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Using STSD for understanding the implementation of automation in organisations

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Abstract:

Workplace automation is a highly studied process. In contrast, the implementation phase, critical for innovation success, where conflicts and misalignments between new technology and various organisational levels and phenomena arise, is less described. In this study, we have followed the introduction of automated guided vehicles in a warehouse/distribution centre aimed at increasing efficiency of operations and thus productivity. Building on socio-technical systems design and the job-demands-resources-model, and theories on technology implementation related to the organisations' ability to handle interferences explained in the language of misalignments and alignments, the study describes using qualitative methodology how system-internal variation becomes "enemy" of the AGV introduction; the automation itself cannot succeed without rebalancing the control capacity of the tasks it is augmenting or replacing. The paper also proposes that existing theories used to explain the success or failure of technology implementation are inadequate as they don't take in the complexity of the complete context but address single level phenomena independently of other relevant levels and phenomena.

Keywords: automation of work, warehouse operations, technology implementation, misalignment, control capacity

Introduction

"*Innovations not only adapt to existing organisational and industrial arrangements, but they also transform the structure and practice of these environments*" (Van de Ven 1986). In other words, the interaction between technology and the various organisational systems must work to succeed with the implementation of new technologies. Implementation success is here understood as the extent to which the technology is used or functions as intended, rather than mere physical integration. In technology-driven organisational change, technocrats have traditionally studied technology's contribution to organisational innovation omitting the social system, while social scientists have studied the social system and to a large extent excluded the technology (Orlikowski 1996). There are numerous studies of organisational change describing the change process as either incremental or radical, as well as more or less static stage theories of technology implementation (Cooper and Zmud 1990). The period during which the technology is introduced into the environment of users, i.e. the initial implementation stage and its parallel and mutual effects on technological functioning, the organisation of work and the performance of those working there, has not been investigated to the same extent. The initial assertion of this study is that the handling of the implementation phase is often decisive for whether the organisation succeeds with the introduction of new technology. This phase should be considered as a dynamic process of mutual adaptation between the technology and its environment, and not simply as the predictable realisation of a pre-defined plan (Leonard 2011).

New technology rarely fits perfectly into the environment of its users. The process of adaptation is necessary to attain a good outcome. Hence, adopting a *process-oriented* rather than a technical-structural approach may be a fruitful way to understand the socio-technical interaction in the initial implementation phase in a more applied than prescribed way. Suppliers and developers of technological solutions may reduce the uncertainty inherent in the innovation process through prototyping and technical iterations. The complexity will, however, increase when the technology is introduced to the real environment of the organisation and its operations. Applying a process perspective on the mutual adaption of technologies and social systems and their inherent structural factors may capture some of this complexity; i.e. the various characteristics of socio-technical implementation and their effects on organisation, work and working relations.

The scope of this paper is to investigate how process-oriented factors in the implementation of automation affect organisational quality; i.e. the ability to continuously cope with challenges inherent in these structures. This is done within a social-technical systems design (STSD) perspective strengthened by an organisational-psychological approach to understanding control and performance structures. As such it aims to analyse the handling of the implementation process, considering control capacity in order to identify and understand the structural parameters that form a technology-driven organisational change. This paper is based on a case study of implementing automated guided vehicles (AGVs) in a warehouse of a Norwegian retailer in the fast-moving consumer goods segment. This is a case of digitalisation and automation that potentially disturbs the quality of organisation, work, and working relations in terms of control capacity (e.g. De Sitter et al. (1997)).

In the theory section, we present perspectives on digitalisation and automation on implementation of technology, as well as STSD and the job demands-resources model (JDMR). The following sections will present the case and methods used, findings, discussion, and conclusion/implications.

Theoretical perspectives

The field of literature pertaining to hardware, software, organisation, and technological change is immense and emergent at the same time. The classic critique that engineers pay too little attention to the organisation and human factors, while social scientists treat the technology as a black box (Orlikowski 2000), is still partly valid and shows the difficulties that disciplines have in radically broadening their scope. The socio-technical approach to understanding the interplay between the organisation and those working there that stems from research in British coal mines in the 1950s (Trist and Bamforth 1951) and industrial relations, needs a recalibration for a better fit with the digital paradigm. Finally, there is a need to be clear on the implications of digitalisation and automation as specific and technology-based organisational changes, which can be both technologically and organisationally driven.

Although working life hopefully has come a long way since the 1950s, the digital paradigm shift impacts and will impact tasks, performance, and employees even more so in the decades to come. While it is necessary to acknowledge and build on previous research and established theoretical perspectives, there is a need to integrate social and technical aspects more fully than so far has been achieved by for example actor-network theory and the traditional socio-technical framework. In order to discern structural elements decisive for a successful technology implementation, we need studies that take into account the completeness of the context and the research, rather than merely identifying and juxtaposing or aligning various elements without analysing the degree and nature of their interrelationships. Trying to address these shortcomings, the analyses in this case study builds on theoretical perspectives on the automation of work as a specific type of digitalisation, the implementation process of new technology, and socio-technical systems design.

Automation of work

Automation of work is a clear political agenda in many countries. Thus, a much-debated topic is how automation and robotisation will affect work. The general perception among academics used to be that only manual and routinised work tasks were susceptible to automation and digitalisation. However, recent technological progress in the fields of artificial intelligence, robotics, computing power and sensor technology have made machines capable of handling more complex and non-routinised tasks (McAfee and Brynjolfsson 2017). Some researchers, such as Frey and Osborne (2017), have warned that a large number of jobs could become fully automated in the coming decades (logistics is one of the occupational genres which is highlighted as “highly susceptible” in their study, and a part of the first wave of automation). Other researchers, using a task-based approach, find this scenario where automation is causing mass unemployment to be very unlikely, at least in the foreseeable future (Arntz et al. 2016, Bessen 2016, Manyika 2017). The main argument of these researchers is that jobs usually consists of many tasks, and that technological solutions only will handle a portion of the tasks, not entire jobs.

In this interpretation of technological progress, the change alters the allocation of tasks to humans rather than jobs themselves. This is similar to the historical effect of computerisation of work which is a more pronounced in a polarisation of tasks rather than a direct decline in jobs (Autor et al. 2015). This is caused by a recombination of technical and non-routine tasks, where employees have comparative advantages vis-à-vis machines in areas such as flexibility, interpersonal interaction, adaptability, and problem solving (Autor et al. 2015). The increase in human-robot interaction will create more complex jobs, but may result in more creative input from operators, more responsibility and decentralised decision making, as well as improving the quality of work Moniz and Krings (2016). More integration with technology could free up time for human workers and give them opportunities to concentrate on activities that machines have yet to master. Hence, work might become more complex, harder to organise and require more time on coaching and reskilling (Manyika 2017).

Automation in the form of Automated guided vehicles (AGVs) automates internal flow of materials, typical routinised work in manufacture- and distribution-systems (Oleari et al. 2014). Technological progress and declining prices have made them more common in recent years. In combination with a management system (e.g. warehouse management system), technology can control the movement of goods through dispatching of AGVs to move materials internally (the movements often referred to as "missions"). This automates *parts* of the production, but leaves core functions such as production, picking, and packing as manual tasks.

Implementation of new technology in organisations

The successful process of implementing new technology in organisations is really an integration of several social and technological processes that are more or less complex. Existing theories on implementation of new technology tend towards a narrow understanding of change and the organisation, and they tend to not problematise use. This is problematic because they then fail to address the interaction between technical and social structuring factors (Orlikowski 1996). Introducing new technology is a specific type of organisational change, and in the situated change perspective the integration of technology and organisation is constituted as enacted through the practices of organisational actors. This implies a certain autonomy for the part of the shop floor employees, the opportunity to make sense of the new technology in relation to own tasks, and situated learning – learning through doing (Zuboff 1988). To avoid misalignments, there are several technological and organisational factors that need to be handled adequately as part of the implementation process, such as technology design and technical requirements, possibility for training and learning while doing, and the technology's perceived usefulness related to one's tasks, work performance and performance output.

Misalignments due to technical requirements occurs when the specifications of the implemented technology do not fit the organisation and its environment (Leonard 2011). Although developers strive to create optimal technological solutions in the design process and make models and simulations (i.e. models of the layout or a specific production line), it is often difficult to simulate the user environment completely. Time pressure and limited testing could push technological solutions out in the organisation before the solutions are ready for use. However, a "perfect match" between the technology and the operations/production processes may not be desirable. The key is during the implementation process to establish and handle balance, or "beneficial misalignment", so that a mutual adaptation and integration between technology and operations happens in order to obtain the desired increase in quality and/or efficiency.

When a well-functioning application is introduced without giving the employees the training they need, this is a misalignment between technology and how technology is delivered to users. In such scenarios, there is not necessarily something wrong with the technology per se, but with the *delivery* system. This misalignment could lead to rejection, underuse or even sabotage of the technology/innovation from the users. Or less severe, the technology itself may affect individual performance due to poor task technology-fit (Goodhue and Thompson 1995). Two dimensions of an organisation's performance criteria interact with technology to produce misalignments. The first dimension is the users' perceived *significance* of technology's contribution to task performance, and the second dimension is about the nature of that. The technology is considered as highly significant if it impacts some of the core activities by which a person's or operation's success is judged. The second dimension concerns the expected net *impact* on the activity being altered, which can be positive or negative. The expected impact could be with regard to the profitability or efficiency of the altered activity, but also include considerations which has nothing to do with financial measures. A technology could "cost" in terms of lost time or unpleasant routine, and simultaneously "benefit" in terms of enhanced quality of the output, increased skill, or the like. Technologies have both positive and negative effects. Hence, the impact should not be considered as an absolute, but rather as a ratio of positive and negative effects.

These misalignments imply the need for adaptive response, with response taking the form of adaptive cycles where the process is one of circling back to revisit a decision point. For instance, an adaptation cycle could be to reopen issues related to the technical design, which the developers assumed were resolved in the first place, redesign the delivery system, or re-examine the goals implied by the current performance criteria. The major proposition from this framework is that change in both technology and user environment is more beneficial than holding one constant and changing the other.

The relevance of the STSD-paradigm for the study of implementation processes

Digitalisation and automation represent a giant leap from the mechanistic work systems of the 1960's, and a shift of attention from work design to organisation design, with a focus on motivation, productivity and industrial democracy (De Sitter et al. 1997). Newer research on sociotechnical systems design (STSD) has leaned more and more towards design theory as in organisation redesign, a retake often referred to as the Dutch tradition, built through the interactions of researchers, practitioners, consultants and organisation managers in close interaction with the Scandinavian tradition (Thorsrud and Emery 1969). There is, however, a significant difference between these two; the Scandinavian tradition embraces to a greater extent participants' understanding and involvement, if not over that of external experts, at least as equal. This was also the norm in this study; the employees in the warehouse were considered experts in their own setting and their own experiences; as the change was self-initiated the warehouse on the managerial/organisational level had strong ownership of the implementation of the AGVs. The indirect (through employee representatives) and direct involvement of employees in the adaptation process is seen as a key enabler for a successful change (Andersen 2015).

STSD within the intersection of these related traditions emphasises process-oriented rather than structure-oriented implementation processes, characterised by democratic dialogues and local theory, which presuppose involvement and responsibility of both managers and employees (Raelin 2012). The field of organisation science is highly cross-disciplinary, which is at the same time a strength and a weakness. It is a strength, because organisation science in general, and digitalisation and automation in particular, are complex fields and thus need complex and multi-perspective approaches, and a weakness because it may lead to shopping and emptying of conceptual content from different phenomena with scientific roots in one discipline and not another: concepts lose their meaning, and thus the research loses its validity. Examples are (human) autonomy, motivation and technology adoption (Beaudry and Pinsonneault 2005). As this study was one of digitalisation and automation in a Norwegian retailer warehouse, there is a need to choose theoretical perspectives that fit this organisational setting. The complexity of the field opens up a careful selection of perspectives as well as elements of those perspectives if the argumentation of fit is clear and concise. In this case three criteria were set to ensure a valid selection: 1) Fit to the setting of the case study; 2) Well-known and previously recognised; 3) Compliance with some of the characteristics of the STSD framework.

A main argument of modern STSD is that technology, work, and employees should not be conceived as neither separate systems nor subsystems that need to be adapted to one another in order to obtain an optimal fit. These components constitute together the larger organisational work system, and need to be studied in terms of how they are connected, interact and produce effects: i.e. their functional and interactive relations (De Sitter et al. 1997). The Dutch tradition in this conceptualisation of integral design relies heavily on expert design of structural parameters in production structures ("the grouping and coupling of performance functions") and in control structures ("the allocation and coupling of control functions") (De Sitter et al. 1997). This fits well with the current study. The challenge is to identify the structural and performance parameters for analysis.

The job-demands-resources-model (JDRM) (Bakker and Demerouti 2007) stems from the demand-control-support model (Karesek and Theorell 1990). The JDRM is not a model of coping per se, but it considers the stressors and enablers at work that influence employees' well-being/degree of motivation and work stress, and thus work performance (Bakker et al. 2010). Job demands are the physical, psychological, social, or organisational aspects of the job, that require sustained physical and/or psychological effort or skills. Therefore, they are associated with certain physiological and/or psychological costs. Job resources are the physical, psychological, social, or organisational aspects of the job, that are either/and functional in achieving work goals; reduce job demands and the associated physiological and psychological cost; stimulate personal growth, learning, and development. Examples are career opportunities, supervisor coaching, role-clarity, and autonomy. In this way, the JDRM can provide a framework for performance and control structures in terms of controllability.

Seen in relation to the case of digitalisation and automation at hand, the conceptualisations of integral organisational design and performance- and control structures appear useful. However, single constructs are less able to explain interactional functions. There is therefore necessary to integrate these perspectives and become concrete in a way that enables the analyses to be more than just a conceptual exercise. Connected to the process-oriented approach of technological innovation presented above, that exemplifies many of the technological characteristics as control structures, the job-demand-resources model represents both performance and control structures. Together these perspectives give us an understanding of the quality and thus controllability of organisation, work, and working relations. Quality is described as a function and refers here to the ability to cope with challenges that arise in the performance structures (Bessen 2016), also called control capacity (De Sitter et al. 1997). In the AGV and warehouse context, important structures for both performance and control are the new AGVs, existing and new software, warehouse layout, work planning and work routines, adequate competencies, local theory and the implementation/adaptation process of the new technology in order to achieve goals of increased productivity and efficiency. These parameters constitute important demands and resources within the JDRM: the introduction of part-automation of certain tasks (AGVs) affects both physical and psychological effort. This combination and integration of perspectives enable at the analytical level to lessen the gap between organisational and individual factors and integrate them as part of e more complete theoretical framework rather than as single elements along a continuum. This also and completes the analytical frameworks of both STSD and JDRM.

Method

This paper is based on a case study of a Norwegian retailer in the fast-moving consumer goods segment conducted over a period of four years, from 2014 to 2018. The data collection was carried out by three researchers, where one of the researchers joined the research project in its final phase. Unlike other methodological approaches, a case study does not necessarily follow a standardised research process with rigorous planned phases. On the contrary, the process is rather informal and goes back and forth between research activities and between the empirical world and theory (Dubois and Gadde 2002). Both focus and boundaries often change during the study, as we experienced throughout this research project.

The process of organisational change is subtle and evolutionary, a study requires a design that non-intrusively can capture and later interpret and make sense out of the data (Gioia and Chittipeddi 1991). The interpretation of data and the generalisation into the subjective experience by those who are a part of the organisational change, relies on an explanatory theory that aligns with the organisation and that the researcher understands or “is grounded” in the organisation’s culture (ibid).

Abduction might bolster the theoretical ground of analyses from case studies, as it permits the use of existing theory as a point of departure for reasoning. Abduction is, however, less theory-driven than deduction (Järvensivu and Törnroos 2010). Deduction relies on a strict and preconstructed analytical framework, while the inductive approach, on the other hand, uses a loose framework. There is, however, a closer interplay between theory and the empirical world in abduction. Hence, while the inductive approach is about theory generation from data, abduction concerns explanatory theory development through the study of specific cases in combination with established theory (Hammersley 2005, Dubois and Gadde 2002, Raholm 2010, Thomas 2010). As this was a case study with an explorative research focus and question due to the scarce amount of studies on the topic at hand, abduction was chosen as the methodological approach as it is simultaneously data- and theory-driven. The natural delimitations of the case, presented in “Case description and relevance”, limited the number of uncontrollable variables and increased the strength of validity and reliability of inferences made in this interaction between the factual situation and previously established theoretical perspectives. The inherent characteristics of case study as research design and the explorative nature of the research question demand a certain amount of flexibility in the data collection and analysis processes that is provided by an abductive approach.

The three following principles should influence the choice of the underlying assumptions in abduction: the factual situation should be explained, that it can be validated through further empirical testing, and adhering to Peirce’s principle of the “economy of research” (Fann 1970). Starting from what seems obvious, the researcher should construct explanatory theories, and then through experiences and observations search for the truth. As such, a deeper understanding of epistemologies is attainable from abductive reasoning, emphasising the prevalence of thorough theoretical and empirical knowledge (Hintikka 1998, Niiniluoto 1999, Eriksson and Lindstrom 1997).

Case description and relevance

The warehouse in this study is a combined warehouse and distribution centre of a major food retail chain with a combination of frozen foods, dry goods, and fruits, with a local pick-slot as well as crossdocking of pre-picked pallets from the retailer's central warehouse. This distribution centre serves the middle region of Norway (one out of five). The operations take place between 06:00 a.m. and 22.00 p.m., seven days a week, with an uneven load throughout the week and workday. This retailer has chosen SAP as their enterprise resource planning tool to handle their logistics. The warehouse operations are managed by a Warehouse Management System, which handles dispatching and scheduling of tasks, as well as integration to inbound and outbound logistics.

As part of a long-term development plan related to efficiency improvements and partial automation of the production processes within the company, a business case was prepared. The goal of the business case was to relieve parts of the internal pallet logistics with AGVs. After the business case was approved by the central management, the centre started an internal improvement process that led to the acquisition, implementation, and commissioning of five AGVs.

The purpose of this case study has not been to make a diagnosis or make a systematic evaluation of the introduction process. Rather, our goal was to conduct a descriptive fieldwork in order to describe the process (thick description), so that the lessons learned and knowledge which is created through such a process will be permanent and accessible for researchers, the investigated retailer and for other stakeholders.

This case was chosen for this study based on three main characteristics that were deemed particularly suitable for the research topic and design. First; the delimitation of this isolated warehouse as well as the specific technology as the case of study. This made it possible for the researchers to have more or less a complete overview of the organisation's change project with its adhering organisational structure. Second; the clear scope of the change process, namely automation through the implementation of AGVs. The clear scope made it easier to discern the processes directly tied to this specific type of digitally driven organisational change. Third; the clarity of tasks to be automated was deemed to make the identification of performance and control parameters more accurate, both regarding the interaction between technological and social structuring factors as well as regarding the tasks that were reserved for the shop floor employees. These three features of the case study support the accuracy of an explorative research design and thus the validity of findings. As mentioned, studying factual situations increases the complexity at hand, but the clear delimitations inherent in this case eased research design, data collection and data analyses. It also made it easier to adopt both a process-orientation and a task-based approach to the research topic, which constitute a logic framework for the study of the implementation process relevance for control capacity. In addition, the geographical proximity of the warehouse to the researchers made it feasible to be close to the implementation process over a prolonged period. The delays in the implementation process were not of interest to the research project.

Data collection

The data material is qualitative and based on focused conversations, semi-structured interviews, observations, and field notes (see Table 1). Most of the data was collected through participatory observation and interviews. The researchers took part in the local project group which was established when the “AGV-project” started, and thereby had the opportunity to follow all phases of the project: from planning to the actual implementation. The local project group worked with a broad range of topics, such as product specifications, technical barriers, human-machine interaction, and the involvement of employees. By being part of this group, we attained convenient insights, a deeper understanding of the projects' inner life, and not least good access to informants. This involvement, furthermore, contributed to some degree of trust between the actors and a better understanding of the organisation overall. Moreover, an extensive observation study was carried out. We examined the operations, observed the operators throughout their workday and participated in internal training courses, together with the employees.

Table 1. Data collection summarised

Group Interviews	**Interviewees**
	Management team
	Inbound logistics
	Outbound logistics
	Operators
	Union representatives
No. of project group meetings	10
No. site visits	7
No. of system demonstrations	3
No. of training sessions	2

In addition to observations and the more “informal” deliberations taking place in the meetings, we conducted five group interviews, composed of informants from the most affected parts of the operation: middle management, outbound logistics, inbound logistics, and employee representatives. The interviews were carried out with a semi-structured interview guide as starting point. Each group consisted of two or three informants.

Data analysis

Knowledge generated from qualitative studies is validated through practice. As mentioned earlier, abduction is characterised by a process of going continuous back-and-forth between the case and the theoretical framework, thus the validity of the findings is controlled during the whole research process (Järvensivu and Törnroos 2010).

The analytical approach has been a “classic” two-fold approach to working with ethnographic data. In order to attain a deeper understanding of the factual situation and establishing “fact of fiction” (Van Maanen 1979) the researchers first analysed the data from meetings and observations alone, before all met to discuss their individual interpretations. Thus, establishing a collective narrative as a first order analysis of the case. The first phase of the data analysis was concluded when the researchers deemed that the identification of categories were satisfactorily saturated.

Through discussion, the first-order categories were challenged by revisiting theory, presenting and discussing our findings with the company project group. This again fed into the more formal interviews, allowing us to posit and test our interpretations on those involved and adjust our subjective interpretations. We also had continuous unstructured conversations with these informants on a regular basis, and the information they provided served as an important validation or rejection of the understandings and interpretations that the group of researchers obtained throughout the project. Further, we frequently presented our findings in the local project group meetings and received important feedback in this forum as well. The group's evaluations and responses in many ways helped to validate our final findings.

Findings

The data analysis led to two sets of findings; *first-order findings* presented as the main process elements of the project and *second-order findings* as a result of further analyses of the first-order findings. In addition, the analyses identified the derived impact of these on quality and control capacity; i.e. the relevance of the findings to the perspectives presented in the theory section. These findings will be described in this section; Table 2 presents an overview.

Table 2. Summary of findings in performance parameters, control parameters and control capacity.

First-order findings	*Second-order findings*		*Displayed impact*
Process issues	**Performance parameters**	**Control parameters**	**Quality/control capacity**
Integrating AGVs with existing software and layout/organisation of work	• AGV specifications • Limitations in existing software • Communication between software	• Design • Flexible production systems • Task-technology fit	Dynamic and flexible production that can adapt to short- and long-term internal and external changes in needs
AGVs, work routines, and local theory	• Standardisation of work performance • AGV rigidity • Rigid norms • Competing interpretations	• Flexible AGV-human operations • New and adapted work routines • Automation and digitalisation as a "team effort"	Efficient organisation of work capable of quickly adapting to sudden changes in work orders
AGVs, involvement and competence building	• Dispersion of information • Communication plans • Arenas for knowledge exchange • Coupling of AGVs and operators	• Communication/ democratic dialogues • Negotiations • Insecurity reduction • Autonomous operators	Efficient task performance through shared values, trust and adequate competencies in operators; a change-/development-oriented work climate

First Order Findings

Prior to implementation, the project group spent a lot of time discussing the technical specifications of the AGVs in internal meetings. For instance, the driving speed and lifting capacity of the AGV were hot topics and debated to a great extent. While discussions about technical requirements and specifications are important and necessary before starting the actual implementation, these turned out to be very time consuming. The overall process almost stopped as a direct consequence of the immersive discussions about the technical requirements. The project group's concern about the specifications of the AGVs reduced the amount of attention the management and the rest of the project group paid to other important factors. For instance, the question regarding how the adaptation of AGVs in the organisation should be initiated was only given moderate attention in the meetings. Some traditional challenges that occurred during the implementation stage could perhaps have been pre-empted by discussing some of the other important factors associated with technology introduction.

When the technology and specifications became more concrete, and hence demands to competence as well as job requirements; a decision to create two AGV-operator positions was made. These were early decided to be announced internally and recruited within the existing operators. The rationale was that this secured that the two AGV-operators had the necessary operational experience and insight into local praxis; *and* to secure involvement and buy-in from the employees themselves. The two positions had a high number of applicants and were filled almost a year before the go live. The two operators were especially involved in the project activity as "hands-on" problem solvers for the project group. However, this was without a clear plan for competence building activities. The job content was made up as the project progressed and was a work-in-progress throughout the project period. One could say that the job content grew with the employee's competence and knowledge of AGVs and the project. Early in the implementation, it became evident that the process of integrating the AGVs with existing and new software became a major challenge. This process turned out to be more problematic than anticipated, both before and during the actual implementation. For the AGVs to work as intended the software they are delivered with must be integrated with the warehouse management system. Simply put, these systems must "speak the same language". The investigated retailer and the supplier of the AGVs faced several problems in the process of making the software solutions work together seamlessly. The solution required several changes to the existing workflow of the operations in order to accommodate the complete separation of internal logistics, cross-docking, repacking and picking operations. As a result of these problems, the AGVs quite often stopped during testing and early phases of the implementation. These unfortunate stops were causing dissatisfaction among the employees and contributed to a weakened position of the AGVs, as discussed more comprehensively later in this paper.

Due to similar reasons as the required software changes, some adjustments to the warehouse layout were necessary. The AGVs were given specific carriageways and predefined routes before they were introduced. In a shared working environment with the human operators, the AGVs cause "mixed operations" (Oleari et al. 2014), where man and machine intermingle. This required changes to goods flow, drop-off points, internal storage, and routines. The employees adjusted their working routines, in accordance with the management's instructions, and accepted that the AGVs were given the right of way. However, workers were less satisfied with this changeover, because they feared their own efficiency would decrease, and thereby making less money (bonuses are partly based on the number of "picking missions" they carry out). Hence, this situation led to misalignment between the new technology and the user's performance criteria (some of the employees felt the introduction of AGVs had a negative *impact* on their performance. Several operators expressed their concern that the AGVs would take many of the less demanding work tasks, leaving "dull" and more challenging tasks to human operators. By removing some of the more comfortable and pleasant tasks, some operators feared that their job would become less rewarding and comfortable after the introduction of the AGVs.

Together with the introduction of the AGVs, the warehouse also implemented dynamic allocation of ports to orders. This was done in order to make the warehouse more efficient and balance the uneven utilisation of capacity over the day and between large and small orders. At first, this new system led to somewhat chaotic events due to "bugs" and technical errors from the warehouse management system and that it challenged some of established local routines. These problems were quickly addressed and solved, and after some days the solution was working as intended. The human operators adjusted their work routines slightly by dealing with the new dynamic delivery points. According to some, the new system had made the operations "run more smoothly" and that the cross-docking area had become tidier. Through observation, we witnessed that fewer pallets were "floating around" after the introduction of the dynamic collection points. One of the local managers reflected that the change was that all the employees complied with the same operating procedures because the AGV required a stricter demand for conformance to procedure than human operators.

Besides the AGV-operators, the wider involvement and competence building activities of the rest of the shop floor employees were pushed towards the go live: and apart from information through the traditional channels (company newsletter and general all-hands meetings), little or no training was performed before going live. The creation of updating processes and job/task descriptions were mostly based on "wait and see", rather than a more systematic and proactive approach to competence and the organisation of work and work processes.

Second-order Findings

The concept of quality in STSD refers to control capacity operationalised as various subsystems' or system levels' capacity to handle internal and external interferences/disturbances. Performance and control structures can be paralleled to demands and resources and are represented by system-specific parameters of which the totality represents the system's control capacity. The final step of the data analysis pertained to the identification of these parameters and structures within the three descriptive categories showing critical issues in the implementation process.

The central elements from STSD drawn upon here, and the integration of the JDRM into this framework, provide a manageable theoretical perspective for the analysis of this automation and digitalisation case, as it captures both organisational complexity, is sufficiently flexible as to be adapted to the context at hand, and thus can contribute substantially to understanding the enablers and disablers for successful implementation. Based on this, we have analysed and categorise the data as structural parameters and considering their parallelism to the operationalisation of demands and resources. Characteristics of the implementation process, as well as inherent implications of AGVs and automation, are critical factors in these considerations. The implementation process constitutes the contextual and operational framework for the study.
Through the data analysis process, three main categories important in the implementation process encompassing both performance and control structures/parameters emerged:

- Quality of organisation: The processes of integrating AGVs with existing software and layout/organisation of work (Goal: Workplace innovation)
- Quality of work: The installation of AGVs, work routines and local theory (Goal: More efficient and flexible operations)
- Quality of working relations: AGVs, involvement and competence building during the implementation process (Goal: Automation and digitalisation as integral parts of employees' work performance)

Quality of organisation: Integrating AGVs with existing software and workplace design

The warehouse already operated with a variety of software systems in order to steer the production and workflow on one hand, and to be able to quickly adapt to necessary changes due to either internal or external factors the quickest possible. The functioning of this software was not without flaws, but the workers were used to it and also managed to adapt their use to their work performance rather than the other way around.

With the introduction of AGVs as well as new software, workers to a considerable extent lost this opportunity. The trouble of streamlining software solutions with AGV specifications and in particular to make the various software respond to changes in each other were identified as indicators of low organisational quality in terms of control capacity. These misalignments thus represent threats to the goal of overall workplace innovation. This workplace innovation besides new software and technology represented a shift from (the organisation's point of view) unreliable manual operations as guarantees for dynamic and flexible production that adapted to unforeseen and foreseen changes in demands and other requirements, to predictable and systematic responses to such changes through a reliable system control.

The concentrated focus on the software and technological specifications led to too little attention paid to workplace layout and the organisation of work, and not least the functional integration of layout, work processes and software/technology all together. Thus, the warehouse was still dependent on, although relatively routinised, ad hoc handling of unforeseen events manually by the workers. The failure to recognise workplace layout and the organisation of work as structural parameters alongside technologies that can either increase or increase organisational quality in terms of control capacity was a major flaw in the project groups considerations. Control capacity in this respect is thus constituted by both technical and non-technical parameters, exemplified by a task-technology fit that enables flexible production systems. Already at the organisational level, the importance of individual factors in combination shows the weakness of conceptualising these separately or along a continuum. It also shows how structural parameters on this level may increase or decrease control capacity, with consequences for both quality of work and of working relations.

Quality of work: The installation of AGVs, work routines and local theory

In STSD, local theory is viewed as important as it represents the organisation's history and social context, and is expressed through the attitudes and behavioural patterns of those working there (Zimbardo et al. 1995). AGVs and the various software that connects them with their environment are embedded with their own logic or local theory, with a set of pre-programmed actions and reactions. The new technology challenged the existing status quo, i.e. the local norms, in that it interfered with internalised habits and ways of performing work tasks. In the warehouse, employees had prior to the AGV implementation, enjoyed great autonomy in work performance, and thus there were as many work practices as there were employees. For the AGVs to function optimally there was a need for standardisation of work performance, which by the employees was experienced as a serious interference with local theory: the right to individual work practices. Local theory can be operationalised in tacit or explicit norms of conduct and manifest on every organisational level. Local theory thus guides actions, and if organisational change measures are seen as introducing conflicting norms, resistance against change may arise (Mikkelsen and Saksvik 1999, Jian 2007). Especially the fact that the AGVs always had priority created negative reactions. Concerns were their slow speed and nature of tasks. Sometimes norms must be changed in order to fit the new organisational reality, thus the importance of early involvement and sometimes negotiations in organisational change processes; "*knowledge is created through conversation and by sharing of information, a process that can only occur in an environment where the value system is based on trust and integrity, not blind obedience*" (Weymes 2002). Taking into account local theory is particularly important, in order to create shared values and relations of trust during organisational change processes (Gill 2002), as organisational change more often than not fosters insecurity on different levels for employees; for example with regard to the job itself, with regard to competence and/or with regard to work performance. This was not sufficiently done, and the various groupings of employees then constructed their own problem perceptions and explanations of these, rather than conducting a more targeted approach to be sure to get everyone on board. The silence from the managers also created insecurity and prepared the ground for a number of alternative interpretations of the meaning behind the AGV implementation. Lack of negotiations and direct involvement of the employees in general were a weakness in this case.

Paralleling the interference of a new logic to existing local theory with the concept of control capacity, or the influence of performance and control structures on the quality of organisation, work and working relations, it seems clear that the AGVs seemingly contributed to higher demands for employees' work performance. At the same time, they perceived the standardisation of work routines as a decrease of control structures. There is little doubt that employees need to work differently than previously but found it difficult to adopt. A more process-oriented implementation, with a greater focus on involvement and competence building, might have increased the control capacity of organisation, work and working relations. As control capacity is used as a parameter of quality, the existing local theory seemed too little motivated for change, rather than being both robust and flexible at the same time.

Quality of working relations: AGVs, involvement and competence building

The introduction of AGVs, and by extension the initiation of the “AGV-project” with project organisation, mandate and involvement of employees and other resources, had from the initial business case design obvious implications for the working relations. The business case for the initiation of the project, which was known in the organisation, was built upon a cost-saving measure by reducing the peak demand for labour. In this sense, the job-safety/threat of automation and digitalisation was evident from the beginning.

The company, and the warehouse/site in study, has a long tradition of close industrial relations between union, local and corporate management. While this explains some of the impetus for early involvement of worker representatives, the project group included and involved a wide range of functions throughout the organisation. This included workers from all functions considered directly involved, some by function, and others through role. The idea and intention were also that this would allow the project team to tap into some *local theory* in which the AGVs eventually would have to operate. However, the real involvement varied throughout the project: from the early technical stages, where the involvement was more superficial and akin to representation rather than involvement.
The different parameters or structures are functionalities that are critical for 1) dynamic and flexible production (quality of organisation); 2) Efficient organisation of work (quality of work); and 3) Efficient task performance (quality of working relations). Parameters that may challenge the control capacity of the production system on the organisational level are tied to the design of hardware and software, as well as the communication between software. Parameters that may increase control capacity are design of the hardware and the software, degree of built-in flexibility, and task-technology fit. Likewise, parameters identified to challenge the quality of the organisation of work are standardisation of work solely on the premises of the AGV, the degree of rigidity of the AGVs' work performance, rigid local theory and competing interpretations of events. If, however, there is an in-built flexibility in the operator-AGV interaction, renegotiated local theory and work routines that make automation and digitalisation a team effort, the production system will be more capable to adapt to changes in the work order situation. Finally, handling of information and communication, the creation of and access to areas of knowledge exchange, and the conscious coupling of AGVs and operators may, if not well-handled, challenge efficient task performance. Communication in the form of democratic dialogues, open negotiations and a focus on insecurity reduction and autonomous operators, will contribute positively to efficient task performance and a development-oriented work climate.

Although many of these parameters may seem to be of a technical nature, including information and communication plans, and the creation of arenas for knowledge exchange, they all contain elements that either challenge or strengthen the operators' work performance, tied to autonomy, motivation and ability to interact with the new technology. The JDRM is therefore important in order to make this point visible, as technology never operates in a vacuum and that there is no production system, at least not in this case, without human operators. The way these implementation issues are handled have a direct effect on the balance between resources and demands, on task performance, and thus ultimately on the efficiency of the production system.

The control capacity within the different issues/categories therefore presupposes each other; there is a mutual interdependency between them that also confirms the logic of the modern STSD: There is but one system.

Discussion

We know from earlier studies (see for example Andersen (2015)) that the implementation of new technology tied to digitalisation and automation represents multiple challenges. A successful technology-induced organisational change implies that the organisation and its workers are set to integrate appending changes into their everyday operations. In order to realise this, managers need to have an adequate understanding of the interplay between work, workers and technology; be able to transfer this understanding to the workers and at the same time operationalise it into adequate actions in the implementation process to create acceptance, learning and ownership. There is a need to develop favourable attitudes to the change itself and a motivation for constructive participation.

A main issue for the warehouse in the study was the integration of AGVs in a setting that lacked the necessary structure, and that had an unrealised potential for improvement of production flow and organisation of work. In addition, this particular warehouse had a strong union association, and it was by no means clear that these AGVs would be initially welcomed. Important conditions for successful implementation was therefore the well-functioning of the technology, the integration of AGVs and human operators: which relied on an adaption of the organisation of work and production flow, acceptance of the changes among operators, and that the operators received sufficient training in order to handle deviations.

Having shown the relevance of STSD and JDRM for analysing the findings in a way that explains how performance and control parameters represent potential challenges and enablers in the AGV implementation process, in a way that influences the control capacity of the warehouse's core operations, the discussion will emphasise in what way these mechanisms may affect alignments/misalignments between the AGVs and its user context, as well as control capacity on a higher organisational level.

The Implementation Stage

The implementation stage is of great importance with respect to the success rate of a new technology. By following the framework of Leonard (2011), we evaluated the introduction of AGVs and tried to identify possible misalignments between the technology and (1) technical requirements, (2) the delivery system of the technology and/or (3) the organisation's user performance criteria.

By evaluating the isolated technological requirements (specifications) there is no room to claim that there were specific misalignments between the specifications and the organisation and its environment. Isolated, the functionality of the AGVs or the technology itself, worked as intended. The vehicles were able to pick up pallets, deliver them at the correct location, drove at the predetermined speed, and so forth. The problems that occurred during testing and implementation were not related to the capability of the AGVs, or technology as such. The supplier could have analysed the layout a bit more thoroughly and thereby avoided some of the issues regarding limited space and the work routines of the human operators. On the other side, a perfect match between the operations/production processes is not desirable. In terms of technical requirements, we will argue that there were “beneficial misalignments” which forced the organisation to adapt and make some changes that benefited the warehouse in the long run.

The troublesome integration of existing and new software caused the AGVs to stop regularly and slowed the work process during testing and implementation. Several workers were negatively affected by this and directed the frustration towards the AGVs. This is an example of misalignments between the technology and its delivery system. It was not something wrong with the technology (AGVs) per se, but the delivery system: in this case, the software of the AGVs and the integration with the warehouse management system. While we did not experience sabotage or rejection, many workers were clearly displeased with their new digital colleagues. Better communication and planning could have solved these issues, although some difficulties must be expected during the implementation of new technology.

There were also misalignments with the organisation's performance criteria. The AGVs had a direct impact work execution, and some of the workers perceived this a threat to their own efficiency. In other words, they believed that the introduction of the AGVs would have a negative impact on their job performance. These workers feared that their own efficiency was threatened by the new efficiency represented by the AGVs; in particular they feared that they would have more uncomfortable tasks and decreased salary. Furthermore, some feared the AGVs eventually would take their jobs. As pointed out by Leonard (2011), the technology usually has both positive and negative effects. In the same way, how people perceive, and experience technologies will also differ. The misalignments listed above could have been addressed more clearly from the management. Also, how the organisation was supposed to handle the implementation's “softer” aspects should have been more emphasised.

Rebalance of Control capacity

Turning back to the concept of control itself (De Sitter et al. 1997); a challenge in organisational renewal is for the members of the organisation to define the (new) division of labour, and in turn the control system and norms and values for this new division of labour. Leaving aside, for the sake of discussion, whether the involvement led to an actual agreement on the division of labour: the redesign or *rebalancing* of the control structure in the organisation remains an unanswered question.

As to the introduction of automations as colleagues, it remains unanswered whether this affects the notion of system controllability. In one perspective, AGVs reduce the amount of control available to the (human) workers. This enforces adherence to schedule and protocol and decreases the workers' control and sense of autonomy. On the other hand, the control specialisation, by isolating competence and operation of the AGVs to certain roles, increases the control capacity required, in turn increasing the capacity required from all workers.

By extension, the quality of work stems in part from the control capacity built into the task (De Sitter et al. 1997), as seen against the control capacity required. However, business improvement processes generally focus on reducing waste, productivity improvements or cost reductions: all of which generally contain an element of reducing *unnecessary* variation, often defined in terms of management or economy rather than working conditions. In this case, the system-internal variation becomes “the enemy” of the AGV introduction. The automation itself cannot succeed without rebalancing the control capacity of the tasks it is augmenting or replacing.

Environment-technology fit vs. task-technology fit

The research literature on information systems has in general forwarded task-technology fit (Goodhue and Thompson 1995) as one of the core models when it comes to identifying and understanding performance effectiveness when using digitalised technologies as part of a work process. Investigating automation with focus on the implementation stage and through the lenses of a combination of STSD and JDRM offer more insight into the meaning and implications of control capacity and quality of organisation, work and working relations. This permits us to see beyond mere individual and/or organisational factors along a continuum and indicates that the construct of task-technology fit is too narrow to study and fully understand man-machine interplay in a context of technological change in terms of digitalisation and automation.

If control capacity is an adequate designation of quality pertaining to the organisation flexible abilities on different levels of the interaction between technological and social phenomena, whether described as systems, artefacts or processes, a mere technology-task-orientation cannot possibly be sufficient to understand and explain these complex and interwoven relationships and interdependencies. Within this context, a model of environment-technology fit might be a more prosperous conceptualisation that still remains to be constructed. This explorative study has shown that the nature of critical elements in organisational digitalisation processes and their interrelationships too complex to be reduced to interactions between single phenomena. Likewise, this complexity of variables that should be considered in order to succeed with the implementation of new technology cannot be handled by aligning different levels along a continuum or by juxtaposing them.

An environment-technology fit model of the implementation of digital technologies needs to 1) take into account the quality of organisation, work, and work relations levels simultaneously; 2) include the interrelationships of relevant phenomena on the different levels; and 3) address important issues pertaining to the implementation process that affect these interactions. The STSD and JDRM frameworks has proven useful to start to assess the face validity of such a model in terms of control and performance structures, but more work is needed on theoretical and empirical levels to test further validity and reliability aspects.

Implications and Concluding remarks

There are many theoretical frameworks available for the study of organisational change in the form of automation and digitalisation. Most agree that the interplay between innovations, technology and organisations is complex and therefore needs multiple perspectives in order to understand it. We have used two main frameworks; STSD including JDRM, and implementation of innovations which gave valuable insight in one way to decipher the implementation process related to its ability to handle interferences, and how the successes and failures along the way can be explained by studying misalignments and alignments. Reflecting on control-capacity, we question whether or not there are inherent challenges in explaining the quality of future work, if by extension automation by design must negatively affect the control-capacity balance.

In analyses and discussions on technology-based organisational change, perhaps especially within STSD and innovation theory, it is quite easy to get caught in technical considerations tied to the implementation processes. However, the discussion shows that there are important underlying dimensions tied to control capacity and misalignment/alignment that have clear managerial implications, and that need to be addressed to ensure as high a quality as possible for organisation, work and working relations in the depth of system structures.

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