DOES THE ENACTMENT OF INFORMATION AND COMMUNICATIONS TECHNOLOGY AGREEMENTS IN A DIGITAL CONSTRUCTION ORGANISATION IMPACT THE MENTAL WORK ENVIRONMENT?

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This study discusses how digital infrastructures in the Danish building industry affect the mental work environment in a project organisation, by focusing on the information and communications technology agreement as a term of reference for the division of labour and the specification of digital work. Based on interviews from a case study, namely a renovation project from a major Danish real estate owner, this paper studies the interactions between social and technical practices in a network and draws on concepts from actor-network theory to analyse the findings. The study sheds light on how the network around the information and communications technology agreement is dominated by one enactment, and it is found that displacements occur when one enactment becomes dominant. In these displacements, the mental work environment is pressurised, which leads to stressors, shifts in core activities and employees' struggle to find meaning in their tasks. However, the study also points out how digital tools can help to ensure a good mental work environment by strengthening project collaboration.

Keywords: digital infrastructure; ITC; mental work environment; S&T studies

INTRODUCTION

Technological development in the Danish construction industry has intensified in recent years, with the creation of digital tools aimed at structuring each part of the value chain in the industry and technology's growing role in agendas such as sustainability, efficiency, and economy, as described in a report from The Danish Building Research Institute about building automation: 'Significant societal agendas such as climate, energy, sustainability, indoor climate, etc. have, in recent years, challenged the construction industry'. The authors state that diverse new requirements for topics like climate management and improved energy performance have, in addition to new types of collaboration interfaces between professional groups, professions, suppliers, and users, led to a significant development in the constructions' use of technology (Forman, Sørensen, and Fredslund, 2017).

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These agendas do not only occupy the construction industry but are broad societal interests, and therefore, they increase both internal and external pressure on the construction industry. With the construction industry contributing a 30% share to Denmark's total CO_2 emissions (Klimapartnerskabet, 2019), the pressure to incorporate more sustainable construction is increasing. Digitalisation is given a central role in the conversion process, as the Ministry of Transport, Building and Housing's strategy for the digitalisation of construction from 2019 stipulates (Trafik-, Bygge-, and Boligstyrelsen, 2019). Here, digitalisation is emphasised as a means to improve the building sector's general development and sustainable conversion: 'Digitalisation can help to connect idea, design, execution and use in a way that promotes productivity, quality and resource savings and, thus, ultimately sustainable construction.'

With this, a strong connection is created to show the digitalisation of the construction industry and the solutions to the problems that the industry may face in the future. The digital infrastructures that continue to grow in complexity and are formed by the development of technology in the construction industry, therefore, play a large role for the people who directly or indirectly work with construction technologies and who experience how their work is affected by this development. In a study of the construction industry's digital infrastructures and how tools such as building information modelling (BIM) affect the existing structure of the industry, the authors conclude that the effective utilisation of digital infrastructures will have significant effects on construction in the construction industry: 'In setting out to achieve their longer-term goals, the idea of digital infrastructure suggests that practitioners need to be aware that the implementation of digital tools, such as extranets and building information models, changes the boundaries between firms, offices, disciplines, teams and roles. It shapes social relations, as it develops new practices and changes the visibility of information' (Whyte and Lobo, 2010).

Therefore, it is important to study how working within digital infrastructures affects the construction process and how the shaping of digital work can entail challenges in the mental work environment for employees within the construction industry. Additionally, a central aspect of digital work in the construction industry is the information and communications technology (ICT) agreement, a contractual document that aims to structure work using ICT and structure the later delivery of data by creating terms of reference for the division of labour, as well as specifying a digital building model and project material. The ICT agreement was introduced in 2007 as part of the law of ICT (By-, Bolig, and Landdistriktsministeret, 2013) and is applicable to public construction projects with the long-term aim to incorporate the application of IT into construction. The agreement holds uniform requirements to define the project's digital level and digital processes by which the project is governed and is a statutory contract between the client and the ICT responsible consultant. However, there is still confusion about what data to deliver at project submissions, in addition to problems with the translation of data between different digital systems.

Analytical Framework

The aim of this paper is to examine whether the ICT agreement, an agreement that regulates digital cooperation in a building project, affects the mental work environment of the project's employees via the network around the agreement as the central actor. This is done by using Mol´s (2002) concept of enactments and ontological multiplicity to study the possible effects and how this connects with the

concept of boundary objects (Star and Griesemer,1989), Star´s (1999) definition of digital infrastructures as a concept for understanding the digital connections and finally are Olsén´s (2008) theory of meaningful work and core activities used for understanding the mental health.

In the study of this network that is formed around the ICT agreement, actor-network theory (ANT) is used to shed light on the processes that arise from the agreement that can affect the project employees' mental work environment. The concept of the network is not limited to seeing the network as a specific type of relationship but provides space for networks to comprise several different relationships (Papazu, Wintereik, and (red), 2021). Additionally, the size of the network is not defined in advance. Unlike the broad mindset of the sociological research tradition, the actor in ANT is not seen as someone who actively defines others rather than being defined themselves; they are seen as part of a network contributing to the actions of others and arranged in a certain way. The actor is, therefore, not limited to being a human actor; it can also be nonhuman, such as a document or technology.

To study how the ICT agreement stems from and influences various work practices, Mol's (2002) development of ANT is used to analyse the coexisting realities of the building project. Mol focuses on how different practices can coexist and challenge each other within a common relationship to a particular phenomenon via the idea that reality is multiple and exists in different overlapping versions. Mol's (2002) concepts of 'enactment' (Papazu, Wintereik, and (red), 2021) and 'ontological multiplicity'" (Mol, 2002) clarify how the ICT agreement is realised as an actor in the network and how different versions of the same reality can emerge and exist in a network. The concept of enactment refers to how something is made a reality in practice, making space for overlapping realities to continuously develop and become material. This understanding implies that each practice produces materially different versions of reality that can both vary in size and in the extent to which they overlap, but they all affect the network around them. Thus, one reality does not exclude the other; they can coexist despite their differences. Continuing this, Mol (2002) develops the concept of ontological multiplicity in connection with her study of atherosclerosis in The Body Multiple (Mol, 2002), to explain how several different enactments of the same disease can exist among professional groups in the same hospital. Over time, management selects a version of the disease as the dominant reality to manage and organise their work. If hospital management focuses on one enactment of the disease, the other enactments' legitimacy is challenged, and they risk being overlooked in practice.

Later, Star and Griesemer's (1989) concept of boundary objects, are used to explain why the dominant enactment of the ICT agreement can challenge digital work during project collaboration and weaken the ICT agreement's position as a boundary object for the digital work. Star and Griesemer (1989) describe a boundary object as an object that makes collaboration possible without the need to agree on what is being collaborated on. Further, 'boundary objects are at once temporal, based in action, subject to reflection and local tailoring and distributed throughout all of these dimensions' (Star, 2010). In this description, the ICT agreement can act as a boundary object between various digital enactments by creating a common understanding of what the client desires, what the digital work should be and what is to be delivered.

The ICT Agreement as Part of a Digital Infrastructure

Star (1999) defines an infrastructure as the invisible layer that makes things possible, such as the complex system of water pipes, pumps, the craftsman, and systems that

make it possible to fill a glass of water from the tap. Infrastructures is a part of a larger technical system, exciting of different interactions and representations or as Star (1999) describes it, 'infrastructure is a fundamentally relational concept, becoming real infrastructure in relation to organised practices.' Based on this, the ICT agreement constitutes a part of the infrastructure in digital construction that connects different professions and digital objects as a structure that precedes work using building models, digital project management systems and ICT cooperation in the project. The ICT agreement is, therefore, a natural starting point for examining the effects of digital infrastructures in the early stages of a building project on the mental work environment.

Mental Health as a Concept

To justify our hypothesis that the ICT agreement's structuring of work practices can affect the project members' mental work environment, we draw on the conceptualisation from, Lorentzen (1988): 'When we talk about the mental work environment, we mean that we take a psychological point of view on the work environment in order to investigate some influences, reactions and contexts that cannot easily be accommodated in a traditional understanding of the work environment' (Lorentzen, 1988). Continuing this way of thinking, Olsén (2008) introduced the idea of studying mental health by focusing on how employees can maintain or develop a positive meaning for their work. The focus is on the tasks and what conditions are needed to fulfil the task, which is done by looking at how the subject makes the work meaningful and how changes affect the subject's core activity (Olsén, 2008). The core activity can be related to both the individual's main tasks and the organisation's overall mission, as well as the connection, goals, procedure, cooperation, conditions, feeling of professionalism, and results of the work. On both levels, the core activity is connected to individual expectations for the work and how these lead to the feeling of tasks being fulfilling and meaningful. Meaningful work is connected to whether the individual experiences meaningful connections among activities, actions, and practices, as well as within social relations. A loss of meaning can lead to discomfort and anxiety, which can cause reactions such as reluctance or resistance. Based on Olsén´s (2008) concept of the core activity and meaningful tasks, it is possible to identify areas in the network in which the mental work environment is pressurised.

METHOD

To study the effects of work with ICT on the mental work environment during the initial phases of design, the study draws on an ethnographic case study of a Danish project organisation. Through qualitative interviews with the project members who comprise the network formed around the ICT agreement, as well as observations of project meetings, the implications and impact of the ICT agreement are analysed. The case study is chosen strategically for the opportunity to study different enactments of the ICT agreement in a shared project environment and how the different professions interact with and are affected by the with same agreement.

The case is a renovation project at a Danish university, which involves transforming an existing depot into modern study areas. The study involves representatives across the entire project organisation to follow the creation and development of the requirements for ICT and how the requirements affect the work of the project members. Through interviews with the project members, observations of meetings and insight into the digital platforms used, we follow the application of ICT in the

project throughout the organisation, as well as how the ICT agreement interacts with the project participants' roles.

The client has its own ICT and project management and associated client advisers. The client is responsible for a total property portfolio valued at 49 billion DKK and is, thus, one of Denmark's largest real estate companies. Internally, the organisation is organised as follows: There are project managers and a support function that supervises the project manager with ICT-specific knowledge. In addition, the client's organisation fulfils the users' requirements for the building. In this case, the users are responsible for the day-to-day operation of the building. As the ICT agreement must encompass the interests of these two parties, it reflects a negotiation between the client's standard requirements for ICT and the users' specific operational requirements.

The client's standard requirements for ICT consist of several complex documents addressed to the contractor and consultant that must ensure that the client achieves the desired standardisation across their projects and complies with the applicable legislation for ICT in public construction projects. On the other hand, the users, namely the university's facility management in this case, rely on the data delivered with the physical building, especially compatibility with the existing operating system and a data structure equal to other buildings in the portfolio. e.g., naming of the location of building parts and the format of delivery. As a combination of the two interests for the project's ICT, an agreement consists of both the client's documentary standard controls and the users' project-specific requirements for data.

The client has entered into a four-year framework agreement with an experienced Danish construction company that, as turnkey contractors, hires architects and engineers as sub-consultants. With the framework agreement, the contractor has the opportunity and the financial interest to be included in both the design and the practical handling of ICT in the project. According to the contract, the turnkey contractor is responsible for complying with the requirements of the ICT agreement but chose to appoint the role as ICT manager to the project engineer, who also has the official role of project manager. He thus bears responsibility to disseminate and enforce the ICT agreement's requirements in the project organisation as well as responsibility for the design phase and internal coordination.

Analysis of the Empirical Observations

Examining the practical use of the ICT agreement in the project, the largest shifts in the project organisation seem to occur in the various professional groups' representations of the building and how these representations affect their relationship with the ICT agreement in practice. As an actor, the ICT agreement is part of a network consisting of four professional groups, namely the client, the users, the contractor, and the consultants (engineer and architect). Despite their participation in the same project, their enactments of the ICT agreement and their representations of the building differ. The various representations of the building that coexist in the network are connected through how the project participant is related to the building in practice, and these different representations seem to affect their enactments of the ICT agreement, as it arises from and interacts with these varying practices.

For the client, the building exists as an economic representation of the physical building, focusing on budgets and costs of long-term maintenance, thus requiring information, values, and capacity. This economic representation of the building, that is embedded within the client's understanding creates a need for the structure and security of digital work, which forms the client's enactment of the ICT agreement as

an attempt to create standardisation and a basis for agreement. This main function, as a standardised document to ensure that the project complies with the structure of all governmental buildings, is stated in the following quote from the client's ICT project manager:

> "There will be discussions back and forth, there will always be, but we have these standard documents and a standard paradigm for ICT agreements, which we use on all our projects, and then you can, of course, change a bit here and there. But it is, in fact, the same fixed requirements for properties in the models and the same requirements for drawing standards."

Therefore, it is clarified in the beginning that it is a standard fixed agreement, but small, project-specific changes can be made to it. Although there is a great focus on the standardisation and quality control of digital work in the client's internal organisation, the client's ICT project manager says that situations arise during which he must defend the need for digital focus in the projects to the remainder of the internal project management and, thereby, defend its position. This suggests that even though there is a focus on securing a standardised process across many different projects, the topic of ICT is still debatable within the internal organisation. This position is also evident in statements such as the following about balancing project economy and the need for digital elements at delivery:

> "There could be some discussions about whether we should do the project in a 3D model, or whether it would be enough with a 2D model. It is all in relation to the project economy, which needs to be strong enough to carry our extra demands for the ICT."

The users' representation of the building is related to the physical practices on site, including the responsibility for the operation and maintenance of the building. The users' everyday work depends on the connection between the digital representation of the building, which generates the material for operating the building, and the physical building that they must facilitate. This need for structure is reflected in the users' enactment of the ICT agreement in relation to the existing operating practices that will be applied to the building when finished. Therefore, they need the requirements in the agreement to be structured so that they comply with existing site practice. The negotiation between the client's standardised requirements and the users' need for project-specific additions will, therefore, be decisive for the operation practice of the building after delivery. This is a concern that the users' ICT manager expresses in connection with the delivery of the operating material, as the users' existing operating system is not considered in the agreement. The users' ICT manager expresses the following concern about handing over the data:

> "So, it will simply be a manual process with some Excel sheets we get in and then we must make the connection from the data we get in and enter them into the system manually. We really want the system to be able to handle that coupling by itself, so we do not have to create these couplings afterwards."

Therefore, if the ICT agreement fails to create the necessary connection between the project and the existing operating practice, there will be a risk of creating challenges for the employees who are going to operate the building.

The main contractor's representation of the building is largely based on an economic and systemic understanding of the physical building in which knowledge of the division of labour, partial deliveries and coordination is embedded. For the contractor, the ICT agreement, therefore, is perceived as a management tool for the digital aspect of the construction process through which important elements of the

contractor's practice are determined, such as what digital project platform will be used to document the project during the actual construction and how the contractor will need to communicate with the remainder of the project organisation. The contractor states how this could have been a problem for them if they did not have the right resources:

> "We are such a big organisation that we have the needed experience with most digital platforms, but if we had been a small construction company with limited digital competencies, I would fear that there would be some challenges in having to change systems from project to project."

Among the consultants, there is a widespread digital representation of the building, which is supported by both the architect and the engineer's digitally anchored work practices and the common need to coordinate the work in and around the digital models. In the following statement, the architect points out how both communication and coordination between the architect and the engineer take place through the combined models:

> "Today, we have a completely different dialogue with the engineers through the BIM model than we had before, where drawings were sent back and forth between the offices. Now, there is a dialogue in the models, where we always have the same updated drawings to look at, and we can see each other's things in 3D."

The consultants (architect and engineer), who have the practical responsibility to perform ICT during the design work, enact the ICT agreement through requirements that define the scope, complexity and level of competence needed in their work. This is where the client's ICT requirements play the most significant role and where even small changes in the contractual relations can cause changes in design practices and collaboration structures, a challenge that the architect addresses in the following quote:

> "It was a requirement that the model should contain a 3D design of the basement floor and a 2D design of the other floors, but how are we supposed to document the walls in the basement floor if we do not have the walls going all the way up through the building?"

It appears from the client's ICT requirements that a full 3D model should only be created for the basement plan rather than the entire building, which does not practically correspond to the work for which the model is to be used. Therefore, the architect had to do extra work to create an adequate foundation for later model work and design. As a further example of this, the architect explains how they spend a large amount of their time feeding the IFC (Industry Foundation Classes) model with information for the client that does not make sense for either the engineer or the architect's practices or needs:

> "We have to name everything very specifically and make sure it has a keynote attached. We are used to working with keynotes, but in addition to that, we need to fill in some parameters that we have already given in the keynote so that the client can read it in the IFC file. It means that every building part must be named in three different places, so I spend a lot of my time doing that, time I could otherwise have spent on traditional architectural work, such as making a material catalogue."

The engineer stats another example of this discrepancy between the practices of the design team and the requirements stipulated in the ICT agreement is the naming of files. The engineer experienced problems with the specific naming of building parts in the BIM model, as the ICT agreement requires that the names of building parts may only be comprised of numbers, as per the Cuneco Classification System. He says, 'For people who are not so much into working with ICT, it can be difficult to sift through

the contents of a file if there is not a topic in the file name.' Despite this requirement for naming documents in the project, the engineer repeatedly noticed that the client's project documents were named incorrectly, creating confusion in the project organisation, and demotivating the employees from maintaining the required naming system.

The architect and the engineer draw attention to another potential effect of the use of digital building models, is the possibility of simulating both the building and the entire construction period digitally before executing the project. Here, the traditional phases of construction and, thus, the division of responsibilities that lies in the transition between phases are pushed forward. Both the client and, in this case, the contractor get earlier access to digital models of the building and, thereby, the opportunity to initiate the decision-making processes for time and economy earlier, causing the consultants to ensure a high level of detail in the models and initiate quality assurance earlier in the design phase.

Examples like these show the client's standardised enactment of the ICT agreement and the enactments need for structure, information, and control, as well as how it leaves little space for project-specific changes and local adjustments, resulting in these dominating the network. Due to this situation, there is a risk of the client determines the dominant enactment of the project's ICT agreement and its content even before the project starts, without having knowledge of the other project participants' relation to the agreement and its content or how it will potentially affect the project work.

Despite this both the architect and the engineer also report of situations in which technologies have helped to strengthen the collaboration between the two professions and how the digital possibilities in the building models have facilitated the stronger quality assurance of the models, as the architect states:

> "As an example, there is the work with our common ceiling plans where the digital tools make a big difference for us. Previously, we got a basis from the engineer model and then drew their lamps into our model. Now, we get their model integrated as a basis for our plan. That is a big win for us."

As previously described, the ICT agreement can, under optimal conditions, act as a boundary object for digital project work by providing descriptions of and support for digital work processes and submissions during project collaboration to be integrated, thereby ensuring that the collaboration will work across the various digital practices and perceptions of the building. However, since the dominant enactment of the ICT agreement aims to standardise a process that requires flexibility and project-specific adaptations, it may affect the ICT agreement's opportunities to function as a boundary object. This is caused by the conditions for the ICT agreement to act as a boundary object not being met if the dominant enactment in the network does not allow for other enactments to be represented in the agreement, which makes the boundary object an interesting topic for future studies on the subject.

FINDINGS

The client's standardised enactment of the ICT agreement dominants the network by determine the projects detail level of digital models, use of digital systems, file naming and file structure, and the process for final delivery of the project material. This is based on the enactments needs of standardisation to control a large real estate portfolio, rather than adapting local experiences from the building operation or further analysis of the full scale of the specific project.

Tensions are reported throughout the project organisation, with members from all professions reporting everyday experiences connected to the digital infrastructures of construction affecting their work. This is not necessarily connected to the specific work task but results from displacements occurring that can lead to workarounds, meaningless work or shifts in responsibility that, together, can challenge the mental work environment.

The study shows that the standardised enactment of the ICT agreement that dominates the network affects the roles of the project employees to such an extent that they allow their professional identities to be compromised and their core activities to be downgraded to satisfy or adjust to the standardised enactment. The same stress factors can be found in the negotiation process between different enactments of the ICT agreement, which create a vulnerable position in which there is a risk that the dominant enactment causes the need for making space for experiences to be overlooked. As described in the project delivery phase, the users, who are to conduct the operation and maintenance of the building, state how the delivery of the material will be done manually, which will be time-consuming.

The possibility of simulating both the building and the entire construction period digitally before executing the project can lead to stressors for the consultants, workarounds, such as creating drawings with tags to ensure that everybody knows what is still incomplete and increasing time pressure during the design phases.

However, notably, the situations in which digital infrastructures help to strengthen project collaboration seem to benefit the mental work environment. For example, in the consultant's enactment of the ICT agreement, a document of requirement, in the section relating to the disciplines that address the design of the building, the consultant succeeded in creating a common structure around the requirements that the ICT agreement outlines for the project and used the digital building models as an opportunity for collaboration and the satisfaction of the common interest of securing a buildable project.

CONCLUSIONS

This study indicates that in the network around the ICT agreement, tensions arise among the project members due to the dependencies of the ICT agreement and the actual practices of which it is a part, which could influence the mental work environment of the employees. It is important to highlight that the study also found situations in which development in the use of digital building models, partly caused by the regulations behind the ICT agreement, seems to affect mental health positively. Specifically, the coordination and collaboration in building models across professions were highlighted as having a positive effect on project work.

The ICT agreement is shaped under an enactment of standardisation to ensure that there is an adequate structure in a large real estate portfolio and the management process across many different projects, but it fails to provide opportunities for adapting to the conditions in a smaller project or practices. This is despite the agreement originally being a flexible document intended to be adjusted to each project to secure a digital level across an entire industry.

The standardised enactment of the ICT agreement plays a significant role in the challenges that project members face, causing displacements in the division of labour, the product, and the responsibilities of the project organisation. Displacements occur when the other enactments aim to satisfy the demands of the dominant enactment by

downgrading their needs. It is in these displacements that the mental work environment becomes pressurised, which leads to possible stressors, shifts in core activities and employees' struggle to find meaning in their tasks. Addressing one of these effects may not cause severe mental health issues, but the combination of effects over time can lead to real mental health problems.

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