EUROPEAN JOURNAL OF WORKPLACE INNOVATION

European Journal of Workplace Innovation

Volume 4, Number 2 Special Issue, September 2019

EUROPEAN JOURNAL OF WORKPLACE INNOVATION

SPECIAL ISSUE: SOCIO-TECHNICAL SYSTEMS THINKING IN MANUFACTURING

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- To develop insights into workplace innovation
- Provide case studies from Europe as well as comparative studies from other continents
- Develop and present new theories in the field of workplace innovation
- To increase international publication within the field
- To become an important publication channel for workplace innovation researches as well as the international research community

Editorial

This Special Issue of EJWI 4.2 is concerned with Socio-Technical Systems Thinking in Manufacturing. We are grateful to Dr Trond Haga and Professor Johan Ravn for organising the collaboration, and to Professor Tor Claussen for serving as Guest Editor. Thanks are also due to the team of reviewers who provided blind peer reviews, and to the contributors for responding to the comments of the reviewers, and for keeping to the series of deadlines. We hope that the Special Issue will stimulate further debate, and we will welcome new papers.

Richard Ennals
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Introductory editorial

Socio-technics and beyond: an approach to organisation studies and design in the second machine age[1]

Tor Claussen
Trond Haga
Johan E. Ravn

[1] In September 2018, Bjørn Gustavsen passed away. Gustavsen was a major actor in the discourse of Norwegian and European work life reform and innovation, and he was always a spokesperson for "concept-driven development" based on practical experiences. Gustavsen's point of departure was the Norwegian industrial democracy projects in the 1960s, where he worked with Thorsrud and the researchers of the London Tavistock Institute, developing the first generation of STS thinking. His later work went "beyond original STS". A book that he co-edited with the philosopher Stephen Toulmin was titled *Beyond Theory: Changing Organizations through Participation* (1996). When we use "STS and beyond" as the title of this article, and of this special issue in general, it is as a token of remembrance of and respect for the role that Bjørn Gustavsen played in European work reform and work research, and for his development of STS beyond the original STS.

"Over the next decade, AI won't replace managers, but managers who use AI will replace those who don't" (Brynjolfsson and McAfee 2017:11).

"With more highly functional and integrated systems in both the office and the factory high performance is obtained by getting all workers to take on values and prerogatives heretofore expected only from management" (Pava 1983:139).

"Technologies are constituted by unique affordances, but the development and expression of those affordances are shaped by the institutional logics in which technologies are designed, implemented, and used" (Zuboff 2015:85).[2]

Introduction

Socio-technical systems theory (STS) is now almost 70 years old. Its empirically grounded analyses were based on production conditions that have since radically changed, as has society. Previously, we saw ourselves as cogs and wheels of a machine; now, we see ourselves as nodes in digital networks, in a work life characterised by blurred and shifting distinctions. Few of the assumptions about organisations, technologies and environments that form the foundations for the original STS still hold. So why bother with it today?

We think it not only fruitful but necessary to reinvent an STS position to address contemporary and future organisational realities. Although the classical core concepts may have not kept pace with societal change, the *inner vision* of STS has analytical, theoretical and practical potential, even today. However, we must be willing to turn over many stones in order to maintain it as a viable position. This article, taken together with the other contributions to this special issue, is an attempt to do just that, and it is not the first such attempt. Among our forerunners, we want to draw particular attention to the work of Calvin Pava, an STS thinker who has not been widely read in the European STS milieu. Pava's attempts in the 1980s went a long way toward correcting the original position and conceiving a new one founded in a forward-looking analysis of what he saw as radical changes in production conditions and society that were about to take place. This makes it worthwhile to present his thinking more fully.

Perhaps the need for organisational makeover, caused (primarily) by globalisation, digitalisation and new technological platforms, exceeds Pava's concepts and recipes. The opening quote by Brynjolfsson and McAfee indicates that the potential for change in the current technological development is large and revolutionary. There are many different technologies, and because of rapid interconnectivity, the links between different thought-fronts are many and ever-evolving. So, this appears to be a new type of situation. Or are we sure about this? Is what Pava considered new (such as the merger of white-collar and blue-collar work) really fundamentally new? Have the differences ever been absolute or categorical? Perhaps it is precisely a closer look at the faults of Pava's empirical analysis that will restore and save his analytical socio-technical concepts.

This article is divided into three main sections. In the first section, we retrieve and reconsider Pava's works. We find his concepts and approaches to be relevant to and connected with recent developments in society and manu-

[2] "Affordances" are to be understood as available space for manoeuvre, or perceptible degree of freedom or agency; that is, only actions are possible that users perceive as possible. Thus, the room for action when faced with a new technology is dependent on the users' abilities, their goals, previous experiences etc. According to Castells, power can be taken as "the structural capacity of a social actor to impose its will over other social actor(s)" (2007:239). There are always forces and power behind apparently neutral technology horizons.

facturing industry. His approaches break with previous STS approaches[3], and through the use of new concepts he makes STS relevant to the new digital reality. Using his concepts as a point of departure, a new STS approach opens up: "STS-beyond (STS-B)". In the second section, we explore some transformations currently taking place in industrial production, providing a rough overview of the most important changes regarding technology, markets, production, skills and change capability. Building on these first two sections, the final section highlights challenges that STS-B must confront, discuss and find operational solutions for. We use a paradox approach to show that an organisation must be able to handle simultaneously conflicting demands. We conclude by summarising and elaborating the consequences of the position of STS-B. But first, we set the scene with a prologue.

Prologue: globalisation, digitalisation and new technological platforms

According to Brynjolfsson and McAfee (2014), the "second machine age" concerns the development of computational power and how this has allowed for the automation of cognitive tasks, in a somewhat similar manner to how the "first machine age" (the Industrial Revolution) concerned the development of mechanical power and how this allowed for the automation of manual tasks. In both cases, a lot of jobs are made unnecessary and obsolete. In the long run, we might conclude that the first machine age was a positive development. As for the second one, we are in the middle of it, and according to Brynjolfsson and McAfee, it is far from obvious that its outcomes will be beneficial to the general working population. In an analysis preceding both the work of Brynjolfsson and McAfee and the arrival of Google and Facebook, Manual Castells coined the term "network society" to describe societal developments at the millennium, and argued that the present age may be described as "replacing the antiquated metaphor of the machine with that of the network" (2000:3). This fits well with contemporary discourses on the digitalisation of work life and society.

Aside from the network society, globalisation, digitalisation and technological developments, other reconfigurations are also taking place. Consider how some of the traditional distinctions between different forms of business and different sectors of society are transcended or blurred, e.g., when manufacturing industries are "servitised", when service sectors are "industrialised," when public administration takes on governance principles from the business sectors (such as "new public governance" and "lean") in management, and how all this produces distinctive socio-technical problematisations.

The network society, globalisation, digitalisation, technological developments, and the blurring of previously clean demarcations between various societal subsystems: all these have again made organisations and work life a highly focused and debated ground. How can we deal with this as organisation researchers? What comes next? How might a STS approach look now, facing such a dynamic and diverse manifold of challenges? Will STS be a platform for the future or are we facing STS-B?

When massive change happens, people are affected. Organisational processes for the domestication of something new (in the sense of total familiarisation, making it their own), be it new technology, new governance concepts or restructurings, often face organisational resistance in the form of "counter-implementation" (or contra-implementation/resistance). The classic example in the history of manufacturing is the opposition between James Hargreaves and the spinners ("the Luddites") when he introduced the Spinning Jenny (Timmins 1993).

[3] Van Eijnatten (1993) identified four existing socio-technical system design (STSD) positions: (a) participative design, (b) integral organisational renewal (IOR), (c) democratic dialogue (DD) and (d) STSD in North America. In his elaboration of the last position, van Eijnatten refers to Pava's "deliberation analysis for nonlinear work" (1993:76) as an alternative to traditional variance analysis. Deliberation analysis is "especially applicable to non-linear technical system (white-collar work), and fits in nicely with the classical STSD approach" (1983:77). So, although van Eijnatten's analysis included Pava's deliberation analysis (1993:98), Pava's approach has not been much discussed beyond this in European STS.

As will be argued below, anthropologically speaking, domestication need not be seen as a process of total merger, adoption or synthesis that eliminates the distinction between import and importer. Even once something is "domesticated", its "otherness" may be sustained. This understanding invites us to think of domestication as something that is both an import and a thing from outside: a paradox. There is value, perhaps even necessity, in allowing for paradox: you cannot choose between competing tensions, because either option intensifies the need for its opposite.

Part I. Calvin Pava: reconfiguring the STS perspective

The purpose of the Pava quote at the beginning of this article is to emphasise how the "original STS mantra" (technology ↔ organisation) is still relevant and valid but has to take on a different texture when the technologies are cognitive support tools as much as manual, and when the organisation is required to coordinate cognitive and manual non-routines rather than to control linear routines and "standard operating procedures". One would normally assume that ideas from 1983 about technology and organisation would be rather dated, but this does not seem to be the case with Pava's work. It seems that the conceptual device that he developed to analyse, understand and develop "non-routine office work" (such as leadership, R&D, marketing or product development) is among the most relevant and precise contributions to "organisational theory from within"[4] for addressing contemporary organisational realities. Pava's contribution to the theory of job design, organisational analysis and change is of interest, but has been ignored or overlooked, at least in Europe. He reconceptualised the traditional STS theory and methodology to adapt it to non-routine work. He introduced a whole new set of concepts to capture an organisational reality characterised by certain "organisational characteristics" that are dramatically different from the linear production line that laid the foundation for the traditional STS thinking.

The core of STS is to conceive of organisations as systems that convert inputs from their environments (such as raw materials, information or energy) to outputs fed back into the environment (such as services or physical products). The organisation, then, is seen as a system consisting of a series of transformations, or *conversion processes*, and transactionally linked to its environments. STS at the outset was developed based on the coalmine and the factory floor. Its theorising and conceptual developments drew on organisations with routine work systems where people did mainly manual work to produce mainly physical things. Pava brought the STS devices into (looser) organisations with non-routine knowledge work systems, where people are increasingly processing data and information, developing knowledge and creating value that is not necessarily physical.

In contrast to routine work (such as classic manufacturing, where the conversion processes are linear and sequential and reasonably predetermined), non-routine work systems involve a much higher degree of ambiguity and nonlinearity in the conversion processes; inputs, outputs and transformations are difficult to specify. Unlike routine STS, the non-routine approach emphasises reciprocal understanding rather than a shared goal and coalition formation rather than group identity, as one finds in self-managing teams that are permanent entities in the social system. Examples of non-routine work systems are research and development, market research, management work and professional practice, and such systems often are organised as project teams, matrices and networks.

Furthermore, the meaning of the technology concept, so central to STS, changes with Pava, from "the long-linked technology" (referring to Thompson's 1967 work) to what is called "intensive technology", "information

[4] Organisational theory is a field of study that for the most part develops broadly in the long term and from the outside. This often leads to a different, more detached kind of focus than do close-up studies from within. Compare theory strands such as institutional and new-institutional theory, approaches that have been developed only to a minor extent on the basis of, for example, analyses of changes in specific work processes. This point was made well by Barley and Kunda (2001), who argued that "work has slipped increasingly into the background as organizational theory converged on the study of strategies, structures, and environments as its central and defining interests" (2001:76).

processing technology" and/or "cognitive technology". With so-called knowledge work, it becomes increasingly difficult to maintain the traditional STS distinction between the technical and thesocial subsystems, since both are more directly related to and interwoven with humans.[5]

In Pava's perception, the digital revolution presents such a challenge that neither the pure "soft" approaches of the behavioural sciences nor the "hard" approach in industrial engineering could achieve and maintain the necessary organisational learning and change that was needed. In digitalised non-routine work, demarcations between technology and people become blurred, since they are interlinked and interact in more ways. The workflows become less one-way, less sequential and less predictable. Several of the work tasks done by individuals and teams are technology-enhanced, in more ways. As Trist notes:

> "By saying that the technological system for such work consists of deliberations, Pava has pinpointed the fact that the technology involved has become cognitive. The conversion processes entail the transformation of equivocal, ill-defined, ambiguous, conflicting issues into problems that can be dealt with" (1983:166).

Furthermore, a reconfiguration, or revolution, between what is to be seen as "the structure" and "the cultural fabric" is taking place (1983:164).

Three changes are essential. First, the organisational focus is changing. The traditional line system, mapped as a hierarchical organisation chart, does not capture how an organisation has to work in practice. Second, the technology focus and content is changing. There is no longer any single manufacturing technology that is in focus.[6] The technology system has become something like a developing ecology, where different sub-elements interact with others, inside and outside of the organisation, and develop. Third, the organisation–environment relationship is changing. The boundary between organisation and environment has become much more complex, fluid, fuzzy, ambiguous and temporary, and the environments themselves are of a changing and complex kind. We will elaborate on these changes later in this paper. Two concepts must now be introduced: *deliberations* and *discretionary coalitions*.

Deliberations are discussions and considerations. A deliberation is a unit of analysis in non-routine work, as a unit operation is in a linear process. Pava identified deliberations as the basic analysis unit of non-routine, knowledge-based work, and he defined deliberations as "sequences of reflective and communicative acts employed to resolve problematic issues" (1983:177). Deliberations come in more shapes than just meetings, conversations or decisions. They also include knowledge-generation activities from people working independently, like collecting and analysing data, documenting reflections or getting new ideas (Austrom and Ordowich 2018:11). They are patterns of exchange and communication in which people engage with themselves or others to reduce the equivocality of a problematic issue; the input, conversion and output of these processes move the non-routine work forward (1983:58). Trist's appreciation of the conceptual/analytical strength of this point is worth emphasising:

> "In introducing his idea of deliberation, a generic concept that covers a whole miscellany of unprogrammed activities, [Pava] has identified a dimension of professional and managerial work that has so far gone unrecognized. This dimension has been obscured by a too exclusive concentration on decision making. Deliberations are not in themselves decisions but their hinterland, which constitutes the world

[5] A similar view of "the social vs. the technical" is maintained in a typical or classical Dutch position on STS. De Sitter et al. argue against the distinction between "the social system" and "the technical system": "The isolation of social and technical system elements into separate subsystems blocks the view of the functional relations between the two, which are at the heart of a real production system" (de Sitter et al. 1997:503). For them, the organisation contains several "aspect systems". For instance, there is the operational and the regulatory aspect of a transformation, and these two aspects belong in the operational and the regulatory aspect systems, respectively. Both (sub-) systems are social and technical; they always "constitute a configuration of social as well as technical functions" (1997:503).

[6] Has this ever been the case? See Nuvolari (2000).

> of cognitive technique. Deliberations provide a new unit of analysis, the equivalent for the intensive technology of unit operations for the long-linked technology. They involve determining the full range of pertinent topics, analyzing their components and ensuring their examination through a series of forums (structured, semi- structured or unstructured), in which all the relevant parties present their various perspectives so that optimum trade-offs can be achieved" (Trist 1983:166).

Discretionary coalitions are alliances of interdependent parties formed to make intelligent trade-offs that enable attainment of overall objectives; in other words, collaboration among heterogeneous parties. Different coalitions are associated with different deliberations. Thus, the social system is defined in terms of discretionary coalitions that are needed to conduct deliberations effectively. These coalitions make the important trade-offs in creative work that are made necessary by the presence of useful but inherently divergent values and perspectives. As observed by Trist, one of the merits of the concept of discretionary coalitions in relation to deliberations is that it offers an "operational approach to the analysis of managerial and professional work in a nonhierarchical perspective" (1983:169).[7]

With the concepts of deliberation and discretionary coalition, Pava offers a new model for a flexible and scalable organisational architecture based on self-regulation. It provides a layout for how to combine self-managed work teams (in production lines, with the stamp of routine work), project teams of "hybrid work" (partly routine and matrix-organised) and the discretionary coalitions of non-routine work, coexisting within a "network organisation". Pava also acknowledged that our increasingly turbulent environment requires us to look at organisational change less as an event and more as a continuous dynamic of iterative design.

Pava's model of workers in interaction is that "disparate people" should work together and that tensions, disagreements and conflicts are thus not only inevitable and necessary but useful and therefore desirable, because this improves ideas, calls attention to the risks of the issues and solutions involved, and strengthens trust between people. This invites us to consider a "a paradox approach", and we will come back to this matter below. This interpretation is contrary to an interpretation of deliberations and discretionary coalitions as drivers for consensus-making and unity. This may be a source of different interpretations of Pava's text, since Trist and others (such as Austrom and Ordowich) seem to pay little attention to or downgrade the importance of preserving contradictions within a workable arrangement. Would deliberations and discretionary coalitions need renewal in order to face such contradiction between consensus destroying the dynamics of paradoxes and the preservation of paradoxes without paralysing decision-making and workable arrangements? Does this challenge us to go beyond the prevailing interpretations of STS? We think so.

As well as developing new organisational scripts, Pava also took on organisational change, finding that traditional approaches to managing change were unable to deal with ill-defined, complex problems that may require change in both behaviour and values. He therefore identified a 2×2 matrix to illustrate various types of issues that had to be addressed to ensure that the chosen change strategy would be viable. The matrix uses a social axis to highlight the degree of conflict between different parties and a technical axis comprising the level of complexity in relation to a contemplated change (Figure 1).

[7] "However much the hierarchical scaffolding may still be in the background, it is the unprogrammable sequences of coalitional formations that must become salient at the higher levels of any organization if it is to succeed in coping with substantial degrees of complexity, interdependence, and uncertainty" (Trist 1983:169).

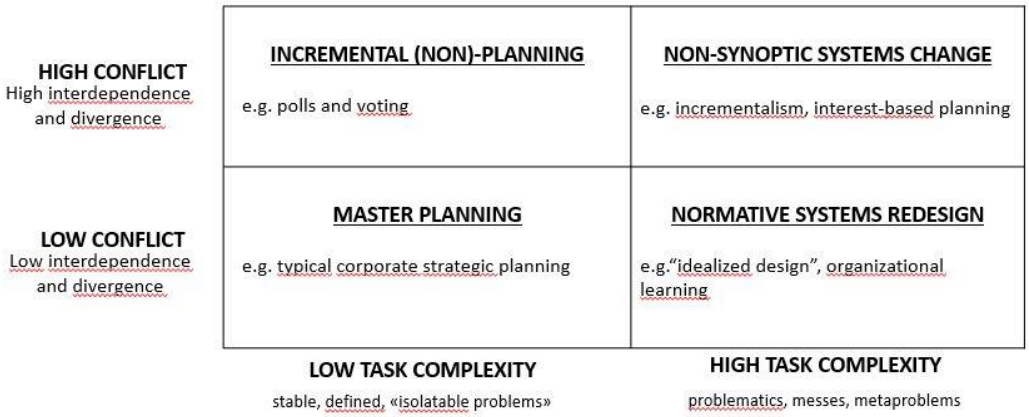

Figure 1. Strategies for organisation change (based on Pava 1986a:617).

On the basis of these two factors, Pava described four types of change: (1) master planning, i.e., low conflict and low task complexity (typically corporate strategic planning); (2) incremental (non-) planning, i.e., high conflict and low task complexity (typically polls and negotiations); (3) normative systems redesign, i.e., low conflict and high task complexity (like idealised design and organisation learning); and (4) complex system change ("non-synoptic systems change"), i.e., high conflict and high task complexity (more like a mission or vocation rather than a strategy, where all contributors are informed and very "change conscious") (Pava 1986a:617).

Trist, commenting on Pava, makes an interesting observation of a paradox: "The paradox is that greater technological sophistication will give more rather than less weight to how the human side performs, albeit that there will be fewer humans around" (Trist 1983:172). This was written 35 years ago, but it seems highly relevant today; regardless of how accelerating or exponential the technological developments may be, organisations will continue to be socio-technical puzzles to solve (although we have some hesitations about the latter part of Trist's observation: are we sure that there will be fewer humans joining the universal workforce?).

On the same issue, consider also a reflection by Austrom and Ordowich:

> "Pava was remarkably prescient regarding the potential impact of microprocessors and related technologies on the world of non-routine knowledge work. He recognized that the distinctions between blue-collar and white-collar work were decreasing due to increased reliance on knowledge work in both the office and the factory, especially given the emergence of "smart" equipment and advanced manufacturing. His influence on the theories and practices of STS […] and organizational change would arguably have been much more significant had he not passed away at a very young age. In fact, we believe that the full impact of his contributions to the design of knowledge work systems and contemporary enterprises is yet to be realized" (Austrom and Ordowich 2017:3).

We agree with the observation about the foresightedness concerning technological disruptions, but, as hinted already, the issue of the interrelationship of blue-collar and white-collar work, whether seen as a distinctive boundary or as a merger in the making, deserves special attention, and we will return to it below. In the next section, building on this discussion of Pava's work, which is rooted in what he at the time saw as revolutionary technological disruptions, we will provide an overview of the present day's disruptions, i.e., the most important recent and upcoming changes in manufacturing industry.

Part II. Industrial production in transformation

Over the last decades, industrial production has changed radically. Nevertheless, the end of the transformation is far from being reached. This process has gone under different labels, with Industry 4.0 being perhaps the most widely used.[8] The transformation is taking place not only in the form of technology developments but also in areas where new technology opens up new opportunities. We may call attention to some areas that are affected without claiming that this overview is comprehensive.

1. Technology

Socio-technical theory was conceived in another industrial era or setting. At that time, STS technology was the technology of the manufacturing industry organisation. Today, to gather all industrial technology into a shared frame would be a gross simplification, both because concepts such as Industry 4.0 cover a broad range of rather different technologies, and because a fixed demarcation between technology and "non-technology" is increasingly difficult to operate. Orlikowski (1993), for instance, observes a more dynamic and fluctuating boundary between (what is understood as) technology and (what is understood as) organisation. How a technology is deployed and appropriated depends on many social and economic forces, which lie beyond managerial control, and "the ongoing interaction of technology with organisations must be understood dialectically, as involving reciprocal causation" (Orlikowski 1993:423).[9] Technology and "the social system" are causes of one another and are sustained by their interaction. Nevertheless, we think it worthwhile and perhaps necessary to develop an adequate typology of various typical technology concepts. The realisation that technology is ascribed in and partly a product of external forces and sensemaking does not remove the usability a more diversified concept. Particular emphasis will be placed on Pava and his distinction between routine work and non-routine work (Pava 1983). The distinction between white-collar and blue-collar work may be regarded as an expression more of a traditional pre-industrial focus on work. On this basis, it is possible instead to indicate a future merger, or fluidity, between "manual and intellectual (cognitive) work" (Table 1).

[8] Industry 4.0 is a name given to the current trend of automation and data exchange in manufacturing technologies. It includes cyber-physical systems, the Internet of Things, cloud computing and cognitive computing. Industry 4.0 is commonly referred to as the fourth industrial revolution. The term, often shortened to I4.0 or simply I4, originates from a project in the high-tech strategy of the German government to promote the computerisation of manufacturing.

[9] A similar argument is also found in so-called actor-network theory, well captured in this Latour quote: "Society and technology are not two ontologically distinct entities but more like phases of the same essential action" (Latour 1990:127). See also the Zuboff quote (and note) in the Introduction.

Table 1. Technology: types, roles and descriptions.

Concept (type, role)	Details and description
Physical reinforcement	Solving physical tasks such as transport, lifting, machining and mass production.
Control purpose	Communication technologies, ERP systems, HRM systems[10].
Conceptual platforms	Structural design concepts such as Taylorism, supply chain design, lean, production systems and total quality management.
Automation	Applies not only to manual production tasks but to even greater extent to cognitive work (administrative, commercial, technical). The use of AI and machine learning will accelerate this development.
Digitalisation	Information in product and service production is digitised, opening up new ways of communicating, handling and making information (globally) available (see the contributions by Govers & Amelsvoort and Haga in this issue).
Social technologies	Facebook, Snapchat, Instagram, blogs etc., and the World Wide Web.
Human extensions	Cyborgs, where technology is integrated into humans; conversely, avatars, when the human is integrated into the machine. Also includes artificial body parts and exoskeletons (external skeletons that support and protect the body). (Lawson 2010).
Cognitive technologies	Technologies that carry out perception and cognition (Brynjolfsson and McAfee 2017); that handle text, speech, sound, vision and can "learn" (AI, machine learning, based on pattern recognitions and also other paths); that move from descriptive to prescriptive analysis; may streamline decision-making like programmable computing streamlined manufacturing. Cognitive technology takes process automation one level up.

2. Markets and environments

There has also been a noticeable change in how companies relate to the market. From having customers within a specific market, there has been a change towards companies acting flexibly in accordance with a number of different markets (Table 2). (There have obviously been deviations from this stereotypical image, such as the traditionally family firm.)

[10] ERP: Enterprise resource planning; HRM: Human resources management

Table 2. Markets and environments: roles and descriptions.

Concept (type, role)	Details and description
Flexible market orientation	Whereas companies previously specialised in specific market segments, we now see a stronger diversification. Companies are oriented towards different markets, and part of their strategy is to move quickly between different market segments while maintaining competitiveness and effectiveness. Such moves are extremely demanding for the organisation and require understanding of how the different markets work, different contracts and contract formats, different quality standards etc. Staff expertise is also required.
Changing organisational environments	A major contribution of Emery and Trist is their analysis and prediction of increasing turbulence in organisational surroundings (1965). Today this is everyone's experience. The flexible market approach, with other factors, causes changing surroundings. The surroundings are not static but increasingly dynamic, and they cannot be broken down into parts (because they interact with each other). This may increase turbulence in how to relate to the surroundings. For example, the set-up of partners and sub-contractors may vary within and between different markets.

3. Production/business process reconfigurations

New technology, more flexible market interactions and the continuous changes in the division of work between different suppliers will open up major changes in the way goods and services are conceived and produced. Changes in technology and in markets may lead to rapid and fundamental changes in the structure of industrial production (Table 3).

Table 3. Process reconfigurations: roles and descriptions.

Concept (type, role)	Details and description
Flexible production set-up	Technology allows a flexible production set-up, which in turn allows for a flexible interface between what the company produces and what it procures. The flexibility also lies in the fact that the partners in the various projects will vary.
Changing "economic laws"	With purely digital products (like apps), the cost of producing one unit is the same as cost price of producing one million units. For products that are not entirely digital, the industrial thesis that unit price drops with increasing volume appears less obvious (Brynjolfsson and McAfee 2014). Physical, serial mass production seems a less viable option.
Less routine work	Because of new technology, new market set-ups, digitalisation and automation, there is less routine work to be done.
Replacement of classical organisation recipes	• Lean production has removed buffer stocks, once the premise for the semi-autonomous work group. • Manufacturing industries are "servitised" (service offerings accompany or replace the physical product). • Service offerings are "industrialised" (and sometimes replaced by "apps"). • Public administration is governed by productivity principles.
Fluctuation/weakening of boundaries	Boundaries between different types of production and different tasks are less visible. Production of goods and services are likely flow into one another.

4. Skills and skills needs in transition

There is a lot of research and many white papers on requirements for new skills (see Øyum et al. in this issue). The changes outlined above will make other demands on individual employees as to the company's personnel. Without being able to predict the total change, it is difficult to list changes in skills requirements. It is nevertheless possible to anticipate a number of features (Table 4).

Table 4. Skills needs: roles and descriptions.

Concept (type, role)	Details and description
Operational skills	Individual employees require knowledge of an increasing proportion of the production process, knowledge of planning, and both technical and practical knowledge to take on varying tasks. They also need to be flexible and be able to move between different "project settings", where the assumptions are different, the division of roles is different (more non-routine work; see Pava 1983) etc.
System skills	It is reasonable to expect that systems must increase in their capacity to coordinate and communicate. The ability to consider system set-up in fluctuating project settings also becomes vital. Fluctuating settings demand communication skills on the part of individuals.

5. Change orientation

Above, we have outlined a change agenda that most industrial companies will have to deal with. Basically, external circumstances will force companies to become change-oriented to maintain their competitiveness (Table 5).

Table 5. Change orientation: roles and descriptions.

Concept (type, role)	Details and description
Change capability	Companies have to be capable of quickly adopting new production technologies and new organisational solutions, and of constantly searching and checking new opportunities and interacting with the external knowledge environment. The ability to translate new solutions into their own business becomes vital (see Govers and Amelsvoort, Putnik et al., Landmark et al. and Haga and Ravn in this issue).
Exploiting the environment	To be able to search for sources of improvement/innovation outside the company to a higher degree than before, one must increase the ability to make assessments/choices of such "external innovation offers".

As indicated in Part I, company configuration is changing in terms of organisational focus, technology focus and the organisation–environment relationship. Companies are expected to relate to the trends outlined above and to other similar trends. As indicated, not all of the trends are visible yet but will most likely appear sooner or later. In particular, we anticipate that the change capacity of companies will be challenged. Consequently, companies' ability to handle change will be of crucial importance (see Ravn in this issue). Relevant questions include how new changes will appear and whether they will be perceived as adaptations or as revolutionary new solutions.

The future: new circumstances, new concepts, new solutions

The different traditions within STS have had different innovation focuses. As articles in this issue show, the Dutch tradition has had a strong *system design focus*, while the Scandinavian tradition has had a strong *contribution and dialogue focus* (see Govers and Amelsvoort, and Haga in this issue). The different STS traditions have developed their distinct approaches over time, but their positions have not been fundamentally challenged or changed. On the other hand, there are fundamental changes in the terrain, as indicated above. It may look as if there is a mismatch. In this issue, inspired by the thinking and approach of Pava (1983), the introduction of new technology, new concepts and new approaches has been used to challenge the traditional STS approaches and to suggest how they may become relevant for present transformations, but how this happens is crucial. Thus, it may be appropriate to introduce the paradox perspective, which allows for an alternative approach to tensions by exploring how organisations can attend to competing demands simultaneously.

The changes that are part of the transformation take place quickly, and various change processes are often activated in parallel. Consequently, both the change capability and the change capacity of companies are challenged. As indicated above, the areas of change are almost all-inclusive, and the solutions will largely be found outside companies, from different competence environments. Thus, making these new solutions and concepts understandable for companies, and making them part of a company's own solutions or ways of operating, have become significant processes that need continuous attention. However, relevant concepts are needed to study and discuss their introduction to and adaptation to companies' way of operating. These processes have been captured through various concepts, such as *sensemaking* (Weick 2001) and *domestication* (Silverstone and Hirsch 1992); the literature considers various aspects of these concepts and discusses their content and practice (see also the contribution by Haga &Ravn in this issue).

In general, organisational set-ups implemented to utilise new technology and simultaneously exercise commercial flexibility efficiently require increased width and depth of expertise among staff. Developing such skills is demanding, because the knowledge that is required is a mixture of practical professional experience and communicative, social and theoretical competence. It is knowledge that cannot be developed through traditional means; a mixture of different forms of learning have to be utilised (see Øyum et al. in this issue). The skills and knowledge needed are also closely linked to the set-up of the company, its technology, market, production etc. The Industry 4.0 transformation can thus hardly be separated from the development of staff skills and expertise.
Traditional organisational set-up will probably be challenged, too. Many organisations are still hierarchical, in that communication follows a (vertical) line, and interaction and communication between different layers or functions are insufficient. New technology, new ways of communicating and new ways of distributing competence and skills will allow for and even require new organisational models. The traditional STS answer to organisational issues has been autonomous work groups. Pava pointed in a different direction, through his concepts of deliberation as basic unit for analysis of non-routine, knowledge-based work (1983), and his
conception of hybrid constellations of self-managing teams, project teams, discretionary coalitions (non-routine) into the reticular organisation (Figure 2).[11]

[11] Reticular organisation: "a network configuration for predominantly nonroutine office work, involving multiple linkages among professionals and executives that complement the existing line organisation" (Pava 1983:179).

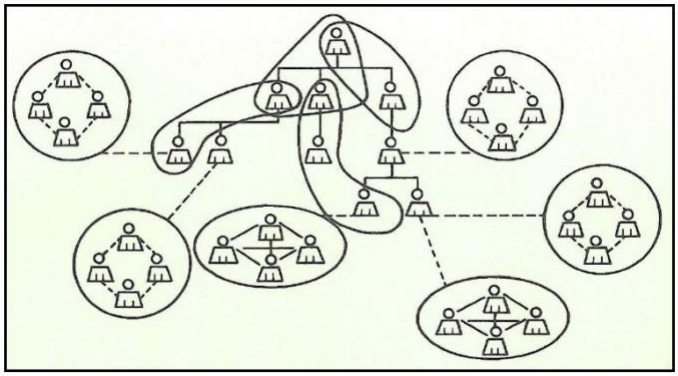

Figure 2. Template for a socio-technically designed high-performance office (Pava 1983:130).

Traditionally, industrial production has been closely linked to quality systems and quality assurance systems. Achieving efficient standardisation of operations and accurate reporting has been an important organisational goal. Detailed tools, such as procedures, have been developed for employees to obey, so as to avoid spending unnecessary time on repetitive operations. A procedure or recipe is established to avoid mistakes and misuse of production time. Standardisation has thus been regarded as a tool for reducing the need for personnel to solve production issues, plan operations and accomplish them. Problem-solving was reserved for production planners and management. The concept of *minimal critical specification* (Herbst 1993) builds on the fact that competent professionals need only a minimum set of required specifications to perform a job. Their skills and knowledge will enable them to solve problems, plan and perform the tasks in the most effective ways. This is particularly relevant in light of the knowledge promotion that companies must make as a consequence of market diversification and the implementation of new technology. Skills and knowledge are also prerequisites for making sensible and well-considered choices. At the same time, making choices based on knowledge and skills is a prerequisite if knowledge workers are to regard a job as challenging and interesting. Choice-making, at the operational level, is thus a key concept in the Industry 4.0 transformation.

STS has in general been concerned with achieving good working conditions for employees, focusing on job content, job requirements and the work environment. Employee participation or deliberation has been regarded as a prerequisite for achieving good conditions (Pava 1983). The mixture of developing professionals able to carry out larger parts of the preparation and implementation of work operations, and who have the competence to make well-considered choices and to create a culture in which participation is cultivated, opens up the issue of operational management based on trust and, to a lesser extent, on control (see Dvergsdal and Haga in this issue). Pava has discussed various aspects of this in terms of operational skills, procedural enhancements, structural factors and cultural fabric (Pava 1983). The way this is done depends on the company's operations, and consequently the way to do it most efficiently must be explored. However, there is no doubt that in this field of excellence there are obvious effectiveness gains for bold and skilled companies.

Above, we have explored recent and likely changes and trends in manufacturing industry. A revitalisation of STS may make a difference in the transformations facing industrial production systems. *How* to do this may be a matter for STS-B to explore and exploit. In the remaining sections we intend to raise issues that demonstrate the relevance of STS for future change dynamics. Such relevance will require a reframed STS, or STS-B as it is termed here.

Part III. STS as a framework for organisational paradox

STS explores and guides identification of change processes where organisations are faced with technology options. Action research and participation are essential when choices are made to explore and exploit certain of the available options. Knowledge and capacities (exploration) are necessary preconditions for the process of exploitation. On the other hand, new knowledge and capacities are achieved through the exploration process. Here, both preconditions (knowledge and capabilities) are required in advance simultaneously as new knowledge and capacities are explored through the exploitation process. Exploration and exploitation are among the key paradoxes appearing in change processes where technological systems are introduced in organisational systems.
A paradoxical approach considers differences that appear incompatible, like exploration/exploitation. One major characteristic of the paradoxical approach is that it copes with apparently conflicting features by converting them into supportive configurations in a change process. Paradoxes can create tension, destructive conflicts and resistance to change; paradoxical approaches aim to configure paradoxes into dynamic drivers for change. In an effort to sketch a theory of dynamic equilibrium model of organising, Smith and Lewis (2011) put it this way:

> "Paradox studies adopt an alternative approach to tensions, exploring how organizations can attend to competing demands simultaneously. Although choosing among competing tensions might aid short-term performance, a paradox perspective argues that long-term sustainability requires continuous efforts to meet multiple, divergent demands" (Smith & Lewis 2011:381).

Smith and Lewis note some examples explored by contingency theory:

> "contingency theory explores the conditions that drive choices between exploratory and exploitative (i.e., Tushman & Romanelli 1985), cooperative and competitive (Deutsch 1968), mechanistic and organic (Burns & Stalker 1961), and centralized and decentralized (Siggelkow and Levinthal 2003) (Smith & Lewis 2011:381)".

In his classic article, Cameron examines the concept of effectiveness as opposed to efficiency utilising a paradoxical approach (Cameron 1986). Pava offers the following elaboration of this distinction:

> "Effectiveness is the capacity to 'do the right thing' against a backdrop of changing conditions […] Efficiency and effectiveness are achieved under vastly different circumstances. Efficiency entails perfecting internal operations under conditions of stability. According to Burns and Stalker (1961), stable organization is mechanistic, providing a high level of routinization and lower immediate costs. Effectiveness entails bettering the match with one's surrounding environment under conditions of change. Fluid organization is dynamic, possessing the ability to adjust to external conditions, maintaining a large repertoire of adaptive behaviors and requiring extensive coordination" (Pava 1983:141).

The efficiency/effectiveness paradox illustrates the shortcomings of a static organisation that depends on a set of stable and given environmental conditions. Change is necessary in order for an organisation to respond with effectiveness and independence when the environment changes. Changing environmental conditions are the *raison d'être* of the modern capitalist economy and its business environment.

Building on this short introduction to the paradoxical approach, we intend to address the following question: how does a paradoxical approach collide with challenges that occur in current and future STS applications and beyond (STS-B)? Introduction of new company-specific production systems face existing organisation systems. Technology systems appear in the external organisational environment as "other" to the existing acknowledged operations and solutions that the organisational "we" regard as "theirs" (Luhmann 2000).

Domestication has been referred to as a way to make sense of the introductions of a company-specific production system, from being external and unfamiliar to being internal and known. This domestication implies that the external is acknowledged and owned by the organisational culture and embedded in its practices (Haga & Ravn in this issue). Such a process of domestication pinpoints something essential within STS: the remaking of externally introduced changes so that they are embedded and acknowledged as the organisation's own, in *their* ownership. The external becomes included as part of the internal creations and responsibilities. Remaking has to take place, both of the external and of the internal capabilities.

The concept of domestication has been applied in anthropology (Goody 1973, Keesing 1972). As a key concept, it covers how external resources in the environment are utilised within specific local entities (families, segments/moieties, villages, districts etc.). Examples are found in the villages surrounding the Sahel belt in Africa, where cattle farmers and agricultural producers operate in a symbiotic relationship (Barth 1964, Durkheim 1933[1893]). Mutual relationships are constantly recreated and renewed through such domestication processes. In the Sahel belt, domestication implies nurturing and solidifying the mutual dependencies among the different production systems (livestock and agriculture). These mutual dependencies include no options for substitutions, flexibility or alternative arrangements. Their mutual dependencies are reinforced by domestication of their respective cultural practices in order to reinforce a community of different practices within a specific local social arrangement. How does this apply to STS and today's industrial environment?

The modern industrial environment fostered standardisation as a means to negotiate wages (Taylor and the piece rate system). Common ground was thereby found on which workers and unions could negotiate wages to create a mutual acknowledgement of the piece rate. Standardisation was the baseline on which to build a common agreement and where industrial relations could be acknowledged. For many scholars, this is regarded as the first Industrial Revolution, as argued in the Introduction: standardisation was necessary in order to create a common ground on which conflicts could be resolved. This was one of the objectives of Taylor's scientific management. Science-based production systems should both enhance efficiency/effectiveness and prepare for dialogue and commitment to the distribution of the surplus created by the changes introduced. Prior to Taylor, diffusion of new technology faced resistance, and even "machine-breaking", as with the first introduction of the Spinning Jenny and the threshing machine (the Captain Swing riots of 1830–31).

Standardisation had no relevance for such hostile forms of resistance. On the other hand, those forms could paradoxically smoothen the introduction and diffusion process of innovations. In a working paper on the machine-breakers and the Industrial Revolution, Nuvolari (2000) cites the historians Rule and Randall and builds on their arguments:

> "Randall shows that in the wool-textile industry the workers' resistance to innovation was highly successful in postponing the adoption of different types of machines for a remarkable period of time. In this respect, Noble has suggested that in some cases one of the aims of machine breaking was simply to gain time and to achieve a slow introduction of the new technologies in the economic system, minimizing the possible negative economic and social consequences of a too rapid change" (Nuvolari 2000:8).

What at first seemed to be a destructive machine-breaking consequence of resistance in fact generated the opposite result. The outcome of the resistance was that time was gained, minimising negative economic/social consequences and providing a more suitable domestication of the new technology. Additionally, the delay through resistance was able to produce flexibility in order to enhance increased capability in the organisation, making it more receptive to new technology. Such capabilities as efficacy, skills and operational/organisational capacities were developed through the greater flexibility and "slack" created by some of these forms of resistance. These remarks on this

resistance paradox could have implications for STS domestication and adjustments between the technological and social systems.

Standardisation also emerged as an important prerequisite for substitution. Necessary replacement of parts required spare parts to be made available according to specific standards. Abundant units conforming to exact measures had to be produced in order to replace required parts, and production systems and human capacities had to be standardised accordingly to fulfil these obligations. Substitution implies replacement of identical parts, but the same concept also covers possible new systems and technologies to replace the existing ones with something improved, new or revolutionary. If substitution is to operate as an alternative to standardisation and replacement, R&D resources are required for innovation and creativity.

Adjustment and domestication proved to be mutual dependencies based on *existing* differences (livestock/-agriculture, external production systems/local practices and theories). Innovations that provide (revolutionary?) changes and development require independence in order to create new organisational arrangements, new technologies, new services and new resources (Schumpeter 2017). These new innovative features are themselves necessary in order to make specific substitutions for change possible.

Domestic human capacities and organisational production systems might lack the capability to meet new demands for substitutions and innovations. On the other hand, external demands not domesticated could be experienced as unfamiliar. Requests to domesticate and familiarise could face resistance. Resistance could, however, pave the way for domestication and familiarisation. For most externalities, such domestication and familiarisation is a prerequisite of the creation of acknowledgement and ownership introduced through change and innovation. This domestication paradox implies both obstacles and conditional opportunities to overcome challenges related to change and innovation processes. This reflection provides us with the following paradox/dilemma:

- On the one hand, flexibility and substitution of existing production systems/technologies requires independence from existing standardisation and human/organisational arrangements in order to create change (revolutions). This is contrary to domestication and adjustment, which interrelate with the existing industrial and human organisational environment.
- On the other hand, domestication to existing industrial and human organisational arrangements must be observed. In order for ownership, engagement and domestication to be complied with, the existing arrangements have to be handled as options for change.

The contradiction between the dependence of existing preconditions and the independence of the same conditions is basic to a paradoxical approach. Resistance can, paradoxically, provide space and coping capabilities for a creative and constructive exploitation process to take place. Straightaway, we are faced with two questions that have to be addressed: how can we make sense ("from label to lens") of paradoxes/dilemmas,[12] and how can we enhance coping capabilities (Lüscher and Lewis 2008)?

STS faces such paradoxes and dilemmas. They are apparent in many of the contributions in this issue. It is important to take account of both the necessity and the ability to reflect on and make sense of these and similar paradoxes/dilemmas. It is important, too, to direct attention to ways of enhancing coping capabilities. Organisations can face tension where there is defensiveness and resistance, reactions brought about when actors are faced with opposing demands and choices. Choosing one option could imply a problematic outcome, with unpredicted or negative impacts from the options not chosen. An alternative to the defensive reaction is to try to incorporate both elements of the paradox. This is the goal of the dynamic equilibrium model mentioned earlier, which tries to

[12] Paradoxes and dilemmas as an approach in organisational science have been examined by a number of social scientists, including Quinn & Cameron (1988), Quinn (1986), Clegg et al (2002), Weick (2001), Smith and Lewis (2011) and Lüscher & Lewis (2008).

demonstrate how paradoxes can be used to stimulate a creative and innovative outcome. Instead of paradoxes being solved or eliminated, they are preserved and developed to facilitate attention to new opportunities and outcomes. Adopting paradoxical thinking opens up the prospect of considering possibilities in the form of both/and, rather than in the form of either/or. This effort thereby offers a way out of vicious circles of tension and destructive resistance to change.

Alternatively, a kind of virtuous cycle is portrayed in accordance to this dynamic model:

> "The dynamic equilibrium model explicates a more positive response to paradoxical tensions. It depicts a virtuous cycle, with awareness of tensions triggering a management strategy of acceptance rather than defensiveness. Acceptance entails viewing tensions as an invitation for creativity and opportunity" (Smith & Lewis 2011:391).

> "by immersing oneself in the opposing forces, it becomes possible to discover the link between them, the framework that gives meaning to the apparent contradictions in the experience" (Smith & Berg 1987:215, quoted by Smith & Lewis 2011).

> "In their action research Lüscher and Lewis (2008) show that helping managers accept tensions as paradoxical enabled their sense making. Initially managers experienced tensions as a dilemma. However, by recognizing that they could never choose between competing tensions, because either option intensified needs for its opposite, they began to adopt paradoxical thinking and opened discussions to consider both/and possibilities" (Smith & Lewis 2011:391).

Such possibilities could be associated with "career success (O'Mahony and Bechky 2006), exceptional leadership capabilities (Denison et al. 1995), high-performing groups (Murnighan and Conlon 1991) and organisational performance (Cameron and Lavine 2006; Tushman et al. 2010)" (2011:393). Tensions inherent in paradoxes may create stress in organisations. Sensemaking and knowledgeable coping with paradoxes can be beneficial:

> "underlying tensions are not only normal but, if harnessed, can be beneficial and powerful. The juxtaposition of coexisting opposites intensifies experiences of tension, challenging actors' cognitive limits, demanding creative sensemaking, and seeking more fluid, reflexive, and sustainable management strategies" (2011:395).

This could be a beneficial approach to moving beyond traditional STS:

> "How would our research and theorizing across the Academy differ if we assumed that for every thesis there is an antithesis? Such an assumption introduces the possibility of seeking opposing views of even our most well-established organizational theories" (2011:397-398).

Paradoxical thinking could, in addition, make us aware of possible trends in modern (post-) industrial society towards merging some essentially founded dichotomies, such as those between white-collar and blue-collar work/workers, between manual and cognitive/intellectual work, between routine and non-routine work, and between theory and practice.

Conclusions

On the basis of the overview of present transformations (Part II), it is reasonable to claim that both technology and social systems/organisation are in transformation. As a consequence, the relationship between technology and social systems is also in transition. STS has developed to focus on this relationship and to develop practical, operational

approaches. However, the major changes or transitions substantiate the need to look at whether established STS positions are capable of meeting the challenges that come with the transformation.

Changes generally generate fundamental and practical contradictions and conflicts of interest. Fundamental contradiction is often referred to as a paradox. Several paradoxes have been identified above; from the overview in Part II, more paradoxes may be added:

- centralisation of decisions vs. decisions at the lowest possible level (digitalisation vs. STS)
- permanent fluctuating partnerships (fixed contract types vs. alternate contract types; flexible forms of cooperation vs. standardised forms of cooperation)
- (implied by the previous item) fluctuations in system vs. environment boundaries (what is "inside" and what is "outside")
- floating work tasks vs. fixed/permanent work tasks.

We have pointed to the relevance of the work of Pava in the contemporary transitions and have considered the introduction of a paradox approach to bring out conflicting trends and interests that have to be accepted as such if an organisation is to be able to develop viable solutions for production and personnel. It therefore makes sense to read paradox into Pava's figures. One point addressed by Pava's commentators is the supposedly fading distinction between white-collar and blue-collar work. This is related to an increase in knowledge work in both offices and factories, and ICT technology is an important influencer in this. As Trist puts it:

> "Several lines of future development are already in their early stages […], such as the dedifferentiation of the factory and office as both become increasingly characterized by computerized tool stocks. This fusion will tend to phase out the distinction between blue- and white-collar work" (1983:174).

One might ask whether this distinction is justifiable or workable. It could be that the concept of manual routine work in a pure form does not cover cognitive aspects of human labour already present in the early stages of industrialisation. Our discussion of the possible constructive outcomes of resistance indicates that even routine work needs "deliberations" to be adjusted to the existing organisational system, in addition to the organisational systems' need for "deliberations". For further elaboration on this point, it would be fruitful to apply Pava's approach to non-routine office work, as opposed to routine manual work. Consider Trist's observation about what may become of the hierarchy:

> "However much the hierarchical scaffolding may still be in the background, it is the unprogrammable sequences of coalitional formations that must become salient at the higher levels of any organization if it is to succeed in coping with substantial degrees of complexity, interdependence, and uncertainty" (Trist 1983:169).

What if "hierarchical scaffolding" was substituted by "linear manual routine conversion process"? Is it not also possible that there are non-linear conversions, non-routine and cognitive aspects in all work? To some extent, this is the core in the concept of "job crafting" proposed by Wrzesniewski and Dutton (2001). They define job crafting as "the physical and cognitive changes individuals make in the task or relational boundaries of their work" (2001:179). Jobs are not only designed by management to fulfil the organisation's purposes; they are also redesigned by the workers. Armed with the concept of job crafting, it is easier to acknowledge that there is also organisational space for paradox engraved in the dichotomies of routine/non-routine, linear/non-linear and manual/cognitive.

Paradox as a source of creativity and sensemaking

Pava reconceptualised the socio-technical organisation. His concept put less emphasis on fixed structures and regularities. Hierarchical structures and linear fixed processes move into the background, and deliberative interactions and temporary task-oriented work coalitions enter the centre of the picture. Perhaps this is less an observation of a change than a shift of perspective. Nevertheless, it allows us to adopt a different socio-technical outlook. To say that structures, linear processes and fixed routines move into the background is not to take them out of the socio-technical organisation equation, but it allows for a different kind of analysis. Focusing deliberations does not obliterate chains of command, nor do discretionary coalitions imply that the hierarchy is gone. Inside of the deliberations there are immanent organisational structures and chains of command, and the principal possibility of going beyond both of these. Seen in this way, deliberation nurtures paradox. It is a process instrument for an organisation that enables both maintenance and transgression.

Allowing for diversity by way of reticular organisations

"It may be that diversity of voices and experiences is an important characteristic of successful organizations".

This quote from Greenwood (1991:88), taken from a gentle and appreciative critique of Donald Schön as a reflective practitioner, captures another important aspect of a reconfigured socio-technical theory that is grounded in Pava's concepts but goes beyond them. Greenwood's study of the Basque Fagor cooperatives in Spain, recast in Pava's vocabulary, is a series of deliberations about the well-being, or otherwise, of the cooperatives. Reflecting on these reflections (or deliberations, as we would suggest), Greenwood endorses reflective practice, but rejects Schön's singular form:

> "Focusing on diversity inside of organizations is a very specific way of bringing this anthropological vision to bear on organizational behavior. The lesson that, within an organization, there is more than one valid view of what is going on is important. Managers and workers alike tend to treat each other's visions and experiences as defective or even duplicitous. The realization that there is room, and perhaps even an organizational requirement, for a diversity of views and experiences of an organization is an essential step in the direction of reflective practice and organizational learning" (Greenwood 1991:88).

The main reason for Pava's proposal that non-linear conversion processes are not fit for the classical semi-autonomous work group is that they tend to be accomplished by a "vocationally separatist workforce" (1983).[13] Elsewhere, he referred to this as "individualistic professionalism (extensively trained specialists)" (1986b:204). In non-routine office work, work is accomplished by individual professionals who cannot come together as a team in the same sense as manual work groups. They are too specialised to be able to substitute for one another and too individualised to have an interest in substituting for one another. Paradox thinking is an option here. Greenwood's argument is that diversity, not homogeneity, is what organisations are made of, even semi-autonomous groups in linear conversion processes. At the same time, diversity is not without limits:

> "Just as equality, in anything but its most mindless form, does not mean that everyone is equal, a respect for diversity does not involve respecting each and every way individuals differ" (1991:102).

[13] Pava defines vocational separatism as "an orientation […] that stresses the individuals and their occupational identity more than a specific collective enterprise" (1983:180).

The general tendency of theories of organisations is to offer a perspective that homogenises the organisation. A revised STS perspective (STS-B) takes account of the many interests and parties in an organisation and their fluctuating and changing interests. At the same time, these diversities and dynamics carry within themselves their own contradictions, in that they are inscribed in an organisation with set values and goals.

Power and paradox

STS theory was perhaps never the best organisation theory to address power structures and power plays. Pava's reconfiguration addresses intra-organisational conflicts but offers little inter-organisational analysis. This is no minor issue. Zuboff's critical assessment of the challenges confronting us from the present day's technologies and "the big other" confirms this (2015). How can we deal with power issues entangled in the rich and multiple transitions taking place?

As we have implied above, digitalisation is ambivalent with regard to steering and decision-making capability. On the one hand, new information systems allow for systematic monitoring and power-related control; on the other hand, they allow for decentralised decision-making and trust-based control. This paradox has been around for a long time,[14] but new digital solutions actualise it in a radical way. While the paradox was previously more of a choice of management principle, the situation following the implementation of new technology is fundamentally different.

Implementation of new technologies implies expected efficiency gains. Technology, either standard or customised systems and solutions, has a cost, and investments made are expected to yield interest through increased competitiveness and higher efficiency. Thus, the steering paradox appears more complex than previously; finding acceptable solutions will require the paradox to be accepted as such and a solution to balance the two extremes.

Closure

Faced with a paradox, you cannot simply choose between the competing tensions, because either option intensifies the need for its opposite. Present-day and future transitions will present organisations and people at work with ambiguity, complexity, uncertainty and volatility, thus bringing to new levels of intensity the need to handle paradox. In the remaining articles in this issue, several such topics are addressed and discussed. For the times ahead, we need new concepts and theories to analyse and understand work systems under different circumstances, beyond the theory that has proven itself so far. Here, we have argued that a remaking of Pava's discursive theory of socio-technical design provides a promising starting point.

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[14] See Dvergsdal & Haga in this issue discussing trust-based management and its success prerequisites.

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EUROPEAN JOURNAL OF WORKPLACE INNOVATION

Introducing a corporate concept into organisational practices: a case study of domestication and organisational choice[15]

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Abstract

This article discusses a case of introducing and launching a new corporate concept, a so-called company-specific production system (XPS), into an organisation. Such concepts are at present very commonly used, but what does it take to implement a new logic into an existing organisation? As a theoretical point of departure, the process was understood as a process of domestication, where the imported concept moves from being external, general and unfamiliar to becoming internal and known, owned by the organisational culture and embedded in its practices. Domestication is a process where the import has to be rescripted through how the organisation, as individual members and as various collectives, enacts it, makes sense of it and understands it. The organisation in this case study had a rich tradition of participation, and in the process under study, members from most levels and functions were involved in the attempts to transform the general concept into something workable and company-specific. This paper takes a socio-technical design approach, which argues that organisations importing new technology or new organisational concepts are faced with choices, not with something inevitable. The study reveals the challenges of the domestication process and how the organisation faces not one choice but a multiplicity of interdependent choices, and how handling the process calls for an untraditional, complex and participatory approach.

Keywords: socio-technical systems, domestication, choice, company-specific production systems, organisational learning, organisational routines, sensemaking, participation

[15] The research behind this article was made possible by a grant from the Norwegian Research Council's BIA program, for which we want to express our gratitude.

Introduction: importing production concepts into an organisation

The purpose of this article is to address what is taking place within an organisation when a *corporate concept* is imported. An import of a new overarching concept such as a production system will imply changes in the organisation, for better or worse, profoundly or superficially. A production system as an import does not lead to increased organisational performance unless it is well integrated. This requires planning, control and management systems, competence and expertise. It also requires the import to be well aligned with the organisation's way of operating and with its culture and cultural expressions. Through its organisational practices, the organisation's members perform actions and behaviours that put the theory of the organisation (its visions, goals, rules, procedures, values etc.) into practice. When an organisation seeks to implement a new production system, institutionalised organisational practices will be challenged.

In has become common to seek to implement a new "organisational concept" or "corporate concept". The launching of such has become a big industry (Micklethwait and Wooldridge 1996, Røvik 2011), and the menu is vast. Examples include Scientific Management, Management by Objectives, Total Quality Management, World Class Manufacturing, Business Process Re-engineering, Lean Production and Balanced Scorecard.[16] Within manufacturing industry, the term company-specific production system, or XPS for short, is in frequent use at the moment (Netland 2013). XPSs in general are built on a mix of principles from, for instance, Mass Production, Lean Production and TQM. The best-known example is the Toyota Production System, TPS, which has been a model for many other companies when forming their own production system.

"Corporate concepts", or recipes, are systems used to manage a corporation's operations at all sites, across cultures. Through such systems, companies attempt to standardise planning, control, monitoring of manufacturing and corporate culture. An XPS expresses the fundamentals about how a manufacturing system is/should be designed, organised and run. It lays out the organisation's ideas about how to focus, develop and run a production facility (Netland 2013).

In most cases, an XPS is somewhat fixed. A local production site cannot ignore or circumvent the XPS rooted in its corporate office. This means that the systems for and practices of managing operations at the local production site must be aligned to or yield to the XPS. It is important to note, however, that XPS is intended to be as much a mindset containing values and principles for leadership and ways of organising work as it is a toolbox for problem-solving or a recipe for redesign.

However, the performance potential of an XPS is linked to its ability to support and facilitate simplification and improvements in the work process and work organisation. These concepts are very general and do not take into account how working life is organised in a specific location (country, state or region). For instance, in Norway, labour unions generally have a significant influence on the governance of a company, and the rights of individual workers are also guaranteed by labour laws and collective bargaining agreements.[17] Any lack of consideration or deliberate alignment between an imported concept and key local organisational features means that the concept is poorly adapted and carries a risk of "involuntary non-use" by the organisation members (Andersen 2018). Thus, the challenges in implementing this type of concept are often insurmountable when the established practices of local working life collide with assumptions in the new concept, especially when such issues have not been given proper attention prior to implementation.

[16] The concept industry has even developed differentiated concepts for the public sector, such as "New Public Management" (NPM), a term for a whole family of different rationalising changes and reforms within the thinking of public sector management, with a strong emphasis on effectiveness and efficiency (Hood 1995, Kickert 1997).

[17] Norwegian labour laws and collective agreements also specify obligations of employees, such as the obligation to engage and participate in enterprise development efforts or safety work.

What, then, is at stake when introducing a corporate concept into an organisational practice? What are the pitfalls? How does such a process end up as the new organisational reality? These questions make up the problem statement of this research.

Consider the role of organisational choice when faced with a concept import. As a rule, the reason for introducing new organisational concepts is to improve company performance, through new and better routines, processes and practices. Nevertheless, for such improvements to take hold, the work organisation needs to be addressed appropriately. A vital principle underlying the socio-technical systems design approach (STSD) was that an organisation facing new technology is facing not inevitability but choice (Trist et al. 2013 [1963], Herbst 1976, Emery and Thorsrud 1976, Eijnatten 1993, Emery 1993, Klemsdal et al 2017). The people of the organisation and their skills, expertise and capacity will be the prerequisites for how an import is set up and used in the organisation, and it is the socio-technical system as a whole that must be addressed. Case studies utilising a socio-technical approach show how alternative modes of work organisation can be developed that exploit the same technology, giving the possibility of organisational choice. A production system does not assume its final shape before it is put into use. The socio-technical principle of choice is generic, but how choices are made, and what form they take, will vary depending on the situation (Clegg 2000).

In a case like this, aiming for an in-depth organisational appropriation of a new production concept, the likely assumption is that it is not a matter of *one* choice but of a whole series of choices, and it is also likely that there will be path dependencies between them. The socio-technical principle of organisational choice is thus correct but far too simplistic to serve our purpose. For that reason, we will pay particular attention to the idea of organisational choice. We will assume that organisational choice is a continuous component of the anchoring and implementation processes associated with the new production concept. We will also argue that the multiple-choice perspective requires customised approaches if the domestication process is to succeed.

Importing into an organisational practice: domestication by organisational routinisation, enactment and learning

An organisational practice may be defined as an organisation's particular ways of conducting organisational functions that have evolved over time and have become institutionalised (Kostova 1999), i.e., the organisation's routines as evolved over its lifespan. Such practices "reflect the shared knowledge and competence of the organisation" and tend to be accepted and approved by the organisation's members (Kostova 1999:309). Organisational practices may be partly outlined explicitly, but will also be partly tacit, embedded in the behaviours of the organisation's members, as individuals and as teams, and also woven into various organisational arrangements.

The introduction of an XPS is a disturbance of the prevailing organisational practices of the organisation. It will rarely make considerable organisational change in itself, unless the organisation adopts it and adapts accordingly. To be able to exploit the potential effects of an XPS, the company will have to focus on organisational matters and on the organisation's role in importing and implementing the new design. XPS does not provide a comprehensive recipe for this. To fully utilise such imports, companies will have to consider a number of issues, and this leaves them with a lot of choices and opportunities. In the following we will refer to this process of introducing and implementing new production systems and/or technologies as a *domestication* process.

The concept of domestication was developed by Silverstone and others as a tool for understanding the introduction of technology but will here be used for organisation concepts. Domestication in a figurative sense is making something taken from the external world applicable, meaningful and useful to the internal word. Originally a term in animal husbandry, domestication meant changing a wild animal species into one that lives in and is useful for a

household. The concept was taken up by the field of science and technology studies to describe how innovations and new technologies are appropriated by users (Silverstone and Hirsch 1992). Domestication in our case is the process by which a new XPS is conceived, made meaningful and put to use in an organisation. Domestication of an import into a system is understood as an interactive process, not as a one-way process that forces cultures and practices to reshape. As Becker (2006) argues, domestication entails cognitive, practical, and cultural/symbolic aspects. The cognitive aspects concern how the organisation's members learn the new concept, individually and among themselves. The cultural aspects concern how they inscribe meaning to it and institutionalise it as part of the presumed reality of the organisation. Finally, the practical aspects concern how to make it operational practice in the concrete work processes.

As an overarching conceptualisation, domestication serves its purpose well, but in order to understand and analyse the case in detail, there was a need for a more fine-meshed conceptual apparatus. Therefore, the concept of domestication was supplemented with theories to develop further the three aspects mentioned above. The concept of organisational routines (Nelson and Winter 1982) was used to operationalise *practical* domestication. Levin's concept of technology transfer as an organisational learning process (1993) was used to address *cognitive* domestication. Finally, to operationalise the organisation's *symbolic/cultural* domestication, Feldman (2000) and Feldman and Pentland's (2003) dual concepts of organisation routines as rule-following and generative enactment practices were used. We take the domestication concept to cover the process that follows the decision to implement an XPS, and also the phase in which the organisation explores or tries to understand the concept and its potential.

Practical domestication: concept import as a change of organisational routines

Change at organisational level requires institutional change: change that affects the organisation's behavioural patterns. According to Nelson and Winter (1982), for an organisation to have changed, it must have changed some of its operational *routines* (scripts or programmes). Routines are the consequence of people working together and gradually aligning their "behavioural relationship" to each other, thereby institutionalising the organisational practices. These new routines/scripts/programmes are then inscribed in the organisation's assumptions about itself and its ways of operating. In the phrasing of Nelson and Winter: "the routinisation of activity in an organisation constitutes the most important form of storage of the organisation's specific operational knowledge" (1982:99). Nelson and Winter proposed routines as the core concept for understanding and explaining an organisation's actions and, correspondingly, *change of routines* as the vehicle for change. A routine is a "pattern of behavior that is followed repeatedly but is subject to change if conditions change" (1982:14).

A routine is a pattern of behaviour at the organisation level much in the same way a habit is a pattern of behaviour at the individual level. Organisational routines, like habits, are often carried out without conscious deliberation. Organisations live by them and carry them out, often without noticing them. Routines are carried out "automatically": people follow them without much conscious deliberation. Therefore, they may slip into the unobserved, tacit realm. On the positive side, routines save or economise on the mental resources of the organisation members who follow them. Thus, they economise on cognitive resources; as they become more automatic, mental resources are freed up. Routines also focus the attention, guiding thinking and reducing the volume of matters that need to be taken into consideration. Routines economise on scarce capacity for information processing and decision-making. In this way, they enable an organisation to cope with uncertainty.

For organisational learning to occur, an organisation must change its routines. Nelson and Winter hold that their model best fits organisations that have some stability in their offerings:

> "since 'routine' is a key concept in our theoretical framework, the framework applies most naturally to organisations that are engaged in the provision of goods and services that are visibly 'the same' over extended periods: manufacturing hand tools, teaching second graders, and so forth, and for which well-defined routines structure a large part of organisational functioning at any particular time" (1982:97).

Thus, routines/changing routines may need some complementary concepts in order to account for an engineering-to-order organisation (ETO; for details, see the case description later in this paper) at aggregated levels, although most operations at the level of the individual worker are routinised.

Cultural/symbolic domestication: concept import as an enactment/institutionalisation duality

The concept of organisational routines has had great importance and has developed into a research field in itself (Becker 2004), and the concept of organisational routine has been developed beyond the idea of repetitive behaviour. One interesting contribution is the work of Feldman and colleagues (Feldman 2000, Feldman and Pentland 2003, Feldman and Rafaeli 2003). In these analyses, organisational routines are made in a mutual interplay between actions and patterns of actions. Routines are considered not just as regulating structures but as generative systems consisting of interacting parts. Routines contain both performative aspects (the actions that reconstitute them) and scripts/patterns of action (the ostensive aspects that embody the abstract idea of the routine), and these are seen as mutually constitutive elements. These systems of interacting parts produce stability and repetition when people (or machines) that enact routines respond to naturally occurring disruptions by making efforts to replicate previous action patterns, but they are also capable of producing change when organisation members within the routine retain emergent variations. The work of Feldman et al. is informed by Weick's concept of sensemaking and organisation as enactment (Weick 1995). Also, in play is Giddens' idea of the "duality of structure", where structures are both the medium and the outcome of human agency (1979),[18] and routines are *ongoing accomplishments*:

> "As we move toward a notion of organisation (or organising) as an ongoing accomplishment we need a notion of routine to match. The performative model of routines that I propose in this paper provides an image of routine as an ongoing accomplishment" (Feldman 2000:613).

Seen in this light, the process of importing a XPS into an organisation may be understood as partly a script, partly an invitation to the organisation to enact it. An organisation (its management) is capable (probably) of introducing and installing new routines, in the form of the scripts around new technologies or new corporate concepts, but this is only one element of the routines. They will also have to be enacted by the organisation if they are to become organisational practice.

Cognitive domestication: concept import as a socio-technical learning and development process

One key characteristic of routines is that they are repetitive; without repetition there is no routine. Nevertheless, it may be argued that repetition, or behaviour in accordance with routines, does not account for ETO practices in their entirety, since these also involve a lot of non-routine activity. Nelson and Winter's model offers an important concretisation of how something new, once installed, comes about in an organisational practice. However, the

[18] "By the duality of structure, I mean that the structural properties of social systems are both the medium and the outcome of the practices that constitute those systems" (Giddens 1979:69).

concept of the repetitive routine does not fully capture the installation, or first phase, of an import as it comes into organisational being. Levin (1993) has argued that the introduction of a new artefact/technology into an organisation should be conceived as an organisational learning process. Levin identifies technology transfer as a socio-technical learning and developmental process. Any imported artefact is also a social construction in which human choices and values determine the outcome, through a socio-technical change process, eventually succeeding when the artefact/technology is introduced practically into the organisation's day-to-day operations. As Levin notes, this argument is not trivial, since technology is usually "considered as a material artefact and not as a carrier of knowledge and cultural values" (1993:498). An equally common mistake is to design a bureaucratic and top-down introduction process instead of inviting the organisation into the process on a broad and participatory base. According to the latter perspective, there is a process of learning among the organisation members, individually and jointly, that enables an organisation to domesticate an import.

Any real change in an organisation, such as a concept import, requires organisational participation: (some of) the organisation's members must be substantially involved. From the discussion above, we are now able to present a theoretical understanding of what is involved when an import such as an XPS or a new technology is to be introduced into an organisation. We started out by noting that such an import, if it is a matter of importance to the organisation, is about successfully developing a new organisational practice or practices. Then we envisioned theoretically what is involved in such processes. For a new organisational practice to come about, the organisation must domesticate the import, making it their own, and this process includes several aspects, practical, cultural/symbolic and cognitive. These different aspects of domestication have been further conceptualised by the use of core contributions from the theory of organisations, technology transfer as a learning process, the concept of repetitive organisational behaviour as organisational routines, and the newer concept of organisational routines as part script and part agency.

A model of an organisation's domestication of an XPS

Table 1 summarises the theoretical discussions of domestication and thus provides an apparatus for seeing and understanding the processes and complexities involved when an organisation is to implement an XPS within itself.

Table 1. Aspects of an organisation's domestication of an XPS.

Aspect of domestication	Theoretical support	Examples	Challenges and dilemmas = choices (examples)
Practical: constructing practices related to XPS	XPS becomes part of the pattern through being repeatedly enacted Routinisation of activity brings it into the organisation's script	• Establish project schedule for XPS implementation with steps and decision gates • Set up implementation groups • Include subcontractors in organisation's own production apparatus	• Conflicts with prevailing practices • Concept does not work in practice • Variance, changes and instabilities
Cultural: ascribing meaning to and institutionalising XPS (values, norms, images)	Sensemaking, organisation as enactment; routinisation as script/agency duality	• Involve IR system (unions) in the translation and sale of XPS • Use familiar terms to give XPS local meaning • Develop XPS local content through group discourses facilitated by IR system	• "Not invented here" • XPS rests on "wrong underlying assumptions" • XPS challenges prevailing power structures
Cognitive: members learn practices and meanings of XPS, individually and together	Introducing XPS may be regarded an organisational learning process and a social construction, and thus requires the organisation's participation	• Training/courses to ensure understanding and commitment • Participation-based realisation in design to ease implementation	• Competence diversity • Misunderstandings • Language • ICT literacy

The table shows that domestication of an XPS, or another concept or technology, is a highly complex process that presents numerous challenges and dilemmas. Domestication is a process where a programme (imported) has to be rescripted through how the organisation, as individual members and as various collectives, enacts it, makes sense of it and understands it. Through this rescripting process, the XPS may become associated with and integrated into the organisation, but it is evident from Table 1 that as part of the domestication process the organisation faces a number of challenges, and therefore choices. The choices made along the way may not be accidental, because one chosen solution can completely or partially take away the effect of previous choices. The selected solution has to be interconnected with previous and later choices in order for the entire domestication process to be successful. There are countless examples, in terms of implementing both organisational and technological solutions, where the process has covered only parts of what should have been included and has thus failed.

The classic literature on STSD (Trist et al. 2013 [1963], Herbst 1976, Emery and Thorsrud 1976, Eijnatten 1993, Emery 1993) emphasised that organisations facing new technology were facing not inevitability but choice. On our reading of this, choice is first and foremost the opportunity to build an alternative to the Taylorist organisation, one based on more holistic jobs and where the individual worker and the (autonomous) team are responsible for a set of

tasks including job planning, job execution, quality control and final reporting. In this literature, choice is more about the guiding principles of organisational design and less about the structural and processual choices to be made in implementing a new organisational concept or technology. The latter are the focus here.

Methods: an interactive approach

The empirical basis for this article is a case study (Yin 2017) over a time span of two years. It is based on action research and interactive research design, in which researchers and groups of partners have worked together to develop new knowledge. Two traditions of research close to the organisation were combined: action research-oriented organisation research and design/development-oriented operations management research (Coughlan and Coghlan 2002). The research team also drew on close cooperation between the researchers and members of the enterprise organisation: insiders played a full part in the whole research process (Coghlan 2003). The concept of interactive research emphasises a shared process between field and research in most or all phases of the research (Holtgrewe et al. 2015).

Among the number of organisation members engaged in different arenas during the initial stages of the project, more than fifty people had a direct voice. There were interviews, encounters, meetings, presentations and discussions, at various workstations and in offices, seminar rooms, canteens and boardrooms. Data types include analysis of secondary data (meeting minutes, reports, presentations, company figures and statistics, and industry statistics), observations, interviews and attendance at meetings.

Organisation members and researchers collaborated in most phases of the research: studies, fact findings, reflections and conceptualisations, and in the case itself. The case study report is based on a thorough and comprehensive organisation process. The number of arenas in which the understandings were put to the test by various groups of organisation members serves as a series of member checks. Member checking, or participant validation, is an established technique for validating the trustworthiness of results (Lincoln and Guba 1985), and it is reasonable to claim that this case study is a credible report of the process taking place. There is no claim of generalisability for the findings, but they shed light on many challenges, opportunities and options that are likely to find parallels in similar projects undertaken by others.

Case study: the yard

Offshore topsides and onshore processing facilities are unique complex products created in similarly complicated processes. The completion time of the projects is compressed through parallel implementation of engineering and construction, and processes are characterised by the involvement of many subcontractors and suppliers who deliver modules (e.g., steel structures and pipes) and other equipment that will be installed at the yard. This way of implementing projects causes uncertainty and leads to many changes, as the design of the complex products has not yet completed when fabrication starts. Galbraith's proposition describes the challenge well: "The greater the task uncertainty, the greater the amount of information that must be processed among decision makers during task execution in order to achieve a given level of performance" (1974:28).

The case project aimed to develop a XPS: a system to cover and integrate the entire ETO value chain. The need for smooth processes including a high number of subcontractors was paramount, not least if the yard was to enter new markets. The overall aim was to establish strong (healthy) linkages between generic concepts for technology and production systems and the distinctive contextual manufacturing characteristics of the case, thereby developing a methodology for better adaptation/mutual adjustment between corporate concepts (recipes) and typical local

manufacturing traits. In the preparation phase of the XPS project and up to the final go/no go decision, considerations around different choices had to be carried out. Questions about all forms of domestication were involved: practical, cognitive and cultural. During the initial period of the R&D project the steering of the corporation that the yard was part of was centralised. Various former independent companies were merged into one joint company. Again, this was a situation that led to a number of choices being made; in particular, cultural and cognitive domestication challenges had to be addressed.

Additionally, after initiating the XPS project, the yard decided to initiate in parallel a large digitalisation project. A pilot study involving a core group of employees and a large number of interested parties working in the affected areas was conducted, and a recommended roadmap was prepared. The pilot study identified a number of areas to be addressed, and a number of development projects within each of these areas. The two initiatives, the XPS and the digitalisation project, were thus set up with separate project management teams, even though there were some interfaces, thereby creating a tension that may have prevented the organisation from fully examining the possibilities for optimising the socio-technical system. Assigning a relative weight to the development of the XPS and of the new technology was another cognitive choice that had to be made during this initial phase. Dealing with such uncertainty required deliberate choices to be made. For example, what assumptions should be made about the implementation of the XPS? What would be the technological point of departure when the XPS was fully developed?

The company's existing project execution model (PEM) covers the entire ETO value chain. The main process in the PEM is divided into five major phases: feasibility and concept, system definition, detailing and fabrication, assembly, and completion. The main phases contain a number of major dated milestones. For example, the system definition phase contains three milestones: (2A) critical purchase orders awarded, (2B) main layout/structure frozen and (2C) global design complete. Each of these milestones calls for detailed information to be transferred to meet the milestone requirements. The PEM thus contains comprehensive and detailed descriptions of the tasks in the value chain.

The main challenge is that the PEM is extensive, communicates poorly and is perceived as inaccessible. Furthermore, the degree to which the PEM is used varies according to the phase in the project; for example, it is used more in engineering than in assembly. However, the PEM provides a necessary, step-by-step description of the various steps in the completion process. As a consequence, clarifying the relationship between PEM and XPS was crucial and called for a whole set of cognitive domestication choices to be made.

Participatory arrangements

The yard has a tradition of participatory operation and takes pride in this. Unions and employees are involved in many ways and play important roles, including in making choices. To comprehend the relationship between management, unions and the employees, it helps to understand how the cooperation structures are set up to ensure dialogue and participation. Table 2 shows how the unions and the employees have a number of arenas where they may influence strategic choices and promote proposals for improvement/change. Combined with a focus on dialogue, this enables them to play an active part in the development of their own workplace.

Table 2. Democratic bodies in the yard's IR system.

Body	Members
Board	The owners and union representatives are members of the board.
Company committee (BU)	The management and the unions are members of the committee. The chairmanship alternates between management and union representatives.
Department committee	The department manager and employees from the department are members.
Yearly cooperation conference	Each year a conference is arranged that focuses on cooperative business development.
Work environment committee	Management and elected safety delegates are members. The chairmanship alternates between management and union representatives.

The production system

XPS was not a familiar concept for the yard. The concept was presented to personnel from the company development department by their research partner. The development department were superficially familiar with the most famous production systems (such as Toyota's) without, however, having any knowledge of the details of such a system.

The R&D project

After the introduction of the XPS concept, a dialogue was initiated between the company-internal development department and the researchers around the concept and company's possible use of it. After an incubation period during which the idea of running an R&D project matured with both parties, it was decided to develop an R&D proposal and to apply for financial support from the Norwegian Research Council (NRC) for a four-year programme to develop and implement a production system. An application was developed by a joint team from the company and the research partner, and the application was accepted by the steering committee. The application was approved by the NRC, and the project was launched shortly thereafter. The company appointed a project manager and an internal project team consisting of personnel from different departments as well as union representatives.

The process

The case company's production system (KPS) was developed over a period of approximately a year and in two steps. To develop and document KPS, a core team of participants from the company and the research partner was formed. Fundamental input was obtained through a series of team workshops. The team was put together to cover the different parts of the organisation and the production process, and union representatives also took part in the workshops. A number of issues were on the agenda.

First, it was necessary to achieve alignment over the XPS concept. In short, an XPS expresses the fundamentals about how a manufacturing system is/should be designed, organised and operated: what the idea is, why it is needed, whether all of it is useful, what should be understood in terms of fundamentals etc. The concept had to make good sense for the personnel involved. Second, it was necessary to figure out what the fundamentals or the main elements in the company's operation were and how these elements could be visualised. Third, it was necessary to detail the different elements to make them understandable for employees who were not part of the core team or the team workshops.

Between workshops, the participants discussed what had been on the agenda of the latest workshop with their co-workers in their departments. In this way a number of questions and suggestions were raised and brought back into the workshops. This included judgements about the different types of domestication, for example, in the third step mentioned above, where familiarity of concepts and their cultural understanding is crucial.

The preliminary proposal

Throughout the process we hoped to collect the information base needed to design a first version of KPS. Based on the information made available from the workshops, the core team created a model and an accompanying description of the system (Figure 1). These main elements were identified: identity carriers, collaborative IR model, knowledge seekers, industrial mindset, synchronised parallel activities, integrator/scope control, information model and future skills.

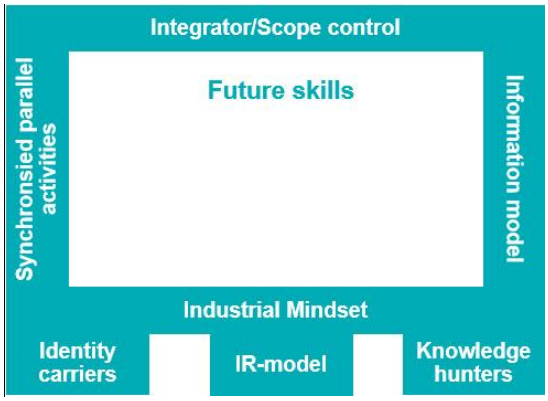

Figure 1. First draft of KPS.

This first version was presented at a number of workshops. On the basis of the feedback received, the first version was rejected, and it was concluded that a second version was needed. In essence, the feedback indicated that there were inconsistencies in the first version's elements, the main parts explaining the company's operation. These elements were somewhat overarching and needed to be grounded in a set of principles that would explain the content of the element. For instance, the "IR model" was identified as an element. To give this element a content, the following principles were identified: equality and team spirit, trust, down-to-earth management, conflict resolution proficiency, focus on training, and distributed involvement, responsibility and judgement. However, the distinction between element and principle was blurred, while some of the elements made it difficult to establish supporting principles. Thus, selecting a set of superior elements understood to be at the same level of abstraction turned out to be dependent on a number of trade-offs and choices. Furthermore, the core team learned that there were conflicts of interest, internally and otherwise, in the organisation, creating dilemmas about which elements to choose.

The company committee (see Table 2) was kept up to date during the KPS development period and had the opportunity to discuss its progress and to make suggestions during the process of developing the first draft.

The revised proposal

The core team, equipped with written feedback on the first version of KPS and detailed feedback from a number of gatherings and from reflection within the project team, revised the model and came up with an advanced proposal. This new model was presented to local management and received their endorsement. The production system presented here is the final version prepared by the project team and contains six elements: credible contactor, partnership, technology, people, industrialisation and company culture (Figure 2). Each of these elements in turn consists of a set of principles, the numbers varying from element to element (Bakås et al. 2019).

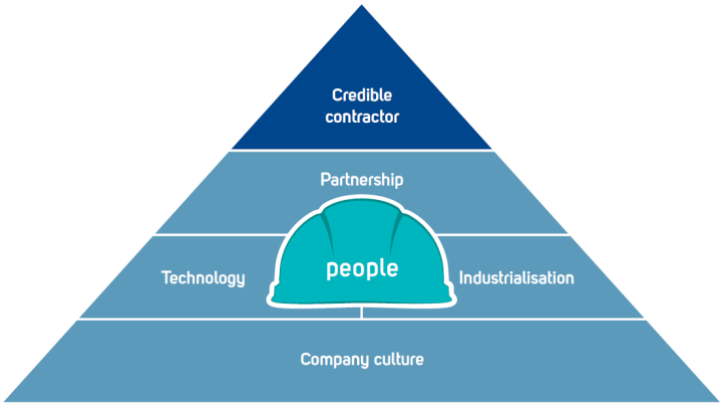

Figure 2. Final version of KPS.

Implementation process and choices

When a new concept is introduced, most likely it will be the specialists in the company who are the recipients. To clarify the content, the specialist will research the new concept. This includes retrieving information about who has already taken the concept into use and what experiences they have had. If these investigations indicate that the company should consider using the concept, an assessment will be made to establish its relevance. This process is about understanding and reflecting upon relevance and ways in which the concept may enhance efficiency and/or develop the organisation. Does the new concept make sense? Will the investment yield the return required to cover the investment cost and to increase earnings?

If the concept appears interesting, the next phase is likely to involve setting up a task force with a mandate to examine advantages and disadvantages, costs and possible efficiency gains. In addition, the mandate will probably set out an expectation of how development, testing, training and implementation may be accomplished. The decision on go/no go for such a task force will, in most cases, be made by the head of the development department. This phase involves transferring the concept and/or technology from something external to something internal; i.e., it takes on the flavour of a company-internal concept. If, on the basis of the task force evaluation, the company decides to realise a project and implement the concept, this will be left to a task force with a broader composition. The composition is absolutely crucial if it is to be possible to develop solutions that suit the organisational culture and competency. The same goes for the way the implementation is intended, how it is presented, the training etc.

The last phase in such a process is operationalising the new solution in the organisation. This crucial phase tends to receive relatively little attention. However, routinising the new technology, solution or organisation entails turning the new way of working/the new organisation into *our* way of operating.

Table 3 summarises the process leading to the establishment of innovative projects, and the phases that projects go through before a new solution, organisational and/or technological, is implemented.

Table 3. Phases and associated actors.

No.	Phase	Participants
1	Pick up and understand new concepts or technologies	Specialist environment in the company
2	Assess possible use in the company/corporation	Specialist environment in the company
3	Translate concept/technology into the company/corporation (language: problem to be addressed, approach etc.); start giving the concept a local content	Specialist environment in the company
4	Establish a participative organisation that continues the process of making this an internal project; make the concept a company-specific one with company-specific content	Work group (union, management)
5	Run a development project to realise the initiative	Work group (union, management)
6	Establish a project schedule that takes the project through several steps and decision gates	Work group (union, management)
7	Perform the development steps and develop the final solutions	Work group (union, management)
8	Implement the final solution	Work group (union, management) and implementation group

At such a general level, it is possible to establish a common step-by-step process for an improvement project regardless of whether it is organisational or technological. Nevertheless, we see that there are differences, including in the anchoring in the collaborative system that has been established between unions and management.

Discussion

As van Amelsvoort and Hootegem noted, "ICT systems profoundly determine organisational design choices, as they create the technical context within which many organisations are operating and, hence, they also affect the social work system" (2017:295). This is an apt way to describe the role of a corporate concept finding its way into an organisation. The discussion here focuses on how better to draw the consequences from this. How can we better conceive of the processes by which a new XPS becomes workable in an organisation? How does an organisation act in order to integrate its import into itself?

In the theoretical discussion of the process of importing a corporate concept into an organisation, it was argued that such a process must materialise in the form of new organisational practices. In order to reach this point, the organisation must go through a process of domestication to make the import its own, and this process consists of many elements. It is routinisation of new scripts, it is an organisational learning process, and it is sensemaking. It is an enactment of the new organisational practices that takes place both through (repeated) practising of the new recipes and through their reinvention. Most noticeably, the process is composed of a number of choices.

Table 3 indicates how such import processes may be organised in a set of phases or steps that will be part of most projects. Each aspect of domestication will have varying importance in the different phases. In the initial phases, the import is still somewhat loosely defined and open to interpretation, and it tends to involve relatively few

organisational actors. This phase will involve sensemaking and learning, in particular. As the domestication unfolds, the import gains weight: more detail is added, and it becomes more concrete, to the extent that it is possible to simulate its unfolding within the organisational processes. In these phases where the concept is understood, interpreted and translated, many choices are made. One chooses to interpret the concept in one direction or another, and these choices give clear guidance on how the concept will be understood in the subsequent phases. Nevertheless, this part of the implementation process is controlled, owing to the limited number of people involved and their common competency and experience. As the process continues, more people, and more diverse perspectives, are brought into the process, including opposition voices. Since this process gradually involves more people, and since the import equally gradually grows in detail and concreteness, the various aspects of domestication will have to overlap. Even if a number of issues have been resolved during previous steps in the process, subsequent steps are also filled with decisions. However, with the increasing number of people, backgrounds and interests involved, reaching consistent decisions becomes more demanding.

Table 4 shows the process of domestication that the yard went through. The different stages involved a varying and increasing number of organisational actors, and a varying set of organisational dynamics: learning, sensemaking, routinisation and enactment.

Table 4. Phases, actors and aspects of domestication.

No.	Phase (step)	Participants	Domestication aspect
1	Pick up and understand new concepts or technology	Specialist environment in the company	Learning process Sensemaking
2	Assess possible use in the company/corporation	Specialist environment in the company	Learning process Sensemaking Enactment
3	Translate concept/technology into the company/corporation (language: problem to be addressed, approach etc.); give the concept a local content	Specialist environment in the company	Sensemaking Enactment Routine drafting
4	Establish a participative organisation to oversee the internalisation process (to make the concept/technology company-specific in its content)	Work group (union, management)	Learning Sensemaking Enactment
5	Run a development project to realise the initiative	Work group (union, management)	Sensemaking Enactment Routine drafting
6	Establish a project schedule that takes the project through several steps and decision gates	Work group (union, management)	Sensemaking Enactment Routinisation
7	Perform the development steps and develop the final solutions	Work group (union, management)	Routinisation Re-routinisation
8	Implement the concept or the technology as organisational practice	Work group (union, management), implementation group	Routinisation Re-routinisation

Within the socio-technical school, perhaps especially within the Scandinavian school of Democratic Dialogue, it has always been argued that any real change in an organisation requires deep organisational participation. Members from all levels and functions concerned must be substantially involved and engaged. Developing and implementing an XPS is as much a matter of developing a mindset and a set of practices of the organisation members as of setting up a set of disciplinary structures. The development of an understanding shared by all requires a persistent and

supportive leadership who understand how to invite the organisation to participate. This requires high-level interplay between skills (individual as well as collective), technology (parts as well as the overall system) and participatory management (hands-on management as well as leadership).

The case studied here is typically Norwegian in terms of industrial relations and participation: most employees are unionised, there are high levels of direct participation (and expectations about participation), and several governing bodies are in place, including union representatives. Cooperative and constructive industrial relations are seen as a resource for dealing effectively with disagreements and for developing high levels of trust and communicative skills all across the subgroups of the organisation. The *collaborability* of an organisation is its proficiency in communication and cooperation across levels, departments, professions, functions, positions and interests (Ravn and Øyum 2009). High-performance collaborability gives companies a competitive edge within both operations and innovation work, because the organisation gets faster and smarter and improves its learning proficiency. All this is perceived to reduce the costs of co-ordination and control and to ease the implementation of decisions.

However, the complexity of the choices inherent in the implementation of the new organisational concepts, combined with a culture of wide and fundamental participation, presents a dilemma. When inviting an organisation to participate widely in implementation processes, conflicts of interest make it inevitable that optimal solutions will not be identified. In this way, participation may prevent the organisation from finding optimal solutions (to prevent open conflict). The way interaction and collaboration take place within companies may be a driver that makes it impossible to identify and agree upon the best solutions. Is it possible to cut this Gordian knot?

Calvin Pava's alternative STSD approach for the non-routine office work is helpful here (Pava 1983). In his work, Pava developed an alternative to traditional STSD. While studying specialist teams in office environments characterised by non-routine tasks, he observed situations that could not be handled with traditional participatory STSD, because they were "too non-routine": too complex, too diverse and too dynamic. Pava coined the phrase "virtually saturated interdependence" to describe an organisational situation marked by "complete interrelation of all variances in a work system" (1983:180). Under such circumstances it is hard to develop designs for work processes. Instead, Pava focused on the organisation's discursive capacities, using concepts such as "deliberation", "discretionary coalitions" and "dilemmas" to describe ways of working and of solving problems in non-routine settings. Pava's work is a promising point of departure for how to proceed and deal with a dilemma like the one presented in this case. His perspective involves a change in approach, away from work process design and toward a focus on the deliberations needed to take place, and the discretionary coalitions and personnel needed in these deliberations. Transferred to an implementation setting in an organisation, Pava's approach may allow for a more varied and selective use of people in the different stages of the process. His approach calls for involvement of personnel who may contribute to finding the best solutions, not a specialist regime in the strict sense; this will have to be tested and elaborated further.

In a case like the one discussed here, the organisation is staffed with competent people from many levels and functions. Furthermore, because of the participatory traditions, many of the employees, and not only the manager, are "competent at discourse". They have experience of being involved and are able to take responsibility. This opens up the organisational ability to handle Pava's recipe for non-routine office work, not just in managerial offices but also on a wider scale. As has been shown, cooperative industrial relations, the ability to deal constructively with disagreements, and high levels of trust and good communicative skills may all contribute to reducing the costs of co-ordination and control and to easing the implementation of decisions (Ravn 2017).

Conclusion: choice as a trigger for domestication of new organisational concepts

This case study has shown the complexity and difficulty of developing and implementing a new logic in the lived world of an existing organisation, and how broad participation from the organisation may not always ease the process. Implementation of new technology and new organisational concepts require a number of decision (choices) to be made, and these choices have to be handled in relation to one another, otherwise one decision might conflict with another and the process will fail. Organisational ownership of the import requires involvement and participation, but it is a significant challenge to achieve a coherent set of choices and decisions in a participatory process involving a high number of participants where levels of complexity are similar to those in the case under study here.

The STSD literature has always argued that participation adds quality and offers solutions that are in no way inferior to pure expert designs. This case does not seek to contradict this position but argues that organisational challenges in situations marked by high dynamics and complexity pose a challenge to the idea of broad participation. A participatory process with a high number of diverse participants and high stakes that requires a large number of interrelated choices to be made, and made well, poses a dilemma that few traditional STSD approaches have addressed. Pava's approach, developed for the non-routine office work of professionals, may allow for more coherent deliberations and decisions, even in a complex manufacturing setting such as the one studied here.

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EUROPEAN JOURNAL OF WORKPLACE INNOVATION

A Socio-Technical Perspective on the Digital Era: The Lowlands view

Mark Govers
Pierre van Amelsvoort

Abstract

Given growing global competition, organisations face the dual challenge of creating workplaces that are, on the one hand, more productive, agile, and innovative, and on the other hand, healthy places to work. At the same time, we are facing a digital revolution with profound consequences in work and daily life. Digital technologies have potential opportunities, but also constraints. To make the transformation successful joint optimise of social and technical systems is necessary. The sociotechnical systems design theory (STS-D) and practice have focused the last 70 years on this challenge. Over the years, different STS lenses have developed like participative design (North America and Australia), democratic dialogue (Scandinavia) and organisation design (the Netherlands and Belgium, the Lowlands). All have in common the aim of designing modern organisations that are humane, productive, agile and innovative. Also, digital technology has developed over the years: from digitisation to digitalisation, and lately into digital transformation affecting societies, organisations and humans. With this article we take the Lowlands STS-D theory as perspective and we discover how this theory, especially the design sequence, should be adjusted to apply successful digital technology. First, we zoom in on digital technologies and its opportunities. Second, we zoom in on the STS-D Lowlands design theory its principles and organisational design sequence. The original design sequence requires adjustment from a digital technology perspective. We propose a combined approach from a digital-technical and social perspective. We end with new routines for designing modern 21st century organisations that facilitate organisational and digital experts to jointly optimise both perspectives in practice.

Keywords: socio-technical systems design, systems thinking, digital transformation, workplace innovation, design routines and sequence, quality of working life, bureaucratic and agile organisation.

Introduction

Given growing global competition and the predicted shortages in the labour market, organisations, nowadays, face the dual challenge of creating workplaces that are, on the one hand, more productive, agile, and innovative, and on the other hand, healthy places to work. There seems to be a need for workplace renewal to transform traditionally siloed organisations into modern 21st century organisations that meet these challenges. In manufacturing, the term Industry 4.0 is widely used to frame this (Kagermann, Lukas and Wahlster 2011; Liao 2017; Stock and Seliger 2016). Laloux (2014) talks in more general term about reinvented organisations. In these 21ste century organisations the human factor continues and remains to play a crucial role. Nevertheless, it calls for renewal of the workplace, with a focus on change structurally (through division of labour) and culturally (in terms of empowerment of staff) to enable employees to participate in organisational change and renewal and, hence, improve the quality of working life and organisational performance. Sociotechnical systems design (STS-D) theory is based on agile instead of siloed ways of organising, and, therefore, STS-D could help to transform these traditional, inflexible, and, consequently, organisations with limited innovative capability. Traditional siloed organisations, however, are defined by and embedded in their structures, support systems, decision making systems, facilities and IT systems. These organisations are, due to their focus on maximising the division of labour and central control of work processes, designed for stable environments and mass production. Hence, they are not well-suited to respond to the need to be agile in a dynamic environment with ever changing customer demands. Therefore, to realise new ways of organising an integral approach to systemic change in the organisation is needed.

Digital technologies, on the other hand, are in the spotlight and are unfolding at a fast pace. They offer new, unprecedented digital and technological opportunities to market new business models and related products and services. In order to fully utilise these opportunities, organisations should be able to cope with these technical features by jointly optimising technical with social features in their context (Walker, 2018). This implies that, besides the technical, improving quality of working life should be considered as well. STS-D theory has a long and standing tradition in jointly optimising both social and technical factors resulting in more and lasting effective organisations. Combining the digital opportunities and STS-D seems to be a promising combination.

STS originates from the insights from the Tavistock Institute in the 50s and 60s (Trist and Bamforth 1951; Emery and Trist,1969). In the study of the implementation of new technology in the Durham mines, two important lessons can be learned. First, only focussing on technology effected in a lower productivity and a decline of the quality of working life. Second, a participative approach with a simultaneous focus on technology and social aspects gave an improvement of both productivity and quality of working life. Nowadays in the digital area, we are confronted with the same question. How can the digital transformation with a dual focus be successful in terms of increased both productivity and quality of working life? With the lessons of the Durham case in mind, we think the STS-D approach has a good proposition.

Over the years, it has world-wide developed into various STS-D directions, like participative design in the USA, Canada and Australia, democratic dialogue in Scandinavia and organisation design in the Lowlands. (Van Eijnatten 1993; Mohr and Van Amelsvoort 2016). All have in common the design of modern organisations, that are humane, productive, agile and innovative (Mohr and Van Amelsvoort 2016). In this article we take the Lowlands STS-D view in which the division of labour is central (De Sitter et al 1997; Vriens and Achterbergh 2011). We consider division of labour to be key as it offers a common starting point for both digital and organisational design. The division of a transformation process into tasks and roles, which are allocated to people and machines leads to designing execution tasks (production structure) and related regulation tasks (control structure).

In the introduction article of this series, Claussen, Haga and Ravn (2019) wonder whether current STS theory still is a platform to deal with the challenges of globalization, digitalization and technological platforms or whether a new STS, which they call STS beyond, is needed. In this article, we approach STS beyond from the Lowlands view

on STS by focusing on the following research question: what are the implications of digital technologies for Lowlands' STS-D theory, especially its design sequence? This is a relevant question for the following reasons. The transforming nature of digital technologies on economic systems, organisations and humans (McAfee and Brynjolfsson 2017, Brynjolfsson and McAfee 2014) has "blurring" effects on system and work relations. The system boundary between what is in-side and out-side becomes more fluid. The differentiation between executive and regulations tasks performed by man and machine also becomes more fluid. Consequently, these blurring effects would affect the design sequence of the Lowlands view on STS. The design sequence may have to incorporate digital affordances for designing 'joint optimisations' between digital technologies and people working in collaboration.

To understand the Lowlands STS approach for designing organisations in the digital era, we explain first in-depth its core organisational design principles. This is followed with a 'STS beyond' view on the Lowlands view by emphasising an integral design sequence to utilise the potential of digital technologies and improve quality of working life. We start the article with explaining our understanding of digital technologies and transformation.

Digital technology and transformation

Technological developments, like data analytics, robotics, big data, artificial intelligence and internet of-things, are positively and negatively affecting existing social relations in a political, cultural and economic sense (Bounfour 2016, Hann 2016). Minorities make their voices heard through social media, and by doing so influence public opinion. Children become addicted to their smartphones and alienated from physical reality. Mothers set up web shops and compete with large companies. It is, therefore, not a matter of digital technology per se but of the social impact of applying and using digital technology. These changes have consciously to be designed, in order for their effects to be or to become positive. In this contribution we zoom in on this and limit ourselves to the consequences in and for organisations. We show how this can be dealt with from an agile, socio-technical perspective.

Digital transformation integrates digital technologies into all aspects of society (Hanna 2016, Harari 2018). As a result, relationships and interactions between actors change fundamentally. Despite the fact that digital transformation is referred to as the fourth industrial revolution, this revolution goes through roughly three digital evolutionary phases (see figure 1):

- *Digitisation* is the first phase. It concerns the conversion of analogue carriers of data (paper) to digital carriers (databases). This phase began in the 1960s and is still in full swing.
- *Digitalisation* is the second phase. It concerns the adaptation of digital technology in business processes. The massive introduction of transaction and management information systems, such as enterprise systems (ERP), at the end of the 1980s marks this phase. This phase is still in full swing.
- *Transformation* is the third stage. It concerns the creation of new business models based on the possibilities of digital technology and platforms to integrate business processes. This third phase fundamentally changes the way in which organisations operate and how organisations realise value for customers. It also implies that the way they think about organising and managing has to transform and that they must learn to look more holistically.

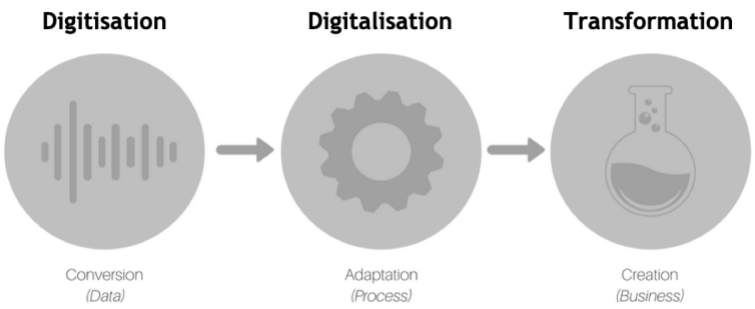

Figure 1. Phases of Digital Transformation (based on: Maltaverne 2017)

The digital transformation is unfolding at a fast pace. This offers new, unprecedented opportunities to market new business models and related products and services (e.g. Rogers 2016, Evans 2017). A business model describes the design of the creation, delivery and capture of value (Osterwalder and Pigneur 2010, Teece 2010; 2018).

New business models triggered by digital technology are, for instance, grounding on free, platforms, data, artificial intelligence (AI) and crowdsourcing. These grounds are, in practice, combined into actual business models. The free business model is possible once offerings to the market are converted into a digital service. The offerings can be copied without any additional costs and without loss of quality. It becomes free, prefect and instant (McAfee and Brynjolfsson 2017). WhatsApp and Skype are examples. The economic value of free comes from the network effects of bringing many users together and from the data users generate (e.g., preferences), which can be turned into revenues (e.g., via personalized advertisements). Viability can also be built on subscriptions. Free is, then, a stripped-down of the full fee version that has to generate revenues. Free business models often go hand-in-hand with platform driven business models (McAfee and Brynjolfsson 2017). Digital platforms bring supply and demand in an unlimited and unrestricted way together, which can result in networks with users running in the millions. Platforms often do not own the physical resources for actually delivering products or services. They just own the platform that facilitates interactions between demand and supply. Examples are Airbnb and Uber whom do not own hotels or taxis but make hotel stays and taxi rides possible. Data and AI go hand-in-hand as well. Interactions in business processes generate data related to behaviours of for instance customers suppliers and employees (Mayer-Schönberger and Ramge 2018). Analysing data reveals new intelligence to manage organisations and to feed decision-making processes. Based on gathered data and with AI, machines can take over defined decisions, like granting of loans. This trend is called data-driven decision-making (Brynjolfsson and McElheran 2016, Lepri et al. 2017). New business models can also emerge from involving the crowd, so-called crowdsourcing (McAfee and Brynjolfsson 2017, Hossain and Kauranen 2015). The idea is that the crowd has more wisdom then any organisation can ever hire. An interesting case is Hyperloop HTT in which they involve 800 engineers to develop a hyperloop transportation system without being employed and paid by HTT (Majchrzak et al. 2018).

Digital triggered business models often transform and disrupt existing industries; see the text box for two examples from healthcare. According to the European Commission (2018:1): "digital transformation holds the key to unlocking future growth in Europe". Threats are, also, lurking because it can overthrow existing business models and related products and services: so-called disruptive effects of digital technology (Mayer-Schönberger and Ramge 2018). Inspired by Sombert (1863-1941), the economist Schumpeter (1883-1950) talked in the 1930s about the process of creative destruction: successful applications of new technology, for example, destroy old professions and

at the same time create new ones. To use the possibilities of digital technologies there is a need to rethink and design new ways of organising the work system.

Examples of unexpected, disruptive effects of digital technologies in healthcare *(Philadelphia, 2019)*

Social robots
A robot with speech recognition and machine learning was used in a care institution for mentally disabled people. The care givers disliked it, because they believed that face-to-face interaction is the cornerstone of good care. Yet the client told the robot much more than ever before to nurses. Besides the ethical question whether this information can be used in the treatment, it implies that the work of nurses will change. Care givers should be able to analyze the interactions between the mentally disabled person and the robot in order to better understand the needs and peace of mind of mentally disabled person. This requires more complex competences from care givers. In other words: the robot changes the nature of the nurses' work by requesting different and more complex competences.

Smart incontinence
Diapers contain wearables to measure moisture, so that it is known when the diaper needs to be replaced in contrast to planned moments. This was at odds with the planning of the carer givers. Due to the sensor changing the diaper depended on the individual patient and his/her context. Analyzing the data showed for instance, that after regular replacement of a diaper the moisture meter of some patients went over the trace-hold again after they were set straight. From this notion, patterns were discovered that each patient has his/her own pattern of needing to urinate and is reacting differently to the way the diaper was changed. So, in other words digital

STS-D theory: The Lowlands view

Digital transformation impacts the division of labour and the division between man and machine. Digital technologies fade away the boundaries between organisations (for example: virtual teams) and make it blurry. Customers are more and more involved in the core work processes (for example: booking an airplane ticket), horizontal co-ordination on digital platforms is possible and execution and control can be integrated (for example: Amazon). Machines are replacing humans in routine and non-routine work and new types work for humans are emerging. For this division of labour between man and machine, it is important to have a common understanding about 'what is work?'. In this respect, the Lowlands STS-D theory provides a general and valuable framework, given that core work processes are rooted in a dynamic systems-theoretical perspective of work and organisation (Kuipers, Van Amelsvoort and Kramer 2018, De Sitter 1994, De Sitter et. al. 1997)

An organisation's core work process is the primary process of an organisation, such as, making products or providing services (Van Amelsvoort and Van Hootegem 2017). How these products or services are produced, i.e. how the core work processes are organised, largely determines the extent to which the organisation's products or services create added value for customers. Hence, orchestrating an organisation's shift towards workplace renewal: related goals, performance and quality of work, typically requires a redesign of the core work process. In this respect, STS-D theory provides a valuable framework, given that core work processes are rooted in a dynamic systems-theoretical perspective of work and organisation (Kuipers, Van Amelsvoort and Kramer 2018; De Sitter 1994, De Sitter et. al. 1997). The design of the core work processes determines the needed degree of (central) co-ordination and the possibilities for (shop floor) self-organising capabilities. A maximum division of labour creates the need for central co-ordination and hierarchical control whereas a minimum possible division of labour creates conditions for self-organisation and horizontal co-ordination (i.e., more job autonomy). Given that organisations are complex social systems, a systemic view as offered by STS-D is helpful in redesigning organisations when

required by changing economic circumstances or introducing digital technologies. Organisations based on maximum division of labour have difficulties in coping with economic changes and the digital transformation, while agile, flow-based organisations are better equipped to handle change and turbulence (Kuipers et al. 2010).

The Lowlands STS-D theory suggests that, as a result of the division of labour, the organisation is an interacting network of people and machines executing tasks and roles, using (ICT) technological instrumentation, tools and machines. These tasks and roles are thus allocated to individuals, teams, departments, business units and to a network of organisations. STS-D makes the distinction between production and management in the following manner:

1. the structure of executing activities (the production structure of the core work processes: PS) and
2. the structure of control activities to manage the core work processes (the control structure: CS).

In both execution and control, digital technology will take over work of humans. At the same time, new work will occur. In STS-D a role or task is the work that needs to be done, which is often related to the work of other people/machines. This is not limited to people in one organisation. All these roles and tasks together constitute the whole of the core work process. In other words, all these roles and tasks together complete the whole task of, for example, a team or an organisation. The notion of whole tasks implies, in theory, that there is no division of labour at all, such as for example, when a team is making a complete end-product from start to finish. This is, however, almost never the case, and therefore, roles can be seen as nodes interacting with other interdependent nodes to complete the core work process (see figure 2). A node is a point where several inputs and outputs from different interaction partners come together to do the work.

In STS-D, as an offspring of systems theory, inputs are transformed into outputs as in the input-throughput-output model. The core work processes function in a similar vein at every level, such as at the level of tasks, jobs, teams, departments and the organisation as a whole. At the nodes, inputs are therefore transformed into outputs or outcomes, meaning that resources are transformed into products or services. Interaction between nodes, for example, the collaboration of individuals in a team, is necessary for a number of reasons, such as: the exchange of information, knowledge creation, planning and/or coordination, and deliberation. Team members are, for example, dependent on each other's task execution. At the nodes, interactions happen with both internal and external interaction partners. In order to ensure productivity either directly or indirectly, these various interactions between nodes need to be established at the right time, between the right jobs, with the right material or information and at the right place. Otherwise, production gets delayed or mistakes become a risk.

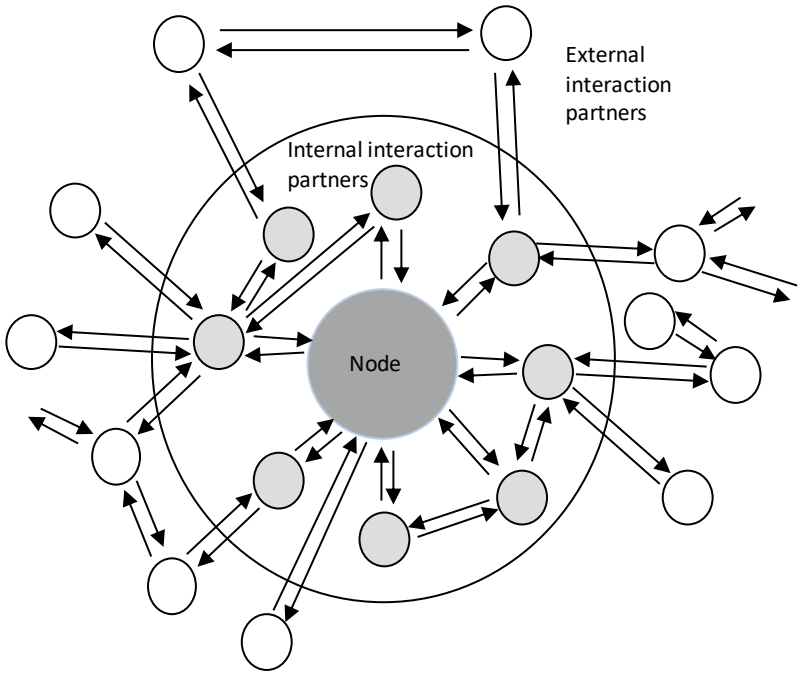

Figure 2. The interaction network with nodes (Kuipers et al., 2010)

However, these (un)planned interactions or deliberations (Pava 1983) between nodes can suffer from interferences, due to variance that is not accounted for in the original planning of the production in the core work processes. For instance, in the building and construction industry, different parties have to collaborate to get the job done, as they are connected in specific supply-chain models. If one of the parties withholds information or drops out of the project unexpectedly, this will interfere with the other parties' capability to get the job done. In this sense, a node has to cope with two types of variance (Vriens and Achterbergh 2011):

- external variance: such as lack of information, communication errors, changing customer demands, incomplete input, conflicting, ambiguous or competing demands;
- internal variance: human errors, technical disturbance, invalid and inflexible capabilities, shortage of resources.

The key question that arises is how can organisations deal with these types of variance at the nodes in ways that do not disrupt the production process? According to Lowlands STS-D, to deal with such variance, organisations should on the one hand, redesign the division of labour in such a way that the complexity of the interaction network can be reduced, and on the other hand, increase job control possibilities so that variances can be controlled at the source. In this respect, De Sitter suggested to create simple organisations but make jobs complex, meaning that jobs become rich and varied (De Sitter et al. 1997). In other words, bureaucracies create jobs that are too simple for the complex changes in the environment. STS-D create complex jobs so that organisations can deal with that complexity in flexible ways (Mohr and van Amelsvoort 2016).

The relation between the division of labour and productivity

The productivity of an organisation is related to its capability to cope with strict external demands: namely, business and customer demands for variety (product mix), and uncertainty about both short- and long-term planning. Therefore, the capability to meet these external demands is contingent upon the needed internal variety: namely

meeting requirements in relation to efficiency, quality, flexibility, and innovation. Only if organisations can internally vary how they operate, are they able to meet the external requisite variety (Ashby 1969):

1. Organisations that are based on the principle of maximum division of labour, which, in turn, leads to complexity and rigidity (Achterbergh and Vriens 2009) (see figure 3). This maximum division of labour can be counterproductive for a number of reasons: simple jobs, i.e., the formation of silos between functional departments, each pursuing fragmented goals and interests;
2. Complex interactions, i.e., long hierarchical communication lines, central decision-making, and a large number of rules and meetings.

These organisations have many nodes and are, therefore, exposed to the risk of many interferences in the core work processes when the work cannot be performed as initially planned. Figure 3 indicates that the performance of the core work processes requires several dependencies in terms of control (c) and execution.

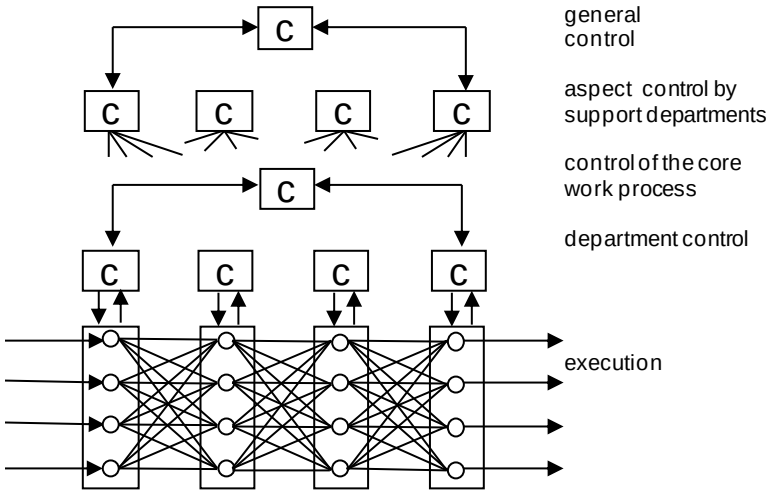

Figure 3. The principle of maximum division of labour (Kuipers et al. 2010)

STS-D aims to reduce complexity by minimising the division of labour (see the section on Lowlands' STS-D principles and design sequence below) and to create the structural conditions for (multi)organisational agility. On one hand digital technologies makes the reducing of the division of labour possible, on the other hand organisations based on minimum division of labour can use more fruitful the opportunities of digital technology.

The relation between the division of labour and employee involvement

The division of labour does not only affect productivity but also the quality of working life. For instance, Karasek's Job Demand-Control model (Karasek 1979, Karasek and Theorell 1990) (see figure 4) suggests that work organisation, specifically, high control (autonomy) in performing tasks is crucial in transforming job demands from risks and stress drivers into learning opportunities.

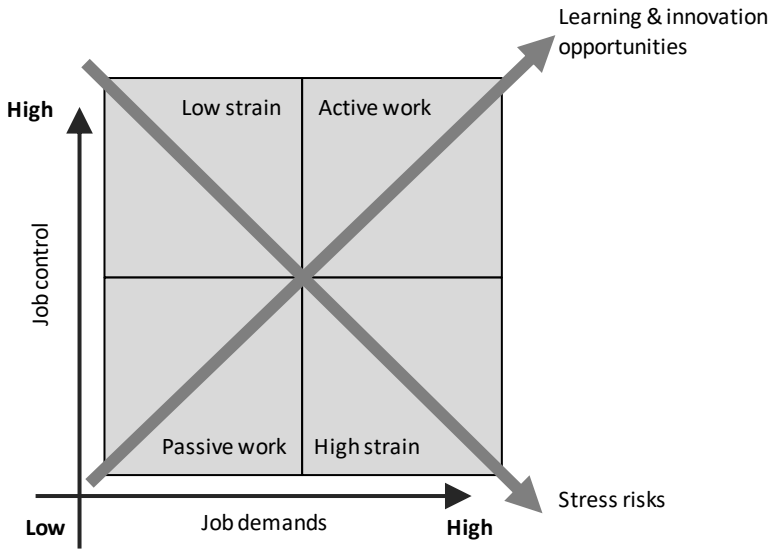

Figure 4. The Job Demand Job Control model of Karasek (1979, 1990)

In this model, job demands are seen as stressors such as work overload, unpredictable demands, time pressure, role ambiguity, interference, and emotional and physical demands. Job control is the combination of autonomy, decision latitude, instrumental support from colleagues, constructive performance feedback, craftsmanship, flexible resources, leaders' appreciation and support, accurate information, and communication. In this respect, there is evidence that high job demand and low job control are important predictors of psychological stress and illness. In addition, De Sitter (1994) claims that job control leads to involvement and motivation, which translates into positive effects on indicators such as absenteeism, turnover and stress. Moreover, there is evidence that a combination of high job demand and high job control in the form of active work is a predictor of an innovative organisation (De Sitter 1994).

In sum, job control is an important predictor for employee involvement and, as such, an important issue to keep in mind while introducing digital technologies. Indeed, STS-D proposes that, by increasing job control, employees are stimulated to learn, better equipped to deal with interference and, thereby, better prepared to respond to challenges arising from job demands. This increased level of job control does not only affect employee involvement but also serves the organisation by affording the possibility to better mobilise the use and development of human talent (De Sitter 1994), and thereby enable the goals of an agile organisation. By applying digital technology, human job control possibilities for all actors should be kept in mind.

Lowlands' STS-D principles and design sequence

Now that we have explained the general theory of STS-D, we address its strategic relevance first. In the next section, we discuss how these strategic choices can result in an operationally robust design. Robust means that interferences in the core work process are minimised and, if they occur, can be effectively dealt with. According to the open-system principle, the design of organisations needs to be strategic, and should include all stakeholder perspectives. This is in stark contrast to the focus on shareholder value alone often witnessed in traditional organisations (Achterbergh and Vriens 2009). From an STS-D perspective, in line with the open-system principle, diagnosing, designing and changing organisations needs to be done by considering environmental conditions and strategic

business choices. These strategic choices, in turn, impose requirements on the organisation, the "burning platform", and dictate the desired direction (see also Adler and Docherty 1998). Moreover, it is highly recommended that the design is drafted in co-creation with the different stakeholders. Indeed, the best guarantee for success is to *fetch the whole system into the room* (Weisbord 2004). This points to the importance of employee involvement, a hallmark of workplace renewal. In the traditional Lowlands STS-D theory, strategy is the starting point and sets the requirements for the design and the design process. From a digital perspective, strategy still remains the starting point. However, as digital technologies offer new types business models - like free, platforms, data and AI – which are continuously developing, strategic decision making becomes an integral part of a continuous (re-)design process.

Apart from strategic choices, we need robust organisations which can cope with the demands of flexibility and innovation in a dynamic world. Hence, from the STS-D perspective, robust organisation design is based on the following three principles on which the design sequence grounds (Van Amelsvoort 2000). First principle is to reduce complexity in the division of labour in the core work processes (PS) by focusing on customer order families. Reducing complexity can be achieved by the introduction of parallel processing (i.e., factory in a factory or between factories or a network in a network). Parallel processes (a) afford a better business focus, (b) create the conditions for decentralised control and horizontal co-ordination (see also principle 2), and (c) custom made technology can be applied. Parallelisation is defined as creating parallel streams of orders based on different customer families (e.g., markets, type of product). According to this principle, the design of the core work processes is based on the type of customers and their orders. This implies identifying customer families (orders) that show homogeneity in terms of business demands, and, therefore, impose identical constraints on the manner in which the production process must be carried out. Identifying these customer families involves finding criteria to divide customers into relatively homogeneous subsets with different strategic demands. For example, a construction company builds tangible products. However, renovating a house or building a hospital represents completely different core work processes with different strategic demands. Hence, a miniature organisation can be formed around these subsets of customer orders (i.e., one for house renovations and another one for commercial buildings) that each complete the process from a to z for this group of customer orders. The application of digital technology can also be customer focussed. In other words, the whole task is performed by a relatively self-organising group (i.e., autonomous work teams). We refer to the process as parallelisation (figure 4). In other words, parallel order streams are created, with each being maximally interdependent within the stream, but minimally dependent across streams. This implies the design of whole tasks and the creation of self-organising (virtual) teams, units and communities of work which are smaller in scale. Segmentation of the core work processes can help to reduce process complexity and create teams of 8-10 people. Segmentation is defined as cutting the flows of orders into parts, in such a way that a whole task of activities with high interdependency is created (i.e., De Sitter's complex jobs at team level).

The second principle is to increase the local (job and team) control capability and horizontal coordination by decentralisation: self-organisation and a healthy control structure. In an effective hierarchy designed to deal with turbulence, the different levels of control (i.e. layers of the organisation) have added value in terms of operational and strategic control. That is, flexible and innovative organisations are structured in such a way that they can react fast both at an operational and at a strategic level. To achieve operational control, work teams are self-organised at the operational level. Operational control is the combination of internal control (job autonomy, i.e., decision-making authority, technological variation possibilities, flexible access to means) and external control (co-ordination, team members' support, recognition, feedback, and influence). According to Ashby's law of requisite variety, control capability at a node (in this case, the self-organised team) is necessary in order to resolve interference at the place where it occurs and to prevent or reduce quality problems, delivery time deviations, or productivity losses (Ashby 1969). To achieve strategic control, different (business) units are set in place. Strategic control is necessary to reduce frequent interference among self-organising units and to explore innovations. Moreover, in dynamic situations, both operational and strategic control imply learning. The preconditions for control and learning are: Participation in goal setting and purpose definition, as well as effective feedback mechanisms for inspiration and learning, as in the

Job demand Job control-model (but now on the level of a team for example). With human job control in mind, digital technologies can help to increase horizonal co-ordination.

The third principle is to congruent infrastructure (technology and facilities) and HR systems: minimum critical specification (Cherns 1987). Because the units in the organisation have different business demands, they will also have different support demands. A supporting HR system, for example, should differ between teams of technically skilled employees operating on the shop floor and administrative teams skilled in financial issues working in the office. Therefore, the design of the different support systems and technology should follow the first two principles mentioned above. Moreover, their design should be based on diversity instead of 'one size fits all' and should be focused on providing support instead of controlling.

To design agile organisations, De Sitter (1986, 1994) original developed a three-step design sequence based on the aforementioned principles. As said, after the strategic decision making, a distinction is made in first the production structure, second the control structure, and third the technical systems. It is only a distinction; in practice the design process has a non-linear character. This sequence is based on the well-known slogan 'first organise, then automate'. However, due to the insight that digital technologies create new opportunities for new business models, and therefore new processes, tasks and roles, the original sequence should be adjusted. We suggest adjusting the strategic decision-making process. Digital technologies make it necessary to simultaneously discover digital opportunities and constrains with the design of the production structure (step 1) and also the same with the design of the control structure (step 2). The adjusted three-step, non-linear sequence boils down to the following.

The first step is about the design of the production structure, or how an organisation produces its products or services. If we assume that strategic positioning, such as the need for flexibility, innovation and healthy work, has been carried out as a starting point, one needs to first design the core work process. The design starts with sorting customers into customer families or product families which have different demands. For each family the different processes should be mapped. With these process maps now the opportunities of digital technology can be researched: which tasks in the process can be replaced by (digital) technology, which new tasks occur, which tasks are done by humans (workers or customers). So now the (new) processes can be organised. *It is also possible that new products or services, or new customer families may emerge from the opportunities of digital technology. Consequently, strategic choices can be discussed again.* In any case, this design of the production structure is done by focusing on the overall picture and then on the details (i.e., first on the whole, then on the parts). Based on the different customer families with different demands (see principle 1), this means that one starts with creating the different (business) units, then the different departments within these units, and finally, ends with the design of the work teams and jobs. In combining the design of the production structure with scouting for digital possibilities, the requirements for the design of digital technology is brought more profoundly and design-theoretically to step 1. This also counts for step 2 the design the control structure.

The second step is the design of the control structure, or how the core work process and supporting processes are managed. It comes down to a redistribution of control capabilities through the design of the management structure. This control structure is designed in reverse order, in other words, from the parts to the whole (i.e., bottom-up and not top-down). That is, first one determines what can be controlled at the (lowest organisational) local level (i.e., team and job level), subsequently what can be organised at the level of a larger organisational operating unit (above that level), and finally what needs to be controlled at the (highest) organisational level. Next, the consultation and decision-making structure can be further elaborated in detail. The principle here is that emerging problems require autonomy to solve them at the level where those problems occur. This implies that the task of managing the core work processes should as much as possible migrate to the lowest organisational level. Also, in this step opportunities for applying digital technologies are researched. For example, digital technologies introduce the possibility that some aspects of control may be automated or better informed, which in turn, may eliminate or provide new 'assistance' to prior control tasks allocated to humans, or may enable or require new control tasks that 'augment'

human roles. Digital technology makes also the distinction between execution and control blurry; more on this in the discussion section. The design theoretical consequence is that the first two steps - the design of the production and control structures – should be designed with digital in mind. During these steps, the (new) opportunities and possibilities of digital technologies should already be taken into account. Until now in Lowlands' STS-D, the design and deployment of information technology was a derivate of the design decisions made in steps 1 and 2. Effectively, we argue that digital technology becomes an integral part of designing work and organisation.

In Lowlands STS-D, information technology has always been seen as a derivative of step 1 and 2 (Govers and Südmeier 2016). This is no longer tenable, because digital technology is penetrating more and more deeply into work systems and organisations. Previously, work was done *with* digital technology, in which we now work more *in* digital technology. Digital technology has move beyond technology by becoming organisational.

The third step is the actual design of the technical systems (and other support systems), or how information streams support production and management. It focusses on the various (technical and support) systems which are required in the new organisational architecture. These systems include IT and support systems (HR, quality etc.). Here the rule is that these systems should support and not control the production and control structure.

It may sound as if the adjusted three design steps are mixed in a one large melting design pot. That is not the case. The sequence between the three steps remains feasible and valid, because it sets the order of the design *focus*. The sequence of and focus on (1) production structure, (2) control structure and (3) technical systems offer clarity for workers and designers participative designing workplaces, work systems and organisations. In step 1 and 2 the opportunities of digital technology are *actively and profoundly* scouted, and, consequently, digital requirements can be developed. In step 3, the 'final' infrastructure of digital technologies is *actually* designed. The realization of the technical infrastructure is seldom first time right; from a key STS design insight, it is known that designs by definition are incomplete and constantly in development. The socio-technical optimisation is a continuous process. This is especially apparent for digital technologies, because digital opportunities are constantly in development. The ability to continuously socio-technical optimise requires, therefore, new design routines in order for workers, digital experts and organisational experts to effectively collaborate for designing humane, productive and innovative organisations.

New design routines

As digital technology will co-determine work and organisation design, the languages and logics of both the digital and organisation worlds should be bridged, if not blended, when actually designing (Govers and Van Amelsvoort 2018).

First of all, we refer to *customer experience*. Customers become an essential part of the (core work) process. They carry out parts of that process themselves and find it self-evident and service oriented. Internet banking is an example. Since customers, for instance, enter their own payments themselves, the bank has fewer administrative tasks to perform. It is important that the customer does not experience this as a burden but as a plus. This is why banks are making their digital infrastructure more user-friendly and extending it to different platforms: mobile in addition to computers.

Secondly, we refer to *operational agility*. Work processes, especially with regard to services, are increasingly taking place within digital platforms. Processes are put together by bringing together basic 'Lego blocks', so that new business models can be put on the market quickly. Setting up different web shops for specific target groups, in which the same warehouses are used at the back (back office), is an example.

Thirdly, we refer to *workforce engagement*. Employees may be given more decision-making powers. This is possible because digital technologies can offer more useful and accessible analyses of situations to employees in the work processes. An employee of a service desk can immediately see what type of customer is on the line, as the customer profile is immediately visible. The employee can better estimate what to do based on the customer's historical data and on the product's historical data. It empowers employees, which has a positive effect on work experience and involvement.

It sounds paradoxical: in order for digital technology to land effectively in organisations, technical design questions must be preceded by social design questions. For example:

- What new interaction possibilities does digital technology offer for a different collaboration between customer-organisation, employees and management staff?
- What does it imply for quality of the organisation (efficiency, quality, flexibility, innovation and sustainability)?
- What does it imply for quality of working life (challenging and active work for people)?

After the answers to these questions have been formulated strategically, technical design questions are on the agenda, for example:

- With which digital technology can the desired different collaboration in organisations and processes be efficiently realised?
- Which conditions are needed for this?
- What is the change/transformation plan?

In addition to the sequencing of design questions, we recommend abandoning five dominant bureaucratically driven design routines, and instead embracing five agile, socio-technically driven design routines. On the one hand, this is necessary because organisations are confronted with increasing variety and dynamics. This requires routines that encourage, rather than hinder, the speed of action. On the other hand, it is necessary to find and continue to find a maximum 'joint optimisation' between digital technology and people working in collaboration.

The five new to be learned routines are independent of digital technology. They are, however, decisive for effectively landing digital technology with a positive transformative effect on organisations and people. For organisations and professionals who stick to the current routines we predict an accelerated and painful end. The transition to and from the next five routines is crucial for the effects of digital technology to land positively in organisations and for people in organisations. *Firstly*, to let go functional thinking about organisations for process- and chain-focused thinking. Based on the requirements and wishes of customers or customer families, processes are organised in organisational forms made up of relatively independent units that are able to respond quickly to customer demands and innovate quickly. The starting point for the design is the intended strategy of the organisation. The primary process and/or primary chains between organisations form the starting point for the design. *Secondly*, to let go of one-fits-all for one-fits-one designs. Today's digital technology offers plenty of options to design and implement various, customised solutions. This possibility is still being sought too little, because we still think and act too much from the experience of complex and expensive implementation and management costs experienced, for example, in the ERP era. *Thirdly*, to let go the expert, top-down and cascade design approach for a participatory, bottom-up and scrum design approach. The dynamics in the environment are so high that the classical approach no longer works: Too expensive and too time-consuming. Instead of elite clubs of (often technical) experts who design a complex IT system with associated working methods top-down, users will design, test and commission organisational and digital processes together with IT and organisation experts in short sprints. In essence, this becomes a continuous design process. *Fourthly*, to let go the 'do more of the same' approach for a 'do different' approach. In a continuous design process, which has already been mentioned, it is also important to break away from the best practice myth. These practices have their value above all for the past and present; they

offer no inspiration for designing the processes and organisational forms of tomorrow. Creativity, out-of-the-box and design thinking are new competencies that are just as important as technical and business knowledge and insights. *Fifthly*, to let go the consolidation of the current structures, processes and working methods for an ambidextrous approach to perpetuating and exploring, such that the organisation is increasingly in the status of continuous redesign. On the one hand, it operates in a perpetuation mode of efficiently and effectively delivering the current services and products. The current processes and forms of organisation are organised and managed for this purpose. On the other hand, the organisation shall ensure that an exploration mode exists for the possible creation of new working methods, processes and organisational forms. The development of new services and products would otherwise be undermined by the current organisational and management principles. In short, organisations and professionals must learn to think and act simultaneously in a perpetuation mode (the exploitation of the present) and an exploration mode (the creation of the new).

Discussion

In the aforementioned sections, we assume that digital technology is more than just technology. It has developed into features and (new) opportunities for designing work systems and organisations. Accordingly, we argue that the Lowlands STS design theory has to grow with this development and incorporate this in its design sequence. We also highlight that digital technology makes the distinction between execution and control blurry. Furthermore, digital technology takes work over from humans and creates new forms of work for humans. In our opinion, digital technology changes the nature of work, which, consequently, has ramifications for the Lowlands theoretical view on the nature work itself.

A fundamental difference between mechanic and digital technologies is that digital is also affecting – what in Lowlands STS is called – executive *and* control tasks. AI, for instance, is more and more used to control processes, and is doing it better than humans (McAfee and Brynjolfsson 2017). Where the focus of technology in general used to be on routine – repetitive and simple – tasks, digital technology enters the field of non-routine – complex and professional – tasks in rapid pace too. From a theoretical perspective, we believe that the Lowlands model to distinct work needs reconsideration. The distinctions between execution-regulation and routine-non-routine is too rough. Without wanting to be complete, we think the following adaptation of the Lowlands work model may be feasible. To understand the relation between digital technologies and work, we suggest defining work differently. Work could be specified by two dimensions: complexity of work and the elements of work. Complexity could consist of repetitive, deductive and explorative. Elements consist could consist of execute, regulate and organise. Figure 5 shows and explains the resulting model on the nature of work. The specific types of complexity and elements are explained in the figure below. This is a first thought and requires further deliberations and (action) research.

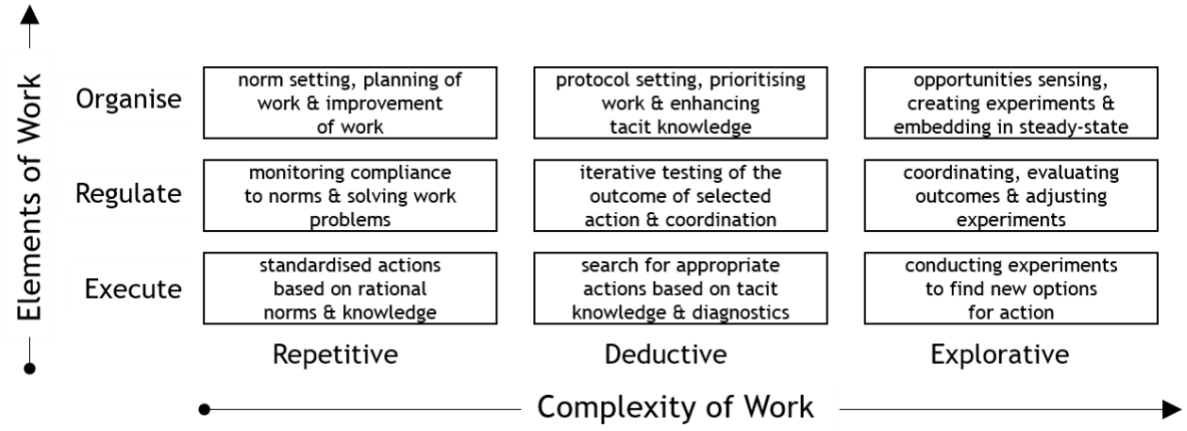

Figure 5. The nature of work

In our opinion, especially intelligent digital technologies can develop potentials to 'penetrate' into all work elements of repetitive work and into regulate work elements of deductive and maybe even explorative work. From an STS perspective, we think that future work will have to be a combination of humans and machines working together. For this to be successful, we advocate that the participative design approach gains importance.

O'Neil (2016) demonstrates in her book 'Weapons of Math Destruction' the need for participative design. Too often, the algorithms behind big data, AI and machine learning ground on quicksand of weak correlations that are linked together into rational outcomes. This becomes an issue when these outcomes are being used as causal truths which are not questioned anymore by humans. Or worst, are used by humans as rational truths in decision-making processes. It becomes, according to O'Neil, even societal undermining when such algorithms are used in data-driven decision-making by machines.

The potential dangerous of AI shows that workers, digital experts and organization designers should participatively collaborate in a more integral manner. For effective participation, it is crucial that the collaborators understand each other's worlds and related languages and logics. Otherwise, Babylonian confusion of speech will occur with undesirable consequences for the joint optimisation and creation of humane, productive and innovative organisations. Digital experts, for instance, could be introduced to STS(-D) thinking to better understand the consequences of digital technologies for the functioning of organisations and for the quality of working-life for humans working with and in digital technology. On the other hand, STS designers, for instance, could show more interest in the functioning and mechanisms of digital technologies as well as its opportunities for designing organisations and workplaces. Understanding digital technology should, in our opinion, become an imperative for STS-D experts.

Conclusion

In this article we proposed a holistic design approach that integrates digital technologies into the STS design sequence. This design-theoretically implication for Lowlands' STS-D, thrives best if also new design routines are embraced that is necessary for a more successful participative design. Changing business demands and stakeholders bring in the demand for new ways of organising work systems. Current and future digital technologies can support this, even have unexpected, disruptive positive opportunities and/or negative effects. To utilise these positive opportunities and to minimise negative effects of digital technologies, the search to joint optimising of the technical

and social system is crucial. With this article we have tried to lay a theoretical basis for this. Smart technology in smart factories also need a smart organisation[19]. We invite both digital technology and organisation design communities to further develop this attempt pragmatically. Practical examples will help to deepen and enrich this theoretical approach empirically. This would help to successfully unlock the potential of digital transformation for the future growth in Europe from which all stakeholders related to modern 21st century organisations can benefit.

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EUROPEAN JOURNAL OF WORKPLACE INNOVATION

Can an unconventional Socio-technical System approach open the way to new solutions and new understanding?

Trond Haga

Abstract

Socio-technical System Design (STSD) was developed as an alternative to the prevailing Taylorist organisational design principles focusing on specialisation and standardisation. STSD emphasised quality of work and has thus been described as a strategy for "simple organisation and complex jobs". This may sound like a partial strategy for developing holistic, meaningful jobs. However, it is as much about developing efficient organisations with interactions between people and technology that increase company competitiveness. STSD has taken different directions in different countries/geographic areas. All these directions emphasise holistic job design and employee participation. However, approaches to achieving holistic job design and to the role of employee participation vary. The ongoing digital revolution, often labelled Industry 4.0, is rapidly changing the conditions for work in general. Tasks that were previously manual are being automated, and communications and information are being made available to an extent not seen until now. In this landscape, it is necessary to consider whether we have suitable approaches for facing the challenges posed by these technological developments.
In this paper, which considers two strands in the tradition of STSD theory and a case study, I will examine the need to introduce a familiar but rarely discussed or used STSD approach to major technological and organisational changes.

Keywords: socio-technical systems design, STSD approaches, organisational concepts, technology, work organisation, proposal box system, participation

Introduction

In his influential book *The Paradigm that Changed the Work Place*, Frans M. van Eijnatten attempted to capture the history of STSD (van Eijnatten 1993). He divided the history of STSD into three distinct periods: (1) socio-technical pioneering work, (2) classical STSD and (3) modern STSD. Van Eijnatten further divided the last period into four variants: (a) participative design, (b) integral organisational renewal (IOR), (c) democratic dialogue (DD) and (d) STSD in North America. In this paper I aim to analyse how two of these variants, IOR and DD, facilitate employee participation.

The geographical origin of IOR is the Netherlands. In modern times STSD development within this tradition has been about developing the IOR model (van Eijnatten 1993). However,

> "The main objective for IOR has been to develop a systematic approach to design which supports improvements in both the quality of work and what is called 'the quality of the organisation'" (de Sitter et al. 1997:498).

Classical STSD has been criticised for the lack of progress in developing concepts and instruments and for being too strongly dependent on experts. This dependence may explain the lack of diffusion of the STSD approach. IOR has been under the influence of the Scandinavian DD model, and this tradition's participatory approach has been adopted by IOR. However, IOR has retained a strong expert component (de Sitter et al. 1997).

The developers of the IOR approach aimed to develop a generally applicable theory that joins social and technical systems in an optimised "best match". Thus the joint system should be as good at shortening delivery times as at improving jobs. The new paradigm for socio-technical design is based on a specific set of concepts that address the architecture of systems structure, capacity to control, ability to distinguish production and control structures, and cohesion between different structural parameters (de Sitter et al. 1997). IOR thus offers a very detailed set of structural principles in terms of design content. For instance, reducing the probability of the occurrence of disturbing events and adding regulatory potential are regarded as essential measures for systemic survival (Vriens and Achterbergh 2011).

The geographical origins of DD are in Scandinavia (van Eijnatten 1993). This STSD variant intentionally does not emphasise the work system design content; it is rather the development process and participation that are accentuated (van Eijnatten 1993, Gustavsen 2008). The reasoning for this turn was, in part, a scepticism about general theories, which were not considered useful. To understand the specific workplace, the notion of "local theory" was introduced (Elden 1983). It was thus the initiation of workplace processes that came to be at the centre of the further development of DD. Particular attention was paid to important procedural tools such as search and dialogue conferences, and employee participation was closely linked to these tools. However, it was not only such processes that were linked to the STSD tradition; the facilitation of participatory improvement processes was also included in the overall framework for work life, as in the Norwegian Basic Agreement (Gustavsen 2008). Two-party co-operation to initiate improvement processes in companies was included in the Agreement, and formal co-operative bodies were created to support this approach.

The two STSD approaches have thus used various methods in their efforts to create complex jobs and simple organisations. The question that will be discussed in this paper is whether these approaches are relevant to the challenges that arise from the ongoing digital revolution (Brynjolfsson and McAfee 2014)[20] and the accompanying

[20] At present, a new wave of technology, known in Europe as "Industry 4.0", is receiving attention. Industry 4.0 consists of a set of new technologies, including artificial intelligence, robotics, automation, big data, network sensors, data exchange, cloud computing and the Internet of Things. These interconnected technologies are anticipated to lead to major changes in business models, production processes, skills, needs and forms of co-operation.

organisational changes. However, the need to redesign STSD emerges not only as a result of technological advances but is just as much a result of the lack of development of STSD approaches (Pava 1983, Pava 1986, de Sitter et al. 1997).

Coping with uncertainty

Uncertainty is part of the operational reality of businesses and organisations. However, as a result of the ongoing digital revolution, companies are confronted with more uncertainty than under normal, almost stable production conditions. Uncertainty calls for action from businesses and organisations if they are to survive. Organisationally, most businesses will respond to an increase in external uncertainty and complexity with an increase in internal complexity. This usually means creating new positions internally to handle threatening external conditions. However, there is a second option for dealing with uncertainty: reducing internal complexity. This may be achieved by distributing tasks and responsibilities internally (de Sitter et al. 1997).

The theory of STSD was developed along the lines of the second option (Emery 1959, de Sitter et al. 1997). The various STSD approaches that have evolved from the 1960s onwards share the aim of developing "complex jobs and simple organizations". The differences emerge when we delve into how to achieve this target. The reason for developing different approaches was the lack of diffusion of STSD in general in the 1960s and 70s. To enable a broader and faster diffusion, work was initiated in various environments and networks to develop more suitable approaches. The development of IOR in the Netherlands and DD in Scandinavia should be viewed from this perspective.

A cybernetic approach to organisational structures

To ensure a broader and faster diffusion, the Dutch IOR initiators laid out a unified strategy. First, they assumed that it was necessary to convince management about the economic benefits of STSD. Second, they anticipated the need to develop a shared set of well-elaborated design concepts, principles, rules and design sequences validated in practice. Such a design theory thus went far beyond traditional STSD, and the mission to develop it was taken up by a network of professionals organised by the Netherlands Institute for the Improvement of the Quality of Work and Organization (NKWO) (de Sitter et al. 1997). Their point of departure indicated that they would take a systemic approach, and so it transpired.

Cybernetics is a transdisciplinary approach for exploring regulatory systems, their structures, constraints and possibilities. The term is often used in a rather loose way to imply control of any system using technology. Thus, cybernetics is the scientific study of how humans and machines control and communicate with each other. Consequently, cybernetics is relevant for mechanical, physical, biological, cognitive and social systems. For instance, a cybernetic approach may be used to study how organisations deal with complexity, understood as disturbances threatening systemic survival (Vriens and Achterbergh 2011). This may be thought of in two ways: reducing the probability of the occurrence of disturbing events ("attenuation") or adding regulatory potential ("amplification") (de Sitter et al. 1997). Thus, the cybernetic approach is closely linked to a dedicated set of concepts (Vriens and Achterbergh 2011, van Eijnatten 1993, de Sitter et al. 1997), and to three fundamental concepts in particular: essential variables, amplification and attenuation. In what follows, these concepts will be given a content accommodated to cybernetic theory.

Ashby has described the "amplify" and "attenuate" methods in terms of the behaviour of a machine and the flow values of certain variables (Ashby 1958). He pays special attention to what he characterises as essential variables.

These variables are closely linked to the survival of the machine: if they are outside certain limits for too long, the machine will have a breakdown or simply disintegrate. In the course of its survival, the machine may encounter all kinds of disturbing influences that threaten its essential variables, and in order to counter them, it depends on "regulatory potential": the potential to deal with disturbances. Given a particular set of disturbances, the machine should have the requisite regulatory variety, i.e., enough regulatory actions to cope with these disturbances. If not, it should try to extend its regulatory variety and action. This is what Ashby characterises as amplification of regulatory potential. If the disturbance is not repeated, another option is to decrease the probability of similar occurrences. Reducing the probability of occurrences of a disturbance is what Ashby characterises as attenuation.

The explanation above is given in terms of a machine, whereas the topic of this paper is organisational. How, then, can the terms essential variables, amplification and attenuation become relevant for such a topic? Generally, the three concepts encompass vital particular variables (essential variables), the capacity to extend regulatory variety and action (amplification), and reduction of the probability of occurrence of disturbances (attenuation).

Essential variables in an organisation, as in the case of the machine above, are closely linked to its survival (Vriens and Achterbergh 2011). As long as the essential variables stay within certain parameters, the organisation will survive. De Sitter proposes three classes of variables that an organisation should keep under control to survive: quality of organisation, quality of work and quality of working relations (Vriens and Achterbergh 2011). These classes can be further divided into external functional requirements and internal functional requirements. Table 1 contains what de Sitter considers as being the essential variables and their norm values. The logic of his argument is that if the internal functional requirements are met, then the external functional requirements are met and the organisation's viability is ensured.

Table 1. de Sitter's essential variables and norm values (de Sitter et al., 1997).

Variable	External functional requirements	Internal functional requirements
Quality of organisation	Order flexibility	Short production cycle time
		Sufficient product variations
		Variable mix of products
	Control over order realisation	Reliable production and production time
		Effective control of quality
	Potential for innovation	Strategic product development
		Short innovation time
Quality of work	Low level of absenteeism	Controllable stress conditions
	Low level of personnel turnover	Opportunity (1) to be involved, (2) to learn and (3) to develop
Quality of working relations	Effective communication	Shared responsibility
		Participation in communication

According to de Sitter, disturbances in the organisation may occur in two ways, broadly speaking: those that are and those that are not related to the structure of the organisation. Those not related to the organisational structure can be a source of disturbance (waiting times, etc.). Structures may also increase the probability of disturbances spreading if there is no regulatory potential to deal with them. In summary, for de Sitter, structural attenuation can be understood as a structure being designed in a way that stops disturbances (or at least reduces them to a minimum), and structural amplification can be understood as a structure having the capability to deal with disturbances.
De Sitter moves on to define structural design parameters for the avoidance or reduction of disturbances as much as for ensuring regulatory operation, a so-called organisational renewal of a company (van Eijnatten 1993). De

Sitter thus sets up a comprehensive theory that contains the overall picture that I have tried to summarise above, and in addition he outlines a number of details to make the theory complete. His comprehensive theory thus includes the following:

1. different levels (class, external and internal requirements)
2. a set of design parameters (seven different)
3. a developed system for evaluating the parameters.

IOR is an applied design strategy for successful implementation of organisational change. Such implementation cannot be imposed, as it calls for a solid basis in the organisation. De Sitter clearly states that it is crucial that the redesign is carried out by the organisation's members themselves in a participatory manner. At the same time, he emphasises that socio-technical design, however participatory it may be, relies on design expertise (de Sitter 1993). Thus, participation is not a sufficient condition for setting the organisation in motion or for changing its structures.

The main objection to IOR is that it is a rigid approach. The recipe that has been developed may be regarded as the only available solution to socio-technical challenges and thus limit the space of opportunities. Furthermore, the strong focus on efficiency and effectiveness may be regarded as an enhancer of the existing regime and, to a lesser extent, as a challenger to the same. At the same time, the approach will require specially trained personnel and thus may be capable of preventing a strong and broad distribution.

A procedural approach to improvement

The Scandinavian-funded DD approach strongly emphasises the initiation of workplace processes. The diffusion of STSD following its classical period was weak. Only in some countries and in some professional environments did the approach gain a foothold. The dependence on professionals, in particular, was regarded as a hindrance to a further spread of the approach; the headline issue of complex jobs and simple organisations was regarded as less of an obstacle than this dependence. For a large number of companies, this meant hiring in external professionals who lacked knowledge of the company, its culture, its way of operating and the composition of its internal expertise.

An obvious alternative was to strongly encourage workplace processes, in terms of both promotion and preparation. In Norway, in particular, initiation of workplace processes was regarded as essential. The approach highlighted by Greenwood and Levin emphasises the inherent potential in individual contributions from employees both for developing the workplace, the individuals and the working environment and for supporting the removal of obstacles (cybernetics) (Greenwood and Levin 2007).

However, individual contributions have not been encouraged blindly. In shaping alternatives to conventional hierarchical organisations, the concept of "industrial democracy" has been vital. This concept emerged from the early action research (AR) efforts in the US, the Tavistock developments and the Norwegian Democracy Project (Greenwood and Levin 2007). Fundamental arguments in favour of democracy in an organisational setting as the main tool for shaping a democratic society were forcefully developed by Carole Pateman (Pateman 1970). One obvious way to promote industrial democracy was to institutionalise it through work life agreements, and that became the case in Scandinavia.

Here, employees are encouraged by their social partners, i.e., by unions and management, through democratic dialogue to participate in developing the workplace and the work organisation (van Eijnatten 1993). This dialogue is regulated in Norway through the Company Development Contract as part of the Basic Agreement between employer and employee confederations (Gustavsen 2008, van Eijnatten 1993). The main concepts behind DD are

learning (being open to new ideas) and dialogue (participation in open discussion). DD both confers on employees the privilege to form local theories and empowers them to come up with their own solutions. The main focus is on process rather than structure.
To fully understand the relationship between management and unions, one must look at how co-operation structures are set up within the companies (Table 2).

Table 2. Co-operation structures within companies.

Body	Members
Board	The owners and union representatives are members of the Board.
Company committee	The management and the unions are members of the committee. The chairmanship alternates between management and union representatives.
Department committee	The department manager and employees from the department are members of the committee.
Yearly co-operation	Each year a conference is arranged that focuses on co-operative conference business development.[21]
Work environment	Management and elected safety delegates. The chairmanship committee alternates between management and union representatives.

From a development perspective, all these arenas are important. The company committee will discuss and make decisions on strategic improvement and training initiatives. The representatives on this committee are free to put forward matters for discussion and decision. In this way, the employees can adopt specific initiatives and promote them within the committee. The union representatives/employees are thus not present for information only, but rather to discuss strategic issues and participate in the decision-making process.

The most important body for supporting participation is likely to be the department committee, which discusses improvement proposals, small and large, that are promoted by personnel in different departments. If a proposed initiative is relatively inexpensive, the committee may make the implementation decision themselves. If the initiative is more expensive and/or needs to be processed or studied further, it may be referred to the development department. Either way, the department committee is a driver in improvement work within the company and handles a number of proposals, especially minor ones. These structures provide employees with a number of forums where they can influence strategic choices and promote proposals for improvement/change. Combined with a focus on dialogue, this enables employees to play an active part in the development of their own workplace.

However, to enhance further the diffusion of STSD, the emergence of links between local company-specific processes came to be regarded as vital (van Eijnatten 1993, Gustavsen 2008). Instead of unfolding within single organisations with networking across organisational boundaries, projects would now have network construction as their prime target (van Eijnatten 1993, Haga 2007). With local/regional networks as a point of departure, diffusion became identical to the expansion of local/regional actor configurations. Resources to front or support networking were scarce; consequently, the use of regional research resources became the solution. Another distinctive feature of STSD development in Norway is the closeness of its links with AR. STSD has almost been removed from the vocabulary and has been replaced with AR. Because STSD was closely identified with processes, participation and the use of research, the distance to AR was short.

Compared with IOR and de Sitter's cybernetic theory, the agenda for the model procedural-based improvement may appear vague. However, it is not vague because of a lack of strategy. Fundamentally, the approach focuses on the improvement agenda, the improvement process and the participatory dimension. As Table 2 shows, there is a

[21] The set-up of co-operative bodies is company-specific and belongs to the company in each case.

strong emphasis on participation: the theorist and practitioners operating within this variant of STSD believe in participation at the strategic level, as well as in the more practical improvement projects/implementation activities. However, compared to the structural IOR approach outlined above, the focus on organisational design and interaction between man and machine is less visible. One criticism that may be directed at both IOR and DD is that they lack the ability to capture what follows Industry 4.0. The availability of information makes it possible to envision entirely new organisational solutions in the place of traditional hierarchical ones (Brynjolfsson and McAfee 2014).

Method

The study this article is based on was set up with a team of researchers from the company's research partner and a team of internal resources from the company. On the one hand, prior to the project start-up, the research team had a close relation to the company, based on previous collaborative development projects. On the other hand, the team from the company consisted of personnel with considerable experience of development work, even in some cases a research background. A representative from the company acted as head of the project. However, it was a *joint* team that

- developed the funding application to the Norwegian Research Council (NRC)
- prepared an implementation plan for the project with a set of defined work areas
- distributed tasks and responsibilities between representatives from research and the company.

To be eligible for funding by the NRC, it was necessary for a group of companies to participate in the project. The company invited two other suppliers and an industrial network hub to join the project, and all three accepted and became partners in the project. To formally manage the project, a steering committee consisting of the CEOs in the companies was established. A representative of the research partner was also a member of the steering committee. The head of the project and the lead researcher met in the steering committee meetings.

The aim of the study was to develop a production system, i.e., a framework for improving the work organisation of the case company and the interaction with its partners. The use of technology and the interaction between technology and organisation was also addressed to support the development. At the same time, it was important to maintain and further develop the strong tradition of participation in the company. The project execution was planned in modules which individually took account of the various aspects that were to be addressed. Thus, one module covered the development of the production system, another one the development of the digital proposal box, and so on. Each module was set up in a way that ensured representative representation in the work groups, and the researchers were also included. The groups developed and tested new solutions for different user and management groups, in this way receiving the group's feedback for further work on the solutions. Start-up and progress varied for the different groups, so whereas some groups are about to finalise their documentation, other groups have not progressed quite so far.

The process may be presented as a stepwise one with the following steps: (1) define target or aim, (2) define detailed content, (3) design the process, system or product/solution, (4) develop the pilot and developments including testing and (5) deliver complete solutions (see Figure 1). As indicated, finalisation of each step had to be cleared by the project committee that overlooked the progress of the different teams. The feedback loops that were designed in served several purposes. First, they allowed for a reality check on the teams' suggestions by letting them receive feedback from others in the organisation. Second, they allowed for internal reflection within each team.

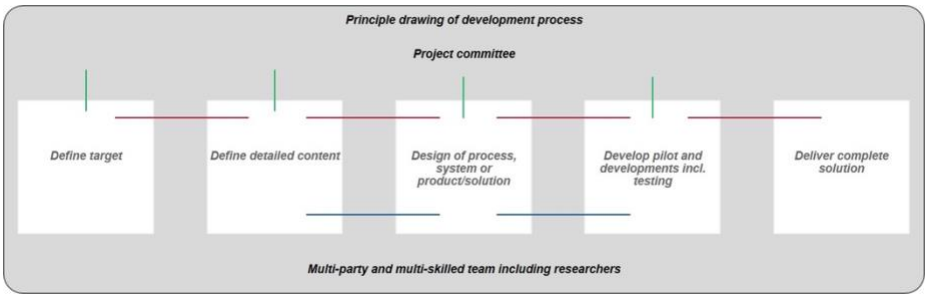

Figure 1. Principles of the development process.

Thus, the method used was not set up on the basis of cybernetic assumptions but rather on a procedural assumption. In spite of this, the aim of establishing the production system was to determine a framework for further development of the organisation, the technology and the interaction between them.

The members of each team had different responsibilities and tasks. When activities were planned, implemented and evaluated, this was done jointly as a team, but it was the individual responsible who carried out the activities and summarised what had been done. The tasks or phenomena were thus not studied from the outside; the research was largely performed in the field. Most of the activities performed were planned and carried out with personnel from the company. Participation was thus a fundamental ingredient in the set-up of the project. To ensure a balanced representation, the unions were actively used as a resource, as well as for legitimation and mobilisation.

The case: preparing for a new reality

New international production concepts and new technologies[22] are being introduced at a fast pace. Businesses are challenged to take up new concepts and technologies, since these have the potential to improve their performance and increase their competitiveness. The concepts introduced are largely international and take little account of national contexts.[23] Various new technologies, such as artificial intelligence, robots and digitalisation, will provide great opportunities if they are set up efficiently. However, it should be observed that new concepts and technologies often take little account of the relationships between process, organisation, technology and competence.
The socio-technical system approach focuses on the fact that technology is not deterministic: it allows for choice (Emery 1993, Eijnatten 1993). This means focusing on the choices that technology provides in order to establish effective processes and work organisation. At the same time, this approach aims to weaken organisational disturbances, thereby reinforcing the factors that ensure stable, efficient operation (Vriens and Achterbergh 2011). The focus is thus on how the socio-technical system is set up locally within the established framework. How the organisation is set up matters and should be based on the concept of "joint optimisation" (Emery 1959). The approach emphasises the work content as being holistic and not Tayloristic in its design (Eijnatten 1993). The socio-technical system is not static but in constant development. The development takes place both as a consequence of external influences and as an effect of internally improvement work within the business.

The case company is characterised by one-of-a-kind dynamic production for the construction of offshore/onshore installations. The value chain is complex, as much of the product is supplied by subcontractors. At the same time,

[22] Production concepts include Total Quality Management, Business Process Reengineering, Lean and Production systems, and broad technologies include automation, robotics, digitalization and the more general Industry 4.0.

[23] For example, national laws and general agreements.

design engineering and construction work in parallel to reduce completion time. A further consequence of this parallel processing is the high number of changes, which, combined with the high number of companies involved in the value chain, illustrates the need for close interaction and control to ensure an optimal installation sequence and distribution of installation personnel. This is necessary to meet the stringent quality requirements in the offshore industry. The fact that the products are one-of-a-kind and that the production process is complex limits the possibility of standardising the project implementation. Thus, the project implementation is also one-of-a-kind, which negatively affects productivity (Galbraith 1974).

The case presented below may function as an illustration of how companies can take new steps to prepare for the new reality. In this case, the company has launched several comprehensive development initiatives in parallel to proactively face up to the industry 4.0 reality. It has launched a large digitalisation programme that includes initiatives in a number of directions. The main components cover the areas of automated project set-up, automated engineering, digital lifecycle information, digital yard and digital project management. Each of these areas is in turn composed of a number of digitalising projects.

In parallel to this programme, the company has initiated an industrial research project to explore the appropriateness of using the *production system* for engineering-to-order (ETO) companies.[24] Production systems have been developed by many companies and have become standard in many industries. As each of these systems is designed for an individual business, the term "company-specific production system" (XPS, where X stands for the name of the company) has emerged. The most famous example, and model for later production systems, is the Toyota Production System, TPS.

A production system aims to increase the efficiency and productivity of the company in question. As strategies and competitive priorities, capabilities, culture and history vary between companies, it is rational for a production system to be adapted to the business and therefore be unique to the company. The same tools will not provide good productivity in each case. The strength of an XPS is that it allows the company to choose from the variety of effective production and enhancement philosophies, and to focus on those that are most suitable.
An important aspect in the thinking behind a production system is that it should be a lasting programme, not merely an improvement project. Consequently, it requires lasting leadership support at all levels, and it allows for long-term planning to develop the production system and to carry out improvement work generally. In particular, long-term thinking and perseverance have proved to be essential. A study of the implementation of the Volvo Production System, VPS, in Volvo Trucks factories worldwide makes this clear (Netland 2013).

A production system is intended to increase productivity, distinctive business and a lasting programme. The system consists of principles and guidelines as to how the company can achieve good levels of efficiency. These principles are grouped into different categories, often highlighting certain parent elements (or building blocks) that together make up an easily recognisable figure. To help operationalise each principle, companies can choose to highlight a set of tools, either for use in daily operations or in the improvement work. These tools are often a mixture of methods that the company has developed internally and methods that have been tested and found reliable in the literature and in textbooks. While the elements and principles are mainly permanent, the tools will to a great extent be developed over time (and some may be discarded in the process).

Creating good profitability in complex projects is demanding. The aim of the Simplex project is to make this type of production process smoother and more precise. We will solve this challenge by developing a production system that integrates the actors in the value chain in a better way than is done today. The key principles of the system are

[24] The Simplex Project was financed by the Norwegian Research Council for a period of four years, starting in 2016 and focusing on developing a production system for an ETO company.

simplicity and intuition: the necessary information is to be made available in ways that are perceived by the system's actors and users as logical and easy to understand and that are communicated in a smooth manner.
As part of the research programme, a model for such a production system was developed (Figure 2).

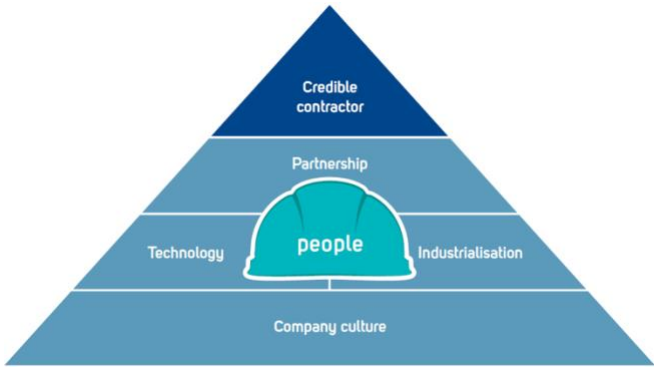

Figure 2. XPS developed for the case company.

The system was developed in two steps over a period of approximately a year. Fundamental input was obtained through a series of team gatherings. The team was put together to cover different parts of the organisation and the production process, and union representatives were present at the team gatherings. In this way, we hoped to create the information base necessary to design a first version of the production system. On the basis of the information available, the researchers and project management in the company drafted a model and an accompanying description of the system. This first version was then presented at a number of gatherings, where feedback indicated that a second version was necessary. This second version was designed using previously collected information, feedback on the first version and reflection within the project team. When the model was complete, it was presented to local management and received their endorsement. The production system presented here is the final version from the project team.

The production system contains six elements: credible contactor, partnership, technology, people, industrialisation and company culture. Each of these elements consists of a set of principles, the numbers of which vary from element to element. In this setting, two elements are particularly important: people and the company way. The principles governing these two elements strongly indicate the wish for participation, initative/improvement and competence liability.[25]

The production system as such is intended to stimulate increased efforts for improvement, with the aim of maintaining or increasing competitiveness. One way to stimulate improvement and innovation is to invite employees to participate actively. This may be done in a variety of ways, but one approach is to encourage employees to come up with suggestions for improvement. A relevant tool for collecting such proposals is the *proposal box*. The case company has operated a manual proposal box system for many years. This manual system failed to deliver, due to slow handling of suggestions and the high cost associated with the case handling. When a proposal was physically delivered in the proposal box, the co-ordinator who administered the system had to register it and decide who should evaluate the proposal. Then the proposal was handed over to the assessor; depending on

[25] The company focuses on participation and training to develop competence liability, which is the ability of each individual to work independently, participate and take responsibility for his/her own workplace. The company's employees are able to take responsibility for more than their own job and thus ensure the suitability of the working environment, HSE, productivity and innovation.

the size and character of the proposal it might require more than one assessor for evaluation. In addition, the department manager had to comment on the proposal.
As part of the Simplex project, it was decided that a digitalisation of the proposal box system was needed to enable continued employee participation.[26] A digitalised system was provided to enable much faster processing of proposals. The system was also expected to allow communication with the proposer(s) during the processing of a proposal, so that they would know at any given time at which step of the proposal handling system their proposal was located. At the same time, the system opened up the use of tools familiar from social media, such as thumbs up, likes, comments and evaluation. Not only did this provide indications of the quality of the proposal, it also made it possible for colleagues to comment on each other's proposals and thus contribute to rapid handling of suggestions. Consequently, by developing and implementing a digital proposal box, a number of improvements have been introduced:

- Suggestions may be delivered from an employee's cell phone (all employees have their own cell phone sponsored by the company).
- Co-workers can comment on, like or evaluate suggestions.
- Proposers are able to follow the whereabouts of their proposal in the process.
- Communication between the proposal box system administrator (department head) and the proposor(s) is dramatically improved.
- Proposals may be promoted using pictures and videos from cell phones.
- Documentation beyond pictures and videos may be uploaded.
- All types of proposals and improvement projects are handled in the same system.
- Management is provided with an overview of numbers and estimated savings.

Most important is the structural facilitation of participation in the design of the handling system. The handling and prioritising of proposals will for the most part be undertaken by democratic committees, which consist of union representatives, safety delegates (democratically elected from among the employees) and both blue- and white-collar workers, in addition to management. This ensures insight, involvement and influence on both strategic and practical decisions.

A fundamental challenge posed by the use of the digital suggestion box system is that the system allows for a far-reaching flexibility with regard to the promotion of proposals. The transparent system encourages users to participate in a progressive development of proposals and in new solutions where the innovation element may be significant. This is reinforced by the fact that large groups within the organisation, through the ongoing extensive digitalisation of the company, are being introduced to large volumes of digital data that were previously unavailable to them. For the system to succeed, the ability to handle proposals quickly is essential. Thus, on the one hand, the new digital suggestion box system encourages an increased number of substantial suggestions that have to be handled thoroughly and quickly. On the other hand, it is expected that the digital system will contribute to efficiency, rather than becoming a cost driver in the handling of suggestions. The handling of this dilemma will thus become fundamental.

The case company's development initiative for facing Industry 4.0 has been presented above. On the one hand, there is a focus on developing and implementing an overall digital production system that includes the entire production process, including subcontractors and partners, and which represents an innovative force for seeking new solutions for operations in existing markets and the new markets the company is considering entering. On the other hand, a digital effort to accelerate the pace of improvement work through the digital proposal box, as well as a number of other solutions, ensures digital access to job documents, ordering of materials etc. Together, these technological developments change the prerequisites for socio-technical interaction. The changes allow for an

[26] A prototype of the system is now in testing for implementation.

organisation that is completely different from the traditional hierarchy in which the foreman or department head leads his or her crew from above by controlling the distribution of work and access to the necessary expertise.

IOR vs DD for participation

A modern company depends on constant improvements to stay competitive. Many improvements will be driven by conditions outside the company. The sources of improvement are diverse and include technological developments/new technologies, new interfaces between customer and supplier, and new construction methods that are more efficient/less resource-intensive. Even though these sources come from outside, the company has to implement internal solutions and make them more efficient (Silverstone and Hirsch 1992). Fundamentally, this is about domesticating new organisational concepts. The case company has a number of bodies, ways of operating and tools to ensure that employees participate in making sense of new concepts and technologies (Feldman 2000, Feldman and Pentland 2003), domesticating them (Silverstone and Hirsch 1992) and routinising them (Nelson and Winter 1992). When solutions and processes are optimised, efficiency is bound to improve. Nevertheless, the personnel must experience the work as meaningful and challenging.

As indicated in the case, major technological changes are taking place in the company, and this poses great challenges to the work organisation. However, technology is not deterministic; it allows for choices. Thus, the way the company decides to implement and use the technology will be of great importance to the work organisation. However, this not solely a technology issue. The way the technology is adopted may be guided by the set-up of the work organisation. The work organisation and technology must consequently be considered in context, and employees should be included and listened to in the assessment of different set-ups. Although new solutions are being implemented, there remains significant potential for progressive improvement through facilitation of the production process, better organisation etc. Gaining this potential is largely a matter of facilitating active participation by the employees. This means that strategic challenges that place major constraints on the organisation and daily improvements must both be addressed at the same time.

The core issue is which framework best promotes and supports these improvements. Above, I have presented two different STSD approaches that provide different conditions for this type of activity. The Dutch IOR approach provides a comprehensive theoretical model that focuses on removal of operational disturbances and efficient handling of repetitive disturbances within a company. This is made possible through a detailed description of levels, design parameters and evaluation of those parameters in terms of key performance indicators. This comprehensive and detailed model will somewhat limit the company's room for manoeuvre. Using IOR determines the direction in which a company will adjust its improvement field, strategically and practically. As with all STSD approaches, IOR focuses on the work organisation, the work content and the responsible competent employee (Ravn 2017); however, given the limited room for manoeuvre, this will somewhat limit the development agenda.

The other approach presented above is the Scandinavian DD. As a point of departure, this approach provides less structure by focusing on democratic dialogue and a procedural approach as the most important tools for improvement. Furthermore, the focus goes beyond the individual company. Instead of unfolding within a single organisation with networking organisational boundaries as an addition, the projects will have network building as their prime target. This focus has emerged from the modest results in programmes initiated in Scandinavia, especially in Norway (Gustavsen 2008). The spread of STS was slow, and making local/regional networks a point of departure for STS/AR was regarded as a strategic move in the right direction. Later, the concept of development coalition, which embraces several local networks, was launched (Gustavsen 2008). Such an approach involves fewer restrictions on which improvement objects/activities/projects to focus on, and may enable a stronger focus on the decisive issues for STSD, i.e., work organisation. However, the almost complete lack of focus on the relationship

between technology and organisation in DD has led the tradition towards a pure AR approach that has trumped the focus on socio-technical systems.

Carl Pava developed an interesting multiple-step approach to the STSD of non-routine office work systems (Pava 1983, Austrom and Ordowich 2018). Based in the US, Pava was outside the IOR and DD traditions, and the foundations of his approach are of particular interest: instead of the self-managed work groups with interchangeable skills that characterise classic STSD, he focused on what he called "discretionary coalitions" and "deliberations".[27] In non-routine knowledge work, deliberations form collectively built frameworks that provide clarity for the communicators without sacrificing complexity. Deliberations are carried out to illuminate problematic issues, innovation tasks etc. and may take place in different forums or settings. By focusing on discretionary coalitions using deliberation as a tool in non-routine knowledge work, Pava moved away from input–output configurations in routine work, focusing instead on the advancement and application of knowledge as the output of deliberations. This represents a whole new approach to nurturing holistic job design from most of the STSD literature. Simultaneously, Pava reinforced the importance of the design process: the process is as important as the design outcome. The outcome must be self-designing, because only the participants in the "system" can determine its nature, purpose and boundaries before designing the details. On this basis, Pava strongly emphasised the importance of participation and of maintaining a distance from the omniscient expert.

The case company is a project-based organisation. Even though much work consists of routine operations, projects differ in their complexity, distribution of work, suppliers and partners, the number of personnel required etc. This means that the organisation and personnel must be able to use deliberation and advanced knowledge sharing to solve challenging issues in any project. Pava's analyses of non-routine office work led him to introduce, or give new content to, the concepts of discretionary coalitions and deliberations. His reconfigurations capture how non-routine work may be organised and applied to work organisation in the digital future. I therefore believe that Pava's STSD approach is a viable alternative to the two approaches outlined above. It includes the necessary structure, meets the needs for involvement, participation and ownership, and is less expert-driven.

In this paper, the case was presented to introduce a kind of combination of IOR and DD. The case company wished to develop a production system (XPS) to frame its development agenda within an overall structure that would enable the establishment of a development agenda anchored within that structure, setting the direction for the development work. XPS can thus clarify what the company regards as the most important areas for development and the reasoning behind those choices. However, this will be brought about in a less structural manner than is found in IOR. Addressing the relationship between technology and work organisation, with an open agenda concerning how technology should be put to use, will encourage engagement and help create jobs that people enjoy. However, these approaches do not fully capture the new challenges raised by Industry 4.0. The distinctions among tasks traditionally given to specific groups may be erased, technology may be widely distributed and used by "everyone" and, because of constant shifts in the type of products being produced, the same person may hold different roles in different projects or for different product types. This situation is brought about by market diversification, where the company enters new markets. As the suggestion box case indicates, new technology and its application may challenge the existing organisation, putting the traditional hierarchy under pressure.

Through the proposal box system, the company ultimately envisages increased efficiency and productivity, but with the possibility to determine the direction of those changes. The philosophy behind the proposal box system is to encourage and allow wide employee participation. Their commitments are not limited to reducing disturbances,

[27] Pava introduced his own glossary in his book *Managing New Office Technology: An Organizational Strategy* (1983:176-180). There, he defined discretionary coalitions as "alliances of interdependent parties formed to make intelligent trade-offs that enable attainment of overall objectives; different coalitions are associated with different deliberations". He defined deliberation as "sequences of reflective and communicative acts employed to resolve problematic issues".

although this may be interpreted widely. Setting structural limits on the development agenda through model restrictions (as in IOR) will consequently place unrequested limitations on the proposal box system. Limitations contrast Pava's approach which encourages new combinations and new non-traditional solutions. The proposal box system will cover both strategical important initiatives and a large number of minor developments that will encourage systemic belonging in any case. Nevertheless, Pava's approach of escaping from the input–output strait jacket may open up solutions that have not yet been considered.

Conclusion

The digital revolution sets entirely new technical preconditions for socio-technical interaction. If STSD is to remain relevant, suitable approaches must be developed within this tradition. As indicated above, established approaches such as IOR and DD will have shortcomings in terms of coping with the new digital era. Pava's non-routine office work approach, in which he introduces alternatives to classical hierarchies, seems to provide a solid point of departure.

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EUROPEAN JOURNAL OF WORKPLACE INNOVATION

Innovation adoption of employees in the logistics sector in the Netherlands: The role of workplace innovation

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Abstract

In this study we examine individual behavioural and organisational predictors of innovation adoption among employees in the transport and logistics sector in the Netherlands. The framework of the study is based on theories of planned behaviour and workplace innovation. Based on a survey of 224 respondents, we see that employees who are expressing innovative behaviour, are feeling engaged in the process of innovation development and implementation and are stimulated to contribute in the team or department's meetings, also have a positive perception of innovation. Ease of use and subjective norm are key elements related to the actual use of innovation, i.e., innovation adoption. The role of workplace innovation, that is engagement of employees in decision making and giving them voice in the process of innovation development and innovation, is highly relevant for successful implementation of innovation.

Keywords: workplace innovation; innovation adoption; theory of planned behaviour; logistics; employee engagement

Introduction

In order to remain economically competitive and to keep up with societal demands, organisations are implementing various technological and process-oriented innovations. For innovations to have their maximum effect these should also be well co-adopted by the workforce. Yet, little is known about combined organisational factors and individual employee behaviour that influences innovation adoption of employees.

Indeed, several theoretical frameworks have examined human behaviour related to technology acceptance as part of the innovation process in the past, for instance the *Technology acceptance theory* (Davis 1989; Bagozzi, Davis & Warshaw 1992; Mun, Jackson, Park & Probst 2006), and the *Innovation diffusion theory* (Rogers 2003). Yet, these theories rather focus on technological innovations, individual factors and the process as a whole with regard to innovation adoption, rather than on organisational and employee factors as predictors of innovation adoption.

We believe the approaches of *Leadership* (Yukl, 2012; Oeij, Gaspersz, Van Vuuren & Dhondt 2017) and *Workplace innovation* (De Sitter, den Hertog & Dankbaar 1997; Pot, Rus & Oeij, 2017) may help to understand the relationship between employee and organisational factors, and innovation adoption. Workplace innovation focuses on organisation of work as a form of innovation and employee participation, with the objective of improving both quality of work and organisational performance (Pot, Rus & Oeij 2017). It refers to non-technological interventions of an organisational nature and regarding the deployment of personnel, that support embedding and adopting technological innovation (Oeij & Dhondt 2017). Workplace innovation is a means to improve quality of jobs and company performance by such interventions. Workplace innovation therefore complements technological innovation and is necessary for socio-organisational renewal. In addition to the two mentioned frameworks, in this study we use elements of the *Theory of planned behaviour* (Ajzen 1991, 2012; Fishbein and Ajzen 1975, 2010), as a validated concept for behavioural change, as we wish to understand the role of perception of innovation for actual use of innovation. We combine these theories into a research model and investigate the main relations in the current study.

In sum, the aim of this study was to explore the role of workplace innovation for perception of innovation by employees, and eventually, innovation adoption by these employees. With these insights we want to assess its implications for further theorising on workplace innovation.
Our article starts with presenting theoretical points of departure resulting in the conceptual model of innovation adoption and the formulation of our hypotheses. We continue by describing the methods and the results we found. In the conclusion we address the hypotheses and thereafter we mention issues for discussion and some implications for practice.

Individual behaviour and innovation adoption

Adoption is the decision to proceed with the implementation of a practice: here accepting to work with an innovation, which is a complex process, as it includes factors at both the organisational and individual level (Wisdom, Chor, Hoagwood & Horwitz, 2014). The *Theory of planned behaviour* (Ajzen 1991; Fishbein & Ajzen 1975) explains that individual behaviour is preceded by intentions to perform that behaviour. These intentions are determined by the individual's motivation driven attitudes, and perceptions (of employees) about opinions of influential others, and one's self-assurance to perform well. Fishbein and Ajzen (1975) operationalise these determining factors as respectively behavioural attitudes, subjective norms and self-efficacy. The *Theory of planned behaviour* is a general theory that needs to be made context specific, here to the context of employees adopting innovations or new technologies.

According to the *Technology acceptance theory,* the motivation or intention to adopt a new technology, i.e., an innovation, is driven by the perceived usefulness of an innovation (benefit) and its perceived easiness in use (user

friendliness) (Bagozzi et al, 1992; Davis 1989; Mun et al 2006). The first, perceived usefulness, refers to the expectation that the innovation will improve one's performance, based on the individual's evaluation of the new technology as relevant for the performer's output (quality judgment), and to enable application of the new technology to specific tasks (relevance). In addition, a user needs to be able to assess or observe that applying a technology is indeed successful (result demonstrability), for example by watching others using it (Rogers 2003; Venkatesh & Davis 2000). The second, perceived easiness, is intertwined with a person's self-efficacy or self-assurance to apply the new technology. Apart from usefulness and easiness of an innovation, subjective norms (for example opinions of managers, as significant others, about importance of use of innovation) determine the intention to apply and adopt innovations. The subjective norm may induce individuals to conform their behaviour into the desired direction (Ajzen 1991; Fishbein and Ajzen, 1975; Venkatesh, Morris, Davis & Davis 2003; Venkatesh & Davis 2000).

Organisational context

While individual factors are assumed to be important for employees to adopt innovation, certain organisational conditions are more favourable than others, especially those environments that stimulate employee engagement and participation (Totterdill & Exton 2017). A first clear building brick for employee engagement is job autonomy (Karasek 1979; Karasek & Theorell 1990), the decision latitude about how one selects and executes tasks to be performed during the production or servicing process. Job autonomy is a feature of 'active jobs' that are designed to have controllable workload levels (to maintain acceptable stress levels) and learning opportunities to fully deploy one's talents (challenging tasks) (De Sitter et al. 1997; Dhondt, Pot & Kraan 2014; Karasek &Theorell 1990). Job autonomy can be relevant to guide one's behavioural intentions and has been in earlier studies positively related to company performance (Preenen, Oeij, Dhondt, Kraan, Jansen et al. 2016). The working environment of employees can propel openness to renewal when, as a second determinant, there is employee voice, and a psychologically safe surrounding that allows making mistakes and learning (De Dreu 2002; Edmondson 2012; Oeij 2018), which is especially important for first-line personnel to feel invited to express their opinions (Weick & Sutcliffe 2007). In such environments, employees will feel more freedom and less pressure for new behaviours, like adopting a new technology. A third aspect of the organisational context is how employees perceive leadership of their management. When it comes to introducing innovation, management should engage, stimulate and support others, especially in the case of differing interests, possible conflicts and ambiguity, to which the introduction of newness is conducive (Oeij, Gaspersz, Van Vuuren & Dhondt 2017; Totterdill & Exton 2017; see also Nusair, Ababneh & Kyung Bae 2012). In such instances, leadership should not only be transactional: directed at task execution and results, but also transformational, inspirational, (Yukl 2012), and synergetic, in that it can deal with conflicting goals and complexity (Lawrence, Lenk & Quinn 2009). Management that can effectively deal with innovation as a complex process with several ambiguities and possible conflicts of interest (Van de Ven 2017), will be an example for employees that helps to accept newness, and will also be internalised as a subjective norm that innovation is important.

Domain specific behaviours and facilitating measures

Apart from organisational and individual factors that determine innovation adoption or the actual use of innovation, domain specific behaviours of employees are expected to accelerate the uptake of newness. Intrapreneurship points to opportunities that employees see, use and improve the innovation and performance of companies (Carrier 1994). An element of intrapreneurship is innovative behaviour, i.e., initiating and introducing new ideas, processes, products and procedures (Farr & Ford 1990). Innovative behaviour is expected to positively affect innovation adoption.

The former discussion has led to the following conceptual model of innovation adoption which has been applied in this research (see Figure 1). The model depicts how employees perceive the work environment in terms of characteristics of the organisational context. This factor, and the individual features of employees, i.e. their attitude regarding innovative behaviour, are elements of workplace innovation. As such these are thought to affect how employees perceive the innovation itself and whether they will actually use it. From previous research on innovation adoption of employees, we saw that workplace innovation (defined in terms of high autonomy, high team voice and engagement of employees with operational tasks in innovation process) was directly related to actual use of innovation (Putnik, Oeij, Dhondt, Van der Torre & de Vroome 2019). Important to note is that in the mentioned study managers evaluated innovation adoption of their employees (indirect measurement of innovation adoption). Furthermore, innovative behaviour was related to perception of innovation and perception of innovation (usefulness of innovation and ease of use of innovation) was directly related to use of innovation. In this study we wished to explore the relations in our model based on the employees of the logistics sector, to see if there is similarity in findings when concepts are measured directly from employees, versus when they are measured indirectly, via the perception of managers, as well as reflect on findings in relation to theory and previous research.

The main research question of this study is: *Which individual and organisational factors are related to the perception of innovation of employees in logistics, and how does this relate to the actual use of innovation by employees in organisations?*

Hypothesis 1 is: The more stimulating the organisational context (autonomy, team voice, employee engagement), and the more innovative the behaviour of employees, the more positive the perception of innovation.

Hypothesis 2 is: Positive perception of innovation (result demonstrability, usefulness, ease of use, subjective norm) is related to higher innovation adoption (actual use of innovation).

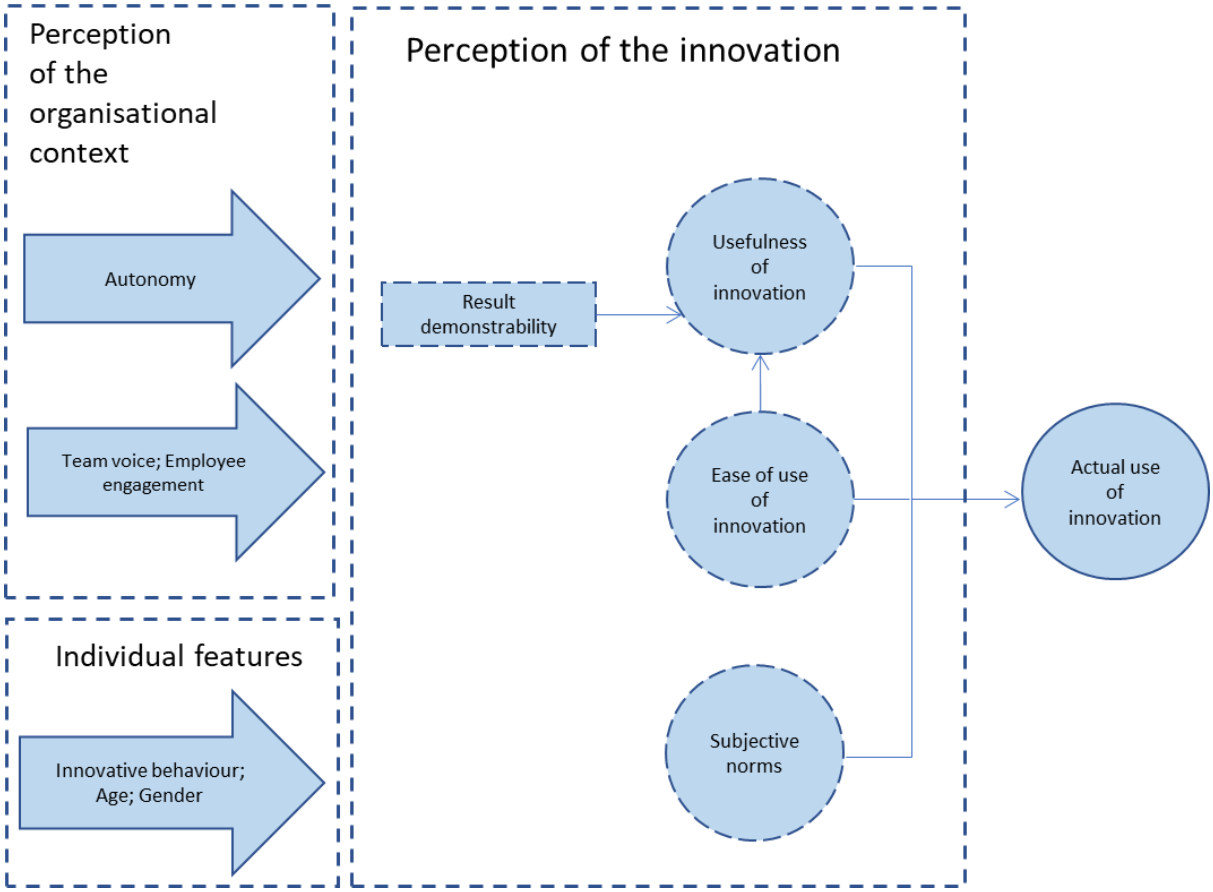

Figure 1. Conceptual model of innovation adoption.

Methods

Measures and data

Electronic surveys were distributed via e-mail in the months of May and June 2018. The sample was drawn from the Netherlands Working Conditions Survey (NWCS), cohort 2017, which is a large representative sample of the working population of the Netherlands (Hooftman, Mars, Janssen, de Vroome, Janssen & Ramaekers 2018). All employees working in the transport and/or logistics sector who gave permission to be approached again, were contacted (n=985). Via an email the announcement about the survey and its purpose were communicated. Following this mail, we received a number of notifications of faulty e-mail addresses, information that employees were not interested in participating, or were not anymore employed. Eventually, 830 employees were approached with the survey. Our purpose is not to assess representative knowledge for the logistics sector employee population, but to explore our theoretical model.

All employees received two reminders to fill out the survey. The response rate was 27% (n=224). The younger employees are underrepresented in the survey (5%=18-28 years old and 15%=28-38 years old). In our sample, 81% of respondents are male and 19% are female. The participants work mostly in the transport sector (54%), followed

by the logistics sector (21%), and both logistics and transport sector (25%). The employees' main function could be described as mostly operational (66%), managerial (15%), supportive (13%) and preparatory tasks (6%). Twenty nine percent of employees work in organisations that have not implemented an innovation in the past two years. The remaining 71% of organisations introduced a new product (28%), service (38%), new work process (69%), new organisation of work (39%), innovative use of personnel (38%) or other types of innovation (9%). Some organisations implemented two or more innovations in the last two years.

Dependent variable:

Actual use of innovation was measured with a self-constructed item: *'I use innovations well'*. Answering categories ranged from 1 (not at all) to 5 (fully). The variable was dichotomised, so that answer categories 1 to 3 were defined as low actual use (value 1), and 4 to 5 as high actual use (value 2).

Independent variables:

Perception of the organisational context:

Organisational variables concern the context in which work is carried out. We operationalised this with the variables of *Autonomy*, *Team voice*, and *Employee engagement* concerning innovation.

Autonomy concerns the degree to which employees can determine the way in which work is carried out. A mean sum score was created (α=0,78) based on six items with three answering categories (1=no, 3=yes, regularly, originating from the NWCS (Hooftman et al. 2018). An example of an item is: *'Can you decide yourself how you carry out your work?'*

Team voice concerns the extent to which employees feel free to express their opinions. A mean sum score was created (α=0,93) based on six items with answering categories ranging from 1 (fully disagree) to 5 (fully agree), originating from a survey of LePine & Van Dyne (2001). An example of the item is: *'Every employee freely shares his or her ideas for new projects or changes in the way work is carried out'*.

Engagement of employees concerning innovation (Employee engagement) was measured with a seven-point answering scale, consisting of six items (NWO Intrapreneurship index: Fleischer & Stam 2018; Stam 2018, which includes a subscale of Workplace innovation). A mean sum score (α=0,87) was created, where two of the original six items were removed, due to their poor reliability. An example of an item is: *'I am approached to give input about innovation and renewals*.' Types of innovation included: innovation of a product; innovation of a service; innovation of a working process/ICT support; innovation in organisation of work; innovative use of personnel; other types of innovation; no innovation.

Individual features:

By *individual features* of employees, we mean domain specific attitudes concerning innovation, as well as their individual characteristics, such as age (age in years) and gender (male, female, other). *Innovative behaviour* is one of the Individual features that we have measured. The mean sum score (α=0, 97) was created, originating from the *Intrapreneurial Behaviour Measurement* questionnaire (Preenen, Liebregts, Dhondt, Oeij & Van der Meulen 2014) and contains nine items, measured on a five-point scale (1=never, 5=always). An example of the item is *'I clearly contribute to improving products/services of the organisation'.*

Perception of innovation:

Perception of innovation was measured with four items: 1) *Visibility of results* (item: 'The effects of using the innovation are clearly visible to me', Fleuren, Paulussen, Van Dommelen & Van Buuren 2014); 2) *Perceived usefulness* (item: *'I perceive the innovation as useful, for myself or for clients'*, Venkatesh & Davis 2010); 3) *Perceived ease of use* (item: '*The ease of use of innovation is high, both myself and clients'*, Davis 1989), and 4) *Subjective norm* (item: *'The management communicates regularly to me about the importance of innovation'*, Venkatesh et al. 2003; Venkatesh & Davis 2000). Answering categories for all four items ranged from 1 (not at all) to 5 (fully).

Analyses

As preparatory analyses, in order to rule out the possibility of multicollinearity, we carried out correlation test for the variables in our model. We then proceeded by carrying out independent samples t-test to compare organisations high in innovation adoption (actual use of innovation) and those low in innovation adoption (low actual use of innovation). Lastly, in order to answer our research question, a path analysis based on multiple regressions was carried out in two stages (Figure 2). In the first stage, organisational context (*Autonomy, Team voice, engagement of employees concerning innovation*) and individual features (*Innovative behaviour, Age, Gender*) were simultaneously examined in relation to the perception of innovation (*Result demonstrability, Usefulness of innovation, Ease of use of innovation,* and *Subjective norm concerning innovation*). In this stage four regression analyses were carried out, where each variable of perception of innovation was used as an outcome variable and organisational and individual features as independent variables. In the second stage, all variables in the model were simultaneously examined in relation to the actual use of innovation as the final dependent variable. In total, we performed five multiple regression analyses consecutively, but we present the results in one visualized solution in Figure 2 as a path-diagram (Hayes & Rockwood 2017). This path analysis was conducted to investigate the process of how different elements of the research model work in practice. Missing values were deleted in a listwise manner.

Results

Actual use of innovation has a significant positive correlation with *Engagement of employees* and all four variables of *Perception of innovation* (Table 1, based on listwise deletion). The strongest correlations of actual use of innovation are with the *Usefulness of innovation* variable, which is part of the *Perception of Innovation*. Overall, the strongest correlations are between *Ease of use* and *Usefulness of innovation* and between *Engagement of employees* concerning innovation and *Subjective norm*. The high correlations are in line with the theoretical predictions.

Table 1: Means, standard deviations and correlations between the variables

	M	SD	Gender	Age	Autonomy	Team voice	Innovative behaviour	Employee engagement	Result demonstrability	Ease of use	Usefulness of innovation	Subjective norm	Actual use
Gender (1=male,2=female)	1,19	,39	1										
Age	49	12,07	*+0,19*	1									
Autonomy (1-3)	2,16	,55	+0,06	-0,07	1								
Team voice (1-5)	2,89	,89	-0,01	-0,03	+0,17	1							
Innovative behaviour (1-5)	2,49	,99	-0,16	+0,02	*+0,20*	*+0,50*	1						
Employee engagement (1-7)	3,15	1,39	+0,01	+0,11	*+0,30*	*+0,45*	*+0,52*	1					
Result demonstrability (1-5)	3,33	1,11	-0,09	+0,15	+0,01	*+0,23*	*+0,40*	*+0,51*	1				
Ease of use (1-5)	3,57	,98	*-0,18*	-0,16	+0,15	*+0,21*	*+0,30*	*+0,37*	*+0,41*	1			
Usefulness of innovation (1-5)	3,12	1,14	-0,16	-0,01	+0,03	*+0,30*	*+0,35*	*+0,38*	*+0,45*	*+0,61*	1		
Subjective norm (1-5)	2,79	1,18	+0,04	+0,03	+0,18	*+0,50*	*+0,50*	*+0,67*	*+0,40*	*+0,30*	*+0,29*	1	
Actual use of innovation (1=low; 2=high)	1,59	,49	+0,16	+0,10	+0,03	+0,11	+0,17	*+0,34*	*+0,39*	*+0,34*	*+0,44*	*+0,35*	1

Note: *italics* represents significant results p<0,05.

In Table 2 (based on the 137 remaining cases) we compared the groups of low and high actual use of innovation and tried to see if the groups differed significantly on the main work dimensions identified in this study. . For the majority of employees, innovation adoption was high (59%). Employees with high innovation adoption differ on a number of aspects from employees who are low in innovation adoption (41%): employees with high innovation adoption have a greater say in their work environment (*Team voice*), show more *Innovative behaviour*, are more engaged in the innovation implementation (*Employee engagement*) and perceive innovation in a more positive light. They see the innovation as bringing more tangible results, being easier to use and more useful to apply and perceive greater support of management to use the innovation than employees with low innovation adoption. There were no significant differences between the employees with high and low innovation adoption when it comes to age, gender and degree of autonomy.

Table 2. Comparison of individuals according to low actual use of innovation vs high actual use of innovations

	Actual use of innovation		
	Low (1)	High (2)	Total
N (%)	56 (41%)	81 (59%)	137 (100%)
Gender			
1 Male	83,9%	79,0%	81,0%
2 Female	16,1%	21,0%	19,0%
Age [mean]	50 years	49 years	49 years
Autonomy [Score: 1−3]	2,17	2,25	2,22
Team voice [Score: 1−5]	2,78*	3,15	2,99
Innovative behaviour [Score: 1−5]	2,38*	2,81	2,63
Employee engagement [Score: 1−7]	2,61*	3,56	3,17
Result demonstrability [Score: 1−5]	2,88*	3,69	3,35
Usefulness of innovation [Score 1−5]	3,18*	3,86	3,59
Ease of use [Score: 1−5]	2,56*	3,51	3,12
Subjective norm [Score: 1−5]	2,32*	3,17	2,82

Note: * represents significant results p<0,05. Total number of employees is less than 224, as 64 organisations did not carry out any innovation and 23 employees had missing values on at least one of the examined variables. (NB the mean scores differ from Table 1 due to the changed N).

Results of the path analysis are summarised in Figure 2. Hypothesis 1 'The more stimulating the organisational context, and the more innovative the behaviour of employees, the more positive the perception of innovation' was partially confirmed. The hypothesis holds for *Team voice*, *Innovative behaviour* and *Engagement of employees*. Employees who feel free to give input to their department or team, experience higher subjective norm concerning the importance of use of innovation. Employees who show more innovative behaviour, also perceive higher results demonstrability by use of innovation. The higher the engagement of employees during the innovation implementation phase, the higher the positive perception of innovation in terms of demonstrability of result, usefulness and ease of use of innovation and subjective norm. Autonomy has no significant relation with perception of innovation.

Hypothesis 2 'Positive perception of innovation (result demonstrability, usefulness, ease of use, subjective norm) is related to higher innovation adoption (actual use of innovation)' was also partially confirmed. Two aspects of perception of innovation, namely, *Ease of use* and *Subjective norm* are positively related to the innovation adoption (*Actual use of innovation*). Two other aspects of perception of innovation, that is, *Result demonstrability* and *Usefulness of innovation* did not appear to play a role for innovation adoption.

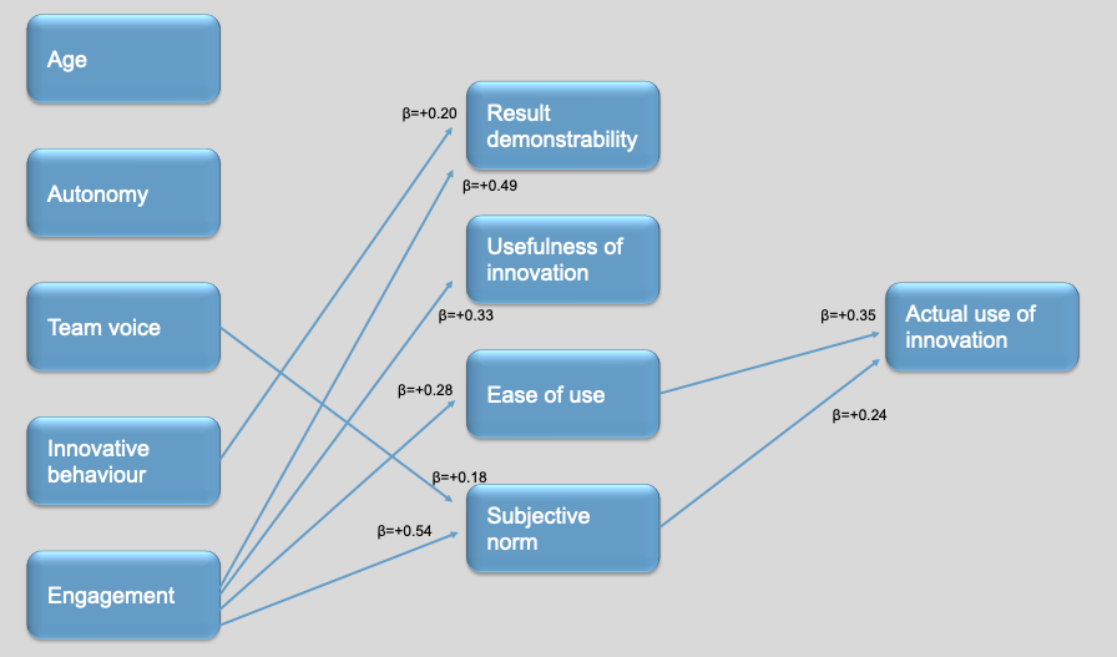

Figure 2. Path analysis for *'Actual use of innovation'* as outcome variable.
Note: All depicted relationships are significant (*p<0,05).

Conclusion

This study aimed to examine which organisational and individual factors, as well as elements of perception of innovation, play a role in innovation adoption process at the level of individual workers. Based on the findings, we conclude that four elements are a key to successful innovation adoption: 1. team voice and 2. engagement of employees, 3. ease of use and 4. subjective norm. Team voice and engagement of employees are positively related to ease of use of innovation and seeing the importance of the use of innovation (*Subjective norm*), which in turn are positively related to actual use of innovation.

From this research, we conclude that certain organisational aspects of workplace innovation, as defined by team voice and engagement of employees, are important for successful implementation of innovation. Employee engagement is a determining constituent of workplace innovation (Oeij & Dhondt 2017; Totterdill & Exton 2017). Not surprisingly, there is however a strong correlation with team voice as there is some theoretical overlap between these concepts. But more relevant is the observation that employee engagement has an influence on all four elements of the 'planned behaviour' of employees (four perception of innovation variables: result, use, ease and norm) to actually use the innovation. As such, workplace innovation largely determines the uptake of renewal, i.e. innovation adoption. Finally, autonomy played no role in the multivariate analysis in relation to perception of innovation or innovation adoption among employees.

Discussion

The general assumptions of our theoretical model (Figure 1) have been supported: both organisational and individual aspects are determining innovation adoption. Organisational context (in the form of team voice and

employee engagement) and individual variables (innovative behaviour) are related to perception of innovation, while perception of innovation (ease of use and subjective norm) is related to actual use of innovation. We see thus that workplace innovation has an indirect effect on positive organisational outcome in the form of innovation adoption (Pot et al, 2017; Putnik et al, 2019), and that intention to use innovation, as postulated by the Theory of planned behaviour (Ajzen 1985; 1991; Fishbein & Ajzen 1975) has also been supported in this study.

In comparison with earlier research on innovation adoption under a sample of managers (Putnik et al. 2019), we see a number of similarities and differences. Similarities concern individual characteristic of innovative behaviour, which is related to perception of innovation in both samples as well as perception of innovation (usefulness and ease of use) which is related to actual use of innovation. On a more detailed level concerning relationships, we see that innovative behaviour in the eyes of managers is related to all aspects of perception of innovation while for employees it is related only to result demonstrability. It can be that in the eyes of management more focus lies on individual responsibility concerning perception of innovation, while among employees, it seems to be determined by organisational factors. Implicitly, managers seem to put more responsibility on employees concerning perception of innovation, while employees put more emphasis on management for innovation adoption (via social norm). Another difference is that in the eyes of the managers, actual use of innovation was directly related to organisational aspects, such as autonomy, team voice and employee engagement, while for employees this went via perception of innovation.

Surprisingly, autonomy in work does not play a role in the regression analysis. It appears that structural elements (as defined by autonomy as part of job design), seems to be less relevant than culture related elements (engagement, input in teams, subjective norm) for the implementation of innovations. Another explanation for these findings may be related to the wording of the questions. Namely, employee engagement and subjective norm have been asked directly in relation to innovation, while level of autonomy has been asked in general terms, and not specifically in relation to innovation adoption. It might be that employee engagement and team voice is perceived as in fact having a say in the innovation process.

Based on other literature, we know that investing in autonomy of employees is essential for creating active jobs (De Sitter et al. 1997; Karasek 1979), and also for ensuring that employees themselves come with ideas for new innovations (Hansen, Amundsen, Aasen & Gressgard 2017). While this research showed no significant relationship between autonomy and innovation adoption: perhaps due to the fact autonomy that was measured indirectly related to innovation adoption, or the fact that we did not make a distinction in type of innovation, like organisation driven vs employee driven, more in-depth examination is needed. Such research needs to distil the exact role of autonomy for the process of innovation, rather than for straight forward autonomy in the primary job execution process.
In interpreting these findings, it is also important to keep in mind that the employees and managers were not from the same organisation, and that the differences in findings may relate to differences in organisations as such rather than differences in experiences among managers and employees.

Although this research has been based on validated concepts to build a theoretical framework, and while it has used validated questions to answer the research question, an issue remains to what extent we have brought theorising on innovation, and workplace innovation in particular, beyond the state of what we already knew. The findings tell us that elements of workplace innovation have at least an indirect effect on the uptake of innovation. Employee engagement of workers in the innovation process seems highly relevant. While their job autonomy might not be decisive, if management provides clear exemplifying behaviour (subjective norm) and the innovation is experienced as easy to use, their acceptance and lack of resistance could be highly crucial conditions for successful implementation of renewal. This observation could shift our attention to processes in which employees perform, instead of focussing on formal job descriptions (having autonomy in one's work) or the division of labour and power relations designed into the structure of job and organisation (as static facts). Innovation processes are dynamic and, in every stage, (like in innovation stage gate models) the tasks, roles and relations of involved employees may shift.

Because this aligns so well with the general notion that workplace innovation is not a goal in itself, but a means to an end, how this exactly works requires further examination.

Limitations

A first limitation is the cross-sectional design of the study. This cannot provide conclusive evidence of causal and mediating relationships. Although we theoretically and empirically hypothesised our relationships, future research could include longitudinal and field experimental designs to investigate the causal directions in our research model. Alternatively, future surveys among larger response groups would allow a more firmly based generalized innovation adoption construct using exploratory factor analysis (see for example Brooke Dobni 2008). While this does not solve the issue of causality, it does provide more insight. Subsequently, gathering information about innovation adoption at different levels of the organisation (i.e. employees, managers, teams, organisation as a whole) would be helpful to support a richer multi-level perspective on the topic (Anderson, Potočnik, & Zhou 2014). Also, a limitation of the study is that the response rate has been rather low, which may be related to the length of the survey and the fact that participants have been approached only via e-mail. For future research, it would be interesting to explore whether different types of innovation (manager vs employee initiated; product or process centred), have different paths of innovation adoption.

Finally, given the importance of employee engagement, it would be necessary to carry out qualitative research more in depth on this topic, to better understand the mechanisms and processes behind it. Additionally, we are aware of the fact that our study is rather static in time and linear in its design. Time studies and integrating a complexity perspective to provide insights in the interactive and iterative nature of the innovation process would better correspond to the reality of innovation as a process (Garud, Tuertscher & Van de Ven 2013; Van de Ven 2017), but remains a recommendation for future endeavours. Lastly, we would recommend carrying out cost-benefit analyses for carrying out innovation adoption based on workplace innovation principles, based on both subjective as well as objective data to support the analysis. This would give us tangible benefits of workplace innovation in relation to innovation adoption capacity and further evidence of the importance of workplace innovation (Dhondt, Totterdill, Boermans & Ziauberyte-Jakstiene 2017).

Implications for practice

Based on our findings we highlight implications for organisations to implement innovation in their organisation: implications for individual behaviour of employees, organisational aspects, and elements of perception of innovation.

Individual behaviour: This study proves that innovative behaviour helps the innovation adoption process. However, there should be enough psychological safety for employees to feel welcome to bring input to their team and not worry about being ostracised for their ideas. When psychological safety is present, it also ensures that ideas that are brought in, are actually heard and seriously considered (Edmondson 2012; LePine & Van Dyne 2001; Oeij 2018). Furthermore, managers could encourage innovative behaviour of employees by giving them enough room to develop their ideas and in this way make use of their professional knowledge and creativity. Providing employees with challenging work assignments can also be a proven practical way to stimulate innovative behaviour (Preenen, Dorenbosch, Plantinga, & Dhondt 2016).

Organisational aspects: Managers could actively engage their employees in the process of innovation adoption. This means not only giving employees the space and time to share their opinion about the innovation (i.e., team

voice), but also engaging them in the decision-making process concerning innovation itself. However, especially the part of giving the decision-making power to the employees when it comes to innovation can seem threatening to managers. Earlier research defies such viewpoints of unease and threat. We showed in a previous study that logistics organisations that gave this kind of power to their employees (alongside with autonomy and team voice), more than twice as likely have succeeded in innovation implementation (i.e. actual use of innovation), than organisations where employees do not have decision making power concerning innovation and have low autonomy and team voice (Putnik et al., 2019). Linked to this, also open and transparent, two-way communication between the management and employees is of major importance, as it benefits innovation adoption by lowering the resistance to change (Dhondt, Totterdill, Boermans & Žiauberytė-Jakštienė 2017). Engaging employees in challenging tasks (innovation development) and giving them room to give input, leads employees to see the relevance of what is being developed and in turn they are more likely to use it. Employee engagement has proved to be effective in different international and cultural contexts (Oeij, Ziauberyte-Jakstiene, Dhondt, Corral, Totterdill & Preenen 2015) and especially also in SMEs (Oeij, De Vroome, Bolland, Gründemann & Van Teeffelen 2014).

Perception of innovation: To ensure positive perception of innovation, it is important that the employees have a chance to try out the innovation while it is being developed or tested for implementation in the organisation. It is also recommended that they obtain support in this phase from the persons who are (more) familiar with the innovation, in order to perceive benefits of innovation when it comes to ease of use and usefulness and also have a chance to give feedback about it, further improving the innovation (Putnik et al. 2019). Furthermore, it is important that the management communicates how much importance they give to the use of innovation by employees, as the more they attach importance to it and make it known among employees, the more likely the employees are to use innovation.

Acknowledgement:
This research is based on a project funded by Netherlands Organisation for Scientific Research (NWO) and knowledge investment programme of the Ministry of Economic Affairs and Climate Policy.

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EUROPEAN JOURNAL OF WORKPLACE INNOVATION

Trust-based steering of large Engineering-to-Order offshore/onshore projects: is it possible?

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Trond Haga

Abstract:

The various traditions of socio-technical system design (STSD) emphasise different aspects of such systems, but the core relationship in the literature is between the use of technology and the set-up of organisations. Therefore, much attention has been paid to organisational issues, including work tasks, distributed responsibilities and processes. An organisation where tasks and responsibilities are distributed requires other forms of co-operation and clarification and, not least, that the actors trust each other. Nevertheless, trust has received little discussion in the STSD literature. This paper focuses on trust as a relational tool: the factors decisive for developing trust in a project management team established ad hoc to implement an offshore development project, how to develop trust in practice, and whether a focus on trust reduces the need for control measures. The purpose of systematic trust building is to develop team members who are, individually and as team members, able to deliver the results expected for their area and to support colleagues to do the same, thereby reducing the need for control measures. Trust building represents one way for the project manager to acquire control of the organisation, and it must therefore be better understood, starting with this question: how efficient are the various factors for the project manager in exercising power, i.e. ensuring control over project execution? The case in this paper illustrates the need to address trust and control in the set-up of a project management team, a focus which is also important for STSD in general.

Keywords: Socio-technical systems, team development, trust, task control, trustee-trustor, trust development, team process, fundamental principles

Introduction

The offshore supplier industry is organised around projects, as much as other ETO supplier industries.[28] When an offshore ETO contractor wins a project, a new project organisation has to be established. Parts of the new organisation may have been actively involved in the bidding phase, while other parts of the organisation have not. The offshore supply industry is an industry that delivers mass-produced tailor-made products, i.e., unique products with varying complexity, scope and execution time. Large projects can have an implementation time of four to five years, while smaller projects can be considerably shorter. Projects that the industry receives vary with regard to the scope division between the customer and the supplier, and between the supplier and the subcontractors. This means that the supplier must relate to different customers and different suppliers from project to project. Consequently, the project set-up varies from project to project, as does the project itself.

This set-up makes it impossible to retain fixed project management teams: they will vary from project to project. A team that works together on one project may thus be split up for the next project, and then may work together again later. However, it may often be many years before the team members are again part of the same project management team, which will be more or less like working with new colleagues. It may also be necessary for various reasons to include personnel from other companies. This constant change applies not only to the management team but also to the rest of the project organisation.

In order to manage a temporary project organisation, it is crucial from the project manager's perspective to quickly gain control of the actual execution of planned activities. Project managers can achieve control by using power and/or by using trust. All organisation is based on a form of balance between power and trust: if there is little trust, it may be replaced by control; if trust is high, control measures may be reduced.

This has been confirmed in the literature. Leaders may, by investing in building trust, increase the efficiency of the organisation (Barney and Hansen 1994). Consequently, control and control measures may be diminished considerably, as trust creates conditions for and mobilises both action and interaction (Sørhaug 1996). Trust is fundamentally a matter of confidence concerning an advantage or a gift that will be received in the future, and the confidence that this advantage or gift will be received without any claim to reciprocity. Building trust may consequently be perceived as a way of establishing control over the organisation and the work performed. To achieve the necessary control, different control agents may be used:

> "For example, Bradach and Eccles (1989), who view trust as form for control, argue that managers direct subordinates by combining market-based, hierarchy-based and trust-based control mechanisms" (Long and Sitkin 2006:87).

From such a perspective, it is crucial for leaders to develop a clear understanding of factors that influence the ability to establish trust in the organisation, while at the same time providing them with control over the organisation and their delivery capacity. Likewise, trust is crucial for developing the individual team member or member of the organisation to be able to take on complex and challenging jobs, which is one of the basic prerequisites for STSD.

In an organisational setting, trust may be perceived as a way of gaining control over execution and results. It may arise through formal control mechanisms, such as contracts, incentives and surveillance, or through more relational mechanisms that touch emotions or values (Long and Sitkin 2006). However, trust may and will be perceived as a

[28] ETO stands for engineering to order. Industry production may be diversified in accordance with the degree of standardization of the products, e.g., MTS (make to stock), MTA (make to Assembly), MTO (make to order) and ETO, the last of which produces the least standardized products.

relational tool for achieving increased well-being and safety, and as a consequence, these achievements mean personal development and the development of an environment in which participants support and encourage each other to deliver excellent results (Dvergsdal and Haga 2013).

Organisational and personal trust may be seen as dealing with different dimensions, the one collective, the other individual. Trust is, despite the distinction between the organisational and the personal, a collective phenomenon. On the one hand, it is a phenomenon that emerges from a collective interpretation (the organisational); on the other hand, it arises from individual characteristics that appear in interpersonal relationships (the personal) (Sørensen et al. 2014). At the same time, building trust represents one way to gain control over the organisation. This duality has to a limited extent been problematised in research around trust (Long and Sitkin 2006).

Trust has been established as a separate research field, and the literature in that field has gradually become significant. Nevertheless, certain areas remain less discussed and developed, including the question of how trust can be cultivated or developed. The research question we are therefore addressing is this: what factors are decisive for developing trust in a temporary team?

Trust in a socio-technical system

The concept of trust may refer to a psychological state, thereby placing the concept within the psychological discipline:

> "Trust is the confidence among team members that their peers' intentions are good, and that there is no reason to be protective or careful around the group. In essence, team-mates must become comfortable with being vulnerable with one another … A crucial property of trust is that it requires an as-if attitude on the part of the trustor which renders irreducible vulnerability and uncertainty unproblematic" (Lencioni 2002:195).

These definitions of trust include two conditions that recur in several such definitions: having good intentions and being vulnerable. These two conditions are emphasised as crucial to achieving individual and organisational learning (Fonagy and Allison 2014). Fonagy and Allison introduced the concept of "epistemic trust" to capture this learning dimension:

> "Epistemic trust – that is, an individual's willingness to consider new knowledge from another person as trustworthy, generalizable and relevant to the self" " (Fonagy and Allison 2014:5).

The intention with team organisation, they argue, is not to delimit performance to the knowledge and insight of specific participants, but to encourage team members to embrace or contribute to other people's absorption of new insights so that new common knowledge can be created. For this to happen, the safety net (the conditions that make participants reserved, defensive and suspicious) has to be lowered or removed so that it does not prevent people from being curious and from accepting and investigating seriously what others are offering. Conversely, it should not prevent the participants from sharing their own knowledge with others.

The concept of trust can also be understood as containing elements of discretion and relational aspects:

> "Trust involves good faith and good will: a shared belief that all parties are genuinely working towards some agreed purpose or objective" (Felstead 2009:25).

As the quotation emphasises, trust involves an element of faith and good will that is discretionary. At the same time, in organisations or projects, much effort is invested to create a common perception that all work is targeted towards a common goal, and that in the effort to achieve these common goals, relationships are generally decisive. Felstead et al. conclude that in order for an organisation to function, three forms of trust are important: habitual, symbolic and community (Felstead 2009). By habitual trust, Felstead el al. understand trust that is about the giving or exercising of judgement being legitimised and validated through real or perceived history and tradition, reliability and solidarity. Symbolic trust is where uncertainty around assessments is validated by moral symbols or ethical values. Community trust is where the parties identify with each other and share a sense of community bonding that is highly emotional.

The concept of trust is also included in a separate organisational-sociological discourse. In this discourse, the concept is interpreted within an organisational framework:

> "it is argued that the survival of such [individual] relationships in the face of these inevitable inter-personal problems requires the establishment of inter-organizational trust. Such trust is characterised by community of interest, organisational cultures receptive to external inputs and widespread and continually supplemented knowledge among employees of the status and purpose of collaboration" (Dodgson 1993:77).

In this tradition, the concept is assigned an organisational element that was absent from the psychological discourse. A backdrop of rapid change, in technological, market and customer relations, is used, which makes inter-organisational collaboration necessary:

> "While this [interpersonal trust] is undoubtedly crucial, this paper argues it is important to examine inter-organisational trust. It contends that effective learning between partners depends on a construction of a climate of trust engrained in organisational modes of behaviour, and supported by the belief in the mutual benefits of collaboration throughout the organisation. Only when such inter-organisational trust exits can the partnership continue when inter-personal relationships break down" (Dodgson 1993:78).

Curral and Inkpen have created a model that summarises various relationships between those who trust (Trustors) and those who are trusted (Trustees) (Curral and Inkpen 2006). As stated in the model, both person-to-person relationships (person–person, person–group and person–company) and inter-organisational relationships (group–group, group–company and company–company) are included (Figure 1).

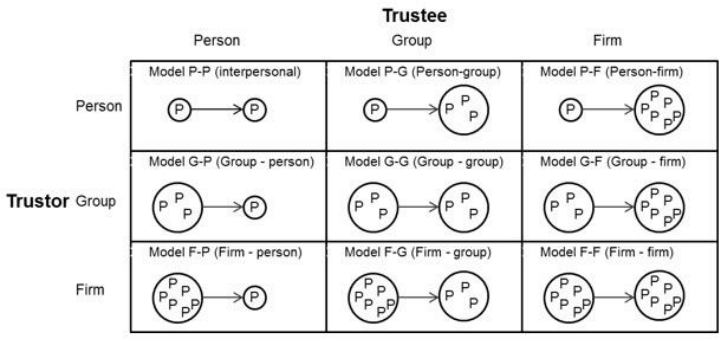

Figure 1. Curral and Inkpen's model of trustor–trustee relationships. Source: Curral and Inkpen 2006.

The model illustrates that trust is a phenomenon that must be given attention both individually and organisationally, and between person and organisation. Even trust in inter-organisational relationships, which are otherwise very important for offshore ETO contractors, completely dependent of suppliers as they are, must be put on the agenda in order to increase productivity, improve competitiveness and reduce risk. Trust should therefore not be underestimated as a fundamental premise in a socio-technical system, particularly in terms of redistribution of tasks and responsibilities when introducing new technology and/or reorganising the organisation

How managers integrate trust building and task control is discussed by Long and Sitkin (2006). They note that although the relationship between control and trust is the key to organisational efficiency, the literature is ambiguous on this point. Long and Sitkin developed a model that identifies prominent trust control relationships and clarifies

> "how various trust-based and control-based elements are determined, integrated and actuated in the ongoing development of managerial attention and action" (Long and Sitkin 2006:96).

They argue that trust-building and task control activities carried out by the leader affect both how the employees perform the work and the quality of the relationship between manager and employees. At the same time, the managers may benefit from evaluating employee benefits and the degree of conflict between management and employees to assess how efficient the task control is and the extent of the trust the leader enjoys with employees. Nevertheless,

> "While recent research has begun to acknowledge the importance of trust and control in facilitating both subordinate task performance and superior-subordinate relationship quality, analyses of how these factors affect future managerial actions is less well understood" (Long and Sitkin 2006:96).

Accordingly, what follows here offers an analysis of how various factors affect the exercise of management.

Building trust is a relational activity between different actors. It may, as we have seen, involve different types of relationships, personal or organisational. The decisive dynamic in a relationship of trust is in all cases between one who trusts (the trustor, or trust giver) and one who trusts in another (the trustee, or trust taker) (Figure 2).

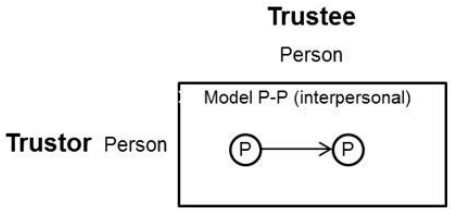

Figure 2. The trustor–trustee relationship.

Figure 2 illustrates the dynamic through an example that involves a personal relationship. In such a situation, there can in principle be a focus from either side: that of the trust giver (who gives) or that of the trust-receiver (who takes):

> "One learns that crucial dynamics in a trust relationship does not always focus on the trust *giver*. Paying closer attention to the trust *taker* and analysing a trust episode by first noting the performance acts the *taker* adopts in order to motivate the trust *giver* to make a one-sided advance concession, recast the nature of the exchange involved in the trusting" (Mehra 2008:273).

In order to be maintained, trust relationships must be continuously confirmed:

> "One learns to pay closer attention to how trust is re-accomplished: how it is treated continuously as if it were a first moment of trusting. Trust has to be worked on: every move is the first move that recognizes the autonomy of the other and the other's freedom to honour or exploit trust" (Mehra 2008:273).

To strengthen trust relationships practically, the focus must be directed toward both parties in the relationship, and continuous confirmation of trust has to be emphasised. Trust is not something that is established once and for all; it must be continually confirmed.
How, then, is it possible to reinforce trust? Empirical studies have shown that it is more efficient to implement dedicated measures in compressed periods, instead of long-term linear processes where the intention is to build "stone on stone" (Bang 2013):

> "Empirical evidence suggests that instead of a frequent assumed linear process of trust development over the history of interaction, trust formation can progress in distinct temporal phases characterized by unique features" (Mehra 2008:277).

The applied theory calls attention to several fundamental conditions for establishing and supporting trust-based operations:

- having confidence in colleagues and managers
- tolerating being vulnerable
- community bonding, symbolic and habitual trust
- the inter-organisational concept of trust, not only the personal concept
- a common understanding of the relation between trust and control.

The theory also calls attention to how to create trust in an organisation, particularly in terms of the following considerations:

- Trust relationships are dependent on all actors being seen and receiving attention.
- Maintaining a relationship of trust requires constant attention from the participating actors.
- A temporal phase with unique features is as efficient as a linear process of trust development.

Method

Creating team processes in project teams is not a self-evident element in project implementation; it will largely be governed by the project manager and his/her preferences. For project managers, it is about control of the project and deciding what is the most appropriate way to achieve this control, i.e., finding the right balance between the exercise of power and trust control.

We, as researchers, have experience from team processes in various projects and, on the basis of these experiences, we have developed an approach that is used and discussed below. The approach may be understood as a stepwise process:

- mapping of team and team performance
- establishment a common fundamental understanding for trust-based interaction
- developing relevant agendas for workshops, both for team interaction and for operations
- individual coaching between workshops
- observation with immediate response in workshops
- individual reflective interviews towards the end of the project.

Throughout the various team processes we have been part of, we have experienced defects and failures that have caused necessary transformations of the approach, and so on. This is purely a consequence of the research design. At the same time, a review of the literature has provided relevant new perspectives, especially regarding the balance between control and trust (Sørhaug 1996).

To understand how team processes are constructed and how they function as trust-building nodes for teams designed to carry out time-limited projects, research may be part of the knowledge building process (Greenwood and Levin 2007). By focusing on the practical situations, we have encountered in the construction and implementation of team processes, we argue that the role of research must be based on the participants' needs, which vary. Despite the variation, it is possible to extract a general understanding from the processes, which can then be presented to the participants. From shared reflection on the researchers' findings, it is possible to obtain new knowledge. For the researchers, the ability to register and integrate divergent interests and many perspectives (and, based on these, input from generalised knowledge) is thus decisive. In such a process, interaction with participants is crucial for shaping new knowledge. The feedback from participants on the researchers' findings and shared reflection on the findings is the engine that drives new knowledge. It requires an open and curious approach from both researchers and participants.

This approach is necessary simply because neither the implementation of a successful team process nor the establishment of new knowledge can be achieved if different actors, who come in with different perceptions of the current situation, are unable to establish a common basis for joint work. For this reason, the researchers have to adopt an open role, and it is inevitably the researcher's task to create situations that give access to areas he or she has seen into position, in order to contribute to the implementation of the phenomenon that is to be studied, and at the same time contribute to knowledge building around the phenomenon.

In our case, feedback from the participants was also collected through formal interviews. The project led by the management team was time-limited, and when the assignment was completed, the participants were interviewed about their experience with the team development process. The participants' reactions and reflexes during the process, as well as their more retrospective assessments and reflections, thus form the basis for this article.

To sum up the main elements of the approach used, the researchers carried out the following tasks:

1. designed the team process that was used and that guided the team through the process
2. conducted a number of formal interviews after the assignment was completed
3. summarised the participants' experiences and drew conclusions from these in this paper.

These steps were carried out in close interaction with the actors involved. Fundamentally, the aim of the company and that of the researchers were at least partly identical: to identify basic principles for building trust in management teams. Of course, the main aim of the company project manager was to get his team to work well, thereby reducing the need for control. The reflexive process of identifying such principles thus included the members of the management team. Their involvement was important to ensure consistency and reliability of results. The chosen research approach was also designed to ensure valid results, as these were continuously the subject of shared reflection.

Thus, the experiences set out below from the implementation of these dedicated measures in a project team will be reviewed, covering both what was done and what experiences the participants were left with after the project was completed. Consequently, this is not a study where a phenomenon is studied from the outside. We as researchers participated as actors in the field, and we not only participated but to a large extent directed what was happening in the field (Greenwood and Levin 2007).

The team process: main elements

In this section we will present a team process carried out in a specific project: what was actually done, what the intentions were and what the results were of the various activities. Activities initiated may have multiple purposes. We concentrate on activities and practices that can shed light on how trust is strengthened, maintained and, not least, maintained when the conversation focuses on topics which one or more members of the team have a demanding relationship with (Table 1).

Table 1. Main elements of the team process and their effect on trust.

Activity	Intention	Technique	Effect on trust
Mapping the present situation	Introductory sale Attention Ownership Trust consultant vs team	Individual conversation Open questions Describe rather than characterise	Engagement Concerns made explicit
Adjusting to the current situation	Adaption to situation and needs Make sure the project manager has support and a place to discuss dilemmas	Project manager's (or HR's) description of needs Coaching conversation about needs Researcher's observations Teaching specifically adapted to the situation	Strengthening of trust between project manager and researcher A well-liked leader learned how to support his team even more
Conducting workshops	Change the team's position strategically and as a team	Two levels in parallel: (1) specific dilemmas and (2) insight and interaction skills	Dialogue increased insight and changed fixed positions, individually and as a team
Individual coaching	Move from insights presented in workshop to daily operational practice	Gestalt engraved method Strengthen trust between coach/researcher and coachee Model a trust-based interaction Individual talks after each team workshop	Alternation between team intervention and individual interventions gave observable changes Motivation for further learning

Mapping the current situation

As a starting point for the process, a mapping of the team situation was carried out. Individual interviews were conducted, and statements were written down, reflecting as far as possible what the individual had said. The principle that everyone should represent themselves was made explicit at this early stage.

The report that was prepared consisted of a foil kit containing chapters with both strategic and real team-oriented topics. In the chapters, the team used their own statements, although the topic was summarised in the researchers' words. The preference was for the form to be descriptive rather than characterising and categorising (Dvergsdal 2014). The report then summarised, as the researchers saw it, which topics were regarded as being of particular importance and which should be addressed. The presentation ended with recommendations related to each main theme/topic.

In this way, we obtained a description of the situation in and around the team and in the team's own words (Dvergsdal 2014). When this report was presented to the team, the participants were given time to consider how they perceived the situation together, and to take this insight into common ownership. The principle of focusing on the experience of those who participated was used (ref. theory chapter on the trustor–trustee relationship).

Workshop planning

The agenda for each workshop should be relevant to the team's current situation; that is, it should help deal with relationships internal to the team, as well as respond to the expectations in the environment. The agenda for the workshops was based on the team's situation and was not conceptually conditional. However, the planning and implementation method was fixed.

At the first workshop, agreeing on fundamental assumptions was the most important point on the agenda: what characterises the starting point of the team, what level of integration the management needs to work at, what requirements and expectations are set by the participants, and what support is needed or expected from the other team members. The basic structures in the team must be in place. If these are present, the experience itself will provide a powerful stimulus to act as a team, between the workshops as well as during them. That means working exemplarily, with each activity illustrating its own purpose. At the same time, the process must be time-efficient, with each activity emphasising its purpose in both content and form.

In terms of planning the next steps (the four workshops), the agenda was less obvious. It was made clear that workshops with purely psychological or strategic topics were not desirable. The strategic situation could be taken as a starting point, but then the team and the individuals should be focused on specific questions. In what way was the team challenged by the present situation? What was it important and necessary to recognise, train, change or develop? Finding the right agenda was work that had to be done close to each workshop. As researchers, we often take models and learning principles as a starting point (ref. theory section), whereas in this case the project demanded a tailored agenda adapted to the project situation.
Such a situation-based agenda required interaction between the project manager and the researchers, but it was sometimes challenging to achieve this. The project manager occasionally failed to find time to sit down with us and reflect on what was needed. When we were coming close to the next workshop, it was hard to find time for a planning meeting. On one occasion, when we finally reached him he was about to board a plane in Eastern Europe and said this:

> "We work individually now, and not as a team. It's noticeable for people working close to us and this way of working will not give us desirable results. If we continue in the same direction, we will not achieve our targets. Are you able to make us a team again? Sorry, but I have to leave. Bye."

We told the project manager that he had to start the next workshop by repeating what he had told us as he boarded the flight. That message made it possible to focus on how the divergent working methods were affecting the team. The discussions and conclusions within the team meant that several individual actions were stopped, and certain other actions were jointly decided on and implemented.

The agenda for each workshop was based on observations, summaries from coaching sessions and input from the project manager, and it was the subject of in-depth conversations between the project manager and researchers. The dialogue was holistic, reality-oriented, purposeful and clearly built trust between the project manager and the researchers. However, the project manager always had the final say.

First workshop: a prioritised agenda based on thorough mapping

The workshop began with the project manager thoroughly, concisely and clearly talking about the need to build the team. We, as researchers, then went through how we had planned to work and why. For us, it was important to give the participants insight into how we worked and, if possible, to create engagement within the team to participate actively in developing the team. We stated that we would like to see involvement and participation in establishing a working method in which it was natural to discuss how the team and the individual members, through internal interaction, could best solve their strategic challenges. However, in order to achieve this, each individual team member had to accept being challenged, albeit in a safe and supportive environment. We, as researchers, did not want to give the participants the impression that we considered ourselves to be external experts with knowledge and concepts that would simply be rolled out.

After that, each team member introduced her-/himself. Most team members opened up when talking about their own situation and what they wanted out of the process. We were aware that this initial phase could mean a lot to the participants, and therefore we emphasised it and gave it a generous amount of time. When the researchers went through the survey report that they had prepared, the point of departure was quickly agreed, but no more. It was possible to see and hear that people had moved closer together during the introduction; they were reflecting in open and personal ways and giving each other feedback.
The next part of the workshop considered whether we needed to be a team and why, and this created much engagement. Someone went so far as to say that they needed their colleagues to succeed. Powerful statements were made, for example that we cannot succeed without agreeing on strategy and problem-solving methodology in the project, and that the company may be in danger of being closed down if we do not succeed. It was the most experienced team members who spoke. The relatively new people at this level in the organisation kept quiet. The project manager concluded by telling the participants that he expected them to work closely together as a team.

Clarifying the sole responsibility of each team member in detail is important, and this was therefore the focus during the reviews of the roles of individual team members. Each team member was asked to reflect on their key management and governing challenges over the next six months. This was not to be considered in isolation from who they were and their expertise but was to be looked at in conjunction with how these tasks would challenge them as a person. Each team member was asked to reflect on what it was necessary to change, what procedures should be changed or adjusted and what support was needed from other areas or other people. When left alone, the team members were asked to write down their reflections. These reflections were later presented to the rest of the team, and the team members received feedback on these reflections. The researchers facilitated this process, which was strictly structured by setting requirements for the quality of the presentation and the feedback. We required

substantial feedback that built on facts and was thoughtful about whether the issues being addressed were essential. The researchers stated that they would intervene, if necessary, for the feedback process to be experienced as useful. We encouraged a responsible process that was characterised not by reactive or distinctive interests but by shared goals and a proactive stance.

In this round, nothing unexpected occurred. Several team members were challenged on tasks and ways to execute them, and the role of the team leader was particularly striking. The whole team expressed great respect for his honour, integrity and diligence in ensuring that the team would succeed. Although reviewing and giving feedback to all team members was time-consuming, the entire team focused on the process, without exception. Participants were encouraged to emphasise what they regarded as important issues and to talk openly about their complexity (Dvergsdal 2014). They all managed to do that, and thus the conversation was focused and clear. At the same time, they were encouraged to confirm each other's views where that was justified.

The conversation was just as focused towards the end of the round as at the beginning. Those who had the group's attention showed, through verbal and non-verbal signals, that the content of the conversation was important to them. It resulted in statements such as the following:

> "it means a lot to me that you confirm that I should now improve the relationship to supplier X" (Interview 1).

It seemed that genuine confirmations opened up good reflections on real and important challenges. The support was obvious, but both expectations and challenges were addressed. The genuine nature of the support seemed to make people more proactive, and they responded to challenges in a clear and nuanced manner. There was almost no explaining away of problems or blaming of other people; instead, there was a lot of serious consideration as to how to move forward and succeed.

It was important that team members should understand the feedback and would be able to sort and understand it immediately. No one should leave the team meeting with an unclear understanding of the content of the feedback. For a good feedback process, it is essential that the feedback be based on observations and/or other facts. At the same time, the feedback must take a balanced form. Where this balance was lacking, the researchers intervened and corrected, until the person being focused on expressed that things had fallen into place. Some participants were unfamiliar with discussing and analysing their own leadership roles openly with many people listening.
In a round of brief comments on what they took away from the first seminar, the participants expressed a consensus that they now felt like part of a team; in other words, something had changed for the better in the course of the seminar.

Individual coaching

Everyone in the team was offered and received individual coaching from the researchers. We choose two examples to include here. The first example involves a highly experienced and recognised professional who, in his own field, apparently operated without being burdened by a managerial role. We will call him Tor. The other example involves a relatively new leader, who is quiet and whom few participants knew from previous projects. We will call him Nils.

Tor was responsible for the project's largest subcontracting contract, but the communication with the supplier was working poorly. Tor, with his professional background, had focused on formal and professional communication with the subcontractor. The result was that the supplier heard from Tor every time something seemed to be wrong, and, as a specialist in the field, Tor was often correct. The supplier was thus pushed into a pattern of responding to

professional corrections from Tor and only to a minor extent focused on correcting errors upstream so that they could be dealt with before delivery. In order for the vendor to be able to change this pattern, Tor had to act in a different way; instead of correcting the supplier, he would have to encourage the supplier to improve his internal process. Tor had to change from being a specialist to being a leader.

The first step was to focus on building closer relationships with the supplier, through more informal and dialogue-oriented communication. Tor started by going on morning walks around the office where personnel from the relevant supplier were located. He was then able to sit down with the supplier and help find good professional solutions. In this informal setting, Tor's warmth and humour came to the fore and contributed substantially to improving the relationship with the supplier. This was appreciated to the extent that if he missed going on his rounds, other people asked for him and he quickly returned to the new routine. During later coaching, Tor reflected on the fact that it had taken him to the age of 50 before he understood the need to use skills other than strictly specialist ones to get close to the supplier.

With Nils, there was a different dynamic in the coaching process. It turned out that Nils had management experience from his previous workplace, both of a general and more specialist nature. However, lacking personal relationships and experience in the new workplace, it was hard for him to become fully integrated in the team. His quiet personality did not help, as he often appeared taciturn and difficult to approach. Consequently, the coaching with Nils focused on whether he could become more open; he had to take action and show more of himself to the team. Nils was subsequently more active in his rounds and with feedback in the workshops. He signed up to take responsibility for joint tasks in the team. The whole process supported him in becoming able to take responsibility and benefit from people's expertise, and to communicate more openly. The development of both Nils and Thor was visible to the other team members, and it inspired the further development of the team.

Fundamental principles for building trust

We have identified six fundamental principles that underlie the scheme outlined above and which

- focus on both the trustee and the trustor
- may be used on measures that are limited both in time and quantity.

We briefly present each of these principles below.

An agenda that is focused, relevant and prioritised

> "Everyone was open in both the first and next rounds. This was a nice way to check out expectations and their impact on others. However, the process was conditioned by the way the rounds were carried out: co-ordinated and under strict control" (Interview 5).

Many approaches offer generous time and theme-related group work to try to speed up the development process. We, on the other hand, are interested in investigating whether a tight agenda with selected topics and short periods of group work with clear expectations for delivery can contribute to a rapid progression. We believe that a distinct framework stimulates creative thinking and establishes ownership of the outcome of the group work. The participants understand intuitively the idea behind the tasks given, and they are able to understand their team's role as part of a totality and why the tasks are being addressed (Zinker 1978).

Operating in such a setting, with a tight agenda and clear delivery expectations from the participants, is a discipline. The participants quickly understand that a regime has been established to regulate time spent in meetings and to encourage timely individual delivery. Experiencing clarity on such issues and on what such discipline does with the quality of discussions, possible solutions and achievable results is convincing and strengthens the support for the project and the approach. Positive experiences in the management team make the transfer of such a regime to other parts of the organisation both possible and desirable.

A model of excellent co-operation

> "The project was characterised by demanding challenges, and a lot to do. As well we lacked knowledge. In this setting the project manager was exemplary" (Interview 6).

Getting more value out of the co-operation within a management team is about understanding human behaviour, particularly when the aim is to create something beyond the present moment. This includes being able to establish effective ways to work together, both within and outside meetings. In addition, team members are expected to acquire teamwork skills quickly, preferably during a couple of one-day workshops. However, a role model in the team will illustrate better than anything else what is expected. It is not necessary to copy the role model; its importance is that it allows a person to see the direction that he/she might take. In addition, role-learning takes place continuously, regardless of whether this is intentional. The more the project manager and the researchers are conscious of "delivering" trust and acting in a team-oriented way, the more this will affect the context. Conversely, if the researchers are reserved, focus on threats more than trust, and are able to operate at a superficial level only, their teaching about key elements in team building will have a reduced effect.

Initiating trust building is a management responsibility. In order to quickly develop a relationship of trust with team members, the project manager must act to inspire trust and signal strongly that he/she wants the others in the team to act in the same way. Communicating the project manager's vulnerability and uncertainty may enable other team members to do the same. It may be frightening for the project manager to experience the openness of other members of the team about uncertainty, risk and lack of competence. On the other hand, it provides security for the project manager that all known risks and problems in the organisation will be made public and discussed. As long as the conditions are known, it is possible to handle them; where conditions are hidden, it is much more difficult to handle them effectively.

A climate that promotes learning and being seen

> "As a consequence of the rounds around the table, communication between us became easier, and not only in the workshops but generally. We thought differently about the way we approached each other and we became more aware of the way we did it. Suddenly a huge desire to succeed with the project, the whole project, appeared" (Interview 2).

> "The rounds around the table gave an overview and overall picture" (Interview 3).

> "Very good to know what others think is important. I would say it's a 'agile way to reach the target'. It was exciting to listen to the others - get to know new ones" (Interview 6).

A number of educational researchers have stated that we learn most from the teacher who sees us (Grendestad 1981). In the mental health services, research has shown that the result of treatment is better if there is a trusting

relationship between helpers and help seekers: "our job is to make us trustworthy". Why should this be significantly different in a project management team? We believe that the climate in which one has started developing the project management team is crucial for the result.
On the one hand, being seen and being given space in meeting arenas makes the individual feel that he/she belongs, is accepted and is worth listening to. A workplace where employees experience this is often regarded as an attractive workplace: that is how many employees would like to see their workplace. It makes them dare to open up more than they would in other settings; since their ideas and suggestions are taken seriously, self-esteem and security are reinforced. On the other hand, such behaviour leads to more transparency, which reduces what can be kept private. If an individual face a challenge or is in doubt about anything, he/she will air it in the team, because that is possible. Increasing transparency will, from a controller point of departure, reduce uncertainty: as soon as risk occurs, it will be aired in the team without barriers.

An investigative attitude

> "These rounds were incredibly important. One could test out if the deliveries were in according to the other team members' expectations. When one team member was presenting, the others could reflect upon their possible contribution to the presenter. Rather positive contributions than making demands to all the others. This allowed us to share tasks and responsibility for succeeding with the totality" (Interview 7).

> "It was important that the check-out was done in plenary sessions: simply more efficient. It created collegial team support. We were influenced by each other there and then" (Interview 8).

We believe that focusing on achievements, as opposed to having an understanding mindset, may be detrimental for building trust. The performance element will always be relevant, but when the performance element becomes essential for the facilitator, project manager and team members, we believe it weakens some of the foundations for trust. Trust partly comes from doubt and curiosity: "I don't know everything; what have you seen?" To display how clever you are and that you are cleverer than your colleagues does not necessarily build deep and lasting trust. If the start of an event is marked by such behaviour, you will almost never get the chance to achieve close relationships with others. It is therefore essential to move away from a relationship based on "from me to you communication" and towards a mutual relationship based on "me-you communication" (Buber 1923). It helps if the project manager and or the researcher say something about this:

> "Be investigative, see if you can spot conditions you have not thought of before, but that others have seen here. Such an effort really contributes to what we are looking for to build the team" (Interview 4).

To explicitly build this value as a norm will help the process move in a learning direction. At the same time, it will build trust in the team, and in the project manager, that will make it possible to be investigative and forthright without being regarded as an enemy. Such an approach is a significant contribution to reducing risk. By acting as "devil's advocate" with team members who have a different point of view, and by asking relevant questions about your suggestions, you are enabled to look at situations through new eyes and make necessary adjustments. In many teams, acting in this way will be seen as an attack; therefore, team members will be reluctant to do it in case of reprisals. Nevertheless, this form of work improves the quality of decisions and dispositions while maintaining control of the organisation.

Accountable and complete communication

> "Being able to criticise each other without hurting each other: incredibly important! We understood that demanding feedback was not meant as an offense, but to improve the process. This was generally the way we experienced the team process" (Interview 3).

The word "authentic" is powerful and must be used with care. Sometimes you may get the impression that if just a few words are authentic and honest, they are worth saying, regardless of how they are said. On the other hand, we believe that the way in which a message is presented and the intention behind the message are decisive. They must emerge from the context that the message is posted in, which is supposed to be an attempt to help the recipient.

It is important to communicate that accepting feedback makes one a trustee and that giving feedback makes one a trustor. The process of switching between the roles of trustee and trustor is itself a strength of our approach. By making themselves vulnerable in giving and receiving feedback as recipients of trust, and by giving trust within a responsible framework, participants feel that others wish them well, and this builds trust.

Fundamental to the relationship between the team members is communicating that criticism is allowed without the receiver perceiving the message as an attack; criticism is to be perceived as positive input to improve the work that is being done in the area for which you are responsible. Criticism is meant to support and help you; the critics wish you well. When the message behind the criticism has been perceived in this way, greater transparency and openness are facilitated, thus achieving a better climate in the team and helping the project manager and the project team to better control the project.

Representing oneself

> "It was tiring to be in focus, unfamiliar to me, but afterwards when I had checked out my way of thinking about my contribution and received constructive feedback, I had a very good feeling" (Interview 4).

> "We learned that something positive came out of it. This gave positive expectations for the future." (Interview 5).

> "When others were in focus and I could give feedback, it was easier" (Interview 7).

> "The first time we sat down. The next few times we stood upright, with our own presentation on the wall. That was a tough exposure, but it became useful" (Interview 7).

Representing one's own experience when it is needed is the individual's own responsibility. In a team process, it promotes order and safety to make it clear that this is the case and that it is expected of the participants. It is worth supporting individuals to do this when necessary. On the other hand, one must follow up and intervene if there is uncertainty about the ownership of a genuine "own" experience. This is a task that the researcher owns.

Bringing the expectation that participants will draw on their previous experience in assessments and in discussions improves the quality control of decisions and priorities. Information about how different challenges may have been solved in other projects is excellent input for how the project team should meet the current challenges. This principle increases the solution space for the project team and the project, thus enabling project management to handle challenges more efficiently and with better results, thus reducing the overall risk in the project.

Interdependence of the principles

Table 2 provides a summary of the principles.

Table 2. The six principles and their effects on trust and control.

Principle	Reason to initiate	Effect on trust	Effect on control
An agenda that is focused, relevant and prioritised	Fast progress, evident delivery, innovative, understandable frames	Safety, higher expectations and quality	Discipline
A model of excellent co-operation	Highlighting the type of behaviour that is desired in the project	Making vulnerability and uncertainty acceptable	Problems in the organisation are raised and discussed
A climate that promotes learning and being seen	You learn best when you are seen	Feeling that one belongs, is accepted and is being listened to	Increased openness: people keep less to themselves
An investigative attitude	Focusing on understanding rather than performance	Permission to explore, ask questions and reflect: no question is stupid	Increased transparency
Accountable and complete communication	Focusing on giving and accepting building criticism	Criticism is perceived as a desire to support and help	Increased transparency
Representing oneself	Strengthening self-confidence among team members	Contributing experience strengthens the team	Previous experiences used to provide solutions and reduce risk

The principles call attention to the attitudes and behaviour of the participants in the team. The participants undergo a harsh learning process during the short workshops: it is not possible to hide behind other people. Individuals must expose themselves, and they are expected to participate actively in the workshops, in management meetings and generally in the team, drawing on their expertise and experience to do so. At the same time, they are expected to be supportive, exploratory and transparent. Signing out and leaving other team members to take responsibility for their own business without getting involved is not acceptable. It is the overall competence, experience and human capacity in the team that will solve the team's ongoing challenges.

Thus, in order to develop trust within a project team, it is not possible to choose principles arbitrarily: the elements set out here form a totality. Fundamental to the approach is the positive desire for individual project team members to function and work well in their positions and to deliver according to expectations in the area which they are responsible. To achieve this, we argue on the basis of the case study that all principles must be present and in use.

If the project manager is to achieve good management and control over the project implementation, a necessary step is to establish a trusting relationship among the project management team members. As a consequence of the trust relationship being established, the following will be achievable:

- control through transparency
- the creation of a joint project team member community
- a common desire on the part of all team members to contribute to the success of their colleagues.

The principles were thus put into practice with the intention of improving the interpersonal relations within a project management team. One of the research questions raised in the introduction was whether such an approach allows for reduced control measures. The approach is built around open communication, brutally honest feedback, and mutual support and desire to do good to each other. Throughout the project period, the team participants experienced that the internal working environment in the project team changed in a direction where they felt less and less of a need to embellish reality in order to avoid uncomfortable questions from colleagues and managers. Raising issues early in order to seek help from the team became the new way of working. However, improved management steering capability and control are also effects of this approach. Control is not only achieved through a large, rigid control system: good governance and control may be achieved through a conscious focus on relationship building and interpersonal skills. Experiencing vulnerability, humility and joy in the success of others reveals fundamental learning, which both enhances the quality of governance and gives better control. Trust-based management is the key.

Taken together, the principles lay the foundation for the development of trust in a team and for indirectly improved control and steering capability. In this case, they were applied to a management team, but they are equally relevant to teams in general. The case focuses on interpersonal trust, and to a lesser extent on organisational trust. However, it is difficult to imagine that it would be possible to construct isolated nodes where trust-based management is developed, unless the company environment is conducive to this. In order to increase the efficiency of projects in the company in general, it is clearly important to be aware of the connection between organisational and interpersonal trust and to develop them so that they support each other.

The case raises the issue of problematising trust and control in socio-technical design in general. Clearly, trust and control are important in organisational design and for operations, particularly where the implementation and use of new technology is concerned. New technology will open up new forms of interaction and communication based largely on trust. Carl Pava was quick to anticipate such developments, especially in non-routinised jobs (Pava 1983, Austrom and Ordowich 2018). In non-routine knowledge work, deliberations form collectively built frameworks that create clarity for communicators without sacrificing complexity. Deliberations are performed to illuminate problematic issues, innovation tasks etc. and may occur in different forums or settings. Thus, Pava left behind the unilateral approach characteristic of classic STSD in terms of self-managed teams and their interchangeable skills.

In the operations of ETO contractors, continuous deliberations between different actors are a common way of illuminating problems and challenges, and such ways of handling issues are becoming ever more popular. However, such methods can only be used where there is genuine trust; individual and organisational trust are fundamental. Focusing on trust and control in the implementation of new technology and work organisations therefore seems inevitable for the success of restructuring processes.

Conclusion

From a review of interviews with participants in a construction project management team and experiences from the development process undergone by the case team, we have identified six key principles for developing trust in a team. This is not a list of principles to pick and choose from; the principles are mutually interdependent, and all six must therefore be adopted together. Neither is there any direct link between increased trust in a team and reduced control measures; a conscious choice to reduce control measures must follow the establishment of increased trust within the team. The principles were developed within a management team in a temporary construction project; however, they may also be applicable for implementation in more stable production teams or in teams of other types.

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EUROPEAN JOURNAL OF WORKPLACE INNOVATION

Minimal critical specification and collective organisational redesign[29]

Johan E. Ravn

Abstract

The purpose of this article is to apply concepts of socio-technical systems thinking (STS), enriched with concepts from more recent organisation theory, to analyse a case of participatory design of core manufacturing processes in a company. The redesign process considered transformation of operational logistics of the installation phase, which is a complex and costly phase. The focus is a test of the concept of minimal critical specification, applied as a principle for work process redesign. In the process under study, managers, supervisors and worker representatives at all levels and functions directly affected took part in the process of redesigning the material flow system and the corresponding control system at the operational level, and the design was put into operation by the company. After a year of operation, the new design was modestly favourably assessed by the organisation. The case shows the possibility and importance of the affected work system's influence in the development, operationalisation and implementation of a new organisation, and the findings demonstrate how manifold relevant participant knowledge may be incorporated into a workable redesign process. The findings cannot be generalised on the basis of this one case, but we will argue that the case serves as a demonstrator project for the model tested.

Keywords: minimal critical specification, socio-technical systems, domestication, organisational design, participation, organisational involvement

[29] The research behind this article was made possible by a grant from the Norwegian Research Council's BIA program, for which I want to express my gratitude.

Introduction

The case in question is a yard whose core products are offshore topsides (processing facilities) for the global oil and gas industry. Topsides are huge, unique and complex products created in similarly complicated processes. The yard may have three topside projects at different stages in progress at the same time. In the global business, it is not uncommon for a topside project to last four years or more. At the case company, the completion time is compressed to three years. This is achieved by letting the phases of engineering and construction take place partly concurrently, something that of course poses challenges in terms of project management and logistics. In the R&D project that took place at the yard, the overall objective was to develop and implement a "company-specific production system" (Netland 2013) and use this to improve work quality and organisational performance across the yard's entire set of operations, in all the very different work phases and with all its involved actors (including subcontractors and temporary employees).

The focus of this article is an experimental participatory work process redesign within the so-called installation phase of a topside project. The installation is a very complex, costly and important phase. To put it simply, this is when the physical offshore topside is actually (materially) built. In this phase, a large number of highly skilled workers are engaged, including plumbers, welders, electricians, scaffolders, crane operators and engineers. They all rely on a system that provides them with a steady flow of work tasks, work materials and the necessary tools and equipment. This takes planning, coordination, management, communication, industrial relations (IR), safety management and more, and there is no doubt that it requires high-quality project management and logistics. Based on assessments, reflections and judgements from a whole set of actors, this process (the material logistics of the installation phase) was judged to be in need of improvement. However, views differed widely between roles and departments, e.g., transport, crane operations, warehouse and installation. How could one create a new system that met this diversity of requirements and expectations? How could one envision, design and implement a new material logistics system for the installation phase that was in alignment with the overall production system and at the same time served the core areas of the installation phase in an appropriate manner? How could such a system allow for the local handling of variety without acting contrary to the needs of the overall system? Within this, how could such a redesign be based on a participatory process in a very multidisciplinary field?

Two concepts were judged relevant for the experiment and chosen as central in the theoretical model: the principle of *minimal critical specification* (MCS) developed in the field of socio-technical theory (Herbst 1974, Cherns 1976, 1987) and the concept of *domestication* developed in the field of science and technology studies (Silverstone and Hirsch 1992). The MCS principle was chosen because it is a core concept in the socio-technical theory of organisation, and because the initial assessment was that it would address well the challenge at hand: how to go about redesigning a work system characterised by diversity, complexity, distributed power and authority, and expectations about participation. It is important to note that the MCS principle was used not only for the design of the material logistics process but also for the design of the discursive processes through which the relevant actors could analyse, problematise, operationalise, concretise and revise in order to arrive at an agreeable, feasible and operational concept for material logistics at the installation phase. The concept of domestication was chosen in order to understand and handle how an innovation from the outside may be appropriated by its users on the receiving end, since the experiment was likely to include a new material logistics system that would be at least partly understood as an import from outside the system.

The research question was this: how is it feasible to envision, design, anchor and implement a new flow for a complex work process, in a multidisciplinary field, on the basis of a participatory process?

The yard, its overall production system and the organisational setting

The yard's model of operation may be characterised as an example of engineering/manufacturing to order. The work is organised into large so-called EPC projects (engineering + procurement + construction). A topside project typically lasts three years, and installation is a core activity of the second half of the project.

Investment in new technology is always important in a manufacturing setting such as the studied case, but acquiring the new technology is never enough on its own. Technology and production systems do not excel unless they are run well through planning, control and management systems, unless the competence is of the right quality, and unless the systems themselves are well aligned with the organisation and its culture. Within manufacturing it has become commonplace to use a corporate business system or company-specific production system (Netland 2013). In general, these are built on a mix of principles from, for instance, Mass Production, Lean Production or Total Quality Management. A well-known example is the Toyota Production System (TPS), which has been a model for many other companies forming their own production system (Ohno 1988). To a large degree, the modern technologies of manufacturing (machines, robots, control systems, communication systems) are available to any organisation with the necessary resources to purchase them. The competitive force lies in the way the technology is put to work in a production system: how the system is designed, organised and managed, and the workforce's ability to perform. The manufacturing model of the studied case, engineering/manufacturing to order, is no exception to this. It is a capital-intensive industry, because of its heavy reliance on sophisticated and expensive technology, but it is also competence-intensive, because of its reliance on competent people from a range of professions.[30] The more technology-intensive and competence-intensive the manufacturing systems, the more important the integration and joint optimisation of technology and organisation.

The purpose of project management is to keep projects on track. There are two sides to this: one is the project management system itself, with its recipes, procedures, standards and general regulations for project execution. The other side of project management relates to the day-to-day management within the working practices of a particular project, with its mix of working by the book and improvisation. These two aspects, the system and actual practice, sometimes contradict each other. For instance, sometimes a project's practice needs to work around, or even break, the general project system rules. A core challenge for project management is thus the handling of variety and complexity. The variety (the perturbations) that a system can be exposed to is in principle unlimited. Since only variety can absorb variety, as Ashby noted (1958), a system's internal variety (or diversity) should be customised to prepare for foreseeable as well as unforeseeable contingencies. The overall aim of the yard's production system is to strengthen linkages between generic concepts for technology and production systems and distinctive contextual manufacturing characteristics, thereby offering a methodology for better adaptation/mutual adjustment between corporate recipes and typical local manufacturing strengths/opportunities. The objective is to develop theoretical concepts and practical models for joint optimisation of technologically advanced production systems, control systems and high-performance work organisations.

In a Norwegian context, high-performance work organisations are often based on a participatory logic. Co-determination and participation in company development are important areas of the IR systems at the company level. Regulated both by law and by collective agreements between the social partners, the practices and institutionalisations of collaborative IR ensure the following:

[30] Including general managers, construction managers, supervisors, union representatives, planners, and various kinds of engineers, plumbers and electricians.

- *Indirect representative co-determination.* Trade unions or employee representatives are entitled to be informed, consulted and have co-determination in areas related to major changes in the workplace. They participate in strategic discussions, and they are responsible for monitoring that general employee participation is taking place.
- *Direct participation*. Employees participate in decision-making that relates directly to their job performance, as well as through their voice in general meetings, department meetings and in the teams (NOU 1985).

Examples of areas where trade unions or representatives are entitled to co-determination are substantial enterprise investments, implementation of new technology, and reorganisation of work, downsizing and restructurings. Co-determination takes place by means of the legislative right for employees to have representatives on the board, and by means of bipartite work councils.

The yard is at the middle of this set of practices and has a strong tradition of seeing union participation in development work as both mandatory and useful. Neither shop stewards nor managers have lost sight of what it is to hold different positions. Although many goals and interests are conflicting, some coincide. This is what makes union–management collaboration a foundation for a very interesting organisational space for exploration of new opportunities. Cooperative and constructive IR are a resource for dealing effectively with disagreements and for developing high levels of trust and communicative skills across all subgroups of an organisation. This organisational proficiency in communication and cooperation across levels, departments, professions, functions, positions and interests has been termed *collaborability* by Ravn and Øyum (2018). High-performance collaborability gives companies a competitive edge within both operations and innovation work. The organisation gets faster and smarter and develops better learning proficiency; this reduces the costs of coordination and control and eases decision implementation.

Theoretical model

The research issue was to envision, anchor, design and implement a new flow for a complex work process, in a multidisciplinary field, on the basis of a participatory process. In order to address this, there was a need for a theoretical understanding of the challenges at hand: a theory to explain the processes by which a model or a set of general concepts can be interpreted, may be reinvented, acknowledged, accepted, rooted and made fit for organisational practice. Therefore, for conceiving the organisational process of acquiring a new import, we chose the concept of domestication; for conceiving the organisational design, we chose socio-technical theory and the principle of MCS; and for conceiving the process design, we chose dialogue concepts from the action research tradition.

A. Domestication: the process by which an external object is familiarised into a social system

New technical solutions, such as a physical machine or an administrative control system, are never "merely" technical. As Orlikowski has argued, "technology results from the ongoing interaction of human choices, actions, social histories, and institutional contexts" (2009:131). Technology or innovation is nothing in itself to the organisation until it has been put to use, and this involves social, cultural and organisational processes. This introduces and strongly supports the domestication approach to understanding technology and innovation. Domestication in a figurative sense is making something taken from the outside world applicable, meaningful and useful to the local world. The concept was taken up in the field of science and technology studies (Silverstone and

Hirsch 1992) to describe how innovations and new technologies are appropriated by users, be they individuals or organisations.

Domestication theory is a shift away from models taking for granted that the introduction and adoption of technology or innovation is "rational, linear, monocausal and technologically determined" (Berker et al. 2006:1). Domestication theory holds that adoption/appropriation is always an interactive process, as opposed to a more one-way view (determinism) where an import is simply introduced and therefore forces the local organisation to adapt to it. Domestication is a process of reconfiguring and reshaping a culture and organisation, and it highlights both the practical/material and the symbolic/cultural sides of the domesticated object. A particularly interesting aspect of domestication theory is that it highlights the role of local users in making symbolic and practical sense of an import from the outside within a local setting. A new system of material logistics, for example, has to be "house-trained", that is, integrated into the structures, routines and values of the place where it is being introduced (Berker 2006), and this is an active reconstruction process within the host system. In the case under study, domestication is the process by which the generic recipe for the topside yard's material logistics is paraphrased and made meaningful and applicable to the local workstations. The challenge is to construct alignments between the concept and the local particulars in terms of technology, competence, organisation and culture. This process entails *cognitive*, *symbolic* and *practical* aspects (Sørensen 2006), as follows:

- cognitively, how do workers and managers get to learn, understand and know the new concept, and how do they learn from one another?
- symbolically, what kind of meanings do they ascribe to it?
- practically, how do the involved actors put the concept into practice during their workday, as individuals, as teams and as a whole?

Understood as domestication, the new system of material logistics will be rescripted when organisation member users read, interpret and act. In this new, local rescript, the system is integrated with the practices, meanings, people and other artefacts at hand (Sørensen 2006).

B: Minimal critical specification: a structure for maximising the system's own role in its design

"There is no social that is not also material, and no material that is not also social" (Orlikowski 2007:1437). Socio-technical theory focuses on the interface of the people and the technology at work. In the decades after WW2, work life went through major changes, and socio-technical systems theory (STS) was developed to address the challenges. STS was a theory of the design and operations of organisations formulated as an alternative to the bureaucratic and Taylorist approaches that advanced universal principles and regarded organisations as machines and, consequently, workers as machine parts. For STS, designing appropriate organisations was based on a comprehensive analysis, with special emphasis on the organisation's environments, the technology in use and, not least, the quality of jobs. Socio-technical theory focuses on the interface of the people and the technology in the work, and it allows for and invites workers' involvement in the organisation of the working processes (Cherns 1976, Trist and Murray 1993).

A core concept from classic STS is the work team (a semi-autonomous team). The concept of work groups or teams first came into organisation theory through the studies of the Western Electric factories by Mayo and others (Mayo 1949),[31] but the concept of team-based organisation design arrived with early STS (Trist and Bamforth 1951) and

[31] The Hawthorne study (Mayo1949), although its results and conclusions have been contested by many later authors, nevertheless formulated the idea of social groups or teams as part of the (informal) organisational structure, and the Hawthorne study is presented in most basic textbooks of organisation theory.

is widely used today. Other important concepts in early STS were *redundancy of function,* e.g., in high-performance work systems, as an alternative to the redundancy of parts (cf. scientific management), the *learning organisation*,[32] *joint optimisation* (of the technical and the social systems of the organisation) and *psychological job requirements* (Emery and Thorsrud 1976). Several of these concepts have survived and have become key concepts within other forms of production organisation and management theory (Klemsdal et al. 2017).

Minimal critical specification. Related to the concept of team is the concept of *responsible autonomy.* A system with responsible autonomy is characterised by the following traits:

- Members of the system share responsibility for a definable total task with measurable outcomes in terms of quantity and quality.
- There are interdependencies between the members of the system.
- There is some system autonomy in how to organise tasks among members (Trist et al. 2013[1963]:21).

It is in the third point, autonomy in how to organise tasks, that Herbst's concept of MCS comes in. Autonomy, or organisational slack, can be established by "deliberately avoiding too much detailed information and specifications of the new" (Amble 2017). STS theory holds that organisational slack is a prerequisite for learning and development processes among employees. MCS is a key design principle when it comes to designing planned change. The point is to make the fewest possible critical specifications in advance of the implementation of a new design "in order to leave it to the workers to complete the designs as they enact them in their daily work, through experimentation, improvisation, and learning processes" (Klemsdal et al. 2017). In the words of Herbst:

> "The principle of minimal critical specification design can be stated as that of identifying the minimal set of conditions required to create viable self-maintaining and self-adjusting production units. An optimal solution is obtained if the unit requires no external supervision and control of its internal functioning and no internal staff concerned with supervision, control or work coordination. The management function should primarily be supportive and concerned with mediating the relationship of the unit to its environment" (Herbst 1993:296).

Minimal is not the same as non-existent: a specification of the critically important elements must be in place, whereas the rest is left to the local users. According to Cherns (1976), the principle may be formulated both positively and negatively: one has to identify what is essential and inevitable, but no more should be specified than is essential and inevitable. Lars Klemsdal (2013, quoted in Amble 2017) connected MCS with the concepts of sensemaking (Weick 2001) in a research project. In good examples, employee dialogues about problematic situations at work became constructive cases of learning that made sense. In the solutions the employees arrived at, sensemaking and MCS came together to support learning within a work organisation.

MCS runs counter to conventional practices of project planning, where one often seeks to specify as much as possible in order to maintain control. To Herbst, the MCS way of specifying work tasks is an alternative to the detailed specification of the typical work hierarchies; that is, a manner of allowing for local organisational space to test out new practices and learning. Herbst promotes this as a hallmark of learning organisations, namely that MCS is both necessary and sufficient to enable learning (Amble 2017). On the basis of their own experience, when faced with MCS, workers are given space to "discuss, learn, and have autonomy to try out what they consider to work well" (Amble 2017:95).

MCS concerns work or organisation design: it is a principle for how a work process, for example, should be designed. In this case, we wanted to utilise the concept for the design of the process of designing, and not just the

[32] The concept was coined by Herbst before being taken up by Argyris and Schön (1978) and Senge (1990).

outcome of the design (the resulting work process). To understand the challenges of each specific workstation, as well as how to address these challenges, there is a need to understand the particulars of the specific workplaces. Another reason why it is necessary to include these particulars is that this requires the participants to "reveal their assumptions for challenge" (Cherns 1987:156). When this is done, some assumptions may hold and will have a role to play in the design, whereas others may be falsified. The general design concepts are useful as a starting point, but when it comes to which concepts to apply (their specific contents as well as the relationship between them), this has to be settled by each workstation in its own way.

C. Action research concepts of dialogues and change

For all its potential usefulness, MCS does not have much to say about how to facilitate a design process. As discussed above, there is a tradition of worker participation and autonomy at the yard. Employees are expected to be responsible, reflective and engaged in developing their own work. Likewise, trade unions, shop stewards and employees expect to be listened to and taken into account. In order to put a principle such as MCS into practice, there is a need for process facilitation.

It was not merely to let voices be heard that we wanted to draw participation and diversity into the design phase. Just as important was ensuring the quality of the solution. As Elden put it:

> "the outside expert has general theoretical knowledge as well as knowledge in organizing change (process knowledge). Workers have concrete knowledge about their own workplace, especially how things 'hang together' in that workplace" (1983:22).

A similar claim has been made by others: that some sorts of local organisational expertise are not tapped into unless the process is sufficiently participatory.[33] Elden, however, goes on to make a slightly different point:

> "different theories lead to different actions, and workers seem to have at least potentially high change-relevant knowledge but low change-relevant authority while management has low knowledge but high power" (1983:33).

This is not just pointing to local knowledge about "how things are"; it also implies that in order to make changes come about, there is something "change-relevant" in the local knowledge. On the other hand, the management side to this is also important, because it contributes the necessary power. Greenwood makes a similar argument but broadens it. There are of course many interests and parties in an organisation such as the one under study. These interests differ, and they may fluctuate and change. The handling of the organisational interest is thus a handling of diversity. As Greenwood puts it:

> "Managers and workers alike tend to treat each other's visions and experiences as defective or even duplicitous. The realization that there is room, and perhaps even an organizational requirement, for a diversity of views and experiences of an organization is an essential step in the direction of reflective practice and organizational learning" (Greenwood 1991:89).

Participation and diversity are therefore called for. However, they do not come about by mere invitation. It takes arena structuring and facilitation of communicative interaction, a process through which the actors aim at reaching a shared understanding. As Habermas argued:

[33] This is, of course, an argument that is valued within action research. See also the section on Methodological approach.

> "in communicative action participants are not primarily oriented to their own individual successes; they pursue their individual goals under the condition that they can harmonize their plans of action on the basis of common situation definitions" (1984:284-5).

The communicative theory of Habermas is a foundation for many action research models of participation. We will not go into them here. Suffice to say that there is solid tradition within action research of placing great emphasis on the facilitation of free dialogue between the participants in any reflection and change effort.[34]

Nevertheless, free dialogue is not all that is required. Even a situation of full inclusion would not guarantee that the process does justice to the knowledge of all participants, because we cannot fit all of our experiences and thinking into an argumentation process. The representation of a practice within a communication process is limited to the part of the practice that we can express, but we know more than we can express in words. As Polanyi put it in his discussion of so-called tacit knowledge, "We can know more than we can tell" (1983:4). The main traits of tacit knowledge are that it is difficult to communicate and that it is embedded in the person or in the organisation, but the concept of embeddedness may help us out. In our approach, we sought to embed the discourse in shared situations of practice. Having been through shared experiences, spoken words can rely on a rich and relevant context and reservoirs of unexplained knowledge about the situation on which we dwelt. This is what we call embedded knowing. Shared contexts enrich the shared conversations about practice. Donald A. Schön's concepts of reflection-on-action or conversation with the situation capture what this is about (1983). Building on the field situation that the actors shared, we were able to keep a conversation going in which the concepts and words were embedded, and therefore more meaningful than otherwise. The participants took part in a joint praxis, aiming at concrete problem-solving, and in this praxis, new shared understandings are generated jointly, within and also beyond the explicit concepts. The process by which this knowledge is generated is one in which the contributors are diverse. It is only because they share a practical activity that they can do this. The knowledge generated transcends disciplinary borders.

Methodological approach

In such a multidisciplinary field, how can work process redesign be built on a participatory process? This question was dealt with using an action research approach, focusing on *interactivity* between researchers and participants through all the stages (Holtgrewe et al. 2015), cogenerative learning (Elden and Levin 1991), pragmatic problem-solving and increased ability of those involved to be in control of their situation (Greenwood and Levin 2007).

The empirical basis for this article is a so-called interactive research design in which researchers and groups of partners worked together to develop new knowledge. The concept of interactive research emphasises a shared process between field and research in most or all phases of the research (Holtgrewe et al. 2015). The cogenerative learning perspective views all participants as capable of and involved in creating new solutions (Elden and Levin 1991) and aims to "open horizons of discussion, to create spaces for collective reflection in which new descriptions and analyses of important situations may be developed" (Greenwood and Levin 2007:72).

In this case, this meant that company insiders took part in previous phases of research (studies, fact finding, reflections and conceptualisations) and in the case itself. From a substantial amount of previous work over several years, including site visits, interviews, observations, meetings, workshond analysis of corporate figures/data and industry statistics, the researchers knew the company well, and many of the participants knew the researchers. This

[34] See, e.g., Gustavsen 1992, Greenwood and Levin 2007, Forester 1999, Argyris et al. 1985, Kemmis 2008.

base strengthened the potential for open and honest communication. Based on this, and on a phase of fact finding and preliminary analysis conducted jointly by the external researchers and company insiders, a draft of a concept for a new material logistics system for the installation phase was developed. This concept was more ideal and in principle than detailed or practical. In order to make it into company reality, two challenges had to be met:

- The core work groups of the installation phase had to understand, accept and adopt a new logic for it to become organisational reality.
- The new shared logic had to be developed into a work process design sufficiently concrete, operational, practical, detailed and fit for the core areas of the installation phase without losing its alignment with the logic of the overall company production system.

There is no valid claim for generalisability about the findings concerning work design processes. The objective was of an exploratory kind: to see, contribute to and interpret the processes of domestication of a logistics design through MCS. We do, however, think that the case works as a demonstrator project. As Herbst argued, a demonstration experiment has two purposes: to show that something can be implemented in reality and to provide data that can be summarised in more general principles (1993:409).

Accounting for the change and development process

The logistics of the installation phase may be set out in the following manner:

- A supervisor at the installation site logs into the company ERP[35] systems and assumes responsibility for a defined work task for a work team.
- Based on the work task, a material order is placed into the system, and this is sent to the warehouse.
- The warehouse gathers the materials, partly bulk material gathered from the shelves inside the warehouse, and partly unique ("tagged") custom-made parts stored elsewhere.
- The warehouse calls for transport.
- Transport picks up the materials and moves them over to a pick-up point somewhere near the installation site.
- Transport calls for crane service.
- A crane operator lifts the material to a pick-up point ("platform") for the work crew at the installation.
- The material is assembled into the installation, and the assigned work team completes the work task and reports it as completed.
- The supervisor assumes responsibility for a new work task on behalf of the work team.

The research team conducted a thorough analysis of the performance of the logistics of the installation. This analysis was based on a multitude of methods, including observation, analysis of previous reports and other secondary data, meetings, interviews, measurements, technical calculations and benchmarking. A number of problematic issues were identified, and the following challenges were presented at a plenary session at the start of the design workshop (Table 1).

[35] ERP systems: Enterprise resource planning systems; a set of integrated software applications used to collect, store, manage, and interpret data to exercise control.

Table 1. Challenges at the start of the design workshop.

Occupied space	• No available space at terminal/crane because the current day's informal buffer storages occupy all the space available • No space to manoeuvre within the installation zone because of all the parts that are stored everywhere
Inventory	• Lots of formal and informal inventories all the way through the work process between warehouse and the final installation zone
Missing parts	• Lots of time spent looking for particular parts stored under the platform and the like, because parts are placed in unstructured piles everywhere
Imprecise ordering, long response time	• Warehouse requiring 48 hours to respond • Parts often ordered many weeks in advance • Imprecise delivery (warehouse – transport – crane) • Lack of flow
Waiting	• People waiting for work to arrive because of long time horizons and imprecise logistics • Workloads piling up on top of each other
Waste	• Parts never found creating the need to reorder replacement parts • Late detection of nonconformities causing errors to propagate and grow

The initial preparatory analysis of the installation work process above was the starting point for the design workshop. Based on analysis of the empirical findings and scrutinised in the light of the company's general makeover plans, a new concept for the material logistics was developed. Our aim was a concept robust enough to withstand the various critical voices that we might meet from the various work areas within installation. According to van Amelsvoort and van Hootegem, "robust" means that interferences in core work process are minimised, and that the design of organisations should include all stakeholder perspectives (2017:291). To arrive at a conceptual model (such as a logic of material logistics) that is understood and acknowledged by the actors involved, the model must solve people's problems and empower them to increase control over their own situations. This process can be achieved only with participation (Levin 1993).

The process thinking we aimed for was a methodology that would help establish a shared situational understanding between participants. There was a need to identify all the key interests and viewpoints to make sure they were included in the further process. The best guarantee for the success of an organisation design process is to fetch "the whole system into the room" (Weisbord 1992) The workshop design was created by researchers and key company stakeholders, but the design of the new logistics system was drafted as a co-creation with several of the operations-level stakeholders.

The gains targeted by the concept for a new material logistics were better efficiency, better flow, lower costs, less waiting and, hence, less frustration. Based on the analysis of the prevailing logistics, a set of characteristics of the new logistics were presented to the participants at the design workshop (Table 2).

Table 2. Target gains for the new concept of material logistics.

Area of work process	Target gain
Construction management	Better efficiency Better flow Lower costs
Warehouse	"Kitting": all work material for a designated work task packed as kits arriving at the installation site at the same time Delivery time (from warehouse) reduced from maximum 48 hours to four hours
Planning	Uncover deviations earlier and/or provide a longer and more precise planning horizon
Transport	All material transport carried out according to fixed route/timetables, with fixed platforms Shorter response time → more accurate ordering → more accurate transport
Crane	Better space at the terminal/crane because of the removal of "buffer storage"
Installation	Better space inside the installation zone because parts do not arrive before they are needed and do not stack up Higher precision when goods arrive → less waiting Less searching for parts under the platform and the like Less walking to get parts from the warehouse → more time spent in the "value field"
Overall	Smaller buffer inventory → no interim storage between warehouse and installation zone Fewer errors and less waste (fewer customised, expensive parts disappear)

The workshop was organised as a model of the material logistics process itself. All involved groups participated: 25 people, including the researchers. The conference process moved from an overall presentation of fact finding/analysis to a general idea for a new concept for yard logistics, and on to local-level concretisation, operationalisation and (in some instances) a reframing of the overall model. The following critical success factors were discussed and anchored at the workshop:

- each of the individual departments/work areas (e.g., transport or warehouse) should take responsibility for developing and improving their own parts of the total work process
- each of the individual departments/work areas should seek opportunities to enable the other departments/work areas to improve.

A critical phase of the workshop was the so-called "world café" session (Klev and Levin 2016), the design of which is shown in Figure 1.

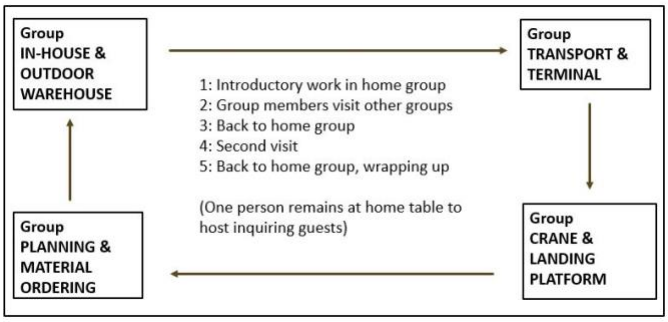

Figure 1. The world café workshop design.

In this phase, the workshop was organised into four groups representing the four main departments/work areas as sequences of the material logistics process. They gave their reactions to the overall material logistics model, identifying errors and challenges likely to appear as the model is concretised and operationalised, and remaking it as their own model, fit for their area, while repeatedly aligning their solutions with the work stages prior to their own (those of their "suppliers") and following their own (those of their "customers").

By the end of the design workshop, the participants had identified a set of challenges, bottlenecks and critical points, but also ways to deal with them. In most cases, they had the necessary resources among themselves, but for some issues, they would have to rely on others (e.g., people at the ICT department and, of course, the wider supply chain of which they were only a tiny part). They had also identified tasks, milestones and people responsible for most of the actions identified and had drawn up an agreement for implementing the new design. This was all put together into an implementation plan.

Almost a year (10 to 11 months) after the design workshop, a review workshop was held. Sixteen persons participated, including union representatives, representatives of each phase of the process, supervisors, overall construction management and researchers. Prior to the workshop, the overall construction management had interviewed various people in the work processes in or related to yard logistics. This feedback was shared and discussed, and the reflections of the participants were added to the picture. The overall assessment of the new design for the work process of yard logistics was positive. The core objective, increased productivity, had not been met sufficiently, at least not according to the metrics used, but several participants held that it was too early to focus on this. Productivity is a lag indicator, and most core lead indicators projected that the new work process would become more productive. Key findings from the workshop are summarised in Table 3.

Table 3. Key performances of the revised material logistics model.

Area of work process	Key findings
Construction management	Zero problems reported from system to construction management Overall outlook: more order and tidiness, fewer superfluous aspects A higher degree of multidisciplinary thinking from all involved
Warehouse	Kitting of work packages completed, with few delays and few problems Material orders handled within two hours (on average) New work process assessed as more manageable than expected
ICT system	Kitting of work packages completed ICT system could be improved to serve the process better
Transport	Better flow and smoothness in transportation Less effort to search out where in the system the load carriers are located Transport's low expectations about the feasibility of the new model proved unfounded
Crane	Fixed terminals had worked well without creating buffer inventories Crane was sometimes a bottleneck
Installation	Less buffer inventory and more space to operate in Warehouse perceived as attentive and helpful
Overall	More work processes should be designed like this Stronger planning required, particularly with regard to vacation periods and high-intensity phases A focus on training also required

Findings

We will first summarise the findings according to what we take to be three core types of results: *value added* (what kinds of practical results have been produced in terms of how participants improved their ways of working?), *organisational involvement* (to what degree and how have the processes developed the capacity for inclusion and participation and, hence, organisational performance?) and *knowledge production* (what new understandings have been developed about participatory design?). After that, we will discuss the merits of the theoretical approach that guided the research.

Value added. Judging from the assessments made by the organisational actors themselves, their new concept for material logistics was a success, albeit a modest one. After 11 months, it had not met their productivity objectives; it is not for us to speculate about whether this is likely to change with time. On the other hand, all of the departments or disciplines involved reported positively about their new design in terms of improved flow, increased smoothness, less stress and more control over their own areas. A system such as material logistics is a complete set of relations between various elements that together perform a certain function. Such relations are always social as well as technical, hence the aptness of a socio-technical perspective. The yard logistics case demonstrates the possibility and importance of the affected work system's influence in the development, operationalisation and implementation of a new organisation.

Organisational involvement. "Long-term change in any organisation cannot be achieved on the basis of remote expert diagnosis by consultants and recommendations endorsed only by higher management. Participation at all

levels is essential" (Jackson 2003:106). The concept for participatory work process redesign developed in this research project describes a new mode of thinking and operating and offers guidelines for how go about participatory design in complex production flows. A new level of performance was sought and achieved through a participatory and diverse interplay between skills (individual as well as collective), knowledge, technology (tools, equipment etc.) and practice. The new cogenerated concept was based on a balanced consideration of a whole set of performance areas. It developed into a concept with added detail and concretisation to make it work better without obstructing the overall company-specific manufacturing concept. This was in line with the guiding principles of local ownership, participation and MCS.

Knowledge production. At the start of the design workshop, as seen from the workstations involved in installation, the new model for material logistics was an import from the external environment. It was very general, and it was clearly not theirs. Nevertheless, this was changed through the reflections and communicative interactions of the workshop, where the participants virtually role-played the material logistics taking place across their workstations. From the pre-studies, it was well known that there were conflicting views across the functions, e.g., between installation and warehouse or between transport and overall planning. These could not be overlooked, and therefore ample space was given in the process design for such conflicts; in fact, they could be immediately addressed, since all parties were present. All kinds of practical issues concerning the concrete operations at the interfaces did not have to be put entirely into words, because both parties to the interface were present. Through this process, the conceptualisation of the new logistics concept was cognitively, practically and culturally domesticated by the actors in and around material installation: the new concept became known and understood, and was reframed through their own concretisations. The workshop also offered the participants a practical rehearsal of the new concept. It is our impression that by means of a concept-defined MCS, put into a carefully facilitated "cogenerated process" and situated in an arena mimicking the actual interfaces, the work system gradually domesticated the concept of material logistics to make it work for them.

Domesticating an imported design by remaking and concretising it. The new design for material logistics was developed from the outside but put to use by the actors on the inside. This is a case of domesticating an artefact. Judged by the local actors themselves, and assessed in the perspectives of value added, knowledge production and organisational involvement, the process was successful overall. As Sørensen put it, domestication is about enactment (2006). This enactment takes place as a kind of taming: the new script will have to be rescripted. This takes place as the involved actors read, understand, ascribe meaning, interpret, reinterpret and act. The yard actors' domestication of a new design for material logistics may usefully be understood as a movement of a preliminary and general idea tamed and enacted "into and within existing socio-technical arrangements" (Sørensen 2006:47). This taming did not end at the workshop, but it started there. If we trust the judgement of the local participants a year later, they have coped well.

Conclusion

To strive and prosper in the global competition of the future, industries like the yard need to remain willing to make changes in their ways of working, and this requires the organisational ability to conceive and implement such changes. A change process in an organisation as complex as the yard, even a process restricted to only a section of it, implies challenges. It cannot be split up and treated as a set of separate elements, because everything is interrelated. Neither can it be dealt with in the classical manner of someone planning and deciding but leaving the implementation to other people, because it takes the knowledge and participation of many to make the change come about. Faced with complexity, uncertainty and ambiguity, the organisation must tap into its total base of knowledge, practice and diversity, and this requires the ability to facilitate collective action. Managers, experts and other leading figures certainly play important roles, but they are not sufficient. To change an organisation, it is not enough to change management strategies, roles or knowledge. The challenge of arena and process structuring in a manufacturing setting is to establish a development process with vested interests, not just across departments but

also across disciplinary-based professional identities and across traditional hierarchies. It is a matter of pursuing productive communication across disciplinary borders without nullifying differences.

In the case under study, the core mechanism in the practical reconceptualisation and enactment of a new theoretical concept was the participants' professional experience and the deliberative space allowed for and carefully facilitated: a collective "conversation with the materials of a situation" (Schön 1983:78). The concept of minimal specification offered a design principle for this. The concept of domestication offered a theoretical model to understand what is at stake when something new is to be enacted in an organisation. Action research offered a communicative and processual understanding and guidance that increased the organisation's ability to go about domestication in a deliberate and collective manner.

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EUROPEAN JOURNAL OF WORKPLACE INNOVATION

"From terrible teen to terrific trainee":

Norwegian cases of innovative workplace-school collaboration to educate young people to become skilled workers in modern manufacturing industry

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Abstract:

Contemporary debates over "the factory of the future" show that industries will need vocational workers that are empowered and skilled to act as decision-makers and controllers, holding technical and social skills of a high standard. Further, industrial development demands enough supply of skilled vocational workers. In Norway, a parallel concern is drop-out rates from upper secondary education. Consequently, it is of joint concern for the manufacturing industries, the secondary education system and the welfare state alike to ensure that young people choose vocational education and that they finish their education with skills and motivation needed to contribute in the "future manufacturing factory". The research question is the following: How can lower secondary schools or vocational colleges collaborate with industrial companies as to motivate young people to become vocational workers who are educated in the technical and generic skills needed for future manufacturing industries? With an action research approach, we explore on experiments of such innovative collaboration. We find that workplace-learning motivates young people to learn both trade specific and generic competencies. Thus, we argue that the lower secondary school-system must be included in what traditionally has been vocational education-workplace collaboration. Further, we find that the learning of future skill requirements presupposes collective learning processes and authentic problem solving. Finally, we argue that competencies fit well as an inclusion in both the social- and technological dimensions of socio-technical systems design, but more research is needed on the mechanisms by which competencies become "inputs" and "outputs" of future work designs.

Keywords: Vocational education, future competence requirements, workplace learning, school-company collaboration.

Introduction

At present there is a huge debate over the transformation of working life. Technological changes like digitalization, Industry 4.0, automatization and robotization are already having great impact, and one radical part of the debate is whether there will be any jobs in the future working life (Frey and Osborne 2013). A parallel debate, and the one which forms the background for this paper, is what competences are needed in a fast-changing global economy as for companies to develop their competitiveness and capacity to drive innovation.

Within this debate, the concern over skill supply is vital. In the EU white paper, *A new skills agenda for Europe* the Commission suggests policies for strengthening human capital, employability and competitiveness for Europe. In 2016 more than half of the 12 million long-term unemployed were considered low-skilled. Further, many people work in jobs that do not match their talent. At the same time, 40% of European employers have difficulty finding people with the skills they need to grow and innovate (p. 2). For the manufacturing industries the challenges are primarily on the supply of vocational workers. Within the context of Norwegian working life, Statistics Norway have made the estimate that Norway will be lacking 90 000 vocational workers in 2035 (Cappelen, Gjefsen, Gjelsvik, Holm and Stølen 2013). The shortage in the manufacturing industries will show particularly for electricians, manufacturing operators and construction workers. A parallel concern to this challenge is drop-out rates from upper secondary education, or lack of recruitment to vocational study programmes. It is of joint concern for the manufacturing industries, the secondary education system and the welfare state alike to ensure that young people make informed vocational career choices and that they leave their education with skills and motivation needed to contribute in the "future manufacturing factory" and engage in life-long learning.

Although practitioners and academics at present seem to agree on the skills needed for future manufacturing, the challenge on how to educate future and present workers remains a tricky one. Vocational education systems play a core role as a link between the general education system and the labour marked as to give young people the opportunity to make informed career choices. However, according to Messmann and Mulder (2011), it is difficult for young people to select an occupation and find apprenticeship training because of a shortage of training positions and because of new job profiles with higher job requirements. In addition, companies have higher demands on apprentices such as being competent, motivated, communicative, flexible and even mobile (Messmann and Mulder 2011, p. 64). In countries like Norway, Austria, Denmark, Germany and Switzerland the dual VET system depends on the willingness of firms to participate (Eichhorst et al 2015). The system is set up as a shared commitment between the school system and work life as to educate students to meet the changing market requirements. Vocational colleges provide the school-based part of dual apprenticeships and the firms must meet certain technical standards to be accredited to offer apprenticeship contracts. However, as Eichhorts et al (2015) argue, while dual training has clear advantages from a societal and individual perspective, it totally depends on firms' commitment to participate.

The challenges of connecting schools and work life are twofold as the rapid changes in the labour marked and work environments also require that vocational colleges and teachers must be responsive towards societal transformations to provide optimal learning opportunities and job preparation for students (Nijhop and Streumer 1994, Messman and Mulder 2011). Wesselink et al (2009) argue that in order to improve the connectivity between learning in school and learning in the workplace three aspect of the quality of this connectivity is important: authenticity, self-responsibility, and the role of the teacher as expert and coach. In a study where their interviewed students, teachers and workplace training supervisors they found that because the stakeholder groups hold different conceptions of workplace learning and often do not communicate adequately about mutual responsibilities, the implementation of the three aspects of competence-based education has not significantly improved the connectivity situation (Wesselink et al 2008 p. 19).

Within this context this paper explores upon three ongoing experiments of innovative workplace-school

collaboration aimed to give pupils in lower secondary school, upper secondary vocational schools colleges and apprentices a real-time encounter with the skills required in modern manufacturing. As partners in the research project "SKILLS: Future Industrial Worker in Skilled Practice"[36] , and which will be described more fully in chapter three, the enterprise partners reported a great concern for their industry in general, and their company in particular, for how to ensure that young people who choose to go for a vocational education have realistic perspectives of what it takes to be a machine operator or an electrical power installer in a factory producing high-quality products for the global marked. Hence, the aim of the experiments has been to prepare the pupils and apprentices on the skill requirements and effective work processes in a modern industrial workplace. The first experiment involves pupils both at lower secondary school and upper secondary vocational school level, where they work together with technical staff in the participating companies to design and produce a mechanical- and electrical vehicle. This experiment is designed to have teenagers at lower secondary school follow what we denote "the value chain of becoming skilled", which will be described in chapter 3. In the second experiment, pupils in the second year at their vocational education are constructing and installing a power electrical system "in-situ" in an electrical power company. For three days they are guided by the company's workplace trainers in solving the task of mechanical- and electrical assembling of a switchboard. Finally, the third experiment is that mechanical operation apprentices spend three months, out of their two-year apprentice contract time, in the company's R&D department as to develop skills in product innovation processes.

Theoretical framework

Competence requirement in future manufacturing work

Knowledge needs in working life has gained considerable attention in research during the last 10-15 years. The European project "Key Competence Network on School Education" (KeyCoNet) identified a set of key competences for the future in national educational systems including 1) communication in the mother tongue, 2) communication in foreign languages, 3) mathematics, science and technology, 4) digital competence, 5) learning to learn, 6) social and civic competencies, 7) sense of initiative and entrepreneurship and 8) cultural awareness and expression (Arjomand et al. 2013). In addition, the EU recommends that critical thinking, creativity, problem solving, risk assessment, decision making, and constructive management of feelings, are added to the list of key competencies. Further, the project "Assessment and Teaching of 21st Century Skills" (ATC2015) identified four groups of skills: 1) ways of thinking, 2) ways of working, 3) tools for working and 4) living in the world (Binkey et al 2012). An Official Norwegian Report (NOU 2014:7) presents similar conclusions. However, the Norwegian panel makes a distinction between distinct competencies and broad competencies. While skilled trade, along with e.g. ICT knowledge, the natural science and mother tongue- and foreign languages are distinct competences, it is the broader competencies like learn to learn, critical problem solving, cultural awareness, skills in collaboration and communication, that are the dominant future competencies, necessary both in working life and in the civic society.

In their survey on competence need for Norwegian manufacturing industry and the construction industry Solem et al (2016) found that mastering of trade specific skills was as important as the generic skills. The novelty of Solem et al's research (2016) is the identification of three specific competencies: 1) understanding the company's value chain of production, 2) how to initiate innovation processes, and 3) how to act autonomously in daily operational activities without supervision. They denote these competences "value creation skills", "innovation skills" and "responsible operating skills". The companies participating in the survey also highlight that an important content of trade specific skills includes knowledge on how to operate safely, as occupational injuries is critical in both manufacturing- and construction industry.

[36] Financed by the National Research Council of Norway. Project number 247747.

Another stream of research addresses the working life itself. Danford et al. (2008) and White et al (2004) argue that the interest for highly qualified workers can be understood as a response to changes in the market and technological conditions. Consumers demand a broader range of high-quality products and services and there are continuing developments in ICT that can enable more flexible manufacturing systems. Such conditions put new demands on worker skill and flexibility (Danford et al. 2008).

Organisational researchers have claimed that skills inside a company are key to success (Bessant 2003). A manufacturing company that starts developing high-quality products and services must increase its response and innovation rate. To do so, it must abandon the tight control-oriented approach and rely on workforce agility and responsibility. This requires higher skills and other kinds of skills among the employees. Then, companies can profit from teaching operators to solve technical problems as they occur, instead of calling in specialist technicians for problem solving and delaying the production (Wall, Corbett, Clegg, Jackson, and Martin 1990). Because companies rely on skilled workers in high-tech manufacturing, workplace practices centred on employee participation are assumed to pay off. Ravn and Øyum (2018) argue that new modes of manufacturing operation result in traditional blue-collar work moving into areas of work previously held solely by salaried staff. Consequently, within this context the educational system for vocational education must offer a curriculum reflecting the organisation of modern manufacturing production lines.

Workplace learning of vocational expertise

The recent debates on skill requirements to cope with future work life complement debates on ways of learning and the epistemology of competency. Hodkinson and Issitt (1995, in Wesselink et al 2009 p. 22) state that "competencies are integrated constructs that are a function of the context in which they are applied. Without a context, competencies are too generic and have little meaning". This statement relates profoundly to the way vocational education is supposed to enable the students to acquire the competencies needed in their future professions, and hence the focus is on competencies and not qualifications (Biermans et al 2004).

The approach to vocational training differs greatly between European countries (Nyen and Tønder 2014, Eichhorst 2015). In Norway, vocational training usually involves two years in a vocational school followed by a two-year apprentice contract in a company. The first year in school provides general education alongside introductory knowledge of the vocational area, while the second-year curricula are more trade-specific. As a contrast, Sweden has a three-year high school programme with a strong emphasis on general theoretical and academic knowledge. The vocational training takes place mainly at school and apprenticeship scheme plays a marginal role. In recent years, however, Swedish education authorities have made attempts to develop a stronger apprenticeship scheme. The scheme has primarily been perceived as an offer for school-tired students, not as the development of highly skilled workers. The German dual-model on the other hand has shown to be more effective than more school-based models to ease the transition to labour market (Eichhorst et al. 2015). Here, the student is an employee of the company from the beginning and receives tasks according to her or his growing abilities. If a company is willing to make an employment-contract with the student after his dual education time, the company will get an employee who knows the company's workflow.

Workplace-based learning and workplace training are terms used to describe the workplace as a learning environment, as opposed to formal learning (Pylväs et al 2017). The system of vocational education as briefly outlined above, relate to a socio-cultural theory of workplace training. In this perspective learning is becoming a process located in the framework of participation rather than within the learner, even if it does not replace notions of individual learning (Hager 2013 in Pylväs et al 2017). Lave and Wenger (1991) and Brown and Duguid (1991)

have proposed that learning happens in everyday interactions and through participation in communities of practice. Learning is happening as part of a process in which learners move from peripheral participants to full members of the communities of practice. In their study of Finnish apprenticeship training stakeholder's perceptions of vocational expertise and experiences of workplace learning and guidance, Pylväs et al (2017) found that being offered authentic work and collective support by experienced workers was crucial. However, they found that in order to become engaged in the learning process and to become active members of a work community apprentices were in a need of strong self-regulatory skills even during the training. They conclude that workplaces provided fruitful learning possibilities for those apprentices with strong motivation, volition and ability to self-reflection.

In her study on bakery apprentices Chan (2013) discuss identity formation processes of becoming a baker and eventually being a baker. She states that "learning to become trade workers requires learning, consolidating and applying ways of doing, thinking, feeling and being (Chan 2013 in Chan 2015 p. 336)". An important point of view raised by Chan is that much of the research done on learning as becoming, Lave and Wenger's communities-of-practice alike, is in the perspective of older and experienced adults and that we need to know more on learning through the perspectives of young people. One study that has explored the notion of identity within young students' vocational aspiration is by Davis and Tedder (2003 in Chan 2013). Their conclusion, that students' vocational aspirations were "inextricably bound up with other aspects of their lives, with issues of identity, with becoming a person" (p. 3), supports research to be undertaken on how people 'become' in terms of vocational identity.

Due to the discussions above it seems critical that workplaces must continue their emphasis on taking responsibility for providing vocational-workers-to be learning opportunities in authentic work situations. Within the sector of manufacturing industries, it is likely that authentic work as 'learning-sites' will become even more critical to learn the competences needed for future manufacturing work. As pointed out it is a knowledge gap on how to involve youngsters in work-place learning to activate their opportunities to make informed career choices. In the rest of this paper we consequently outline and discuss three innovative cases on how workplaces and schools can collaborate on this challenge.

Research method

The methodological approach in the experiments is action research oriented (Greenwood and Levin 2006) with an emphasis on cogenerative learning processes (Elden and Levin 1991). As discussed by Holtgrewe et al (2015) the choice of which method to use depends on the research question and the rationale behind it but also on which role the researcher shall have in the research project. They state that the logic behind interactive methods is co-generation, and where "the researched are research partners". Hence, in our research the researchers' role has been to initiate dialogues between the companies and the schools and facilitate their process of setting up the experiments. The input to setting up the dialogues has been contemporary debates over future skill requirements in manufacturing industries and the industry's experiences on the skill level among vocational education students, apprentices, and recruitment strategies. The aim of the experiments has been to gain knowledge on how manufacturing workplaces, vocational schools and lower secondary school level can collaborate in new ways which will benefit the pupils, teachers and the workplaces alike, and what is required for innovative collaborative practices to be institutionalized.

Table 1 below gives an overview of the various participants in the experiments:

Table 1: Overview of the participant in the case experiments of innovative workplace-school collaboration.

Case:	Participants	Research method
Case 1: "From terrible teen to terrific trainee	• 9th grade pupils on lower secondary school (N=16) • Students on vocational education college (N=10) • Teacher in lower secondary school **(N=1)** • Teacher in vocational school **(N=1)** • Production engineers in company **(N=2)**	Focus group interviews Observation Process facilitation
Case 2: "Situated learning of power-electric skills"	• Workplace trainers **(N=6)** • Pupils in 2nd year at vocational college (**N=15)** • Teachers in vocational college **(N=3)**	Process facilitation Self-reported evaluation from students
Case 3: "Blue-collar R&D apprentices"	• Apprentices within CNC machining **(N=2)**	Semi-structured interviews

The cases are thoroughly described later in this chapter. In all cases we have used process facilitation techniques to involve the workplaces and the schools into reflection processes on how to set up new learning opportunities. Data sources are interviews and observational data from Case 1, interview-data from semi structured interviews in Case 3, and the pupils' self-evaluation data from case 2.

Table 2 below summarizes the stages of conducting interviews in case 3, "blue-collar R&D apprentices", and the research methods used to accomplish the experiments and to gain data on the results. As this experiment is still ongoing the findings are preliminary although providing valuable insight on what role workplaces can take in initiating innovative learning processes together with schools, and to some extent what the pupils and apprentices report on their learning.

Table 2: The stages and content of interviews with the CNC-operators participating in R&D activities as part of their vocational education

CNC machine operator R&D apprentices		
Interview 1 Before the R&D work placement	**Main focus:** • To learn about the apprentice's expectations	**Interview guide, main questions:** • What are your expectations for working at the R&D department? • What do you expect to learn? • What do you know about innovation?

Interview 2, 3 and 4
During the R&D work placement
	Main focus:
	• To learn how the R&D department have organized the placement
	• To learn what the apprentice have experienced so far
		Interview guide, main questions:
		• What has the placement been like so far? Please give examples of ordinary tasks, or incidents that have happened.
		• Please describe your normal workday at R&D
		  ○ What are your areas of responsibility?
		  ○ How do you get tasks?
		  ○ How does a workday at R&D differ from working in the production department?
		• Have you collaborated with the engineers at R&D? What has that been like?

Interview 5 After the R&D work placement	**Main focus:** • To learn how the R&D department have organized the placement • To learn what the apprentice have experienced and what he/she has learned	**Interview guide, main questions:** • What has the placement been like? Please give examples of ordinary tasks, or incidents that have happened. • What have you learned during this placement? • Has anything been different than you expected? Has anything been difficult? • How do you think your experience with sitting in at the R&D department could affect your cooperation with the engineers at the company? • Could anything been done differently during the placement? • Do you think the company should continue offering apprentices to sit in at the R&D department? Why/why not?

The apprentices' workplace trainer		

Interview 1
Before the R&D work placement
	Main focus:
	• To learn about the CNC machine operators' expectations
	• To learn what plans the R&D department have for the apprentices during their stay there
		Interview guide, main questions:
		• Why do you think it is important for the company that apprentices sit in at the R&D department?
		• What are your previous experiences working alongside apprentices?
		• What expectations do you have for having apprentices here at the R&D department?
		• What are your plans for the apprentices during their stay here?
		  ○ What tasks will you give them?
		  ○ Will you set any goals for them?
		  ○ What will be your role as a trainer?
		• What do you think the apprentice will learn by working here?
		• Do you think the staff at the R&D department could learn anything from having apprentices working here?

Interview 2 After the R&D work placement	**Main focus:** • To learn how the R&D department have organized the placement • To learn what the apprentice have experienced and what he/she has learned • To learn what the staff at the R&D department has learned	**Interview guide, main questions:** • What has the placement been like? Please give examples of ordinary tasks the apprentice has been given, or incidents that have happened. • What have you learned during this placement? Do you think other staff at the R&D have learned anything? • Has anything been different than you expected? Has anything been difficult? • How do you think this experience could affect the R&D departments collaboration with other parts of the company? • Could anything been done differently during the placement? • Do you think the company should continue offering apprentices to sit in at the R&D department? Would you like to continue being a trainer for them?

Cases of workplace-school collaboration

The SKILLS project[37] is an R&D project financed by the Research Council of Norway and three global industrial manufacturing companies with sites located in the middle of Norway. Our funding- and collaborating partners in SKILLS are the local sites. The project also involves three upper secondary vocational education schools, as well as one start-up company developing digital learning platforms. The primary objective of SKILLS has been to develop new theories, methods, and models for high-skilled vocational knowledge practices in the factories of the future. A key goal[38], and which form the basis for this paper, has been to develop a systematized model that describe vocational education as enabler for future vocational work in manufacturing, and to develop a framework for coaching in practice that enable future vocational work in manufacturing. Within this context the three cases which

[37] The project started in 2015 and will end in 2019.

[38] In the research proposal the objectives of SKILLS are formulated as:

1. Establish an **empirical foundation** by synthesizing prior knowledge on vocational work in future manufacturing and extend this knowledge through case studies.
2. Develop a **systematized model** that describe vocational education as enabler for future vocational work in manufacturing.
3. Develop a **framework** for coaching in practice that enable future vocational work in manufacturing.
4. Design an **overall system** for future vocational work in manufacturing. The design will include the arena/interface between school, company, unions, management and apprentices, and how to use technology as enablers for future high-skilled vocational work.

will be explored in this chapter are experiments launched as collaborating initiatives between companies, upper secondary vocational schools and two lower-level secondary schools. Seen as one innovative effort within the SKILLS project, all three experimental cases either have involved lower secondary school pupils, students in upper secondary vocational schools, teachers, workplace trainers, company representatives from the shop-floor union, HR-department and production departments, and the researchers.

Figure 1 below illustrates what we have denoted "the value chain of becoming skilled". Norwegian youngsters spend three years of compulsory lower secondary school, and three months before the end-date they apply for their next education in upper secondary school. Either they apply for university-preparatory curriculum or a vocational school. After two years of vocational school the pupils start on a two-year apprenticeship contract in a public- or private company, depending on their trade specialisation. Within this context the hypothesis in SKILLS have been related to test if the steps between these educational systems can be organized so that young people can make informed career choices so that companies can recruit vocational students who have a high level of inner motivation and knowledge on what it takes to be a future expert, into apprenticeship.

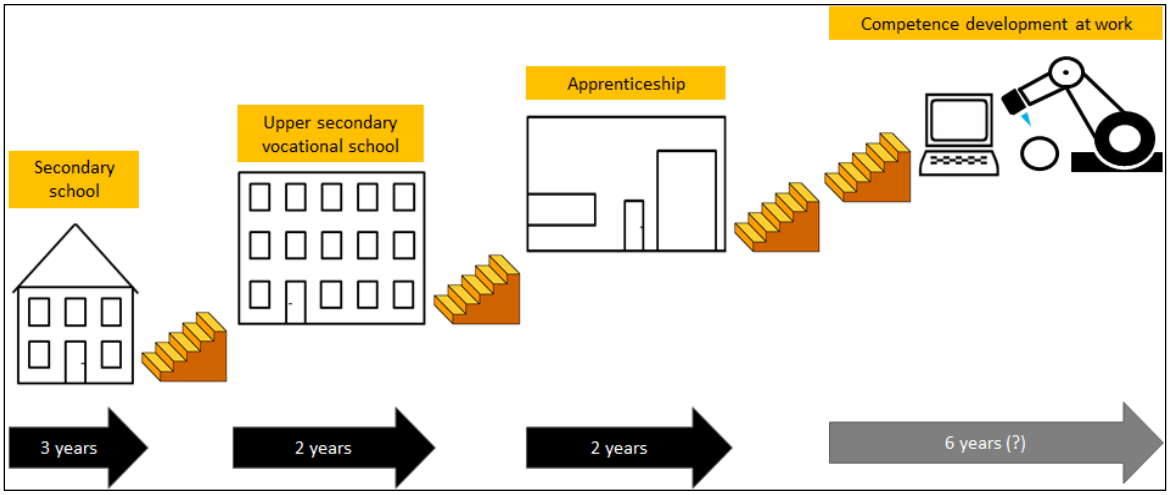

Figure 1: "The value chain of becoming skilled"

This value chain of becoming skilled has been the point of departure for the experiments which are presented below. The research question for the experiments was the following: How can school-workplace collaboration motivate young people to become vocational workers who are educated in the technical and generic skills needed for future manufacturing industries? Within the context of figure 1 the experiments have thus aimed at reducing the steps between the various school levels, learning contracts and manufacturing workplaces.

Case 1 is about collaboration between a lower secondary school, an upper secondary vocational school and a company, while case 2 involves an upper secondary vocational school and a company. Case 3, however, is about how a production company has redesigned their apprenticeship program so that production operator apprentices learn the competencies of collaboration, communication and parting in innovation practices by working in the R&D department for three months in their two-year apprentice program.

Case 1: "From terrible teen to terrific trainee"

Figure 1, the value chain of becoming skilled" was developed by the research team and the participating companies and upper secondary vocational schools alike in the early phase of the SKILLS research project. The companies and vocational schools argued that innovative workplace-school collaboration must involve the lower secondary school level as it is on this level the pupils apply for a college education. Thus, the schools, companies and society benefit from young people making their choice based on motivation for learning.

The experiment “From terrible teen to terrific trainee” is collaboration between one of the companies participating in the SKILLS project, a lower secondary school and an upper secondary vocational school. The goal for this experiment was to give lower secondary school pupils an opportunity to make an informed career choice through getting a better understanding of what it is like being a vocational education student and what working life would look like. Related to figure 1, the aim of the experiment has been to give the pupils a glimpse into what it is like to walk the two first stairs.

The experiment started out in lower secondary school, where the pupils were given the worktask of making a raft. It was predefined that the rafts should be made of a plastic pipe system and wood, as the two main regional companies and hence workplaces, produce these materials. In the beginning, the students worked individually with their ideas, and after a few weeks they were placed into four groups. Each group had to develop all their ideas into one concept that they would continue to develop further. When each group had decided on one concept, engineers from the partner company helped the students develop their concepts even further by asking questions about the rafts and making suggestions on how to improve them. When the concepts were finalized, the engineers made 3D-drawings from the pupils' hand-made drawings, included technical specifications, and produced plastic pipes to be used in the construction of the drafts. The pupils presented the drawings to vocational education students, who got the role as the pupils' mentors (alongside the teachers) during the process of building the fleets. The vocational education students also produced some of the parts which were to make up the draft's construction.

Case 2: "Situated learning of power-electric skills"

As discussed in chapter 2, Solem et al's (2016) research on skills needed in future construction- and manufacturing work, competencies in mastering the basis for the study program are as much important as generic competencies. This is in line with what Wesselink et al (2007) call Aspect 1 of competence-based education: The competencies that are the basis for the study program.

Within this context the case called "situated learning of power-electric skills" were launched as a joint initiative by a power electric manufacturing company and an upper secondary vocational school offering studies in electrical installation and maintenance. With this basic vocational education, the students can proceed with apprenticeship within various areas. The company offers apprenticeships in power distribution, where a key work task is to produce and install, both mechanically and electrically, switchboards for power distribution. In the experiment "situated learning of power-electric skills" teachers and company workplace trainers collaborated on designing an authentic work task for a power distribution fitter. Then, a group of 12 pupils spent three working days in the company's production department to solve the task in an authentic situation. During the task performance the company's workplace trainers were the pupils' teachers, and the schoolteachers were shadowing the training instructors to observe their way of engaging the pupils into the learning activity.

The company is an attractive employer for apprentices within this field and has for years offered several apprenticeship contracts to pupils from this vocational college. The experience of the workplace trainers is, however, that when the pupils have finished their school-based education and enter apprenticeship they lack

fundamental knowledge on handling the modern equipment necessary to perform the work tasks of producing a switchboard and a power distribution unit. The vocational school agrees on this competence gap but lacks financial resources to invest in modern tools and materials. Further, the learning goal of the national curriculum for electrical installation and maintenance do not specify what competencies are needed in tool handling. Consequently, the aim of the experiment was to train the pupils in handling modern realistic perceptions on the work tasks and the area of work responsibility for a skilled power distribution fitter in this company. The teachers and workplace trainers designed the experiment according to the following learning criteria:

- The pupils' learning should aim at learning:
  - how to use a torque wrench when screwing nuts,
  - proper use of wheel discs,
  - electrical power wire preparation and -handling,
  - transformer construction (including Al/Cu connections).
  - mechanical installation of a switchboard into a power distribution unit
  - learn how to use modern tools and equipment and authentic materials
- The pupils should solve their task by spending three full-time working days in the company's production department.
- The workplace trainers should guide the pupils in their work, while the schoolteachers observe how the trainers work in engaging the pupils in a learning process taking place in an authentic work situation.
- Afterwards, the produced switchboard and the power distribution unit is given to the school as a gift from the company as to be used in later teaching activities.
- During the winter the workplace trainers will visit the school to observe how the teachers work with the pupils.

Case 3: " Blue-collar R&D apprentices"

As discussed above, competencies in critical thinking, creativity and problem solving are recommended by the EU as key competences for the future in national educational systems. Further, Solem et al's (2016) study on critical competencies for skilled workers in the construction- and manufacturing industry identified competencies in engaging in innovation processes and knowledge on the company's value creating processes as critical. Within the Norwegian dual system of vocational education, the students spend two years in school and two years as apprentices. The company involved in case 3 in our research, employs CNC (Computer Numerical Control) machine operator apprentices.

The national curriculum standard for CNC apprentices[39] includes two levels of competence requirements: 1) production technology and 2) quality assurance and documentation. Further, five generic competences are specified, all related to varieties of digital competence and mother tongue communication skills. However, there are no explicit references to what we in this paper have discussed as future competencies in engaging in or initiating production innovation, and more specifically the competency of collaborating with technical staff.

In order to test how CNC-machine operator apprentices can learn how to engage in activities directed towards innovation of mechanical products, this company have set up a pilot experiment motivated by being upfront in ensuring that future operators have competencies in innovation- and value creating processes. The core of the experiment is designing their CNC machining apprenticeship contract to include a three-month period of sitting in

[39] https://www.udir.no/kl06/CNC3-01/Hele/Kompetansemaal/etter-vg3

at the R&D department as to learn technical staff work tasks. The company is a world leader within machine tooling and the main area of responsibility for the R&D department is to develop new products and redesign existing products. Due to this, the design of the experiment has two aims: Firstly, to educate future skilled CNC machine operators into competencies on creativity in innovation processes to prepare them to contribute to effective realization of product innovations into new products to the customer. Secondly, an indirect aim is in the long run, to develop technical staff's competencies on collaborating with the production department as to reduce the time to marked for new product innovations.

Time to market for new products depends, among other things on the collaboration between the R&D- and production department. It has been a recurring issue that technical staff do not involve the operators in their creative group processes where new ideas arise or in the development of the technical specification of manufacturing test products. The consequence is a back and forth process between the departments caused by the production department's input on machining requirements for the product to be fully realized. For years machining operators have asked for a closer dialogue between R&D. The technical staff on R&D has not been reluctant but have no practice in cross-departmental collaboration. Further, the initiative among the skilled operators to enter a closer dialogue with R&D have varied due to years of experience and product knowledge, not all being comfortable in this cross-professional dialogue. For plant management and production management this lack of cross-departmental collaboration is not perceived as bad will but rather a result of preconceived perceptions of professional roles, work task responsibilities and educational background.

At present two CNC machining apprentices have finished their three-month stay in the R&D department and one more will start during the winter of 2019. The apprentices' workplace trainer has been the same person as they have during their entire apprenticeship period. The apprentices, who up to this point in their training had worked in the product production department only, have as R&D-apprentices performed some of the work tasks which typically define the importance of closer dialogue between production and R&D. One example is to handle orders from the technical staff on needs for pilot testing, then to produce and test pilot products. When the pilot product is produced and tested technical staff evaluate the results. In this evaluation process there are great benefits from closer dialogue between technical staff and CNC-machining operators, a benefit who was one of the company's argument for why CNC-machining operators must gain training in advocating their knowledge towards R&D. The other way around, the apprentices have also run vibration stress tests of product parts developed by technical staff. Finally, the apprentices have also participated in setting up product-demonstration events for customers, where they have gained training in meeting customers and explain the functioning of the company's range of products.

Discussion of findings

This chapter presents the preliminary findings from the ongoing experiments and discuss how the findings relate to the research question of how lower secondary schools or vocational schools can collaborate with industrial companies as to motivate young people to become vocational workers who are educated in the technical and generic skills needed for future manufacturing industries. We organize our discussion by analysing case 1 and 2 together as these cases demonstrate innovative workplace-school collaborations. Case 3, on the other hand relates specifically to why and how apprentices learning curriculum can be changed as to include skills related to innovation and knowledge on the company's value chain, as pointed out by Solem et al (2016), and how such competence development can be organised within an apprentice's learning contract with a company.

Motivation to make informed career choices

Drawing on case 1, the students in lower secondary school express great enthusiasm over this innovative way of working. As the experiment is organized as a learning activity in the optional subject called "work life science" it is likely that the pupils' preferences are towards vocational education as opposed to an academic degree.

The lower secondary school pupils, as well as the vocational students, express that they are motivated by producing a physical object (a raft) and that they enjoy practical work. The teacher reports that during these weeks where the experiments have been ongoing, he has observed that the pupils find school more meaningful. He finds that the pupils have become more motivated for putting an extra effort into compulsory subjects like mathematics and natural sciences, and the level of school absence has decreased. In our interviews with the pupils three, out of four, say that they will apply for a vocational education. We cannot conclude that this is a direct result of the project. However, the following quotes from focus group interviews with the pupils demonstrate that the project's design of collaboration with a company and vocational students have generated motivation and knowledge on complex problem solving as a collaborative effort:

> *"It was cool to receive the 3D-construction drawings from the company. Then we could really envision how nice our raft could be, and it motivated us [to continue the project]".*
>
> *"The vocational education students questioned us on whether the raft would float and showed us how we could calculate the flotational force of the pipe construction."*
>
> *"It was fun, and I got a feeling of mastering [a complex task]".*
>
> *"To use mathematical calculations when solving practical problems is much more motivating [than learning theoretical mathematics]. It is fun to calculate something [a physical object] you can visually see. It turns out that we did use mathematics all the time [in this raft construction task]".*

The pupils in the vocational school, on the other hand, express that they have enjoyed mentoring the pupils and contributing to the production of parts used in the final raft construction. They report learning gained from having to provide arguments and knowledge to the pupils on which materials are the most suitable for the raft to float well, and which machines are the best ones to use in producing various parts of the raft. Thus, we find that they have learned key elements in communication and collaboration. The following quotes from some of the vocational students exemplifies how they have increased their communicative and collaborative skills: *"we have learned to be patience and solve problems when they arise", "we must simplify the message [when explaining things to them", "I believe we have motivated them to apply for vocational education",* and *"we have learned that we can solve problems together [across the school-levels]*".

Both the lower secondary school pupils and the vocational students report that they have spent a lot of time outside school of thinking about how to make the best raft. Consequently, several pupils and students say they have brought parts from home (for instance parts from a bicycle, from a lawn mower, or an old chain saw) in order to construct an effective motor on the raft. Putting an extra effort into the project indicate motivation and a will of taking responsibility for getting the task done.

The research question in our paper relates to how workplace-school collaboration can motivate young people to become vocational workers. As discussed in chapter 2 there is much evidence that workplace learning is a key variable in developing skills relevant for working life. Drawing on case 2, situated learning of power-electric skills" we now discuss in what way vocational education students' motivation for their career choice has developed further due to workplace learning.

Our key finding from this experiment is that the students found the linkage between learning at school and workplace learning to be at the core of getting to understand the complexity of the job operations involved in the company's production of power distribution switchboards. Included in the learning were the skills of handling modern equipment. The following quotes from students illustrate this learning:

> *"We got knowledge on the Switchboard mounting training as it is in real working life. I liked that the task started with the switchboard, as we do it in school, [but ended with a switchboard control centre unit]. It would have been nice, however, if we had some more time to work on the 3D-documentation drawings, and more time to finish our work properly".*
> *" We were allowed to work with a lot of modern equipment and tools".*

> *"The work task was very relevant and authentic for us in second year at school. The task was also well designed as it included the process of which materials and tools to use, and unit function test and quality control of the product in the end".*

Baartman et al's (2018) study of what types of knowledge VET-students learn and how they integrate these different types of knowledge shows that students recognize the importance of vocational knowledge learned in school-based learning environments while they are in the workplace and vice versa, and continuously contextualize knowledge to make it applicable for new circumstances. They also find that students learn differently at school due to their experiences in the workplace. Our findings are in line with Baartman et al's (2017) conclusions. The students' highlight authenticity of the work task and the tools used, exemplified for instance with the statement *" (...) liked that the task started with the switchboard, as we do it in school".*

However, we also find that the students expect some standards of the company instructors involved in the workplace training. The following quotes illustrates this:

> *"I liked the guided tour, but the workers who guided us could have explained to us in a better way, the function of the various parts and products. This have made it easier for us to understand the production line".*

> *"The section where the trainers explained to us the various nuts and mechanical wheels was not very well organized (...) and we were not given good enough explanation on how to use the torque wrench. This made us end up bending the first four nuts before we got it right".*

Here, the students provide the company with valuable learning on how to design collaborative teaching activities together with vocational schools. They express the necessity of instructors having pedagogical skills and to have profound knowledge on the technicalities of products and equipment. When the company received this feedback from the students, the company decided to rethink their company-based instructor education. At present they are in the process of giving the instructors state-of-art knowledge on the complexity of the products. We find that, in the encounter with students, whose aim was to learn in authentic environments, this may generate new learning for the company as well. Thus, innovative workplace-school collaboration may trigger innovations both ways.

Halvorsrud (2017) has done a review of extant research on student dropout in Norway. Markussen (2010 in Halvorsrud 2017) has identified five categories of dropout measures that have been prioritized in Norwegian policymaking, one being elements of practice in VET, and a second being to improve the competence level of key actors working around and for the students. We will argue that this experiment and the pupils' self-reported experiences demonstrate a learning in what NOU (20114:7) refer to as broader competencies like learning to learn, critical problem solving and skills in communication and collaboration, but also the trade-specific skills as highlighted by Solem et al (2016). Further, these findings support that workplace-school collaboration for young

people can contribute to the development of their inner motivation. Pylväs et al (2017) find in their work that internal motivation is related to the interest in the field of vocation, willingness to learn and interest in the development of expertise, as well as initiative and positive attitude. Findings from the experiments prove that this way of working has provided the participating youngsters with an opportunity to not become "hopeful reactors" Vaughan et al (2006; Chan 2013) but developed their capacity to make informed career choices.

Merging competence requirement for future industrial excellence

Ravn and Øyum (2018) argue that, in new industrial models, traditional blue-collar work is moving into areas of work previously held solely by salaried staff, and that a merging of work content will cause a process of identity-mergers. From the competence requirements discussed in chapter 2 and demonstrated in the discussion of findings related to case 1 and 2 above, we may also argue that there is a competence-merger between blue-collar workers on the one hand, and technical staff on the other. As discussed in chapter 2 one of the key competence requirements for skilled workers is knowing how to initiate- and partake innovation processes. Within this context, findings from case 3 and results from the experiment called "blue-collar R&D apprentices" are presented below.

The following quotes from the two apprentices describe their process of learning generic competences by working with R&D innovation processes and -personnel:

> *(…) You get to try so many different things. You quickly learn to become independent. You must to be steady and self-confident to work here. You can't be reluctant of pushing a button, you can't be reluctant of asking for help. You shouldn't be a first-year apprentice, you must know how the machine works before you get here. You also get to learn more about what clients want."*
>
> *"At the R&D department, I can choose to work with the things I need to learn more about. I can ask for tasks that give me more experience. R&D gives me the possibility to achieve standard curricula goals like being creative, being independent, to learn how to handle the unexpected, and learning to plan." (Apprentice)*
>
> *"Some of these people with PhD's only think about designs and concepts, and they're not practical at all. They are the exact opposite of me. But we manage to communicate and cooperate. It's a very good collaboration, it's like having one person that knows everything. They know something I don't, and vice versa. They don't look down on me. (…)*

The findings suggest that the apprentices found working at the R&D department very different from working at the production department, with deviating work content practices. One of the operators at the R&D department were responsible for training and following them up, but the apprentices were soon expected to manage on their own. When working in the production department, they were used to an ordering system always telling them what the next task would be. At the R&D department, however, choosing which tasks to prioritize became more challenging as there were different ways of receiving an order. Orders would be delivered by e-mail or the phone, and sometimes someone would just stop by and ask them to do something. They got the freedom to choose how they wanted to perform their tasks. The ability to self-organize, communicate and make decisions was of crucial importance. The apprentices also got the opportunity to learn how to use new CNC machines, and they got experience in programming. The apprentices say that the work placement at the R&D department has given them the opportunity to develop their creativity and independence and increased their skills in planning their tasks and responding to problems.

It is the R&D department who is responsible for arranging product demonstrations for clients. Both apprentices got to take part in several demonstrations during their work placement, and this experience has increased their understanding in why the products are made the way they are. The following quote from one of the apprentices demonstrate the motivation and learning gained from participating in a meeting with customers, where they performed a product demonstration:

> *"You get a very good comparison. You get to see how big of a difference it makes using something we have made, against something else that's not as good. To see how good that attenuator works… It was like, "why do people buy that other stuff?"*

Seeing the clients' positive reactions to the products have also given the apprentices even more of a professional pride of working at the company. The apprentices' trainer at the R&D department thinks that CNC machining operators may be a productive link between R&D and the production department in the future. However, this will require rather self-confident apprentices with enough practical experience in machining processes. The apprentices' training instructor describes this in the following way:

> *"Some people can find it very frustrating not knowing what they will be doing tomorrow. I think it's exciting. But I'm sure it can be difficult for some people. That's something we can be considerate about. (…) I think it's important that the apprentices that come here have a solid ground to stand on, so they can be quite independent. If not, it could almost be traumatic for them, I think. We demand that they do something, and then they can't do it. The task becomes too big, too difficult."*

If an apprentice with too little experience was chosen to sit in at the R&D department, the tasks would turn out to be too difficult, the trainer states. Consequently, the R&D work placement would become a bad experience as opposed to an opportunity for them to learn and develop their skills. Thus, the trainer thinks that this way of working could be difficult for some people. The apprentices had learned that product innovation processes included a 'try and fail'-method of working, and a key characteristic of the work was that it did not produce immediate tangible results. The workplace-instructor warned that this way of working may reduce the CNC machining apprentices' motivation unless you are prepared about the different nature of producing "nuts and bolts" on the one hand and partaking in product innovation processes on the other. We believe the following quotes from the training instructor gives an illustrative picture of these different natures, and how it plays out for the apprentices:

> *"I think they're learning a lot here. Because now they really must* think. *It's not enough just pressing a button or doing something that's been done 300 times before. Like I said to them, everything we do here is something new. (...) You have to behave like what you're doing is really dangerous, you have to be really attentive. (...) In the production department you get to see the result of your work right away. You don't get that in here. But this is a job too. Somebody wants an answer."*

Sitting in at the R&D department does not automatically give insight into innovation processes. It is decisive that the apprentices themselves are active and ask their colleagues questions. This is in line with Pylväs et al.´s (2017) findings on prerequisites for effective workplace learning for apprentices. She found that to get required support to develop their vocational expertise, apprentices were expected to not only be motivated, self-directed and responsible employees, but also brave enough to ask for help and guidance.

We find it important that the R&D-colleagues include the apprentices as a part of the work processes and share their experiences for the apprentices to become part of the R&D community-of-practice. Julian Orr's work (1997, 2006) on how copier technicians diagnose problems by storytelling may bring us further on suggesting how the work of production innovation processes must emphasize the work as a practice and not as 'tasks' designated to technical

staff, and that effective manufacturing processes in the future requires a rethinking of both organisational design and varieties of competences across business functions.

Conclusions and implications for further research

We will draw attention to two findings and perspectives in the work presented in this paper. The first is that in order to ensure enough access to young people who have an inner motivation for becoming skilled expert in future manufacturing work, the lower secondary school-system must be included in what traditionally has been vocational education-workplace collaboration. We have seen that workplace-learning opportunities for young people generate motivation for learning both trade specific and generic competencies and make it easier for young people to make informed career choices. We find additive effects of learning in school(s)-company collaboration in both the lower secondary school, the upper secondary vocational school as well as in the companies. When young people meet across school levels to solve an authentic task, we find that motivation goes both ways: the pupils in 9th grade increase their motivation of vocational education as a career choice due to having learned what vocational students learn and work with. Likewise, the vocational students have developed their competences in communication and collaboration in the role of mentoring the younger ones. These competencies are at the core of generic skill requirements. Finally, the company has gained more insight into which role they can take, as a provider of modern tools and machining, formulating authentic work tasks which the students must solve, and demonstrate the importance of mathematical calculations in core job tasks in the production system.

Secondly, the learning of future skill requirements presupposes that much of the learning must take place as collective processes and dealing with authentic problem solving. Such a prerequisite for young peoples' motivation to become vocational workers challenges the two different systems of private enterprises versus public schools. Obviously, for manufacturing industry learning, development, innovation and production mainly takes place as collective efforts in workgroups. Quite contrary, the school system is organised as to develop the individual student measures by quantifying learning with grades and marks. It seems reasonable to challenge the school system on how they can contribute to developing young workers with the varieties of competences asked for by "factories of the future". Consequently, we must strive for developing new models for young people to present their qualifications, including their motivation and self-confidence. If this becomes a part of schooling in all undergraduate levels, we may get young people who increase their self-confident in seeing themselves as partaking in a rapid change of work characteristics. To institutionalise workplace-school collaboration, with inspiration from the cased discussed in this paper, may be a valid contribution to solve this challenge.

The background for our research has been the contemporary debates over future competencies required in future working life. As discussed in chapter two, the emphasis put on generic competencies like communication, collaboration and ability to take on responsibility for ensuring a task to be done, challenges the curriculum and teaching methods for young learners. The challenge is partly a pedagogical, structural, collaborative and financial challenge one. No matter how the school system and the industries themselves set up innovative collaborative activities, however, there is a need for future work environment research on which capacities these new competencies represent when it comes to organisational design and industrial productivity. Being a skilled worker in modern manufacturing industry means that one holds both technical and social skills and that both dimensions are necessary to operate the complexity of future manufacturing. From this, we will argue that competencies fit well as an inclusion in both the social- and technological dimensions of socio-technical systems design, but research must be done on the mechanisms by which competencies become "inputs" and "outputs" of an STS design. Claussen, Haga and Ravn (2019) argue that there is a need to re-invent an STS position to address contemporary and future organisational realities. Originating from The Tavistock Institute of Human Relations and their studies in coalmines during the 1950's, and developed further in the industrial democracy project in Norway (Emery and Thorsrud 1970) during the 1060's, social-technical systems theory challenged the perception of universal principles

and designs of organisations based on specialisation and coordination. Rather, the empirical work on work-processes, tasks, technology and organisation as performed by, among several, Trist and Bamforth (1951), Herbst (1974), and Emery and Thorsrud (1976), suggested simpler organisational designs that allowed the workers' involvement in the working processes by increasing the complexity of the work tasks and not reducing the complexity of the organisation. Within this perspective it seems necessary to include new competence requirements, and even young peoples' expectations of further skill development in work, as a parameter when designing work tasks in future manufacturing industries.

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EUROPEAN JOURNAL OF WORKPLACE INNOVATION

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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