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Workarounds in application and use of manufacturing software as enablers to organizational change

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Abstract

In this paper we look at four Norwegian manufacturers' Information System and stages of Information Technology adaptation, explaining how practice of technology and actions/workarounds to IT systems, that enables, hinders, and drives change in wanted or unwanted directions. Four stages of technology and organizational integration is described: Planning, Adapting, Improving, and Firefighting. These change perspectives are either emergent or deliberate and the workarounds plays an important role in enabling an organization to evolve through the phases. The choice of methods comprised a collection of qualitative methods, such as fieldwork, case studies, observation, interviews, and focus groups. The analysis process of the collected data was based on abductive reasoning. The results can serve as a backdrop to the implementation of Industry 4.0 and how technological and organizational evolvement can be intertwined.

Keywords: Manufacturing oranizational change, Workarounds, Information systems

1. Introduction

Manufacturing industry undergo transformation enabled by technology and under the concept of digitalisation. This is often referred to as the fourth industrial revolution or Industry 4.0 [1]. This transformation affects the way products are manufactured with strong interoperability between software/Information Technology (IT) and manufacturing hardware; equipment, machine tools, robots etc; so-called "cyber-physical systems [1]. Industry 4.0 also implies increasing availability of data and new tools (so called digital twins) for exploiting these data in analysis, learning and decision support. A successful implementation of Industry 4.0 will need both technological and organisational knowledge. It affects how employees go about their everyday activities, making improvements and changes of routines, work processes, social structures, workforce skills, organisational climates, management, and leadership. Central to this is how employees understand, prepare, and adopt the information system and information technology, and the paper describes a contribution to research in this field.

1.1. Information systems

The digitalisation moves from the notion that change is either enabled by technology, leaving people to change accordingly, or socially enabled, the technology has to support the existing work processes. In the Information Systems (IS) research field descriptive and behavioural aspect of Information Technology (IT) has often been neglected and thus treating technology as a 'black box', which resulted in a lack of theoretical visibility [2]. The IS field has been coloured by research leaning towards technological determinism or social constructivism [3]. How IT shapes organisations has been the subject of research for decades [4-10] IS change can be seen as a deliberate alteration to an organisation's technical and

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organisational subsystems [10], or as an emergent change situated in everyday sociomaterial practices [11]. In recent years this topic has been discussed under the theoretical perspective of sociomateriality in which the technology, having materiality, and social behaviour being an imbrication and constitutively entangled. The sociomaterial practises of technology can lead to improvisations creating workarounds to intended use of technology. A workaround is a method, shortcut or similar for achieving a task with deviations from the planned method either because the planned method is not working, because it perceived as too cumbersome or similar. Theories about workarounds are receiving increased interest in research involving technology and organisation [12,13]. There is, however, a gap in the literature regarding the impact workarounds have on organisational change. This paper attempts to address this gap by discussing stages of evolution of technology in organizations and how workarounds play a role in these stages.

The literature study on workarounds, by Röder, et al. [12], concludes that studies on of workarounds on organisations needs to focus on differentiating types of workarounds to understand *how* they affect organisations. Understanding the influence of workarounds on an organisation could be used for analysing and designing new technology, providing a more realistic assumption for system analysis, and a proper theory of workarounds would question the negative implication of workarounds and, instead, focus on possible benefits [13].

This paper challenges two assumptions in the research field of technology and organisation: a) that technology-based change is either determined by technology or humans; and b) that organisations are dynamic in nature and technology is rigid. The aim of this paper has been to further investigate these assumptions to understand the evolution of technology in manufacturing companies as well as the role of workarounds. The research question guiding this paper is: Which phases of technology evolution can be observed in manufacturing companies, and what implications do workarounds have for technology change and the organisations?

1.2. Sociomateriality

The impact of technology and use have on organisation has been a central concern in the field of IS for decades [6], [14] and [15]. To understand technology-based organisational change, the materiality feature of technology needs to be understood as something that is always bound to organisational practice. '*Materiality is not an incidental or intermittent aspect of organisational life; it is integral to it*' [16] (p.1436). Seeing technology not as separate to the social and organisational provides a theoretical foundation for understanding technology-induced organisational change. A technology-based change can be seen in correlation with Orlikowski's [11] concept of change and stability. Lewin's [17] theory of change management 'freeze-unfreeze-refreeze' has dominated the way scholars theorised change and is still debated. Change is seen as a planned event that is implemented for a period of time, and then stability is obtained once more. Technology change has also been seen as deterministic and change is predictable from the IT implechange', where change is seen as 'ongoing practices of organisational actors and emerges out of their (tacit or not so tacit) accommodations to and experiments with the everyday contingencies, breakdowns, exceptions, opportunities, and unintended consequences that they encounter [11] (p.65).

The concept of situated change, according to Orlikowski [11] is not trying to replace other concepts or perspectives on organisational change but be complementary. This means that technology-based organisational change is not based on planned change, nor is it based on assumptions of stability; it is based on the assumption of action, particularly regarding human agency and technology use, where social action enables organisational change. A technologically induced change in an organisation will change the information infrastructure and thereby affect all areas of an organisation. An information infrastructure deals not only with providing an organisation with effective IT capability but also with aligning IS strategy with IT architecture and key business processes, global standardisation, and interoperability of systems [18]. Change, in contrast to control, formalises outside the control of human actors and is considered the outcome of two processes linked together: actors learning and exploiting IT features, affordances, and potential; and actors' continuous inventions, tinkering, and improvisations of the IT [2], i.e., workarounds. Workarounds can be categorised into three major categories: convenient, innovative, and necessary. Convenient workarounds are created to ease a task that is perceived as too complex or time consuming. They are created because an employee can do it. The innovative type of workaround is made with the intention to improve the information flow and system for the organisation on a more permanent basis. These are created because the employee wants to. Necessary workarounds are those created because the technology lacks affordance to the task to be performed.

2. Field studies in manufacturing companies

For this research, in-depth, field studies of four Norwegian manufacturing companies where made. All four are globally competitive in demanding markets and are undergoing significant changes in their IT architecture. Company 1 develops and produce advanced tools used for metal cutting, and due to a merger with a large global engineering group they are in the process of changing their ERP system to meet the corporate requirements of standard global information infrastructure. Company 2,3 and 4 are Tier 1 suppliers in automotive industry and are at different stages in their IT strategies. While Company 2 has implemented a change 2 years ago, company three and four have more mature technology implemented four and 7 years ago at the time of the study.

2.1. Methods

The choice of methods comprised a collection of qualitative methods, such as fieldwork, case studies, observation, interviews, and focus groups. Observations were made by attending meetings and shorter briefings for the employees. This was useful for being able to understand how the production information

mented. Orlikowski [11] introduces the perspective of ‘situated

was shared and interpreted, and to understand the level of transparency the company had and needed to have. Interviews were set up to give meaning to how people understand and describe their actions and environment. We wanted their explicit knowledge to be captured for interpretation and analysis. We specifically wanted the interviews to be informal and attempted to leave as much room as possible for reflection and discussion. A small survey was distributed in order to investigate the communication and information flow among the employees.
Workshops and presentations afforded the opportunity to report and discuss the material and preliminary findings with the companies. The feedback that these workshops provided was invaluable for the validation and further understanding of the results from the fieldwork.

The analysis process of the collected data is based on abductive reasoning. The analysis of the collected empirical material was an on-going process throughout the fieldwork and both empirical and theoretical perspectives has been equally forming the understanding of the research area and were derived from the spoken expectations and the presumed consequences that an IT system has for the IS and organization. In the analysis the data were categorized into observations, descriptions, and stories of how the technology use where about to changed, in change, or requiring change. Through iterations of analysing the empirical data the final iteration was identified as organizational perspectives.

2.2. Results from field studies

The results are presented in regard to the companies being situated in different phases of a major change to the infrastructure: prior to implementation, early adaptation, system acceptance, and outdated system. This was done to investigate the relationship and dynamics between the organisation and technology and what role workarounds, as socio-material practice, play in the adaptability of technology and organisational change. The four phases of technology-based organisational change to be discussed are: (1) Planning, (2) Adapting, (3) Improving and (4) Firefighting.

Table 1. Overview of the four stages of IT /IS in a manufacturing company

	Planning	**Adapting**	**Improving**	**Firefighting**
Technology change	Pre-IT impl, re-org change	Post-IT impl, pre-org change	Post-IT impl. post-org change	Pre-IT impl. post-org change
Character	Anticipation	Negotiation	Synergy	Imbalance
Challenges	Uncertainty, Rumours, knowledge gap	Human inertia, sub optimisation	Improvement management, IT stagnation	Frustration, lack of control, sub optimisation
Workaround	-	Medium	Low	High
Type	-	Convenient	Innovative	Necessary

Maturing through phases can be seen as result of time using a substantial role as enablers of change. The mature level of full integration and adoption of the IT system is not seen as a last step; this is a continuous process and, although phase three is preferable, the next step seems inevitable. The following table sums up the different stages and their characteristics.

2.3. Stage 1: Planning new IS and IT system

Planning and preparing for the new IT system revolves often around technological issues. From an end-user perspective the focus of concern is on how the new system will affect their everyday work. The first case company, is in this phase, going from an outdated tailor-made IT system to a new corporate rolled out ERP system-implementation (SAP). The global information sharing and the organisational transparency that comes with a standardised infrastructure will give new potentials, but employees are uncertain on future workplaces, roles and how this will affect individuals. The concern of losing knowledge and methods built into the tailor-made system adds to the concerns for future change and how it will affect the company. There are in principle no workarounds since the system is not implemented yet, but in the transition between old and new system the company might be in both 4th and 1st stage.

2.4. Stage 2: Adapting to a new IS and IT system

The second company has recently implemented a new IS and IT system and is undergoing organisation changes to adapt to the new system. They experienced a lot of workarounds during implementation, where users had to change their current ways of working. The result was many individual workarounds that often went unnoticed by management. Employees kept many of their old routines and thus experienced a mismatch in the work processes. This creates ad hoc evaluation and negotiation of the routines and improvised creation of workarounds. The convenient workarounds being created were not desired because its effects are unpredictable and potentially harmful to the information flow. Learning the new system and adapting the new work processes characterise this phase and one major challenge is human inertia towards change. Balance between new technological possibilities and current advantages in organisational processes are important to find, and in this phase, this means negotiation with the users. Employees has to come to terms with the new system and new routines, and a new culture is created for how to learn and adapt. Number of workarounds are medium, and the type is “convenient”.

2.5. Stage 3: Improving existing IS and IT system

Following the two first phases of planning and adapting to new technology, the phase of improving begins. The intention for workarounds in this phase is typically to improve information flow and acts as improvements. The third company have reached this phase with enough stability for innovative workarounds to emerge. In a state of synergy and stability in the organisation, there is time and room for improvement. Local situations and workarounds are being considered, or already implemented as improved information flow at this

Maturing through phases can be seen as result of time using the system; however, these results show that workarounds have

company. To thrive towards and have the ability to sustain this

phase depends on the flexibility in the technology and the ability to change to be aligned with the organisation. With synergy between IT use and organisation, which allows creativity and innovation among the employees, the workarounds are mostly of the innovative type. While improving however, the workarounds tend to increase due to rigidness in the technological infrastructure contradicting the changeability in the organisation. The procedure and routine improvements are easier to implement in the organisation than in the technology, and therefore the workarounds of the IT increase. Number of workarounds are low, but they are innovative.

2.6. Stage 4: Firefighting outdated IS and IT system

While the IS/IT-system is maturing, an increasing imbalance between technology functions and the organisational needs create frustration among the users. The need for necessary workarounds to overcome obstacles increases and, in turn, results in increased sub-optimisation and loss in management control. The lack of required functions and the interoperability of the IT systems result patchworking of the IT architecture, or as the informants called it: firefighting. For the fourth company, this phase illustrates the stagnation of a rigid system and an organisation in change. Typically, are additional software introduced to solve specific tasks but with a lack of interoperability between the IT systems in a complex information architecture. Creation of "firefighting" workarounds and local solutions for handling data outside the IT systems adds to the complexity. Departments such as production, logistics, maintenance etc. has their own routines applying many local unofficial Excel solutions. Sub-optimisation of information flow and data handling creates negative effects on efficiency and productivity. Number of workarounds are high, and they are necessary for operations.

3. Workarounds as agents for organizational change

Technology-based change is dependent on the changeability of both organisation and technology. An organisations changeability relates to the flexibility in the procedures, an organisation's ability to allow internal influences of innovation, and how an organisation adapts to external pressures. The matrix in Figure 1 below, relates the four phases of change perspectives in relation to organisational and technological changeability. It is inspired by is inspired by Cordella and Simon's [19] interpretation of technology and organisational inscription and intends to further explain how tension between organisation and technology changeability and rigidity relates to the phases presented earlier. From this perspective, a high number of workarounds indicates that an organisation and its IT architecture are too rigid, while a low number of workarounds indicates flexibility towards change.

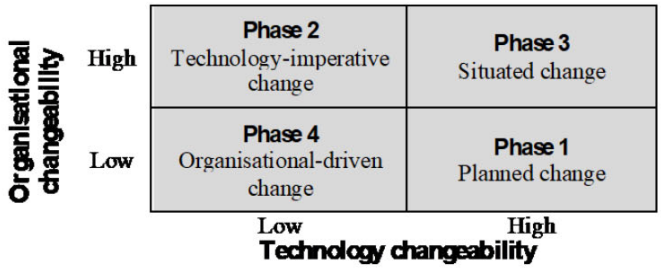

Fig. 1. Matrix of change agents in the IT/IS phased

There may be several reasons for tensions in changeability: organisational culture, type of business, level of knowledge intensity, etc. For the manufacturers in this research study, however, the reason for tension depended greatly on the global top-down decision for standardisation and the local bottom-up improvisations and adjustments. Most of the research on ERP implementation has been done from a top-down perspective, such as success criteria and reasons for failure, competitive advantages, and business alignment [20]. In this study, the ERP implementation and the issues involved are from a bottom-up perspective, and more specifically the sociomaterial practices created by its users.

In an organisation, there are both humans, the social, and technology, the material, working together to, through improvisation, create everyday work and organisational change and development. In the meeting of human and material, agency is the explanation for the outcome of the action. Human agency with the intention of using IT can foresee, react, and reflect upon the action-provided perception of the affordance the material agency offers. Humans perceive affordance to be non-existent – false; non-available – hidden; or available – perceived. This can explain the actions and explain workarounds created towards an IT system. It is not a view of only human action regardless of context, nor is it the constraints of the technology that generate workarounds; it is the sociomaterial action that is technology use.

For the manufacturers in the fieldwork, the phases can be said to begin with a top-down decision of implementing a standard IT system. The phases of planning for, adapting, improving, and firefighting the IT system are each reflected in the companies. The findings suggest that the drivers, and how a company manages change, are slightly different in the four phases. This means that there is a need for both deliberate and emergent change in technology-based change that is either planned, technology-imperative, situated, or organisational-driven. These change processes are not mutually exclusive, and the fact that workarounds exist in all post-implementation phases demonstrates that there is continuous emergent change enabled by fine-tuning and adjustments by users in the companies. In this sense, the importance of understanding and being aware of the nature of workarounds and how they influence change is crucial. Acknowledgement and attention to workarounds can support an organisation in being able to shorten the adapting phase and to sustain the improving phase. The sociomaterial perspective reveals the understanding of enablers and drivers of technology-based change in organisations.

3.1. Discussion

The sociomaterial aspects of workarounds play an important role in the understanding of workarounds' impact on organisational change. When broadening out from the micro perspective on IT use and examining the use from an organisational perspective, this indicates that technology integration also provides important understandings of why workarounds emerge. The fieldwork took place in organisations where the technology-based change was in different phases. The following section discusses these phases and the change perspectives related to workarounds.

Software evolution focuses on software maintenance, business rules, and user preferences [21], while organisational change focuses on the theoretical level of change and stability [21,22]. Information System evolution, then, can be said to focus on the technology-induced change and the effect this has on the IS, and in turn on an organisation. The technology change within an organisation refers here to the implementation of new IT and the changes this makes to the organisation. From the perspective of IS evolution, it can be said that an IT implementation is a static 'one-off' event, and that the IT following implementation is left with no change, and therefore the organisation can be in a state of stability. An organisation is in continuous change of an evolutionary nature and therefore the IS is likewise as evolutionary as the organisation. The four phases presented in the previous chapter are the result of a sociomaterial perspective on how technology use transform organisation. The change and the stability can be seen as constitutively entangled [16] focusing on technology use and organisational evolution.

The different phases organisations experiences when doing substantial changes in the IT architecture correlate with how the company handles change and what perspective they have towards change. In the first phase, Planning, the IT system is not yet implemented, and the change can be described as a *planned change*. For the second phase, because implementation has just occurred and the IT system is new to its users, the system dominates and determines new work routines. This means that the organisation is in a state of *technology-imperative* change. When there is synergy between the technology and organisation, as in phase three, there is the ability for *situated change*. As for the fourth phase, the organisation is now the dominant incitement for change and the state is *organisational-driven* change.

The phases explain how the different use of the IT system reflects the perspectives of, or state of, change being emergent or deliberate. Mintzberg and Waters [23] distinction between emergent and deliberate strategies relates to the change perspectives in this study. The planned changed phase here is similar to the concepts for planned change in a Lewinian "*unfreeze, change, refreeze*" [17] perspective of stability. The companies in this research did not have any choice regarding IT system and the decision for a technology change had already been taken, they are therefore entering a state of preparing for the deliberate change. Preparing the current architecture involves evaluating the current information flow to decide which processes and routines to maintain and which require redefining.

Table 2. Relationship between phases and change perspective

Phase	Change perspective	Characteristic
Planning	Planned	Deliberate
Adapting	Technology-imperative	Deliberate
Improving	Situated	Emergent
Firefighting	Organisational-driven	Emergent

In a phase of adapting the new system, the technology determines the change within the organisation. This can also be said to be a deliberate change because the change is pre-set in the IT system and directly influences new processes in the organisation. Here, the employees adjust to the new way of working and it is in this phase that the focus is on the IT and the unlearning of previous work routines. Since the IT demands time to learn and adapt, the users are often creative about finding their own ways of interacting with the system, thereby creating workarounds.

In situated change, the change is dominated by emergent change through the innovative workarounds and results in continuous improvement. This perspective is described by Orlikowski [11] as an improvisation in everyday activities that results in an ongoing transformation of the organisation. Moving away from more traditional notions of change, such as planned change and IT-imperative change, and presents a view that the change is subtler over time and driven by an organisation's actors in their practices. Evidence of the situated change perspective is visible at all four manufacturers in this study and in the phases described. The workarounds represent the sociomaterial action of technology use and enable change in all the phases. It is in the third phase, Improving, where the situated change perspective is most prominent, and the stability (lowest amount of noise from convenient and necessary workarounds) allows the continuous transformation and improvement. In the fourth phase, Firefighting, the emergent change perspective is similar to the situated change perspective in the sense that it is enabled by the technology use. The difference here is that the workarounds are necessary to overcome obstacles in the IT system, a situation that occurs due to a static IT architecture. The use is therefore characterised by users creating the necessary workarounds to be able to meet requirements. In this view, the organisation is changing more rapidly than the IT system, forced forward due to mismatch in technology use and is a more challenging and undesired state of change than the situated change. The organisational-driven change is characterised by moving towards a new planning phase.

The technology innovation and organisational changeability is rooted in an entangled relationship between new possibilities in technology and organisational and social drivers of change, and these change perspectives mutate as the organisation goes through the phases. The social interaction with the technology gives innovation momentum for the organisation to evolve. The sociomaterial practices in workarounds are the mechanism that enables change and change perspectives.

3.2. Suggestions to guidelines

The authors suggest to monitor and evaluate the workarounds as indicators for potentials and need for change. Understand which workarounds might be a hinderance to change (typically in the adapting phase), which workarounds could be a starting point for improvements and innovations (typically in the improving phase), and which are unwanted but still necessary (typically in the firefighting phase). In this monitoring and evaluation is understanding on sociometrical aspects important to be able to make correct decisions.

4. Conclusions

Workarounds to manufacturing IT can indicate and enable change in organisation, but information infrastructure and IT, are typically rigid in comparison to the flexibility of organisation. From that perspective, the workarounds provide awareness of possible innovation needs/potentials, lack of changeability in the infrastructure and, furthermore, enable change in the direction aligned with the organisation's vision and strategy. The type of workaround indicates where in the loop of continuous change an organisation operates. Allowing the IT use to influence and enable change contributes to the apparent ideal organisational condition of situated change.

In this paper we have tried to address the theme of technology integration and evaluation in the manufacturing industry in Norway, and furthermore discussing the implications workarounds have on organisational change. In the fieldwork, four phases of change were found: planning, adapting, improving, and firefighting. These phases seem correlated to incitements of change in the organisation correspondingly; planned, technology-imperative, situated, and organisational-driven change.

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