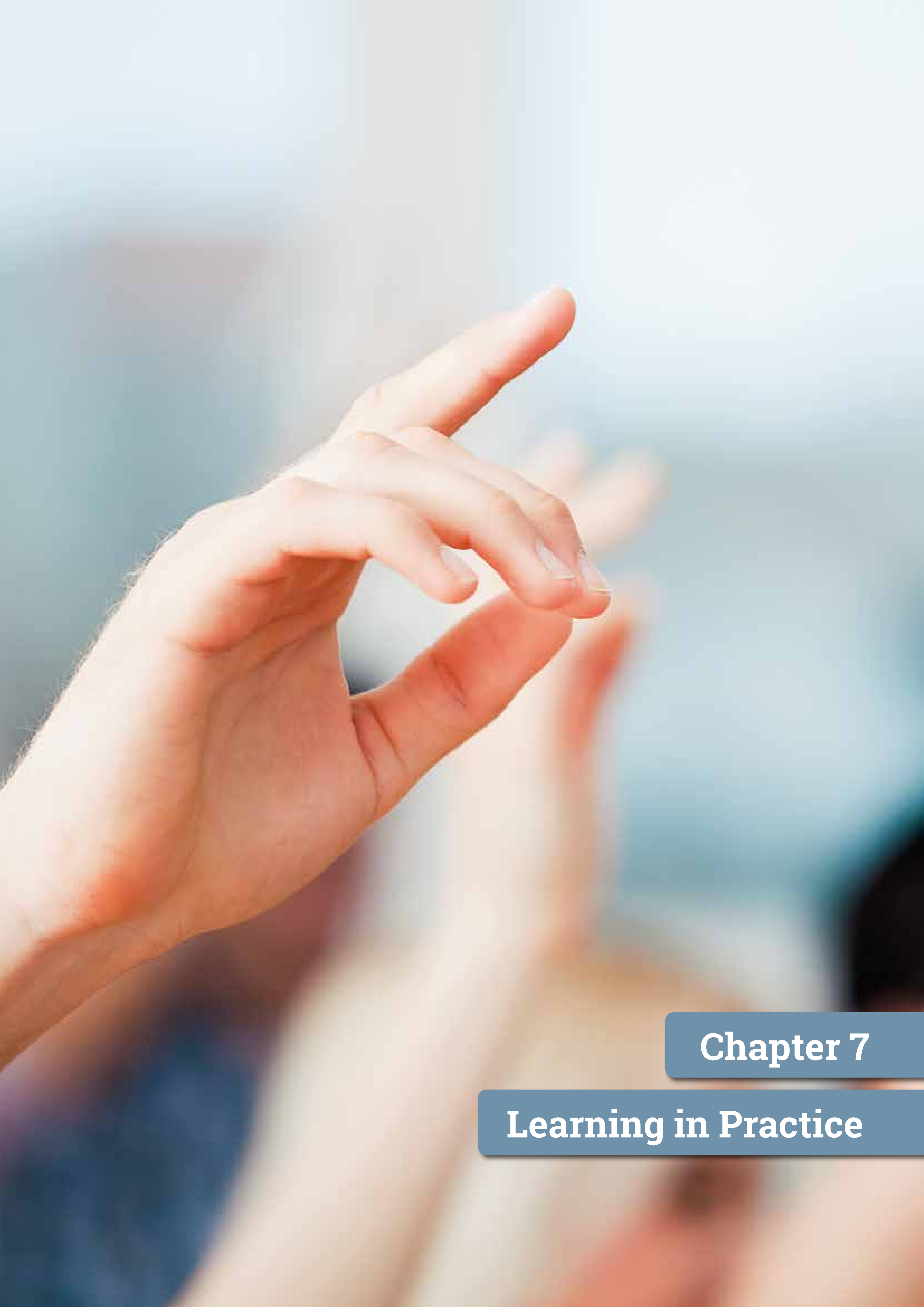


Chapter 7

Learning in Practice

You have to learn this: What are the positives and what are the limitations? So, I should not have this idea that the device can do anything [by itself]. That will never be the case I mean, if I know it, then I can use it, but it’s a matter of learning! You see, I have to know the device, and I must be able to analyze human movement.

(Viktor, physiotherapist, affected stakeholder, REGAIN)

7. Learning in Practice

How what we know about robots and humans matters

You will find here

- Definitions of knowledge, learning, and education and the naïve user
- Presentation of the types of learning undertaken by users and robot developers
- Presentation of problems with training
- Practical examples of learning in situ (every day on-the spot-learning)

You will acquire

- Awareness of learning perspectives in robotics
- Awareness of educational biases
- Awareness of educational contradictions
- Awareness of situated in-situ learning
- Awareness that naïveté is relative

In a micro-perspective REELER has found that whenever robots are attempted implemented, a learning process begins and continues on an everyday basis (*see Bruun, Hanghøj and Hasse 2015, Blond 2019*). In fact, even for robot developers themselves, learning is an ongoing process. However, the relation between what the robot can do by itself, peoples' knowledge of robots, educational background, and the situated learning taking place when robots are implemented are at present not well understood. It also raises political questions: Who is to provide the workers with the necessary skills to operate the robots? How do we ensure the right kind of upskilling? And do robots risk amplifying educational inequality? These are some of the questions dealt with in this chapter.

As Viktor states above, in order to understand what the rehabilitation robot he is working with can do, he needs to get to know it in a situated practice. For the purposes of this chapter, *knowledge* can be defined in a broad sense as a corpus of conceptualised ideas about the world codified (as words, pictures, symbols) for communication through social and material relations (Barth 2002; Hasse 2015; Jöns, Heffernan, & Meusburger 2017). *Learning* can be defined as the process of developing this corpus through engagement with a social and material world (*see also 1.0 Introduction*), and *Education* as the social infrastructure and systematization of learning (often for some other end). All of these terms represent ways of understanding the world, and are useful in describing how people develop and adjust their understandings of the robot, of each other, and of the world as it changes.

This chapter will present these three aspects of human learning with regard to robots, drawing on the ethnographic data from REELER:

Knowledge:
1) How new information about robots affects both robot developers and users' acceptance of robots,
2) How new information about humans affects robot developers' design and implementation decisions.

Learning:
1) How humans learn to adapt to robots,
2) How developers learn about the users and the robot in the context of use.

Education:
1) How increased robotization and automation place new demands on education, including ethics in engineering education,
2) re-skilling the workforce (who can be reskilled, technological literacy, dyslexia), and
3) the increased need for "learning to learn" in order for workers to remain relevant in an increasingly automated world.

7.1 Knowledge

This section covers how information about robots affects acceptance, and how information about humans affects design and implementation. **Knowledge** is an accumulation of conceptual ideas about the world that a person forms through transformative experiences engaging with the material world (i.e. learning). A person's past experiences frame their future engagement with the world because learning transform perceptions (e.g. Hasse 2015). Acquired knowledge, or lack of knowledge, shapes a person's perceptions of robots (*read more in 8.0 Imaginaries*), and can affect how robots are designed, how they are regulated, and how they are taken up or resisted (Nickelsen 2018). The robot makers in the REELER project are not all developers (the group also comprises policymakers, representatives from funding agencies, economists, biologists, and even psychologists), but most have a background in engineering. Their knowledge about robots has been developed and consolidated over many years in educations such as mechanical engineering, but also more specialized areas like bio-engineering and industrial engineering. They know so much more than affected stakeholders about their technical tools and about technical problem-solving (Barak and Zadok 2009), and often they describe and care about a particular technology as an isolated phenomenon and often do not consider environments or the wider context.

Knowledge: *A corpus of ideas about the world which is codified (both as concept and as words, pictures, symbols and other material externalisations) for communication through social relations.*

7.1.1 The naïve human

Opposite the knowledgeable developers we find what some robot developers define as **'naïve humans'**. While the term seemed puzzling and somewhat offensive initially, we soon found out that robot developers do not intent this term to be derogatory. It simply refers to inexperienced users, whose experiential knowledge of robots is limited, and whose imaginaries are informed by popular, non-technical (and sometimes inaccurate) information that may peddle fears and uncertainty with change, which frames their orientation towards technology (Nilsen 2016).

Naïve human: *A term used by robot makers (and computer scientists) to refer to persons unfamiliar or inexperienced with robots (or other digital technologies).*

When a person has real-life experiences with robots, their fears become more realistic. (Photo by Kate Davis)

When a new robot is introduced among "naïve users" (Kennedy 1975), technological apprehension may limit the user's ability or willingness to engage with the robot.

Technology apprehension: *An initial reluctance to use a new technology, tied to a lack of experience or lack of information.*

> *I am entirely sure that there are some who won't use [the robot], because they don't dare.*
>
> (Elif, hospital cleaning staff, affected stakeholder, SPECTRUS)

Enabling users to observe a robot in use can provide the users with situated knowledge that may alleviate some of their initial apprehension toward robots.

STORY FROM THE FIELD:
How lack of knowledge can elicit fears

Elif works at a hospital in Northern Europe cleaning patient rooms and common areas. She has worked with cleaning machines and other advanced cleaning technologies, but has no experience using or working near robots. Her working conditions are good: her work is well-paid, she has peers who support her and a boss who listens to her, and she enjoys a fair level of autonomy in planning and executing tasks. She is very content in her work and is confident that machines cannot do the complex work that she does. Nevertheless, when asked how robots might impact her life over the next decade, Elif has a grim outlook.

"It [robots] will. It definitely will. It will change the entire world - not just work days, but also private days. It will, for sure. It will destroy it all, I think. It is going to destroy it all."

Elif's fears about robots are tied to her conceptions about what a robot is. She does not have real-life experiences with robots, so her imaginaries are informed by entertainment and news media., and she has little to no information about actual robots used in workplaces. When REELER visits her workplace, Elif is introduced to a robot that is still under development, but intended for use in hospitals and other industrial settings, cleaning floors and surfaces. Elif is given detailed information about the robot, its weight, risks and safety features, and she watches videos of it in use. When asked to reflect on this particular robot, Elif says:

"I think it is quite nice. It is a good idea. It is positive. I am positive now. Initially, I was very cold. I said no. But now, I have looked at the video, and I think, it is very important that it kills bacteria. And so it changes my mind, actually. Yes. It could be a good idea that we got it."

When asked again how she feels about robots in general, and a human future with robots, Elif no longer feels robots will *'destroy it all'*. Her new experiences (her exposure to new knowledge) changed her perceptions of robots to more realistic or grounded understandings, and as a result she is more open to new experiences with robots.

(Based on an interview with Elif, hospital cleaning staff, affected stakeholder, SPECTRUS)

As demonstrated in the story about Elif, **technology apprehension** related to general fears or concerns can be mitigated to a great extent when a person has access to basic knowledge about the particular technology at hand (Hasse 2017) or when they get to see it function in practice.

It is also here naïve robot developers stand to gain from engaging with everyday workers like Viktor and Elif, who have a **situated knowledge** about what works in manual processes. This situated knowledge can be explained, but often remains tacit. It has often been learned without any explicit education involved and it is therefore an effort to put words back on the knowledge that has been learned.

Situated knowledge: *Knowledge acquired through social engagements in a particular activity, context, and culture in situ i.e. (at local sites).*

While workers may be naïve about robots, they far from naïve when it comes to understanding the ins and outs of a particular task. In fact, some of the most reflective robot developers are fully aware of how much they can learn from users at local work sites.

I think the biggest challenge we've met has been that every time we've visited a construction site, we've encountered something new. Fully understanding what goes on in these sites is very difficult. Even our extensively thorough pre-analyses are being put to shame, because what we're competing against is a craftsman, often a specially trained one at that, meaning they are using their hands in ways that we can almost never fully register. We've even tried taping them, but there's still a lot of things going on that we don't see. On one occasion we were putting up a small element, one of the workers commented that it was a bit crooked, but before I even had time to consider it, two of them had walked over, done a little dance, and that was the end of it. As soon as they had seen what the problem was, it took about 3 seconds. They're trained to solve problems as soon as they arise, no matter the cost. The show must go on. To pick up on all those details, that's a tall order. That is one of the biggest challenges we're facing. Maybe we ought to send a staff member there for six months or so, but even then, we'd likely see differences between the individual construction sites. Most of the sites we've visited have been major renovations or new constructions, not a big difference in this context, but there are still a lot of differences from site to site.

(Valdemar, engineer and CEO, robot developer, WIPER)

In this quotation, Valdemar puts into words the tacit processes of construction work and illustrates the complexity involved in emulating such processes in robots.

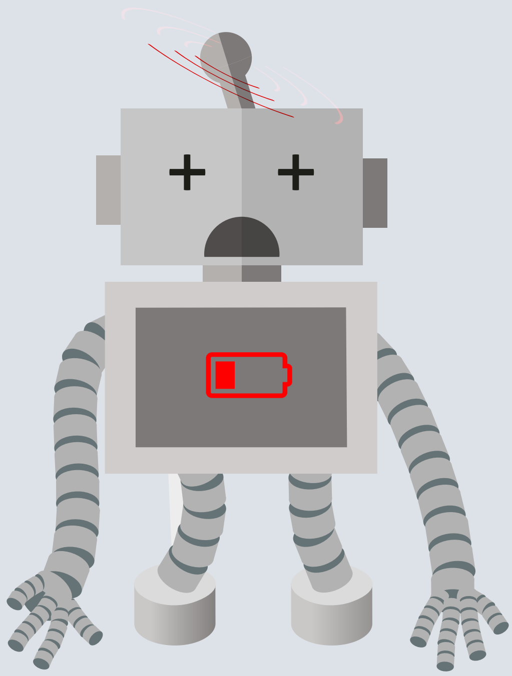
7.1.2 The resistant user

As familiarity with a technology increases, instead of a general fear of robots or technological change, a user may become aware of the particular challenges one meets when working with that specific technology. When the user experiences the robot as a threat, for example to their wages or their identity, a new type of technology resistance may pop up (Nilsen 2016). Technology resistance differs from technology apprehension because it is based on real learning experiences rather than imaginaries (*see 8.0 Imaginaries*). Left unaddressed, this resistance may even lead to non-use, misuse, or sabotage (*see 10.0 Meaningful Work*).

Technology resistance: *Opposition to an implemented technology, whether by passive non-use, active misuse, or deliberate sabotage.*

STORY FROM THE FIELD:

Technology resistance



A construction company approaches a robot developer with a request to co-create an assistive lifting device. The purpose is to comply with labor regulations that are in place to protect workers from the risks of heavy lifting, and to reduce human labor. Working in close cooperation with the construction company and construction workers, the robot developers test the intuitive robot at real building sites. The robot is on a construction site for some time before the developers are notified that it had been operating poorly. Werner, one of the robot developers, explains that his team *"talked to the foreman over there. 'They [construction workers] have run it and installed some doors with it,' he said. Well, that was good. Then two days later we talk to him again. Well, they thought it was running strangely, so they had just put it aside. They didn't want to run it any longer. 'Okay,' I said, 'we will come pick it up Thursday'. And then, when we got there, the workman says: 'We haven't run it all.'"*

During the testing of the robot, the developers met some resistance (non-use) based on the users' experience of the technology in use. The users recognized the demands the robot placed upon them and their workflow, and they resisted these demands by abandoning the technology.

"What actually happened was someone had tried driving it down the hallway and it was all wobbly. One of the guys had tried installing a door, and that had been tricky and then he had just given up. And then it stood there. So, they hadn't even, like –they didn't inform themselves, or whatever," Werner notes.

Though co-crating the robot, thee developers had overlooked the demands the robot would put on the workers, because, from their own experiences, the design was user-friendly. Put differently, the developers learn that the users experience their robot differently from themselves. Their intuitive assistive device was perceived as 'wobbly' and 'tricky', and would require a great deal of learning and adaptation. This clashes with the workers' expectations and conditions for performing their job and hence they decide not to use it.

(Based on an interview with Werner, operation and production technologist, robot developer, WIPER)

Learning in situ can counter imaginaries (typically informed by science-fiction or news hype) and lead to reduced technological apprehension and greater acceptance (Nomura et al. 2008; Turkle 1986), as was the case with Elif. However, as users gain more situated knowledge through use, and their imaginaries become more rooted in lived experiences, resistance may emerge again (de Graaf, Allouch, & van Dijk 2017); this time from tangible issues that the robot developers may actually have an opportunity (or responsibility) to address.

Thus, knowledge can be a powerful instrument in bringing users' imaginaries about robots closer to the actual robots they might encounter in their everyday lives, and it may decrease fears and increase acceptance of robots in general. Specific knowledge about a particular robot may also reveal issues with that technology which could lead to resistance, if left unresolved.

7.2 Learning

This section presents data from REELER on how the humans in our study learn to adapt to robots and how robot developers learn about the users and the robot in the context of its use. Learning is the process that organizes knowledge and know-how in recognizable patterns (also known as 'cultural models' – see Hasse 2015). We form expectations, habits and meaningful perceptions on the basis of learning. In this respect, knowledge (what we think we know) and know-how (our ritualized embodied unreflected knowledge) are continuously transformed as we learn (Hasse 2015). Colloquial learning is often tied to education, and education, of course, matters for the kind of knowledge one organizes. In the context of REELER, learning is more than what goes on in formal education. It is a process that provides us with situated knowledge about our social and material world on a daily basis. Learning, making sense of the material world, is the social process by which we acquire knowledge of what to expect (D'Andrade and Strauss 1992).

Whenever a new technology is put to use, a new learning processes are initiated that teaches us about how the technology fits (or does not fit) with our daily routines.

Organized learning: *The process of developing organization of knowledge or know-how through engagement with the social and material world.*

There are four particularly relevant areas of learning occurring in robotics between humans and machines:

1) Users learning to adapt to robots, to meet the demands the technology places on the human.
2) Developers learning about their robot as a technology-in-use, situated in a context with actual users.
3) Collaborative learning, learning what is important to each other and aligning motives to work toward a common goal.
4) Workers learning to learn, in order to remain relevant in an increasingly automated world.[1]

All of these learning areas are best understood from a perspective of **technology-in-use,** which bears with it the importance of situatedness, which is a theoretical concept developed by Jean Lave and Etienne Wenger (1991) to explain how learning occurs as a product of social engagement in a particular activity (e.g., using an assistive robot to install doors in new construction). Situated learning is practical and social – *it is not* formalized training or education, nor is it an individual mental activity (Lave & Wenger, 1991, p. 49). Further, the learning occurring is shared or distributed in the community of practice, meaning that learning is inscribed in the social and material practices of the context (Hasse 2015). Going back to the story from the field about technology resistance, when the workers discovered that in their particular site the robot became wobbly, it became a particular situated knowledge. In other situated contexts, the relation between the (maybe more plain) ground and the design of the robot would not have been a problem. However, these workers also came from a culture where they speak out, and react directly when unsatisfied, whereas in other cultures workers may put up with more. To treat the situated knowledge as divorced from the context would be to render it meaningless (see examples in the discussions that follow).

Technology-in-use: *An understanding of a technology not as a static object, but as a thing defined and redefined by its context of use.*

Therefore, "enhanced technological literacy [for both users and robot makers] must include an awareness of how 'engagement' changes when technologies are used in situated practices" (Hasse 2017, 370), as seen in the resistance example in the previous section. Situated learning occurs both among users beginning to work with or alongside a robot, and among robot developers learning about users and their robot in the context of use.

7.2.1 Users learning about robots

A lot of learning in situ is required to make robots work, even when designed in the laboratory to be user-friendly or intuitive. On the surface, users must learn how to operate or interact with the robot. This can be a hard task for the worker when they have to learn by themselves how to operate a robot, e.g. through a tablet. In this story told by a company owner, a metal worker, who was previously considered a good worker,

1 It could also have been relevant to include how robots and AI 'learn', i.e. how machines adapt their own behavior (output) based on the data they acquire (input). This point does not relate to human learning, but learning in machines. Because we recognize irreconcilable differences between human and artificial intelligence, and because machine learning was not an explicit target of the REELER project, we will not address non-human learning, however see Hasse 2019 (forthcoming).

was all of a sudden under scrutiny by management because he began to make serious mistakes.

> *Well, you hire a 50-year old Russian, who is a really good metal worker, a good person as well. But now, I try to teach him that on a touchscreen, he has to register this [order to the 'printing' robot], and re-register that [order]. Everything stands and falls with him. If he doesn´t scan, then the system says we still need to make a thousand pieces. I need this much capacity, and so forth. So, what also happens is he scans wrongly. He makes 50 and scans 70 and closes the order. Then, after that starts to ship, [the system] says, '20 are missing'. This simply is a system that says 'nope' [laughs], 'those [missing 20] are finished, they should be with you.' It then searches for them in the whole place and says, 'they are not finished.' Just because one person scanned wrongly! You know, these are the kind of issues, basically, where the theory is clear and where everyone knows why we are doing it. But your workers, you have [the worker] who is a simple metal worker who wants to do his job. He says, 'What is it you want with it? How? What is it I have to do?' And you need to teach it to them, and there are different people as well. The first is open to it, since he already has a smartphone, and you have to prevent him from playing with his smartphone. And the second has a problem when entering three digits on the touchscreen.*
>
> (Karl, SME owner, affected stakeholder, COBOT)

The 'simple' Russian worker that Karl is telling about had to learn new things on-the-spot in his situated practice because this practice was changed by new demands introduced by the robot and its operations (*see also 4.0 Ethics Beyond Safety, section 4.1.2*). This type of learning is sometimes addressed by training (online or in-person), through user manuals, or in tutorials built into the interface itself. At other times, the robot is sold off-the-shelf as a plug-and-play solution – its assumed intuitiveness rendering training unnecessary.

Depending on the type of robot and application sector, the need for training of staff before or during implementation varies. However, the more we move into industrial areas and bigger industries, the more we find that employers recognize the need for official training (particularly in the cases OTTO, COOP, and some robots in COBOT). Here, the robot developers and companies often work together to provide training. These kind of training programs can last from a day to several weeks, and in one case with follow-ups several times a year. This might be explained by a long history of automation and system integration in production sectors.

Yet, when we speak to the workers' Unions, we hear tell of disagreement about who should be responsible for training. Arne is a district Union secretary in one of the largest countries in Europe, with many robots in the industrial sector. He explains we should recognize that different workers have different needs for reskilling and training, when robots are introduced in the work life.

> *Arne: "Well, we should of course understand that employees have different experiences, are of different ages as well, and are different in how open they are. Even today, some of the older people are saying: 'Keep those computers away! I haven't received much training in the recent years, anyway.' He won´t scream 'hooray' in front of an e-learning platform. Others are more used to it. There are many different starting conditions. One has to take this into consideration, that it is different for each person. Don't create a digital divide with this [new technology]."*
>
> *Interviewer: "Is training popular in general then? Do the employees want to receive training? Or do they think that it is annoying and irritating?"*
>
> *Arne: "I believe, this is very different as well. The guy who says that he is going into retirement in half a year, he probably won´t be very open for training because the period of time for actually using this is too short. Whereas a younger employee will benefit from it. I primarily believe that the employees are open to it. I notice a contradiction here [in relation to] the qualification, training, lifelong learning – namely, that the employees are being forgotten if they are on the lower levels of the hierarchy and do not have many qualifications. [The training and qualification] is being made for those, who already have a lot, and we have to think more about how we, in the area of trainees and unskilled employees, can facilitate qualification offers for those people [as well]. This would otherwise be a contradiction, if one only always focuses on the few."*
>
> (Arne, district union secretary, affected stakeholder, COBOT)

Whether or not learning is anticipated, the amount of learning that takes place in implementation goes far beyond learning to use the device. Looking more closely, humans must learn to adapt their routines, behaviors, and environments to accommodate a robot (Bruun, Hanghøj, & Hasse 2015) (*see also 5.0 Inclusive Design*). For example, a patient using a feeding assistance robot may need to learn to tilt his head in a particular direction to receive the awkwardly angled spoon; or, a care professional might need to learn to use sticky porridge-like foods, but not loose food like rice. Making these small adjust-

Rapidly-changing technologies place new demands on the workforce, requiring reskilling and 'learning to learn'.

ments –also called tinkering – is necessary for the robot to fulfill its intended role (Nickelsen 2018). Understanding the use of robots as situated is to acknowledge that robots are relational objects, which do not do the same work alone that they do with human interaction (Sorenson 2018). If the patient did not tilt his head, or if the care professional did not alter her meal plan, the robot would not be as effective. The users learn to make these adjustments through actual engagement with the robot.

Sometimes, users go one step further and learn to adapt their environments, and in some cases the robot itself. The same feeding assistance robot, BESTIC, can be mounted on a user's wheelchair. However, one user experiences that mounting the robot precludes their use of another device used to access television and other media. BESTIC takes up space normally devoted to the television controller, and so the wheelchair setup requires the removal of a device that the user values. Thus, the user cannot eat independently (with the robot) whilst watching television, and consequentially has to learn to adapt his physical and social environment (Nickelsen 2018). In the case of Silbot, the eldercare robot developed in South Korea and implemented in both Denmark and Finland, the robot itself is reprogrammed to include more culturally appropriate interaction after having been rejected by users for using an overly disciplinarian style of communication that clashed with the new users' more passive style (Blond & Olesen 2019) (*see also 6.0 Innovation Economics*). Rather than learn to accept the new communication style, the application experts choose to adapt the robot to the existing cultural context.

Whether learning to adapt one's own conduct or lifestyle, the surrounding environment and physical setup for the robot, or learning to adapt the robot itself, the learning goes far beyond an orientation to operating the robot.

STORY FROM THE FIELD:

Learning in practice with a robotic wheelchair

Many rehabilitation centers in Denmark are using robotic wheelchairs in rehabilitation. In one case, the robot is too complicated for the staff to use. This is not due to the robot in itself, but related to the space around it. As a result, the robot was simply put aside for a long period of time. REELER speaks to Nina, a physiotherapist with experience with the particular robot, and she explains:

"At first, the poor robot was in another room, in another department, and it was forgotten. It was forgotten by the department, both the nursing staff and the therapists. It wasn't as easy [as with another robot], because you had to put the patient in a wheelchair, and then go all the way down [through the building]. So it was a big task in terms of planning. We also had to set aside those rooms to make room for it, even though we were under a lot of pressure already. Because it is very visible here, it isn't as forgotten as it used to be. Back then, it was only used once every three months or so."

There can be many reasons why staff give up learning to use a technology. It can discourage use, if simple things like the electrical system and batteries are not working when the robot is attempted implemented. Britt, one of the directors of the rehabilitation center, notes that:

"The technology needs to be so stable that it doesn't turn off every other time if it dies all the time, then it'll be a strain instead of, what's it called 'a help'. There are quality requirements for the technology to communicate with the computer [for example]. If it's through a cable or if it's something to do with WIFI, then you need to make sure that all those things are in working order, so the technology at least runs reliably."

Nikoline, another physiotherapist who also has experience working with rehabilitation equipment, including the robotic wheelchairs, underlines that for users to want to use a technology "it should be unmistakable what to do". Even when the robot is designed to be intuitive, and is actually used in situ, it can still be a steep uphill learning process for the individual worker.

"Of course they [the staff] have to learn some stuff and they also need an introduction to what all the functions do and what to do if it breaks down. They have to learn that if [they] have to set it up, and if there's a mistake in [the] settings, how do [they] calibrate it again. Of course they need an introductory course to the technology and what parameters you need to change in different situations. They obviously need a course in that when they implement the technology and they need time to become familiar with it before they are going to see citizens", Nikoline explains, and continues: *"But the actual settings need to be simple as well. Obviously you need to be able to change the different relevant parameters, but it needs to be very intuitive: "What is the first thing I need to adjust? Is it the shoulder joint I need to begin with, and then the elbow, and then the wrist or what is it, and what screws do I need to start with?"*

Formal training is necessary, but formal training must also take account of the situated learning that goes on in everyday practices. It may seem easy for the robot developer to imagine what is 'intuitive', but if the necessary situated learning is not intuitive in the same way, it can become so challenging for the staff that they simply give up, Nikoline explains:

"If she [staff] started screwing those on the chair so the height was right. Then after step one was 'place the screw so it fits the citizen's arm', and step three 'Now you need to adjust this joint', so you are guided through it, because it's not impossible for them [the staff] to understand technology and adjust it. It just needs to be simple and intuitive. If you haven't seen a citizen that use [the wheelchair] for a month and a half, and you come back and haven't used it for a month and a half, then you need to be able to get a sense of it again pretty quickly: 'What is it I need to do now?', because you have so many different citizens and the problems that the citizens come with are different."

However, Nina also stresses that, if the training and subsequent situated learning is a success, the robots are no longer 'forgotten':

"We may have had such concerns at first when we bought it: 'Will ever be used?' Because we hadn't discussed whether to buy it or not. But once we've been trained in its use, and things like that, and people have seen it operating, it's been really good."

(Based on interviews with Nina, physiotherapist, Britt, director of rehabilitation center, and Nikoline, rehabilitation therapist, affected stakeholders, REGAIN)

7.2.2 Developers learning about users

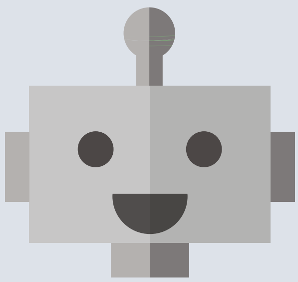
Developers must also learn about their robots as technologies-in-use; that is, they must learn to see the robot as situated in a particular application context among particular users. A robot developed and tested in laboratory settings is likely experienced completely differently in use elsewhere in the world. For example, a healthcare robot developed in Northern Europe is operated using a tablet interface that should hang on the door of a patient room when in use. The tablet was initially mounted to the door by magnets, until the developers learned that some doors are made of glass and hospitals may not want to modify their doors. To account for this new knowledge of different contexts, the developers opted for an alternative over-the-door hook, designed for doors of all materials. However, after implementation, the developer learned that some users are shorter on average in certain parts of the world, so the developer had to adapt his thinking and design again to accommodate the new information. Here, Oswaldo explains how learning about contextual differences can be accommodated into designs:

> *Yeah, we have had an issue in Asia, because depending on the type of door, we can use a metal plate and some magnet on the tablet. If the hospital doesn't want to modify the doors, then we have a hook that you hook on top of the door. The people in this particular country are too short to use this hook. And that's funny because when I designed it here, I already tried to make it longer because I imagined that maybe the people will be short but it was not long enough. And that's a bit crazy, but I mean that happens sometimes.*
>
> (Oswaldo, industrial designer, robot developer, SPECTRUS)

This learning in real-life test environments and implementation settings demonstrates the importance of understanding robots as technologies-in-use. Engagements with users and the robot situated in an actual or potential implementation site can open for learning about users, and what matters to them.

STORY FROM THE FIELD:

Learning what matters to users



In the development of the mounting robot used at construction sites, the developers were left with questions about the workers' resistance to implementation. Implementation at this site consisted of a demonstration and an explanation of the 'quick-start guide', but did not include on-the-job training. The developers went to another testing site where they worked alongside users to help them really get hands-on experience with the machine while the developers were available to facilitate the users' learning. Werner, one of the robot developers in the WIPER case, explains:

"We have had a lot of hassles with the controls, mostly when driving it, the part about getting a smooth movement when you drive it so it doesn't go, like, jerk, jerk. If it moves in a jerky way then it will be like, whoops, now it is running, and then you become more nervous about using it. If it just moves slowly in a smooth movement, well then you feel like you have better control over it. And at the same time, it has to be fast but it also has to be safe. We want to be faster than the workmen. Because if not, then they will think, 'then we might as well do it manually, because that's faster.'"

Here, the developers were finally able to truly experience the robot as a technology-in-use, alongside the users. This allowed them to understand the "wobbly" and "tricky" performance that had led to non-use in first testing site. It also allowed the users to learn how the robot developers operate the robot differently from themselves. In the end this process resulted in several adjustments to the robot.

(Based on an interview with Werner, operation and production technologist, robot developer, WIPER)

Both users and developers learn a great deal in the implementation process – which is most prevalent at TRL6+, but feedback from users, with experiences of the robot in their own everyday lives, is important to all design phases and for all robot types. In light of how much post-implementation learning, tinkering, tweaking, and adapting occurs across all REELER cases, the robot developers need help from people, like alignment experts, who knows about the everyday lives of affected stakeholders. They can help anticipate challenges (to situated learning practices), and to successfully integrating the robots on site, rather than assuming a plug-and-play approach. Learning about the technology in use can bring robot developers' imaginaries about use closer to the users' lived reality – which may allow developers to address issues that might otherwise lead to resistance.

So, we studied all these areas and then in the end we had to choose one of them to focus on. I chose interaction design but in the end I wrote my thesis about ethical considerations on the introduction of roads for a construction industry. Yeah, so that's how I ended up here [in Europe] and actually I wrote the thesis with this company. When I was in the third semester of the Master's I discovered that I could do a company period and then I started here full time and I have been here since then for - in three days, it's going to be five years.

(Oswaldo, industrial designer, robot developer, SPECTRUS)

7.3 Education

This section presents findings in REELER's data related to education, specifically on how increased robotization and automation place new demands on education including 1) ethics in engineering education, 2) re-skilling the workforce (who can be reskilled, technological literacy, dyslexia), and 3) the increased need for "learning to learn" in order for workers to remain relevant in an increasingly automated world.

While situated and collaborative learning can address demands on the individual user or organization (e.g. issues in design, such as inclusion/exclusion, education may be an answer to new demands on society, to train the workforce to contend with robotization and to train engineers to incorporate ethical thinking and practices in design processes.

Education: *The social infrastructure and systematization of learning organized knowledge.*

7.3.1 Ethics in engineering education

Oswaldo has a background in computer science from a Latin American country. He studied computer science for four and a half years, and then decided to change to industrial design. He graduated in industrial design and went to a European country to take a Master's degree in IT product design. That is a program with several focus areas, he explains. Among the themes are design anthropology, interaction design, and participatory innovation.

Education to become an engineer is global in so far engineers can work all over the world often involving early contact with companies. There is a close relation between engineering education, companies, and jobs. Sometimes students learn something about ethics, but many of the robot developers interviewed in REELER did not have much experience dealing with ethics in their education (*see 4.0 Ethics Beyond Safety*). Even they are acquinted with ethics in through educaction, once they begin working for a company, discussions of ethics are usually removed from their everyday work. In bigger companies, such discussions are carried out by dedicated branches removed from development.

Samuel, an engineer from SPECTRUS, has a Master of Science in product development and innovation. It is a business-oriented engineering education, with a mix of traditional engineering courses, basic engineering courses, but also management courses and business courses. They are also introduced to ethical issues during this education.

We had some experience-based design courses, where we touched upon ethics. Not a big focus in my education, I would say, but something we definitely discussed. But [in the company] my role was not to focus too much on that. It was more someone like [the social scientist] who was in charge of applying the methodologies that we were using and making sure that ethics is covered in the design process.

(Samuel, product innovation manager, robot developer, SPECTRUS)

7.3.2 Reskilling the workforce

Technological change is not new (e.g. the Spinning Jenny and the Luddites, the automobile, or the computer), but the breadth and pace of technological displacement may be unprecedented. Some caution that this latest technological revolution is different from historical automation events, in that robots and AI may eliminate entire sectors of human labor (Osborne & Frey 2013; Ford 2015). With some automation, not only is a principal activity lost (driving, e.g.), but there is a ripple effect through the supply chains and related markets (e.g., manufacturers of parts, oil and gas industry, parking lots). When workers are not displaced, their work environments, workflows, and requisite expertise are nonetheless changed (*see 6.0 Innovation Economics, 9.0 Economics of Robotization*, and *10.0 Meaningful Work)*. This also goes for the developers themselves, who are regularly offered reskilling courses. Like affected stakeholders, they learn mostly 'in situ' in their own practice.

These changes require reskilling and/or entirely new educations, whether to fit the new demands in an existing job, or to meet the requirements for a new job. Formal education provides the social infrastructure and systematization necessary for a mass reskilling of the population. Still, some simply will not – or cannot – adapt to these changes, and these people may be left behind. It can be people like Karl's Russian worker, a physiotherapist who cannot adapt to the new technologies, or it can be the construction site workers, who love to drill and lay bricks, but cannot get used to operating a robot through a tablet. Across cases, the REELER research find examples of people, who may suffer from technological development if initiatives are not taken to ensure appropriate educational opportunities. As is expressed by this company owner who has begun using brick laying robots:

> *The bricklayer robots, you know them, right? Yeah. They are good for those who know how to, adapt, right? So, there's this thing about being ready to embrace changes. [It is] good for those people who know how to do other things than just laying bricks. But those who don't know how to do anything else than laying bricks, they will somehow end up as the losers in all of this.*
>
> (Jens, CEO at technical equipment rental business, affected stakeholder, WIPER)

7.3.3 Learning to learn

Finally, one of the greatest demands robots and AI are placing on humans is the necessity to constantly stay updated: learning to learn. As work changes rapidly, workers require reskilling to remain relevant in the workforce. Thus, automation is changing the nature of work and the worker. Both robot developers and affected stakeholders feel it is absolutely necessary for the worker to change and adapt in order to stay relevant. In the REELER data, two issues run across cases, and both are tied to education and reskilling of the workforce as robots and AI increasingly change the meaning of the term work. The first issue is the need for continous reskilling and (formal and informal) training, to be able to develop, maintain and operate new technologies. The second issue is how to best educate humans to do, what humans do better than AI and robots - i.e. that which cannot (or should not) be done by robots or AI. Both issues require a flexible work force that learns to learn in a 'meta-perspective'; that is, learning to learn in new contexts rather than domain centered learning. In this respect, the required educational learning is moving beyond situated learning and attempting to create a learning potential across the particular demands in situations (*see Technucation: www.technucation.dk & Hasse 2017* for a further discussion).

Future education is not all about leaning to operate and adapt to robots. REELER's research suggests that our understanding of work is changing altogether as a consequence of robotization (*see 6.0 Innovation Economics, 9.0 Economics of Robotization*, and *10.0 Meaningful Work*).

> *I do not think that safe workplaces exist anymore. You just have to constantly stay updated. Our knowledge and our durability of knowledge changes much faster. Things really change a lot. Especially in the field of programming and technology. If you do not educate yourself and keep up with the times, you will be left behind. So, this working model where you think: 'Okay, I'm at [a very established company] therefore my life is now secured', it will not exist anymore.*
>
> (Marc, university researcher, affected stakeholder, COBOT)

Some, like Marc who is based at a university, recognize that remaining relevant requires a particular way of distinguishing one's labor as something different from machine labor – a craft, or a creative, cognitive job, such as design – while others stress that soft skills will matter most.

> *I believe that communication is also very important. How do I talk to people? How do I deal with people? Social contact, as it is always postulated, will be more important and not less important as it is postulated, I believe. With these soft skills one can see how someone is dealing with people?! Also, to make a certain reflection and self-assessment.*
>
> (Marc, university researcher, affected stakeholder, COBOT)

The questions raised by REELER is who can be reskilled to adapt to and work with robots? Who is responsible for preparing workers for reskilling? And who can decide if it is worth the trouble to reskill a worker? In the future, we may need new educations that aim at determining the best solution in particular cases: AI, robots, or humans? (REELER has proposed the development of a new type of profession *alignment experts, see 13.0 Conclusion*). They could help develop relational responsibility as well as the needed 'learning to learn'. Workers and developers need to remain relevant in an increasingly automated world – and help avoid unnecessary (eventually mothballed) technological developments.

One affected stakeholder, Dan, works with workplace environments in a big construction industry and he tells us about a project with a brick-laying robot, which was supposed to revolutionize construction work.

The robot developed could indeed reduce the workload in some areas, but it increased the work load in others. Where previously a worker had to lay bricks and tiles, the worker now has to feed the bricks and tiles to the robot – and so the problem is relocated.

> *Then you do that [feed the robot bricks or tiles] full-time and that might wear you down even more than stacking rocks.*
>
> (Dan, construction company employee, affected stakeholder, WIPER)

However, even when a robot makes sense, there are some workers who are motivated and willing to use new technologies and others who shy away from them (cf. the Danish Technucation project, see Hasse 2017). But many affected stakeholders, eager or hesitant, will expect or require some help from management or the government, in the form of education or training.

> *Elif: "I am entirely sure that there are some who won't use it, because they don't dare. So it might be information is very important, and some courses maybe. How can one protect oneself? It is actually very, very important."*
>
> *Interviewer: "Do you dare to use it?"*
>
> *Elif: "Well, of course I do! Yes, but, I would rather have the information: How should I use it? What should I do? Instruction is very, very good."*
>
> (Elif, hospital cleaning staff, affected stakeholder, SPECTRUS)

It may not be all workers who can be reskilled, and even if they can and are willing to, who is responsible for preparing workers for reskilling?

In general, even among the affected stakeholders with the shortest formal education in our REELER research, like the cleaners from Portugal with as little as seven years of schooling, there is a great willingness to learn more:

> *Interviewer: "Would you like to learn more in this area? The technological part?"*
>
> *Frida: "Yes, I love everything that has anything to do with science, I like it a lot. For an example this device [audio recorder] is here, it's recording, but how was it made to record? A person is always curious."*
>
> (Frida, hotel cleaning staff, affected stakeholder, SPECTRUS)

7.3.4. Reskilling responsibility

However, in order to provide reskilling or a new education for people like Frida, who works as a hotel cleaner in Portugal, it is not only important to recognize that she only had seven years of schooling. Like several of her colleagues, she left school when her daughter was born and is now a single mother. So, it is not enough to provide education – support is needed to help people with practical issues as well.

> *Interviewer: "Do you think you could reconcile work with [going back to] school?"*
>
> *Frida: "No, but because I'm living alone. I don't have anyone to help me. I live alone with my daughter and when I'm working she's in school, when I leave work, she leaves the school, then I have to go get her and stay at home with her."*
>
> (Frida, hotel cleaning staff, affected stakeholder, SPECTRUS)

Enabling users to observe a robot in use can help learning – but there are differences in how people learn, and (*as argued in 5.0 Inclusive Design*) these differences cannot just be explained away with a reference to age or being 'digital native'.

> *When I look at my staff, they are very used to taking courses and [adapt to] new things that they have to be aware of and so on. I mean, they're fairly open to the fact that they have to learn new things. Very often we present them with things [and they just say]: 'Ah, now again we're learning something new.' So, for this particular part of the staff, I am actually sure that they are pretty open-minded and also interested. However, when I look at the staff as a whole, I can definitely see some that just can't see themselves doing it, and they will never get around to it.*
>
> (Inge, hospital cleaning department manager, affected stakeholder, SPECTRUS)

However, Inge emphasizes, these difficulties are not about being afraid of or unfamiliar with technology.

> *Strangely enough, they are all very good at using their smartphone, but if I put them in front of a computer, they kind of freeze. But that might be like 10% of the staff; the rest of them, I'm sure, yes, they would have to work a little bit with the idea. We would have to come up with some really good reasons, why we're doing this, because that's mainly what my staff is, is interested in. Well, if I can present a very good reason, if they can see that reason, they can adapt almost to everything. And then there's a part of the staff, that are gonna love it.*
>
> (Inge, hospital cleaning department manager, affected stakeholder, SPECTRUS)

As Inge is emphasizing here, most people can learn to adapt to new technology if they are given good reasons for doing so in relation to their practice. It is a cross-case finding that affected stakeholders are not always convinced that robots are the best solution – and this may affect their unwillingness to learn to use them. However, from an affected stakeholder point of view, educating the staff to work with robots would in some cases also require a close collaboration with robot developers.

> *For us, as a team, to go out and convince the staff or teach the staff to use this kind of technology, we have to be very convincing. And you can't do that, if you don't know the product well enough. And the only one, who knows that well enough to be able to also answer all the questions that would arise, would actually be the ones that are manufacturing the thing. So, it would definitely be with the help from whoever is manufacturing the product.*
>
> (Inge, hospital cleaning department manager, affected stakeholder, SPECTRUS)

The robot developers are often aware that new educations are needed.

> *The educational standards need to change, because the tasks, which humans now do, they do not exist anymore. Which means that humans now do higher quality tasks.*
>
> (Nathan, mechatronics engineer, robot developer, COBOT)

However, most robot developers are eager to defend against replacement issues, usually by citing reskilling as a solution. As explained by Arne from the Union previously in this chapter, the CEO robot developers, do not think it is their task to ensure education and reskilling – even if they believe it is needed.

> *So, I mean, it's different. If I am a university person, I have to take care of educating people. Or if I am in a school, I have to take care of educating people. And it's [their] task to explain what a robot is. You cannot ask a company [to do this].*
>
> (Angus, robot developer and CEO, REGAIN)

However, others, like Yves, who is an industrial policymaker, believes it is the companies, who are responsible:

> *We have a social dialogue with employer organizations and basically their tendency is to place the burden of all these changes on the shoulders of the workers; that is they should bear the responsibility for their own employability and they should therefore take on their free time and their salary to pay for their own training. Well, we disagree with that, to be very honest. We actually tend to have the relatively opposite view that it is up to the company to maintain the employability of its workers by paying for the training and by enabling the training to take place during working hours. So you see the positions are pretty different here.*
>
> (Yves, policy advisor, robot maker, COOP)

Some robot developers do agree that companies should take on the responsibility of training workers. But not the companies that *sell* robots, but the companies that *buy* robots. From REELER's data, it's clear that some companies have willingly taken on the task. We have examples of robot developers who work together with the robot buyers to train the staff.

However, even if robot developing companies or companies in general take on this responsibility (at least in the development phases studied across many cases by REELER), they do not take responsibility for people who may be skeptical of technical solutions and question whether robots are the best solutions:

> *We have had robots that were taking over people's tasks. So the way that we try to deal with those users is to try to get them on the train where they become users of the robot. Because in the end, the people who are cleaning now are the ones who have the knowledge of how to clean. And that is very important for the robot to perform in the best possible way. So that is how we deal with the users: we try to teach them as much as possible, we give them that opportunity, and they can grab it or not.*
>
> (Mathias, system integrator, robot maker, SPECTRUS)

This system integrator means that only those willing to adapt to the technology might be retained. This argument shifts the burden of reskilling onto the worker to accept the robot, the same robot that depends on their expertise to function and that will replace them or their colleagues.

If a worker is willing to be reskilled, what kinds of aptitudes and abilities make it possible/impossible? Besides willingness, things like language, cognitive and physical abilities, technical aptitudes, and culture affect a worker's chances of being reskilled. Some manual laborers are not entirely literate, and thus may not have the same aptitudes for acquiring new technical competencies that are based in literacy or academic skills.

> *We also have ethnically Danish people, employees that have very big difficulties reading or writing – we have lot of e-learning programs, and that can be a little difficult for those 30%, I should say maybe more. But that is due to dyslexia? Most of them, all of them I guess, have been to school. I don't think everybody has a level of high school but they, definitely all of them, more or less have levels of junior high.*
>
> (Inge, hospital cleaning department manager, affected stakeholder, SPECTRUS)

It may be that certain jobs attract people who are less competent or confident in the local language, or who have less education. Many of those working as cleaners in Denmark, for example, were immigrants or descendants of immigrants, and/or Danes who struggled with literacy. In Portugal, most of the cleaners did not study beyond 7-9th grade or fell into cleaning because of some difficult life situations.

> *Yes. That's why I say that I feel embarrassed, because if I had studied, I would have had a better job. I would like to work in a school. I consider all positions. Any [kind of position], because I am not in a position of choosing. I want a proper wage. Yes, and do you know why? Because of the divorce, and my husband leaving for his land, he is going to [a European country] and I remain here with all the bills to pay, understand? I'm very afflicted.*
>
> (Rosi, hotel cleaning staff, affected stakeholder, SPECTRUS)

This points to a significant problem with offering reskilling as the solution to technological displacement – manual labor often includes last-resort jobs appealing to a particularly vulnerable niche of disadvantaged workers (*see 10.0 Meaningful Work*).

7.4 Concluding remarks on Learning in Practice

Learning is a basic embodied process situated in material and social environments. Through these processes we gradually build situated knowledge of these social and material environments – which may be disrupted, when something new comes into our lives. Robots and AI can be seen as such new phenomena which come into people's everyday lives and challenge their habituated learning habits and their situated knowledge of how things are and should be done (and even, as noted by Lave and Wenger (1991) their identities). If workers are unfamiliar with the new technologies entering their workplaces – or are only acquinted with them through popular media, technological changes may be met with fear and skepticism. When people learn what robots really are, part of this fear is often alleviated; or, fear of the unknown is replaced with a more grounded and realistic skepticism. In any case, whenever a robot is implemented in a practice, a learning process is initiated, whether connected to an explicit training or not. Robots can be more or less intuitive, but situated learning will always be an issue when new technologies are implemented. To create 'intuitive robots', the robot developers need to learn from users what matters to them, and they need to be aware that not all users share their sense of what is intuitive, when it comes to operating a robot. Though it is a difficult task, there is a lot to be gained from following technology-in-use in an everyday practice, and not just in laboratories.

However, formal education is also needed in at least two ways: 1) To operate, maintain and co-exist with robots in everyday work life. 2) To establish a learning-to-learn paradigm, which facilitates workers' developement of new skills, to compensate for those tasks taken over by robots. Here, there is a basic dilemma. It is not clear who will feel ethically responsible to reskill a workforce in response to robotization. Across cases in REELER, many robot developers, especially from big companies, see it as part of the robot development to offer re-skilling of workers, however other robot developers are unwilling to do so. Generally, the upskilling and education of workers made redundant by robots and AI remain largely an unsolved problem – and it is further complicated by the fact that we do not know what kinds of educations will be needed. What REELER research point to is that it is not just a question of reskilling 'digital natives' who are able and willing to engage with robots. For many stakeholders, going back to school is not possible (for financial or social reasons) without societal support – even when they are willing to learn. Furthermore, REELER findings indicate that we also need to be careful in determining, in which cases robots are preferable to humans and vice versa. Finally, we need to prepare our educational system for the possibility of a robotic future.

Concluding remarks to Part Two

As noted in the introduction, one of REELER's main recommendations is to apply a two-pronged strategy to improve responsible and ethical learning in robotics. We have shown that robot developers, mainly engineers, have much to gain from learning from end-users and affected stakeholders. This awareness may pave the way for more ethical and responsible learning in robotics and may even lead to new and more productive innovation processes. Yet, we have also found many issues that are so complicated and tied into wider societal concerns that it would be unreasonable to ask engineers and other robot developers to solve them all.

In this first part, we have mainly focused on issues tied to the original objective of the REELER project; namely to align robot developers' (and especially engineers) visions of a future with robots with empirically-based knowledge of their own understandings, while providing new insights into the REELER findings on situated practices and innovation models. By giving voice to those affected by robots, we envision not only more ethical and responsible robots, but also a potentially better uptake on robots, simply because the robot developer's iterative design practices can be improved. To that end we have developed a number of tools that can be found online (*see www.responsiblerobotics.eu*) aiming at helping robot developers improve their practices.

In this section (Part Two), we have mainly focused on enhancing robot developer's awareness of how they view ethics, humans and how design can be hampered by their own normative perceptions of affected stakeholders, their needs and concerns (*4.0 Ethics Beyond Safety and 5.0 Inclusive Design*). We have also pointed to the enormous complexity and uncertainties in engineering design processes – and the need for iterative processes that consider both structural aspects and situated practices (*6.0 Innovation Economics and 7.0 Learning in Practice*).

Already from reading this section, it is clear that the burden of ensuring responsible and ethical learning in robotics cannot be put solely on the robot developers, nor the application experts helping them to develop robots. Not even the facilitators (the third sub-group of robot makers) who fund and make policy concerning robots can be expected to solve these problems on their own.

In the last part, Part Three, we unfold the wider context of the challenges we can envision in a society permeated by AI and robotics. We argue that relational responsibility is one step towards solving these problems. We end Part Three by explaining what we see as a need for a new profession of *alignment experts*.