly.

O5: *A good day is the job moving forward steadily and well-done. Not having pieces to fix, nothing. A steady*

job is everything coming into the line as it should. Sometimes this doesn't happen because of the fabric, because of everything. The machine isn't always working well and needs fixing. That's it, if it comes nice to us, we let it go nice as well. It moves forward.

Flow, in this case, has a certain synesthetic quality to it: one can see the steady movement of the pieces down the production line, when production experiences no glitches. Flow is also more associated with some clients than with others.

RESPECTING AND OBEYING TIME

The garment business runs on cost-per-minute. Every hour, operators need to note down how many operations they did. Since they mostly work on the same operation, regardless of the work order, operators have in mind their personal 'number' for the operations (i.e., how much they produce per hour) depending on the type of fabric and pattern they are handling. Time is, therefore, a source of daily pressure, as operators quickly understand if they are delayed. Line managers are also controlling how many pieces leave the sector, so they quickly know whether they are on schedule. If the production is delayed, line managers will pressure operators to work faster. When time is tight, operators will likely begin by saving time in work control: rather than checking all the pieces after they are done, they may start checking less and leave it for others to do that quality control; however, this is uncomfortable, as it has implications on one's work values as described above.

The concept of time is also present at a longer-term scale. Although factory work tends to be thought of as repetitive and unskilled, operators know that it takes a long time for one to master one's skills in a garment factory. Line managers play a prominent role in teaching operators a new operation, and less experienced operators often highlight that they are still learning. All operators accept that only time will allow them to master their art.

***O6**: …I haven't been a professional in this job for long because I've only worked in jackets for nine years…*

Once an operator reaches a certain level of seniority, they have a greater leeway, as illustrated by O5 below. However, together with years of experience, hierarchy must also be respected.

***O5**: Sometimes it's not even with me, because I can very well defend myself, because I'm old enough. It's not just anyone who walks over me anymore. You understand? I have another mentality. Sometimes I get hurt, but now I answer back, I'm no longer one of those who keep silent. That's over. As long as I am right… Before, when we were young, we would shut up and cry and do everything. But now I think that my age can't be overlooked. If I have my job, they must respect me, they must respect everyone, as I must respect my superiors.*

RELATING TO ARTEFACTS

Operators are often attached to 'their machine', which allows them to make 'one's own work' the best. It is generally accepted that everyone knows about their own work the best. Since the company strives for flexible operators who can work equally well in several operations and machines, this is repeatedly a point of tension.

***O9**: It's funny because I went on sick leave and when I came back, she wasn't working well and I started rambling: 'The owner was out, and they came here to mess with my machine.' They [mechanics] had to wax it all. Because I'm used to her, I know how things work, I know how she works.*

***O3**: …For example, I spent around 3 or 4 years in the same machine, and we try to take care of our machine, right? Now, if we jump from one machine to the next, it's easy to see that they… One doesn't take care of them the same way we do when we have our own. Later they even took my machine away and I'm like: 'Damn, so much care and she's gone'.*

Operators say that they know their machine, they know how to fix it, they know how to bring the best out of it, and their machine is fine-tuned to their way of working. Operators recognise its noises, sometimes they personalise it and they keep it clean. Cleanliness is often associated with machines, while using someone else's machine is often referred to using expressions of disgust and fear of breaking the machine.

Operators also mention that their machines have something special compared to others, e.g., being hard to use by others, being technologically advanced, or being complex. Machines seem to be associated to memories of learning the trade, as operators tend to mention the machines they like the best are those they first learned to work with. It is frequent to see machines and other utensils marked with operators' names.

Machines are always in interaction with operators' bodies and with fabric. In the garment industry, fabric must be respected. But fabric has meaningful associations and a strong impact on operators' spirits. In a place where fault tolerances are very low, seams need to perfectly match patterns in the fabric. Although operators can rarely name the type of fabric they handle, all associate plain fabric to easy work and flow, striped fabric to more difficult work and a decrease in production, and checkers fabric to difficult and highly stressful times. So much so that operators suffer in advance when they realise that their next work order will be stripes or checkers.

Apart from the machine, operators use utensils – some provided by the company, but most owned by operators (Figure 3). All operators brought personal objects, such as water bottles or cushions. There are also tools, like jigs, made by operators or line managers. Operators are not allowed to have non-work-related objects over the sewing machine table. Many machines come with a small drawer, which is used to store operators' utensils. Other than that, operators use their vest pockets to store and carry utensils and personal objects, such as medication, sanitary pads, alcohol gel or hair rubber bands. Operators are not allowed to bring smartphones onto the shopfloor.

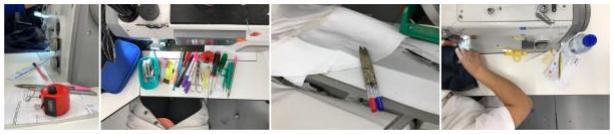

Figure 3: Personal tools brought by operators (two pictures to the left) and two tools created by line manager and operator, respectively (two pictures to the right).

ACKNOWLEDGING A SUB-CULTURE

Operators often mention that existing stereotypes associated with the textile industry match reality. Working in the textile sector means acknowledging and accepting these stereotypes. One's work is dependent on others and affects the work of others ahead in the process. This interdependence affects not only how quickly pieces are produced, but also how easy they are to produce. As stated above, each person has 'one's own work' in which they are good at. The person who is the best at their own work will likely be asked to teach novice operators – something which might or might not be done willingly due to fears of losing one's uniqueness.

Expertise may be signalled by work vests. Operators wear white vests, line managers wear blue, and quality control wear yellow. All operators receive a couple of vests from the company, and all receive vest replacements every few years. Workers are free to discard the old ones. While vest models are similar, they

Figure 4: Work vests (from left to right): embellishment of personal vest (two pictures to the left), older operator vest, and line manager vest in blue.

change slightly over the years. The vests given to the very first operators in the factory had a blue rolled hem, while the newer ones are all-white. Older operators may keep and still use the vests with blue rolled hem, which signals their seniority (Figure 4). Exhibiting external signs to other members of the same work sub-culture has been reported before in relation to seniority (Chakravarti, 2011) or expertise (Cross, 2012).

When line managers who are regarded by the operators' group as having less experience in a certain operation force operators into doing their work in a certain way, this causes social tension:

O3*: …Because she wasn't a chief, she was an employee like we are and she was going to learn from us, right? Because she was like us. Like if I go do another work, I don't know about it and someone must teach it to me, right?*

Interviewer*: Sure, sure.*

O3*: And we were the ones who should do the teaching. But there were moments we told her 'look, it's not like that'. Because it's, like, my work. It's obvious I knew much more about my work than she did, right? Like she knows her work better than I do. And if I gave her ideas, if I said 'look, no, it's better like this'. Forget about it. Forget about it because she wouldn't accept it.*

In the textile industry sub-culture, the role of the line manager is a prominent one. The line manager pushes and pressures operators, but she also often teaches them the trade, instructs them whenever new models come into the line, often improves work conditions to avoid injuries or to make the job easier, and she might shield operators from external harm. A line manager who is younger in the trade than the average operator in the sector or a line manager who will not respect operators' knowledge of 'one's own work' will not easily gather respect from the sector. This will cause animosity and, in operators' words, even someone from the outside can recognise 'stressed sectors'.

Operators often complain when there is too much pressure, but also accept they will be pressured by their own sense of perfection, will be pressured by externals looking over their shoulder or asking them to produce at a higher speed, and they will be pressured by seeing that colleagues ahead are waiting for work.

Interviewer*: You don't feel that pressure exists.*

O6*: No, no. I don't feel it. Well, of course my chief [line manager] is in our sector and the more we produce the better, right? And she obviously won't be patting our back. She must reach her goal because she also has her duty. That we understand.*

In an environment where work is interdependent, operators often comment on colleagues helping each other by sharing knowledge, doing work in a certain way to facilitate the work on the person who will work on the garment next, or even adjusting production rhythm not to strain colleagues who might work at a slower pace.

O6*: …When I'm working on checkers or stripes, I put to the side the half with a chest pocket from the half*

without, so that the girl ahead doesn't have a lot of work sorting them.

However, it is also common for operators to refer to a difficult social environment where each new person is scrutinised by the others, especially when they join the group. Younger operators report it was more difficult to learn how to deal with the social environment than to learn the trade. Although we have never posed follow-up questions about what this might mean, remarks on the social environment were often associated with comments about the fact that most operators are women.

***O8**: …Just an evil look would bring me down. That's what I meant. But it's natural. I think it's a lot of women together. I think it's difficult.*

LESSONS FOR THE DESIGN RESEARCH PROCESS

Our results outline common issues highlighted by Barcellini et al. (2014) and Schwartz (2021): the 'creation of researchers' presence' in the field – associated with the appropriation of the jargon of the trade; the knowledge of the significant objects related to the job; or the singular dynamics of work teams; as well as the principle of 'commensurable knowledge' between researchers and workers during the process of codesign.

Next, we describe how we have operationalised our findings from user research to inform the *design product* into findings to inform our *design research process*.

RESPECTING OPERATORS' PERFECTION

Seeking perfection was part of who the operators in this sample were. Not being able to reach this goal has implications on operators' openness to take part in our research activities because it causes poor spirits and because it leaves operators less free time to engage in research. This is one of the signs that we learned to read from operators. When operators are not able to reach perfection due to design research activities, chances are operators will evaluate the fault as being their own, not researchers'.

After some days in the shopfloor, researchers start picking up the signs on the sectors – a sector with garments piling up is stressed and less willing to take part in research. A certain operator working on a different machine may also be a sign of a stressed sector. A sector working with checkers will show a group of operators who are more stressed, and researchers should disturb operators as little as possible, as higher degrees of concentration are required to make checkers meet in the seams. By observing operators in preparing a sample or, more critically, by observing an operator while they persistently fix a defective piece will likely cause an unnecessary and nefarious burden on operators. On the other hand, recognising which client the sector is working for on that day can already give researchers an idea of how easy that work order might be for the operators.

Being perfect reflects on research artefacts too. When preparing materials for codesign, we took extra care to make them echo this quality of perfection and neatness (Figure 5), which was something operators noticed and spontaneously expressed appreciation for. These acts signal to operators that researchers are paying attention to the information that is being shared, that they respect operators and that they place effort in carefully designing bespoke materials.

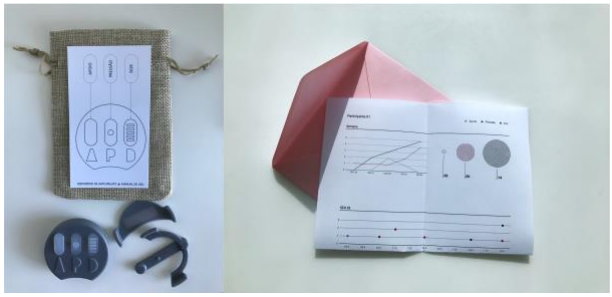

Figure 5: Kit delivered during codesign phase: individual bag with device to test and respective instructions (left) and individual envelope with personal data collected with device (right).

CONSIDERING MANIFOLD DIMENSIONS OF TIME

For operators to be involved in design research activities, line managers need to be informed and may need to authorise it. User research activities prepared in detail assist line managers in managing their sector while some of the operators are away. However, because absenteeism can be high and unexpected, detailed planning might not suffice. Once reaching the shopfloor, researchers learn to read whether the sector is feeling stressed and whether the work order may be delayed by looking at piles of pieces. Learning to respect time also means that researchers should be prepared to improvise to deal with time constraints, e.g., by changing order of participants or deciding which parts of the protocol may dropped and carried out on another occasion.

Understanding seniority levels, especially relative to other operators participating in the research, is critical to build rapport, e.g., asking a senior operator if they do tasks associated with junior positions can be offensive. Furthermore, a senior operator is one who is more likely to be called upon for samples, for assisting with other machines or to engage in other activities which fall outside the planned tasks for the day. Therefore, researchers must be especially aware that experienced operators may be suddenly unavailable.

Crying is a reaction that is often mentioned by operators and is especially associated with early times in the career. User research allows researchers to understand what may be trigger situations for operators and which

supervisors are more likely to upset them. Being aware of these helps researchers read situations in the field, e.g., during contextual inquiry or systematic observation. User research reveals this by observing how operators react to others and in interviews by the terms that operators use to refer to others.

MINDING ARTEFACTS IN DESIGN RESEARCH

Once the operator-machine relationship was understood by researchers, we knew we had to respect it. This meant regarding the machine almost as an extension of operators' bodies and, therefore, refraining from leaning on it or placing objects on it, at least not without operators' consent. The intimate relationship with tools of the trade has been reported among professional chefs (Robinson and Baum, 2020) and finds echoes in intimate relationship of human bodies with assistive products or wearable devices as body extensions (Winance, 2019; Nelson *et al.*, 2020).

Understanding this relationship also helps researchers to understand the limitations to the quality of data they might be collecting if the operator participating in contextual inquiry might happen to be displaced from their preferred machine at that specific time. Rapport can be nurtured in this case by making sure that researchers revisit this operator when they are back on their machine.

Often, operators resume working after some activity with researchers. From these activities, they can bring with them artefacts given by researchers, including prototypes and leaflets. Understanding the importance of a material culture and where the artefacts given by researchers may be placed, stored, and hidden from sight if needed becomes very relevant to promote engagement of operators in the design research process and opportunities for collaboration.

EMBEDDING ETIQUETTE IN DESIGN ACTIVITIES

Operators report to their line managers. However, to participate in design research activities, they can be recruited by others who are higher in the hierarchy than line managers, in which case line managers are only informed that their operators will be participating in activities with researchers. Learning about the power relations taught the researchers to seek implicit approval from line managers despite the process flow described above. The inter and intra tensions, in tandem with sense of belonging, were also reported by Chakravarti (2011) in an ethnography of a garment factory.

Understanding the workflows is critical to identify features for the design of devices that can be used during work hours. However, the process followed by operators is not always the prescribed one and this cannot be disclosed. Neither by the design itself, nor by actions from the researchers in the field. This is in line with dilemmas faced by Heikkilä et al. (2018) that led them to adopt Ethics by Design, or the type of situations originated by the use of participatory design techniques that has led Frauenberger et al. (2017) to suggest In-Action Ethics. Fieldwork helps researchers to understand and respect etiquette in this and other regards.

During our interviews and observations, we understood that the etiquette prevented operators from addressing sensitive topics. To respect this etiquette and still allow operators to express their concerns and expectations about the information that different actors in the factory should have access to, we have created an externalisation exercise that took advantage of the fact that materials and utensils have meanings associated with them.

In individual sessions, we presented operators with four cards, each naming a job role: operators, line managers, production management, and administration. We also presented operators with an array of objects related to their trade and we asked them to associate each card with one of the objects (Figure 6). After operators made the associations between job roles and objects, we asked the reason for the association and, finally, we asked operators what information that object was currently lacking. The understanding of a sub-culture, its symbols and its values allowed us to design a user research activity that simultaneously respected and leveraged that sub-culture.

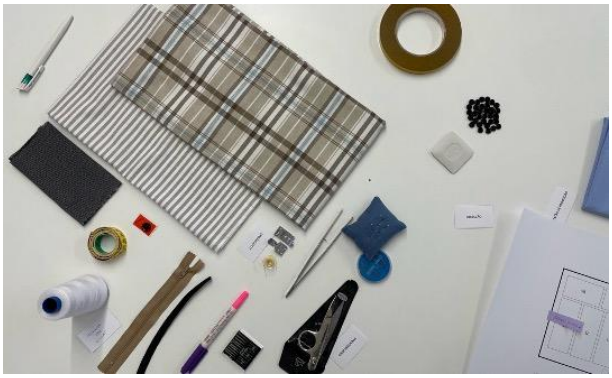

Figure 6: Externalisation exercise with objects presented to participants and job role labels.

A TEST TO THE LESSONS

After gathering the insights described so far, we engaged in design research at another garment manufacturer in a different research project entitled STVgoDigital. Here, we sought to test the lessons learned in a project meant to create an exoskeleton to reduce musculoskeletal injuries among sewing operators. We began by bringing our lessons learned to inform a semi-structured interview script followed by non-participant observations to 10 operators, all female. Fieldwork amounted to one week. The interviews were

recorded in audio and the observations complemented with notes by researchers as well as photos and videos. The data were analysed by two design researchers using affinity mapping.

The less than 50 operators in this factory produce high-end, technical garments. Here, there was one line manager for all operators and several work orders being prepared simultaneously. Contrary to the other factory, here most operators can operate multiple machines.

The concept of '**perfection'** arose again. Despite the different organisation of the workers, machines and workflows in the factory, the signs of perfection being met or unmet were the same. Furthermore, flow (Csikszentmihalyi, 2008) arose again with its synesthetic qualities and we were able to read the signs of flowing work from the factory shopfloor by combining prior knowledge with information provided by the operators during the interviews.

We did not witness stressful sectors of the production line affected by **time**. Therefore, we did not witness this dimension of time. This might have been because it did not exist or did not materialise in the same way in this context. We found the concept of time as applied to seniority, which was then useful to swiftly understand hierarchies. This ability to grasp a social dynamics and value constellations is critical in fieldwork, where design researchers are often faced with the need to make split-second, ethically appropriate decisions (Frauenberger, Rauhala and Fitzpatrick, 2017).

The **operator-machine relationship** was very pronounced in this factory, even though operators switched machines very often and the management kept conveying the message that machines have no owners:

P9*: When I came to work here, I came to work as a seamstress. Because I came as a seamstress, they gave me a machine. From that point onwards, and while I work here, I have a machine.*

P9*: Sure, one also drives any car, but it's not the same. In the beginning you start getting to know that car's tricks. (…) For instance, I rarely call the mechanic because I already know how to deal with the machine. I know my way.*

Equipped with this knowledge, we were able to, whenever possible, observe operators in 'their machine' and in 'one's own work', which also allowed us to then observe where operators kept their belongings and how they made small hacks to 'their' machines and utensils so that they would work out best for them. Having an artefact that is 'one's own', in this case an exoskeleton, may lead to a different person-product attachment. Here's operator P9 again:

P9*: If you have a car, you'll take good care of it. So that it won't give you any trouble. If you own a machine, you take better care of it.*

The single line manager knows how to work in every machine and is often supervising five work orders simultaneously. This is very well-regarded by operators – an aspect that was observed in the first factory as well. Again, here there was the aspect of acknowledging and accepting a **sub-culture** with similar traits.

P3*: When a new person comes in, she [line manager] must do her* praxe *[Portuguese term for the hard time given to freshmen when entering college], you know? They take the day to mess with our head. (…) I didn't cry! I swallowed it up, swallowed it up.*

This operator goes on to tell us that she thinks the line manager is pressed by the company management and ends with: '*I couldn't to her work. She can take all the money that goes with it.*'

Here we also witnessed the mixed feelings in these hierarchical relations and, since operator recruitment had been done by the company, we asked to include the line manager in the study and permission to address her during the observations.

CONCLUSIONS

In the process of analysing data collected in non-participant fieldwork in a garment factory shopfloor, we have extracted lessons associated with each theme in the thematic analysis that were used by the researchers to create rapport (mostly by respecting participants and a sub-culture) and to seek to guarantee ecologically valid data through appropriate behaviour, through crafting activities and through crafting bespoke materials that echoed the value constellations we encountered.

User research data thus informed what to design for the specific context, but also how to engage in codesign in this same context. We were able to operationalise the lessons learned in a different research project, with a different group of people, and for the purpose of designing a different artefact. The lessons are likely not generalisable to all contexts, but analysing the research context's underlying values could steer and improve the design research process in terms of researcher's **behaviour**, **methods** employed and **materials** created.

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REFERENCES

Ardito, C. *et al.* (2014) 'Human-Centered Design in Industry: Lessons from the Trenches', *Computer*, 47(12), pp. 86–89. Available at: https://doi.org/10.1109/MC.2014.355.

Barcellini, F., Belleghem, L.V. and Daniellou, F. (2014) 'Design projects as opportunities for the development of activities', in *Constructive Ergonomics*. CRC Press.

Béguin, P. (2007) 'Taking activity into account during the design process', *Activités*, 4(2), pp. 1–8. Available at: https://doi.org/10.4000/activites.1727.

Braun, V. and Clarke, V. (2006) 'Using thematic analysis in psychology', *Qualitative Research in Psychology*, 3(2), pp. 77–101. Available at: https://doi.org/10.1191/1478088706qp063oa.

Breslin, M. and Buchanan, R. (2008) 'On the Case Study Method of Research and Teaching in Design', *Design Issues*, 24(1), pp. 36–40.

Chakravarti, L.Z. (2011) 'Material Worlds: Denim on the Globalized Shop Floor', *Textile*, 9(1), pp. 62–74. Available at: https://doi.org/10.2752/175183511X12949158771473.

Cross, J. (2012) 'Technological intimacy: Re-engaging with gender and technology in the global factory', *Ethnography*, 13(2), pp. 119–143. Available at: https://doi.org/10.1177/1466138111410621.

Csikszentmihalyi, M. (2008) *Flow: The Psychology of Optimal Experience*. 1st edition. New York: Harper Perennial Modern Classics.

Daniellou, F. and Rabardel, P. (2005) 'Activity-oriented approaches to ergonomics: some traditions and communities', *Theoretical Issues in Ergonomics Science*, 6(5), pp. 353–357. Available at: https://doi.org/10.1080/14639220500078351.

Erete, S., Israni, A. and Dillahunt, T. (2018) 'An Intersectional Approach to Designing in the Margins', *Interactions*, pp. 66–69.

Frauenberger, C., Rauhala, M. and Fitzpatrick, G. (2017) 'In-Action Ethics', *Interacting with Computers*, 29(2), pp. 220–236. Available at: https://doi.org/10.1093/iwc/iww024.

Groeneveld, B. *et al.* (2018) 'Challenges for design researchers in healthcare', *Design for Health*, 2(2), pp. 305–326. Available at: https://doi.org/10.1080/24735132.2018.1541699.

Heikkilä, P., Honka, A. and Kaasinen, E. (2018) 'Quantified factory worker: designing a worker feedback dashboard', in *Proceedings of the 10th Nordic Conference on Human-Computer Interaction*. New York, NY, USA: Association for Computing Machinery (NordiCHI '18), pp. 515–523. Available at: https://doi.org/10.1145/3240167.3240187.

Mattsson, S., Fast-Berglund, Å. and Åkerman, M. (2017) 'Assessing Operator Wellbeing through Physiological Measurements in Real-Time—Towards Industrial Application', *Technologies*, 5(4), p. 61. Available at: https://doi.org/10.3390/technologies5040061.

Nelson, E.C. *et al.* (2020) 'Embodiment of Wearable Technology: Qualitative Longitudinal Study', *JMIR mHealth and uHealth*, 8(11), p. e16973. Available at: https://doi.org/10.2196/16973.

Orr, J.E. (1996) *Talking about Machines: An Ethnography of a Modern Job*. Cornell University Press.

Ortony, A., Clore, G.L. and Collins, A. (1988) *The Cognitive Structure of Emotions*. Cambridge: Cambridge University Press. Available at: https://doi.org/10.1017/CBO9780511571299.

Peng, L. and Chan, A.H.S. (2019) 'A meta-analysis of the relationship between ageing and occupational safety and health', *Safety Science*, 112, pp. 162–172. Available at: https://doi.org/10.1016/j.ssci.2018.10.030.

Peruzzini, M. and Pellicciari, M. (2017) 'A framework to design a human-centred adaptive manufacturing system for aging workers', *Advanced Engineering Informatics*, 33, pp. 330–349. Available at: https://doi.org/10.1016/j.aei.2017.02.003.

Robinson, R.N. and Baum, T. (2020) 'Work(ing) artefacts: Tools of the trade, totems or trophies?', *Human Relations*, 73(2), pp. 165–189. Available at: https://doi.org/10.1177/0018726719828447.

Romero, D. *et al.* (2016) 'Towards An Operator 4.0 Typology: A Human-Centric Perspective On The Fourth Industrial Revolution Technologies', in *Computers & Industrial Engineering*. *CIE46*.

Schwartz, Y. (2021) *Travail, ergologie et politique*. Paris: La Dispute (Travail et salariat).

Winance, M. (2019) '"Don't touch/push me!" From disruption to intimacy in relations with one's wheelchair: An analysis of relational modalities between persons and objects', *The Sociological Review*, 67(2), pp. 428–443. Available at: https://doi.org/10.1177/0038026119830916.

Wixted, F., Shevlin, M. and O'Sullivan, L.W. (2018) 'Distress and worry as mediators in the relationship between psychosocial risks and upper body musculoskeletal complaints in highly automated manufacturing', *Ergonomics*, 61(8), pp. 1079–1093. Available at: https://doi.org/10.1080/00140139.2018.1449253.

World Health Organization - Regional Office for Europe (2021) *Depression in Europe: facts and figures*. Available at: https://www.euro.who.int/en/health-topics/noncommunicable-diseases/mental-health/news/news/2012/10/depression-in-europe/depression-in-europe-facts-and-figures (Accessed: 26 July 2021).