Paper to be presented at NFF, Bodø, August 23-25, 2017.
Track 22: Digitalization: Information technology, knowledge and sustainability

Digitalisation and work – sociomaterial entanglements in steel production

Anette Hallin[1], Lucia Crevani[2], Chris Ivory[3], Marie Mörndal[4]

Abstract

The purpose of this paper is to theorize how different sociomaterial entanglements affect work practices. Based on a qualitative case study, we compare and contrast three empirical Factory-cases; the Non-digital-and-non-lean factory; the Somewhat-digital-and-lean factory; and the More-thoroughly-digital-factory. When comparing these three cases, we are able to show that the different sociomaterial entanglements enact different spheres of concern. The contribution of the paper lies in its' unveiling of *how* the spheres of concern differ in terms of temporal orientation and localization, and depending on the entanglement of technologies and production management models.

Key words

sociomaterial, entanglement, matter of concern, digitalization

Introduction

Despite the valuable inheritance from researchers such as those in the Tavistock-school, who coined the term "sociotechnical system" in order to acknowledge the interrelationship between technical and social systems (Trist, 1981); scholars within the Science and Technology Studies (STS), who proposed a "turn to technology" (Woolgar, 1991), and the emergence of social constructivist thinking in technology studies (Bijker, Hughes, & Pinch, 1987), current developments in organisational life, such as the increased embeddedness of technology in daily life, reveal how ill-equipped traditional organisation theories are to address contemporary industry transformation. Lately it has been argued that further work is needed to theorize the fusion of technology and work (Carlile, Nicolini, Langley, & Tsoukas,

[1] Associate professor, Mälardalen University, Sweden. Corresponding author: anette.hallin@mdh.se
[2] Associate professor, Mälardalen University, Sweden.
[3] Professor, Anglia-Ruskin University, UK and Visiting Professor, Mälardalen University, Sweden.
[4] PhD candidate, Mälardalen University, Sweden.

2013). In this context, the emerging genre of sociomateriality is a promising path (Orlikowski & Scott, 2008).

The sociomaterial perspective has already been fruitfully applied in the study of IT-systems development, (Doolin & McLeod, 2012) waste management (Corvellec & Hultman, 2012), and strategy development (Balogun, Jacobs, Jarzabkowski, Mantere, & Vaara, 2014), however, the potentially far reaching effects of digitalisation in a range of work setting warrant additional studies and further theorizing (Zammuto, Griffith, Majchrzak, Dougherty, & Faraj, 2007).

Defined as "the constitutive entanglement of the social and the material in everyday organizational life" (Orlikowski, 2007:1438), sociomateriality reflects a shift in organization studies towards a posthuman ontology where humans and non-humans are granted equal status (Barad, 2003). Moreover, the social and the material are viewed as entangled in such a way that the material may not be considered as separate from the social that created it, and the social may not be considered as external to materialities (Gherardhi, 2017). It has been argued that if sociomateriality is to be an enduring lens through which we are to understand organizing we must focus on the *entanglement* of the social and the material rather than on upon independently existing affordances and scripts (Jarzabkowski & Pinch, 2013). In this area, there still remains work to be done, though and the purpose of this paper is to theorize how different sociomaterial entanglements affect work practices.

Sociomaterial practices are situated practices (Gherardhi, 2017) and, as such, understanding the development of new empirical contexts is important to further develop the entanglement concept. We study sociomaterial entanglements through a comparative case study of two steel companies that display several similarities in that they both are large, international companies producing premium steel products and since the production facilities studied here are in the same country – but that have reached different degrees of automatization/digitization and where the enactment of "production management" is different.

Based on observations and interviews with managers and operators in the production line, as well as support staff, we describe two different presently existing cases: Non-digital-and-non-lean-Factory and the Somewhat-digital-and-lean-factory. Based on the visions of those interviewed we also construct a narrative of a future factory yet to be realized: the More-thoroughly-digital-factory, as an extrapolation used for analytical comparison and for raising questions about possible future developments.

Comparing these three case descriptions (two real and one imagined), we suggest that sociomaterial entanglements can be seen as qualitatively different, depending on how different spheres of concern are enacted (cf Latour, 2004). A reason for this is that as digitisation and individual machine design has improved in terms of usability and reliability the machines themselves become less a 'matter of concern' for the operator. Work practices' 'sphere of concern', as we have called it, shift from the particular operator at a certain machine, to instead concern the broader production system. That is, the individual operator is less entangled with the machine and entanglement is more visible in the form of collective sociomaterial entanglement – involving both the machines, the colleagues and the production process as a whole. We also hypothesise that, in the future, individual operators may disappear to be replaced by even more mobile service- and repair technicians who will be entangled with the technology in new, more virtual, ways. Again, different entanglements, differentiated by differing spheres of concern, become apparent.

The contribution of the paper lies in its' unveiling of *how* the spheres of concern differ in terms of temporal orientation and localization, and depending on the entanglement of technologies and production management models.

Technology, work and sociomateriality

As the century has progressed it has become clear that the relationship between technology and work is far more complex than former determinist 'impact' studies suggest (eg Woodward, 1958/2011). There are many routes to increased efficiency and companies are not always served simply by deskilling workers through automation. Faster moving innovative companies require their workers to maintain discretion and creativity (Kelly, 1990; Spell, 2001) and workers may also up-skill (Gray, 2001) or develop new skill sets (Grugulis & Vincent, 2009).

More theoretically sophisticated and less deterministic approaches to technology change in the firm have also recognised importance of the context of adoption. In particular, it has been observed the technology rather than simply determining how work is done, is in fact shaped 'in use'(Grint & Woolgar, 1997; Mackenzie & Wajcman, 1985). This has led to a growing research focus on technology use and to what has been termed, the 'turn to practice' (Gherardhi, 2015). While early social constructivist studies of the role of organisational context and its influence on technology use, have fore-grounded the role of the social and organisational context, this has been at the expense of a fuller understanding of the role technology itself (Kallinikos, Ekbia, & Nardi, 2015; P. M. Leonardi, 2013; Orlikowski, 2000, 2007, 2010). Balancing this over-focus on the role of the social has been what has been termed post-humanism movement – studies which seek to describe the role of the social and the technological in relational terms to one another.

In studies of work and technology, the main proponent of this drive toward a symmetrical treatment of the social and the material (viewing them both as actors in change) has been what has called Sociomaterialism. Sociomaterialism is concerned primarily with the implementation of technology, particularly ICTS, but draws inspiration from actor-network theory (ANT) and relational approaches to organisational change. ANT assumes that the actors driving change are both human and non-human. Relational approaches to organisations view organisational change, not as planned, rational, contingent or even, necessarily evolutionary – but as emergent and ongoing, the result of multiple internal and external influences and so as potentially multi-directional.

Sociomaterialism is concerned with the way in which new technologies transform existing work environments. However, they view organisational change in post-human and relational terms, as an interactive amalgam of social and material elements, the results of which are emergent. Sociomateriality, as itself an emerging field of study, does not present a consensus view on how the relationship between the social and the material should be characterised or studied (Mutch, 2013). Different views posit differing degrees of inseparability between the social and material. Some authors have suggested that the one cannot be seen as existing without the other (Orlikowski, 2000, 2007) while others have suggested different forms of interaction in which the two remain distinct but interacting (P. Leonardi & Rodregez-Lluesma, 2012). Authors have also disagreed as to the amount of influence the one should be accorded over the other (Kallinikos et al., 2015). The focus of empirical work is also contentious. While some writers suggest that only a practice focus is appropriate (Orlikowski, 2000), others suggest that this can lead to an over-focus on the perspectives of the user and ignores what occurs outside of those situated encounters (Kallinikos et al., 2015; Mutch, 2013).

Our own position draws on what we see as the core tenets of sociomateriality: the notion that the social and the material are entangled, that they should be viewed by research as symmetrical (as both having effects); that practice should be the focus of research and that entanglement should be viewed as an emergent phenomenon intrinsically tied-up with the ongoing emergence of the organisation itself. We view the nuances of the relationship between the social and material as an empirical and contingent matter, not an ontological one.

By taking a relational, emergent and sociomaterial view of the organisation we are able to deal more effectively with the case studies that are of interest here. Our case studies are about the changing nature of work, not just as a result of digital technology, but, simultaneously, the introduction to the organisation of Lean production thinking. By viewing sociomaterial entanglement as an aspect of the organisation's emergence, we avoid favouring either technology change or lean thinking (or indeed any other aspect of the social) as a primary 'driver' of the changes we observe.

Analytical framework: spheres of concern

Our application of sociomateriality (re)introduces two concepts made famous by Latour (2004): 'matters of fact' and 'matters of concern.' We use this distinction as a way of highlighting the changing nature and experience of work as new technology as well as a new production processes come into play within the factory.

Simply put, 'matter of fact' denotes that which is taken for granted, whereas 'matter of concern' denotes that which for some reason has caught the attention of people and around which people have gathered (Latour, 2004). Central in Laour's argument is the word '*thing'* (derived from Danish word meaning a political gathering or debating hall). A 'thing', such as an antique vase, can deploy its connections to craft processes, art, artists and craftsmen whereas mere 'objects', like a can of Coke, cannot – they are the unremarked product of mass production, science and technology; 'empty mastery'. A rock is an object – but a 'dolomite' is a thing – the traces that led to its existence or writ large on it.

What is a matter of fact and a matter of concern is however not inherent in the object itself; an object can shift from one mode to the other. The Columbia space shuttle that broke apart only seconds after having been launched in 1986 was transformed from an object (fully mastered, gathered taken for granted 'matter of fact') into to a thing, when it exploded – a disaggregated object, each piece of which became the evidence in an inquiry to see how it got into that state (so, a 'matter of concern'). This way, things may change from being matters of fact to being matters of concern, and vice versa.

Matters of concern are thus disputable, they matter and carry you away and when something is a matter of concern "it has to do with our relation to the world in which we live" (Gherardhi & Rodeschini, 2016:267). This way, that which is a matter of concern is not only voiced, but also negotiated, transported and recognized (or not) as legitimate (Vásquez, Bencherki, Coreen, & Sergi, 2017).

Cases: Alfa and Omega

Two cases have been studied: Alfa and the Omega. Both cases are constituted by units at large, international steel companies with operations across the world, employing thousands of employees within different divisions and producing premium steel products for different uses.

Empirical material

The cases were studied in the "bringing work back in"-tradition (Barley & Kunda, 2001); privileging work rather than the organisation as such. Following such a stance, the cases have been studies through observations and semi-structured interviews, all taking place during the spring of 2017. When observing, the researchers took the roles of Observer-as-participants (Gold, 1958) when participating in various meetings, such as morning meetings and project- and strategic production meetings at Alfa, and morning meetings and improvement meetings at Omega. Observations were also done of the daily work of the Operators and other members of staff at the two departments. During observations, field notes were taken by hand by the researchers and transferred to digital format in the afternoon/evening of when the observations took place.

The semi-structured format of the interviews involved the use of an interview guide where the following topics were covered during the interview: background about the interviewee, work tasks, culture, organisation, management and leadership, technology and the future. The same guide was used in both cases and all interviews were recorded and subsequently transcribed verbatime.

The empirical material from Alfa consists of 21 interviews with staff from the production unit (*Operators* and their *Foremen*, a *Support Technician* who shared his time between being a Foreman and a Technician; with managers on two levels higher up in the hierarchy (*the Product Manager*, *the Logistics Manager, the HR Manager*) and their boss, *the CEO.* One of the operators also worked part time for the metal workers' union. Everyone was interviewed once, see table 1.

/Insert Table 1 here: Interviewees, gender, age and duration of interviews at the Alfa/

The empirical material from Omega consists of 21 interviews with staff from the production unit (*Operators* and *Operators/Shift managers* from three of the shifts, *the Support technician*, *the Production unit manager*); with managers on two levels higher up in the hierarchy (*the Site manager* who is the Production unit manager's boss and his boss *the Product manager*); of support staff from the division (*The HR/Business Process-officer* who has a strategic responsibility and who is support the Production unit managers and the Site managers, and *the IT Site Operations manager* who has a strategic responsibility to develop information technology and operations technology across the division); of *the Production technician* (who formally belongs to the Maintenance unit but who has his office at the Production unit since he is dedicated to this unit); and of *the Health and Safety Union representative* who works for the metal workers' union. For a full list of interviewees, see table 2. Everyone was interviewed once, apart from the Production unit manager who was interviewed twice; the first interview being an unstructured interview where he described the operations of the production unit while showing the researcher around at the shop floor, and the second interview following the same semi-structured format as the interviews with the other interviewees.

/Insert Table 2 here: Interviewees, gender, age and duration of interviews at the Omega/

The analysis of the material took place through an iterative process where the researchers looked for various types of relations and interactions between the different elements in the material (cf Gherardhi, 2015): operator-machine; operator-operator; operator-manager; operator-production system. Instances of such relations/interactions were recorded in a separate document. At an early stage it was clear that the two companies were different both regarding degree of automization/digitalization and that they enacted the idea of "production" differently. In addition, the operators viewed their work as well as their companies differently, which is why Latour's (2004) concepts of matter of fact and matter of concern were brought in in the analysis.

Through the iterative analytical process, we have constructed of three different empirical case descriptions:

- the Non-digital and non-lean factory (Alfa)
- the Somewhat-digital-and-lean factory (Omega), and, finally,
- the More-thoroughly-digital-factory (constructed based on expectations on the future expressed by staff of Omega).

Below, the three cases will be described briefly below: a summary of the descriptions may be found in table 3. Then we will discuss how they differ in terms of shifting loci of concern and sociomaterial entanglement.

The Non-digital-and-non-lean factory

The Non-digital-and-non-lean factory consists of a number of small lines consisting of one or several machines performing different processes on the material that needs to go through different stages before being the product is packaged for delivery. Some of the machines are several decades old and require a lot of manual work, both in setting-up and in assisting while processing the material. Operating such machines requires a lot of experience and constant attention as problems may arise suddenly. One of the operators, working at one of the oldest machines, for instance, tells how he never takes more than one week of holiday, since otherwise the factory would stop because nobody but him can handle that particular machine.

> "The worst thing would be if I broke my leg or got a heart attack or something […] I had the discussion at home last week [about being away from work]. We are going on a holiday. I looked at my wife when she said: let's go for 14 days. I told her that it was impossible. I usually have three weeks in the summer like everyone else. One week is fine if you plan […], but nobody is doing the work while I'm away […]. That's how it is." (Operator F1, Alfa)

Operators are rather independent in their daily work. They receive production orders on paper and then to some extent organize the sequence of the orders. The information from the logistics department is understood as suggestions and not orders:

> K looks in at the computer and sees that the next order is urgent. 'We can't do them now', she says. 'We have the machines set for [another order]." (Fieldnotes, Alfa, 2017-02-16)

They get some brief information about how the machines have been working and if there is any prioritized product to consider before they plan the days' work, from the operator of the shift before (if there was one) either via written notes or ad hoc individual meetings.

If there are two or more operators at a machine they discuss the best way to handle the orders and how to prioritize between them. Then the machine needs to be adjusted before the order is processed.

The operators have access to a stationary computer which is used to register when a product is ready to be transported to the next step in the production process. It is also on this computer that they recieve information from the logistics' department about which products that should be currently prioritized. Operators do not have company phones or personal company email addresses.

The operators' work is only fairly physically demanding, even though certain operations are dangerous (for instance because of high temperatures) and others are "monotonous". But operators also use their bodies to assess the quality of what is being produced, as for instance when using nails to feel how sharp an edge is. There are no routines for following up the production process from the operators' perspective, that is the Foremen's responsibility and is done by them every morning.

Every morning the Foremen attend a morning meeting, which take place in a corner of the shop floor next to a white board where current information relevant to the production is available and discussed. The Foreman also walks around the different machines every day, visiting each operator once or twice a day in order to check how production is running, if there are issues or needs, and to communicate if something that the operator needs to know is happening somewhere else. The Foremen also have the keys to the room where spare parts are kept, and operators therefore need to call them when they need spare parts (which happens rather often). Foremen are also called as soon as a problem arises.

The CEO is seen on the production floor regularly, but operators claim he would need to be more present. There is generally a skepticism about how well the management of the company understands production and the machines.

The operators have to fill in several forms manually on paper which are kept in folders in order to facilitate the foreman's monitoring of the production process, but at the same time they also have to enter the same information in the computer system which Operator A3 experiences as time consuming and frustrating:

> "Now we write an inspection card, then we have to copy the card twice, but it also must be entered and handled in the computer for statistic reasons. The copies have to be put in folders here and there. [.....] It would be much easier if we could fill in everything once on the computer and the statistics would be analysed at the same time. Because what I'm writing on the inspection card, is basically the same [information] that I write on the computer, but it's not a card but different boxes. And then everyone could have access to it. [.....] Then they come out and look in our folders [from the logistics department]. It would have been so much easier if they had been at their computer and searched for the special product. So it's a lot of time that would be saved if they could do that." (Operator A3, Alfa)

The operators are organised in six groups with one Foreman for each group. The groups differ in size from about 20 to 40 operators and every group has their own support technician. Some groups are organized in three shifts others in two and some are working ordinary daytime hours. The groups are then organized in units, with a Production Unit Manager on the level between the Foremen and the Product manager. The Production Unit Managers have economic as well as responsibility for the staff within their unit and therefore they need to have close interaction with the logistics department in order to be able to plan the production process. The majority of staff in the production unit is male, about 14 per cent are female and there is a spread in ages ranging from 21 to 64.

No formal education is required for becoming an operator. Rather, the job is learned by doing and by working together with more experienced operators. Many operators are recruited locally, from the village in which the facilities are located. They have had their parent or grandparents working at the factory and at times they may actually end up at the same machine or doing the same kind of work as them. Operators claim that they continuously learn when working as you never fully understand a machine or a process and new products are introduced. There are no formal training initiatives and there is no formal career path for operators taking into consideration their performance. They are not evaluated based on individual performance either. The only formal meeting in which the operator participate is the yearly information meeting where the higher management informs about current developments and possibly plans.

The Somewhat-digital-and-lean-factory

At the Somewhat digital and lean-factory production is carried out in cells. Each cell is like a mini-factory, fenced in, and consisting of a robot and 2-3 machines that do perform various operations on the steel material, such as lathing, routing and threading. The operators fetch boxes with steel and place them outside the cell. They then use a magnetic lifting device to lift the bits of steel onto a tilted bearings that distributes the bits of steel into the cell. From there, the robot takes a bit of steel and puts it in the first machine, and onto the second one, when the operations are complete in the first one. While these operations are going on, the operator monitors the robot with the help of a computer outside the cell.

The operator is also responsible for maintaining the machines, by for example replacing cutting devices; filing up oil and cooling liquid; by removing waste, such as small bits of steel; making sure that the components that are produced have the correct dimensions, and by keeping the cells clean.

When the machines have done their work, the operator moves the components from the cell to the shelves where they are picked up by the next production unit. The robots in each cell can work on two bits of steel at the same time and it takes 1-4 hours for the robot to perform its operations on a bit of steel.

In order to perform their work, the operators interact both with information systems (IT, eg the order management system, a system in which they report faults, maintenance systems etc) through the computer that is placed on a table outside of each cell, and operation systems (OT, eg the system that operates the robot and the system that operates the machines). Support technician 1 at Omega describes how the operators need to work “manually” with the different systems during a shift, for example they need to print out new orders, enter data from this piece of paper to the robot, provide the order system with information about an order that has been completed and so on.

The responsibility for the IT-systems lies with the IT-people, which are employed at another company in the division. The responsibility for the OT-systems lies with the production technician who is not employed by the production unit, but by a specialized production technology unit within the division.

The “Standard Operating procedures” for the operators are both kept on paper in a paper file in the production unit hall and may be found in a digital repository.

When a new component is to be developed, the RnD-unit makes a drawing of it. When complete, the drawing is sent to the Production technician at the production unit who creates a program for the robot and sends this digitally to the robot. It is the task of the

Support technician to test the program in order to see if it works as intended; i.e. if the robot produces a component with the correct measurements according to the drawing. If this is the case, the order is given a 'go' and the production of the new product is started. The operators are responsible for manually measuring every tenth sample of a product in a batch during production.

The operators are organised in four shifts with one of the operators in each shift having the function of being the Shift manager. Each shift consists of five operators, including the Shift manager and these five together take care of the robots and the machines in the six cells, with one Operator having the prime responsibility for one particular cell. The operators are thus completely self-organized within the shift. There are also some interns at the production unit; either from a CNC-operators' training course at a nearby education facility or from the secondary school that the company runs. These stay for a few weeks or months and help out with different chores according to the Operators' and Operators/Shift managers' instructions. It is quite common to start out as a such an intern; get a summer job, and then, stay on. Despite the dedicated work that the Production unit manager and the Product manager do to improve the gender balance in the organisation, there majority of staff in the production unit is male. The Production Unit however does display a spread in ages when it comes to staff, ranging from 28-55.

The Shift manager does not only do work of an operator but also leads the daily Pulse-meetings that take place each morning at 8am where the operators that work the morning shift gather in front of a whiteboard and go through corner stones of quality work that are included at the Score Card of the company: Security, Quality, Delivery, Machine status, Staff. This is part of the production unit's quality assurance work and it takes place according to the company's version of the Lean Six Sigma-framework that was developed a few years ago by the Product manager, the Site managers and the Production Unit managers.

Present at these daily meetings are also the Support technician, the Production technician and the Production unit manager. Half-an-hour hour after the Pulse-meeting at the Production unit finishes, at 8:45am, the Production unit manager attends a quality assurance meeting with the other Production unit managers held at the Site manager's office where the same procedure is repeated, but on a higher level, and after that (at 9:15am) the routine is repeated again with the Site managers at the Product manager's office. This way, the production is followed up on a daily basis through all levels of the organisation.

In addition, the operators gather weekly for improvement meetings chaired by the Production technician, one for each type of component, during which the operators that work with the component in question gather together with the Support technician, the Production technician and the Production unit manager to discuss reoccurring production problems, perform root-cause-analysis of these, discuss how they can be solved and decide who should do what and when.

Operator/Shift manager A describes an example of a problem that he intends to bring up at the next improvement meeting:

> "it is not precise when it puts things down. Maybe our way of thinking is not right when it comes to how we treat the robot. […] When you're done in the […] cell, the robot finds the pallet and puts it down in one place. This can't be done from a certain height. But if this height is under a wooden box. If it's down here, or up here [shows with his hands], there is a clash, and if it drops it from up here, it says [hits his hand in the table…]. This is not a good way I think. I would like it differently." (Operator/Shift manager A).

Operator/Shift manager A:s suggestion is that the Production Unit starts using standardised boxes of a certain height and that the robots are programmed to perform this work in a more precise way.

The More thoroughly digital-factory

At the More thoroughly digital-factory, production is carried out in numerous cells, similar to the ones in the Somewhat digital systems-factory with stationary robots that move bits of steel between the machines. Here, the cells aren't fenced in, however, in order to make it easier for support- and maintenance robots to perform work on the machines. These are mobile and digitally connected to the robot and the machines in the cell. The support robots provide the machines with bits of steel and communicates with the robot when production can commence. The support robots monitor production digitally and fetches the products from the cells when operations have been completed, and takes them to the storage shelves where they are stored before it is distributed to the next part of production.

The maintenance robots perform maintenance work on the machines like keeping the cells clean, but since these are updated and digitalized, things like replacing cutting devices, filling up oil and cooling liquid, the machines do themselves. The robot that moves bits of steel between the machines is now also able to measure the components after each operation in order to make sure that the components produced have the correct dimensions.

There aren't any operators left since both manual labour and information transferring is done by robots with various degree of artificial intelligence. The factory is "smart" in this sense. There are still humans at the Factory, however. These work as Production technicians (white-collar workers) and Support technicians (blue-collar workers). The Production technicians carry the overall responsibility for the production technology at the unit – in which all technology is included; both that which at the Somewhat digital and lean-factory was called "IT" and that which was called "OT". They also create, as before, new programs for the robots, based on the RnD-units' drawings. All information about production procedures etc is available digitally through an interface that is easily accessible for the Support technicians. Information is digitally transferred from various systems.

The Support technicians are responsible for daily maintenance of the machines. They test new programs and make sure that the machines run smoothly. They are organized in self-organised teams that work day time only and some weekends, depending on the order status. During nights, the factory runs by itself, and since all technology is digitally connected the support technicians don't need to be physically at the Factory. They often are, though, since they appreciate the social interaction with the other members of staff and since they train new Support technicians. The staff is balanced in gender, age and ethnicity. The Support technicians are specialized on different types of robots in production but may develop by learning about new types of robots.

As in the Somewhat digital and lean-factory they meet daily, either physically or virtually, for Pulse meetings where they go through the items on the unit's score card, which is digitally visualized. The information entered on the score card is automatically uploaded to the score card of the Site manager. There is no longer any Production unit manager. The Support technicians organize themselves and work under the manager of the Site manager.

/Insert Table 3: The three factory-case descriptions/

Shifting loci of concern and different types of entanglements

The three case descriptions display different loci in terms of what we have chosen to call 'spheres of concern'. With 'sphere of concern' we mean that which is enacted as a matter of concern in the work practices carried out by those working in the factory (cf Latour, 2004).

The case study suggests that as machines become 'matter of fact' the close relationship between the worker and the machine is weakened. The machine simply does not need the worker in the way that it used to. However, this does not mean that the worker retreats into a state of stultifying boredom or that less skilled workers will be deployed in their place. In the Somewhat-digital-and-lean factory we find instead how working practices enact a different sphere of concern; moving from the localized machine-operator interactions to entanglements including more machines and the plant at large and new social relations. We use this possibility, of shifting social and material relations, defined by shifting spheres of concern, to explore the sociomaterial entanglements in the three cases.

The Non-digital and non-lean-factory

At the Non-digital-and-non-lean factory, production is largely a matter of fact. The machines are old, sometimes 40-50 years, and the production site has been in the same village/town for decades, meaning that generations of families have worked in the factory with the types of tasks being quite similar across time. Operator F1 in Alfa who has worked in the factory for 37 years says: "I was taught to handle this machine by my father". Production is planned in a traditional way; often on paper. This parallels what one operator in Omega remembers: thirty years ago "a lot of things were done with paper and pen" (Operator A1, Omega).

The operators perform the tasks that are assigned to them by the Foreman: "we had a factory manager or someone who walked around with a book, he knew exactly were all the orders were, he knew when they were to be finished." (Health and Safety representative, Omega). At Alfa, the black book is still in use:

> Foreman B in Alfa is still using a black book where he writes down the issues that need to be solved during his meeting with the operators in the group. He and the other Foremen use a system where they prioritize the issues and give each issue a figure between 1 and 5. This system facilitates the Foremen's organizing of the day and enables them to do "the right thing in the right order". (Fieldnotes, Alfa, 2017-02-09)

Working as a Foreman in Alfa means to be prepared to work any time during the week, night and day as well as weekends. After the working day ends the operators on the nightshift or a Sunday shift are aloud to call the Foremen at home if there is a problem with the machines that can not be solved by the operators. The factory expects full loyalty from the Foremen:

> [I'm] loyal to the company, the company goes first, it goes even before me. [.....] Yes, I can hear that at home, too. I will never come home on time. I think I'll do everything I can for Alfa. It's always prio one. (Foreman A, Alfa)

Operators focus on one task/process at a time and when having performed the tasks that he/she is responsible for the (half-finished) product is handed over to the next stage where another operator performs a new series of operations on it, and so on, before the material, eventually, is ready to be shipped to the customer. The individual operators often have little or no idea about what the final product will look like or what it will be used for when completed. They do their tasks as told, with the equipment that they are responsible for. This means that the production process itself is enacted as a matter of fact in work practices performed by operators; people work on their own, close to their machine: "then [thirty years ago, before production was automised] everyone used to work on their own much more than what we do now (Operator A1, Omega). At Alfa this is visible:

> "When you meet some one you say hello, but you don't discuss the material. If you want to discuss anything you talk to your boss [the Foreman], and he will do something about it." (Operator A3, Alfa)

The machines, on the other hand, is a matter of concern. The machine is a continuous source of mystery and mastering how it works is source of pride. Some of the operators carry with them a black note book in which they write down their best ideas of how to work with the machines. These books are not necessarily shared with the other operators:

> "When I began [15 years ago] there was some, still, pride, somehow, among these people who were still considered very, very skilled, they knew their machine, had their little black book, secret black book, where they had written down how to do stuff." (HR/BP Officer, Omega)

The sociomaterial entanglement in the Non-digital and non-lean-factory is localized to the the shop floor, site of the machines, and more particularly is fragmented in different entanglements taking place around each machine. This is where the operators stay when at work including lunch and coffee breaks. The entanglement is thus an individual one, between the individual operators and one or few machines. The entanglement is fixed in space and in time, the entanglement exists only then and there; and concern is enacted for present issues when performing the practices of producing the steel product as machine and operator interact.

The Somewhat digital and lean-factory

At the Somewhat digital and lean-factory, production is largely enacted as a matter of concern. It is the production system at large that is produced as matter of concern. This takes place through the entanglement of lean production processes and various forms of technology.

As part of the lean production process, operators' work is decentralized: "We are our own managers, within certain limits", as Operator A1 at Omega puts it, and most other operators describe the work at the production unit in similar terms.

Next to each cell there are screens displaying the productivity status in each cell. The cells are either marked green, indicating full capacity; yellow, indicating less capacity; or red, indicating that something has happened and that there is a problem. Some operators strive at having the screen display green all the time, but this is a mistake, Operator A2 at Omega says:

> "I think that they see it as some sort of competition with themselves or… but it may be wrong sometimes, because there may be a steel-scrap-stop in some machine because they haven't looked down to see that the stop is about to happen or maybe because they are too much in a hurry when you do like that. I don't do it. I strive at keeping production going all the time, but it doesn't have to be exactly green all the time." (Operator A2, Omega)

The same screen is also positioned in the coffee-room which is situated in between the production unit hall of this case study and another production unit hall. With the help of this screen, the operators can monitor production while having coffee-, or lunch breaks together. The operators are allowed to take breaks whenever they want to, but the machines have to be served with new cutting parts regularly and these intervals are pre-set based on time, and therefore, the operators need to make sure that the machines have fresh cutting parts before they go on a break.

The daily morning, 15-minutes-long, stand-up Pulse-meetings at Omega take place in front of a large whiteboard situated in a space next to the production unit hall where the cells are. During these meetings, the production is still ongoing; the robots perform the work without any operators present.

In the meetings, the participators use pens and an eraser to add, remove and change information on the board in relation to the five sections corresponding on the board that all correspond to the company's corner stones of quality work: Security, Quality, Delivery, Machine status, Staff:

> "Operator/Shift manager B asks for input on Machine status. Someone says that Cell 1B has an error and that it is currently not operating. Maintenance staff has been called in and are working on it. In

> another cell there has been a clash and they are waiting for a drawing. The Production technician asks why but the Operator/Shift manager B doesn't know.
>
> Operator/Shift manager B tells everyone that Operator A3 is back. Another person is on leave to have a small operation, and since Fridays is her day off she will not be back until Monday.
>
> All through the meeting, Operator/Shift manager B makes note on the whiteboard and now he turns to me and says that 'in the future this board is probably digitalised, considering your project'. Everyone laughs.
>
> The discussion moves on to Deliveries and then Good examples. The Production Unit manager points out that Operator A3 last week got eye rinsing liquid. Operator/Shift manager B makes a note on the whiteboard. One of the other operators asks if there is anything more that can be done now and the Production Unit manager gives them positive feedback for asking. Then a topic is brought up that I don't catch, but the discussion ends with the Support technician saying 'let's bring it up on tomorrow's Pulse-meeting, and in the next improvement meeting.
>
> [….]
>
> One of the interns raises her hand and says that she has yet another thing to bring up. It's about the floor in the room where the water is to be poured out, after cleaning. The floor has metal bars, which is a problem when pulling a bucket on wheels filled with dirty water – the water spills out. She wonders if it is possible to put something on the floor. The group discusses different solutions: mdf-board, a piece of steel and so on. 'It must look nice', says the Support technician. The Operator/Shift manager B writes this down in the box labelled 'Suggestions for improvement'." (Fieldnotes from Pulse-meeting at Omega, 2017- 03-30)

During an observation one month later, Support technician 1 proudly shows the newly installed steel ledge that has been assembled on the metal bars. "It looks professional", he says. "As if it has been there all along" (Fieldnotes from Observation at Omega, 2017-05-03).

Operator B2 says that he likes the morning meetings: "good ideas are always brought up, if they then are acted upon is another matter, it depends on what it is, but I think that we normally get what we want" (Operator B2, Omega). Operator C1 agrees. She describes how she brought up an issue with a tool; a tool that she always hurt herself when using, which is why she decided to suggest another tool. Very soon after she had brought it up the new tool was in place, which makes her feel that the managers listen to her. "It's easy to give suggestions here", she says (Operator C1, Omega).

The operators want the machines to run as smoothly as possible, i.e without them having to do anything with them, which makes them interested in being involved in improvement work, according to the Production Unit manager:

> "The Operators want to contribute, improve continuously, want things to run smoother. [..] but does the machine stop a lot during a shift they are, like, 'Oh, god, what a tough day I had… I have had to work the whole shift'." (Production Unit manager, Omega.)

This shows in the described sociomaterial practices, production at large is enacted as a matter of concern – in the entanglement of lean production processes as it is performed at

Omega, such as the pulse meeting; artefacts (the whiteboard), and digital technologies (monitoring screens, system for production stops, etc). The production process is a collective matter of concern at the Somewhat digital and lean-factory and the sociomaterial entanglement includes several operators and machines, as well as “the factory” (or at least “the unit”) (interrelations between machines and between machines and the broader process).

It is spatially not limited to the machines themselves, but partly de-localized, since the operators’ practices also take place in other spaces at the factory, such as the meeting room where the whiteboard is situated or in the meeting room where the improvement meetings take place. Operators can also decide themselves where and when to meet; when for example to go for a coffee break. The loci of the enacted matter of concern is also the future since improvements are continuously discussed, at pulse meetings as well as at dedicated improvement meetings.

Even though the operators still care for the machines (“Each machine is unique”, as Operator/shift manager A at Omega says), the machines are no longer mysteries in themselves, but rather have become parts of a chain of production and the operators are concerned with giving feedback on details in this chain, not because they particularly care about the machines themselves, but because they enact care for production at large.

One interesting aspect is that the changed locus of the matter of concern leads to not all operators being able/enabled to become fully entangled in the described work practices. For instance, operators observe themselves that, compared to how the workforce was recruited and managed before, there is no longer place for people that are deemed not able to make a meaningful contribution to improving operations or not able to take such a responsibility. This to compare to previous practices of recruiting from the local community also people that were deemed in need of assistance or able to carry out simpler jobs. The shifting locus of the enacted matter of concern has thus consequences for which people are included in producing it, and the entanglement could be characterized as somewhat closed. This could be argued to be, to some extent, a consequence of the lean processes promoting efficiency and therefore leading to concern being produced in a specific ideological way.

The More-thoroughly-digital-factory

A More-thoroughly-digital-factory is one in which machines and systems directly communicate and physically interact with each other thus eliminating work practices today necessary for making different technologies communicate (systems, machines, paper artefacts) and for handling the material during production.

> "We have a system now where we get the drawings but we must generate our order, the work order, first in order to get the drawings to appear on the screen. It takes time because you must open a programme, click on one drawing at a time. But if [the system is improved] then you have the drawings and you can "schutt" [indicates that it will go quicker]." (Operator A1, Omega)

Operator/Shift manager A (Omega) agrees: "I don't want to deal with files, paper, perforator, and fill in forms and stuff... [….] my dream is that all papers disappear".

Machines are imagined to be able to take care of themselves to a larger extent, as for instance the Product Manager's vision (Omega) of "Reduced staffing of machines", also called "Staff-less production", indicate: the production unit should aim at fewer operators that monitor more instead of working with the machine to the extent that they do now.

A More-thoroughly-digital-factory seems thus to be constructed as one in which machines are even to a larger extent matter of fact, as they can take care of themselves. Production systems would seem to become enacted as matter of concern as sociomaterial practices become more focused on programming and monitoring than serving, or interacting with, a machine – something that echoes current descriptions of future smart factories, "dark factories", Industrie 4.0, etc (McKinsey, 2016). At the More-thoroughly-digital-factory we also see a division of labour between production technicians and support technicians, in which the former are providing the machines with the proper programming, and the latter make sure production is running well. At Omega, a Lean approach is imagined to characterize how production is managed also in the future, implying different kinds of meetings and tools (digital now) to gather around the production process and emerging issues in it. The production system is thus enacted as matter of concern, even though operators are now more closely entangled with digital technology rather than machines. But the strength of such enactment is not to be taken for granted. When it comes for instance to practices involving support technicians, given their focus on monitoring, the entire production system may easily become a matter of fact, if it stops gathering attention, care, interest, together with people and artefacts to make sense of it – thus eventually becoming just a matter of fact to be surveilled.

Imagined future practices, both those involving production technicians and those involving support technicians, enlarge the temporality of the enacted matter of concern to include both the present and the future since traditional divisions of labour are dissolved, for instance between operating the machines and maintaining the machines. Hence, attention, efforts, affects, tools are mobilized and used both for taking care of production, running and directly solving issues, and for taking care of production in the longer term by improving it. Also the fusion of IT and OT could lead to a wider range of temporal orientation, as the systems have different temporal timeframes. Whereas OT:s are in operation in the present, supporting machines as they are running; IT:s reaches into the past and the future by being repositories of information.

In a more distant future, the question of whether machines and digital systems will be deemed more reliable when it comes to managing for improvement and to making decisions than workers may be relevant to pose, as already now such ideas are being presented in different settings (Autor, Levy, & Murnane, 2003). This would mean that, for instance, lean principles and routines could be inscribed in digital system and the technology would then enact the production system as a matter of concern, with a more peripheral presence of workers. Hence, although the production system may still be enacted as matter of concern, the entanglement between workers and digital systems could change, relegating workers to a more marginal role.

The sociomaterial entanglement in the More thoroughly digital-factory is to a larger extent also de-localized as technology enables programming and monitoring at distance. Not only the workers would no longer need to be close to the machines, but also artefacts that now need to follow the material during the production process, as paper documents, could be eliminated, thus spatially de-coupling the production process from the information and knowledge needed for steering it. Operator/Shift manager B (Omega) for instance says that a lot of time would be saved if the operators wouldn't have to print the orders on paper; papers that need to follow the steel physically through the operations in the production unit.

Table 4 summarizes how the loci of concern and the entanglements in the three types of factories shift.

/Insert Table 4: Shifting loci/entanglements in the three types of factories here/

Conclusion

Following the call for studies in the posthuman tradition to take an interest in how the social and the material may be understood as being part of the same ontology, the purpose of this paper is to theorize how different sociomaterial entanglements affect work practices.

Through a comparative case study of two steel companies we were been able to construct case descriptions of the Non-digital-and-non-lean-factory and the Somewhat-digital-and-lean-factory and of an imagined future factory: the Most-thoroughly-digital-factory. Using Latour's (2004) notions of matter of fact and matters of concern we were able to explore sociomaterial entanglements and how they enact matters of fact and of concern in relation to changing entanglements of technology and production management practices.

The paper thus tells the tale of how the technologies, in combination with existing production management ideologies makes possible shifts in work practices related to production of steel. The case studies show that as the production became more digitalized, and as the production management practices of lean were implemented, the work practices enact different spheres of concern.

The relation between machine and worker and between the worker and other social relations, seems, in other words, to be complex and, shifts depending on the factory. Experienced workers may learn where they can avoid slavishly following the scripts implied by the machine and use their initiative, and how they can work without contravening 'local' organisational norms about 'the way things are done' with regard the use of machines (Berner, 2008). Newly enrolled workers must learn which rules can be ignored to get the job done and which are sacrosanct - they must learn also who can ignore which rules (Darrah, 1994, 1996).

Using machines, even in 'unqualified' assembly work, often requires considerable learning in terms of the fine handling of tools and components. The requirement for speed, in particular, can make apparently simple tasks seem impossible at first. Working competently with machines can also be, perhaps because of this, a rewarding experience in its own right. Working with machines can produce very different emotional responses and perceptions (McCarthy & Wright, 2004). Pleasure can be had from 'performing' competence and displaying that for others – for example, performing the operation a machine quickly and safely or by deftly pushing the machine to its limits (Berner, 2008). Self-respect comes to those who can respond quickly and coolly to the machines' needs (Berner, 2008). Workers, 'perform' their identities through the use of particular technologies (Wajcman, 2006). Though machines can also be a source of anxiety. Machines can 'make a fuss' and demand an unflustered response (Bremer, 2008) and so always contain the possibility of revealing your incompetence to fellow workers.

We suggest that machines that work reliably, don't threaten to breakdown or 'make a fuss' can be regarded as a 'matter of fact'. Machines that do not operate reliably, require ongoing attention, might be regarded as a 'matter of concern'. This paper then considers the relationship between digitalisation and machines that, having been 'matters of concern' become 'matters of fact'.

What does this mean for the way in which work is conducted then? First, it may be argued that there are dangers for workers whose identity is tied to engaging with troublesome machines that have become reliable matters of fact. Sennett (1998), for example, compares the work of pre-mechanisation bakeries, in which the judgement of 'the baker' is still key to a good product, with the corrosive experience of working in an automated bakery, where the only contact with the bread is to throw it out when the processing machinery has burned it. (Sennett, 1998) On the other hand, the workers may still be able to keep their identity by mastering the troublesome, regardless if this occurs in machines or in systems. What is required is that the operators embrace the shift from machines being the matter of concern to the production system as a whole being a matter of concern.

Second, depending on how the entanglement develops, such an issue may not appear. In the Somewhat-digital and lean factory, engaging with the troublesome is still part of operator's identity construction, but the troublesome is no longer only the single machine, but the production system at large. Whether such shift, that also means a more collective rather than individual identity construction, is challenging or smooth may depend on how the process develops.

To be noted is also that the concept "matter of concern" should not be interpreted as signalling "concern" in broad sense. In the case of the Somewhat-digital and lean factory "concern" is often enacted through Lean methods and workers' attention is directed to specific questions in search of increased efficiency. Hence, we are not claiming that the

Somewhat-digital and lean factory is better than then Non-digital/non-Lean factory; and from an emancipatory point of view there may be even issues related to the changing loci of concern: as we have mentioned in our analysis work practices are more closed and excluding certain people as concern needs to be performed along the lines of increased efficiency.

The contribution of this paper lies in its' unveiling of *how* the spheres of concern differ in terms of temporal orientation and localization, and depending on the entanglement of technologies and production management models. Such a contribution adds to our understanding of the relation between technology and work, recognizing both technological aspects and work practices, and empirically studying their entanglement.

Our way of conceptualizing configurations of concern could also enrich current discussions about, and efforts to, achieve smart work places, for example smart factories, by providing the language to analyse the interaction between technology and production system models and their relation to work practices – the question of whether there will be operators involved in enactments of matters of concern in a more fully digitized future is a compelling one.

Finally, not only have we produced case descriptions of two types of factories building on two empirical cases. We have also constructed a narrative about the future, based on how it is being talked about in the present since we believe that it is not enough to analyse the shifting of the past to the present. Doing so we are also co-creators of the future organisational mode of our narration. We however deem this necessary to start discussing what such a future may entail.

References

Autor, D. H., Levy, F., & Murnane, R. J. (2003). The Skill Content of Recent Technological Change: An Empirical Exploration. *The Quarterly Journal of Economics*, 1279-1333.

Balogun, J., Jacobs, C., Jarzabkowski, P., Mantere, S., & Vaara, E. (2014). Placing Strategy Discourse in Context: Sociomateriality, Sensemaking, and Power. *Journal of Management Studies, 51*(2), 175-201.

Barad, K. (2003). Posthumanist Performativity: Toward an Understanding of How Matter Comes to Matter. *Signs: Journal of Women in Culture and Society, 28*(3), 801-831.

Barley, S. R., & Kunda, G. (2001). Bringing Work Back In. *Organization Science, 12*(1), 76-95.

Berner, J. (2008). Working knowledge as performance: On the practice understanding of machines. *Work, Employment and Society, 22*(2), 319-336.

Bijker, W. E., Hughes, T. P., & Pinch, T. J. (Eds.). (1987). *The Social Construction of Technological Systems. New directions in the Sociology and History of Techology*. Camridge & London: MIT Press.

Carlile, P., Nicolini, D., Langley, A., & Tsoukas, H. (2013). *How matter matters: Objects, artifacts, and materiality in organization studies*. Oxford: OUP.

Corvellec, H., & Hultman, J. (2012). From "less landfilling" to "wasting less": Societal narratives, socio-materiality, and organizations. *Journal of Organizational Change Management, 25*(2), 297-314. doi:10.1108/09534811211213964

Darrah, C. N. (1994). Skill Requirements at Work. Rhetoric versus Reality. *Work and Occupations, 21*(1), 68–84.

Darrah, C. N. (1996). *Learning and Work. An Exploration in Industrial Ethnography*. New York and London: Garland Publishing.

Doolin, B., & McLeod, L. (2012). Sociomateriality and boundary objects in information systems development. *European Journal of Information Systems, 21*, 570-586. doi:10.1057/ejis.2012.20

Gherardhi, S. (2015). How the Turn to Practice may contribute to Working Life Studies. *Nordic journal of working life studies, 5*(3a), 13-25. doi:10.19154/njwls.v5i3a.4831

Gherardhi, S. (2017). Sociomateriality in posthuman practice theory. In S. Hui, E. Shove, & T. R. Schatzki (Eds.), *The Nexus of Practies. Connections, Constellations, and Practitioners* (pp. 38-51): Routledge.

Gherardhi, S., & Rodeschini, G. (2016). Caring as a collective knowledgeable doing: About concern and being concerned. *Management Learning, 47*(3), 266-284. doi:10.1177/1350507615610030

Gold, R. L. (1958). Roles in Sociological Field Observations. *Social Forces, 36*(3), 217-223.

Gray, P. H. (2001). The impact of knowledge repositories on power and control in the workplace. *Information Technology & People, 14*(4), 368-384.

Grint, K., & Woolgar, S. (1997). *The Machine at Work*. Cambridge: Polity.

Grugulis, I., & Vincent, S. (2009). Whose skill is it anyway? Soft skills and polarization. *Work, Employment and Society, 23*(4), 597-615.

Jarzabkowski, P., & Pinch, T. J. (2013). Sociomateriality is 'the New Black': accomplishing repurposing, reinscripting and repairing in context *M@n@gement, 16*(5), 238. doi:10.3917/mana.165.0579

Kallinikos, J., Ekbia, H., & Nardi, B. (2015). Regimes of information and the paradox of embeddedness. *The Information Society, 31*(2), 101-105.

Kelly, M. (1990). New process technology, job design and work organisation: A contingency model. . *American Sociological Review, 55*, 191-208.

Latour, B. (2004). Why Has Critique Run out of Steam? From Matters of Fact to Matters of Concern. *Critical Inquiry, 30*(2), 225-248.

Leonardi, P., & Rodregez-Lluesma, C. (2012). Sociomateriality as a lens for design: imbrication and the constitution of technology and organization. *Scandinavian Journal of Information Systems, 24*(2), 79-88.

Leonardi, P. M. (2013). Theoretic foundations for the study of sociomateriality. Information and Organisation. *23*(2), 59-46.

Mackenzie, D., & Wajcman, J. (1985). *The Social Shaping of Technology*. Milton Keynes: Open University Press.

McCarthy, J., & Wright, P. (2004). *Technology as Experience*. Cambridge, Mass. : MIT Press.

McKinsey, D. (2016). Industry 4.0 after the initial hype. Where manufacturers are finding value and how they can best capture it.

Mutch, A. (2013). Sociomateriality: Taking a wrong turn? . *Information and Organization, 23*, 28-40.

Orlikowski, W. J. (2000). Using technology and constituting structures. *Organization Science, 11*(4), 404–428.

Orlikowski, W. J. (2007). Sociomaterial practices: Exploring technology at work. *Organization Studies, 28*(9), 1435-1448.

Orlikowski, W. J. (2010). The sociomateriality of organisational life: Considering technology in management research *Cambridge Journal of Economics, 34*, 125-141.

Orlikowski, W. J., & Scott, S. V. (2008). 10 Sociomateriality: Challenging the Separation of Technology, Work and Organization. *The Academy of Management Annals, 2*(1), 433-474. doi:10.1080/19416520802211644

Sennett, R. (1998). *The corrosion of character: the personal consequences of work in the new capitalism*. New York: W.W. Norton and Company.

Spell, C. (2001). Organisational technologies and human resource management. . *Human Relations, 54*(2), 193-213.

Trist, E. (1981). *The evolution of socio-technical systems. A conceptual and an action research program*. Retrieved from Ontario Minister of Labour:

Vásquez, C., Bencherki, N., Coreen, F., & Sergi, V. (2017). From ‘matters of concern’ to ‘matters of authority’: Studying the performativity of strategy from a communicative constitution of organization (CCO) approach. *Long Range Planning*, 1-19. doi:10.1016/j.lrp.2017.01.001

Wajcman, J. (2006). New connections: social studies of science and technology and studies of work. *Work, Employment and Society, 20*(4), 773-786.

Woodward, J. (1958/2011). *Management and technology*. Indiana uiversity: H.M.Stationary Off.

Woolgar, S. (1991). Configuring the user: the case of usability trials. In J. Law (Ed.), *A sociology of monsters : essays on power, technology and domination* (pp. 58-99). London: Routledge.

Zammuto, R. F., Griffith, T. L., Majchrzak, A., Dougherty, D. J., & Faraj, S. (2007). Information Technology and the Changing Fabric of Organization. *Organization Science, 18*(5), 749-762. doi:10.1287/orsc.1070.0307

Tables

Table 1: Interviewees, gender, age and duration of interviews at Alfa

Interviewees	**F(emale)/M(ale)**	**Age**	**Time (h,min)**
Operator manager A	M	60	0:51
Operator manager B	M	55	0:56
Operator manager C	M	53	0:57

Operator manager D	M	48	0:40
Operator manager E/ Support Technician	M	49	0:41
Operator A1	M	53	0:49
Operator A2	M	49	0:56
Operator A3	F	30	0:44
Operator B1	F	35	0:35
Operator B2	M	42	1:01
Operator C1	F	31	0:44
Operator C2/metal union rep	M	53	0:59
Operator E1	M	30	0:35
Operator F1	M	54	0:34
Operator F2	M	26	0:45
Operator F3	M	27	0:40
Operator G1	M	59	0:46
Production department manager	M	40	1:12
Logistics department manager	F	40	0:55
HR manager	M	50	0:52
CEO	M	50	0:50

Table 2: Interviewees, gender, age and duration of interviews at the Omega

Interviewees	**F(emale)/M(ale)**	**Age**	**Time (h,min)**

Operator/shift manager A	M	28	0:53
Operator/shift manager B	M	38	0:53
Operator/shift manager C	M	53	0:28
Operator A1	M	50	0:46
Operator A2	F	55?	0:36
Operator A3	M	50	0:24
Operator A4	F	45?	0:29
Operator B1	M	34	0:52
Operator B2	M	37	0:39
Operator C1	F	31	0:20
Support technician 1	M	30?	1:18
Support technician 2	M	30?	1:14
Production technician	M	30	1:14
Production technology manager	M	30?	1:16
Production unit manager	M	40?	0:55 + 0:53
Site manager	M	45?	0:46
Technology manager	M	45?	0:45
Product manager	M	44	1:12
HR/BR-officer	F	40?	0:55
IT Site Operations Manager	M	50?	0:52
Health and safety union representative	M	60?	0:55

Table 4: Shifting loci of entanglements in the three types of factories

Shifting loci of entanglements	**The Non-digital/non-lean-factory**	**The Somewhat digital and lean-factory**	**The More thoroughly digital-factory**
Spheres of concern	Matter of fact: the production system Matter of concern: the machine	Matter of fact: the machines Matter of concern: the production system	Matter of fact: the machines Matter of concern: the production system?
Temporal orientation	The present	The future	The present and/or the future?
Spatial location	Localized	Partly de-localized	De-localized
Entanglement	Individual operators with single machines	Collectives of operators, machines with production processes	Individual operators (support technicians) with digital technology

	The Non-digital-and-non-lean factory	The Somewhat-digital-and-lean-factory	The More-thoroughly-digital-factory
Set-up of operations	Lines with one or several machines.	In cells. Each cell has a robot and 2-3 machines.	In cells. Each cell has robots and machines. Robots moves material between cells.
Age of machines	Some very old.	Mostly new.	Mostly new.
Qualifications required of staff	Experience; no formal training required.	CNC training and certificate required.	Formal training and certificate required.
Role of shop floor staff	Mainly manual labour (moving material between machines); Quality control	Mainly monitoring; Maintenance; Quality control.	Mainly Program development: Testing.
Degree of shop floor staff autonomy	Operators decide to some extent the sequence of orders.	Large within each shift.	Large. Staff may also work elsewhere.
Use of ICT:s and OT	Minimal: Operators have access to stationary computers; Blue-collar workers do not have a company e-mail adress. A few IT-systems used in daily work.	Moderate: Operators run the robots from stationary computers; Each member of staff has a company e-mail address; The only blue-collar-worker equipped with a mobile phone is the Shift manager; Several IT-systems used in daily work by all members of staff.	Extensive: Shop floor staff are equipped with mobile digital devices through which they can access, monitor and control robots.
Use of paper	Extensive: work routines, orders printed on paper.	Moderate: work routines, orders are sometimes printed but also available digitally.	Minimal (all information available digitally)
Characteristics of operators' work	Fairly physically demanding, monotonous and sometimes dangerous.	Social, creative, problem-solving. Sometimes monotonous.	(Operators have been fully replaced by robots.)
Organisation	Groups of 20-40 operators with a Foreman. Each group organised in units with a Production Unit Manager.	A group of 20 operators working in four shifts.	Specialists of support technicians working in self-organized teams.

Responsibility of management	Production Unit Managers: staff responsibility for the units, production flows . Foreman: overall production flows, spare parts.	Operators who are also Shift managers: responsible for the work during their shift. Production Unit Manager: staff responsibility for the whole group. Site manager: responsibility for the production at one site Product manager: responsibility for the whole production at the factory	Team-leader: responsible for the work of the team Site manager: responsibility for the staff at the site Product manager: responsibility for the whole production at the factory
Informal meetings	Daily meetings when one shift hands over to the next one.	Daily meetings when one shift hands over to the next one.	Daily team meetings, also virtual participation.
Formal meetings	* Daily follow-up meetings (Foremen) * Yearly information meetings (Operators and higher management).	* Daily pulse meetings (operators within the morning shift with the Support technicians, the Production technician and the Production Unit Manager) * Daily pulse meetings (Production Unit Managers with Site manager) * Daily pulse meetings (Site managers with Product manager) * Weekly improvement meetings (Operators, Support Technicians, Production Technicians).	* Daily pulse meetings where staff also participate virtually (Support technicians with the Site manager). * Weekly improvement meetings where staff also participate virtually * Project meetings where different members of staff participate depending on the project

Table 3: The three factory-modes