"I Work All Day with Automation in Construction: I am a Sociomaterial-Designer"

Henrik Buhl
KEA-TECH, Copenhagen School of Design and Technology, Copenhagen, Denmark

Michael Andersen
Center of Research on Activity, Development and Learning, University of Helsinki, Helsinki, Finland

Hannele Kerosuo
UCN Technology, University College Northern Denmark, Aalborg, Denmark

Abstract

Purpose – The construction industry is one of the least automated industries. In the aspect of automation, the technical understanding is very dominant. Focus has mostly been on tools, robots and industrialisation. sociomaterial design shows us that what may first appear technologically deterministic can be replaced and actually call for reinvisioning the traditional focus. The purpose of this study is to introduce the agency of a sociomaterial designer in construction.

Design/Methodology/Approach – This is a conceptual paper with an empirical example. To understand the sociomaterial complexity and dynamics of automation, practice theories are applied. To test this approach, the authors give an example from a Danish (global) supplier engaged in a development project about technical aid (tools) in mounting and assembling gypsum walls.

Findings – The sociomaterial-designer can help to understand and make innovation happen when doing automation in construction; as the centre of innovation in construction processes, she works all day with practice, together with practitioners, focusing on material arrangements as located not only in practice, but also in the artefacts. She can help the supplier of construction materials in understanding different professional practices and the transformation to use smarter tools.

Research Limitations/Implications – This research is within a new practice domain "sociomaterial-design" and it has to follow up with an empirical study that covers a development project with a sociomaterial-design approach.

Practical Implications – Developing competences (agency) as a sociomaterial-designer when linking the sociotechnical understanding of Automation with practice.

Originality/Value – This research showcases how sociomaterial perspectives can inform automation in construction.

Keywords Automation, Sociomateriality, Agency, Sociomaterial-designer, Practice, Supplier, Construction

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1. Introduction

We challenge the traditional focus on digitalisation and automation and state that this understanding neglects a coupling between technical issues and the broad range of identified challenges related to automation, interface between humans and robots, practice and implementation approaches. We introduce the agency of a sociomaterial designer in construction. The sociomaterial designer devises new technological artefacts to connect the technologies with what people do in their daily work environments. Material arrangements are seen as not only located in our practices, but also in the artefacts with which we work. Artefacts do not have stable boundaries that one can point to and rely on. They develop through their continued use, organisation and placement. This view treats design and technology less as a stable outcome and more as a continually emergent phenomenon (Rosner, 2015; Harty, 2008).

This is a conceptual paper with an empirical example. We are looking at practice from a sociomaterial design perspective to understanding automation from a supplier's view. The construction industry is one of the least automated industries. In the aspect of automation, the technical understanding is very dominant. Focus has mostly been on tools, robots and industrialisation. Most activities have been taking its origin in using existing materials in new, smarter or even automated processes. For the supplier of construction materials, the question is how this transformation will affect the construction material industry. Is it just a question of utilizing smarter tools on the same materials or will automation require a completely new generation of materials? There is a lack of understanding of which role the material industry will play in the automation of the construction sector. Our research aim is to transform the understanding of "improving processes" to "sociomaterial agency", as a base for better understanding of practice to make it possible to improve existing products or develop new products, systems and solutions.

We follow the ideas of sociomaterial approaches according to which the social and the technological subsystems are entangled in human practices. Our focus is on how the entanglement and/or imbrications of the sociomateriality (the technical subsystem created by automation) and the social subsystem (construction industry) shape the new social forms of working in practice. We share our interest with our colleagues in information systems design that is important to follow what people actually do and how they bound the relevant aspects of sociomaterial things in practice (Bjørn, 2012; Bjørn & Østerlund, 2014). However, besides bounding relevant practices, we suggest that the focus on the agency of people is helpful in the examination of entangled practices through imbrication. Sociomateriality is our theoretical contribution/perspective that opens for a broader understanding (1). In the next section, we present our literature review on sociomateriality in studies of technology and organisation and the concept of agency in social sciences (2), followed by our empirical example concerning a product development projects on drywall installation (3), which is reflected in a discussion about sociomaterial design perspectives (4). The paper concludes on the agency of the sociomaterial-designer and the research gaps needed to be addressed (5).

2. Sociomateriality in studies of technology and organisation

Some scholars in studies of sociology of technology, software development and practice-based approaches have started to regard the indivisibility of the social and the material useful in the examination of human activity. The development of new technology is driven

by human interest and constructed socially in contested negotiations (Bijker, 1995). Multiple terms are used to refer to sociomateriality in the studies of organisations and technology. For instance, sociomateriality is referred to as "socio-technical ensembles" (Bijker, 1995), "mangle of practice" (Pickering, 1995), "technology-in-use examined through practice-lens" (Orlikowski, 2000; Gherardi, 2012) "entanglement in practice" (Suchmann, 2007; Orlikowski, 2010; Olikowski & Scott, 2008), "use of technology in human activity" (Miettinen, 2009) and "imbrication of social and material agencies" (Leonardi, 2012).

Orlikowski examines sociomateriality through a practice-lens as "sociomaterial assemblages" (Orlikowski, 2000, p. 409). Social and material are deeply connected and "there is no social that is not material, and no material that is not also social" (Orlikowski, 2007, p. 1437). Entanglement is included in sociomaterial practice and is often interpreted from the perspective of relational ontology. Entanglement is "[e]nactment of a particular set of activities that meld materiality with institutions, norms, discourses, and all other phenomena we typically define as 'social' (Leonardi, 2012, p. 42). Leonardi uses the term "imbrication" to describe how the social and the material become entangled in human activity. The verb imbricate has a Roman origin referring to roof tiles "tegula" and "imbrex" tiles that are interlocked in the construction of waterproof roofs. Leonardi emphasises human enactment in the understanding of sociomateriality.

According to him, the sociomaterial entanglement is enabled by the ability of a human agency in the realization of one's goals and the capacity of material agency embedded in social practices. Leonardi (2012) assures: "Social and material agencies, though both capabilities for action, differ phenomenologically with respect to intention. Thus, like the tegula and the imbrex, they have distinct contours, and through their imbrication, they come to form an integrated organizational structure" (p. 37). Leonardi also suggests that an organization may be conceptualised as a "sociotechnical system" that is constituted of a "technical subsystem" and a "social subsystem" (see Figure 1). Leonardi draws a parallel between a technical subsystem and sociomaterial practices as "both refer to a space in which work is made possible through the imbrication of social and material agencies" (p. 41). However, the sociomaterial practice is limited in the sense that it does not only refer to organization of work but as an entanglement between the collective human (social) and material agency, which both are influenced by and affecting the social subsystem. A social subsystem involves the typical "social formulations" such as roles, status, hierarchy, power relations, and communication networks. Section headings within the body text should be numbered sequentially. The wording of headings is at the discretion of the authors.

The shaded boxes at the right side of the figure indicate that people are purposeful actors and that technological artifacts have materiality. In an automation context, the purposeful action may refer to a process of organizing the implementation of new tools/technology and new collaborative practices. The materiality may refer to the use of physical or technical aids and materials. The entanglement (or imbrication) may emerge between the collective human (social) and material (technical aids) whereas human agency emerges as an outcome of working on various requirements in practice. Several different situations were simulated and performed, which subjected the analysis of different designs and functions. In the next section, we will use Leonardi's concept of the socio-technical system (and its technical, i.e., sociomaterial and social subsystems) to discuss drywall installation.

This understanding of sociomaterial practices appears complex, dynamic, and highly entangled. The Sociomaterial-Designer knows that the physical properties of coordinative artefacts matter by conditioning in particular ways, in which sociomaterial practices can occur. Therefore, the Sociomaterial-Designer must carefully consider how the creation of

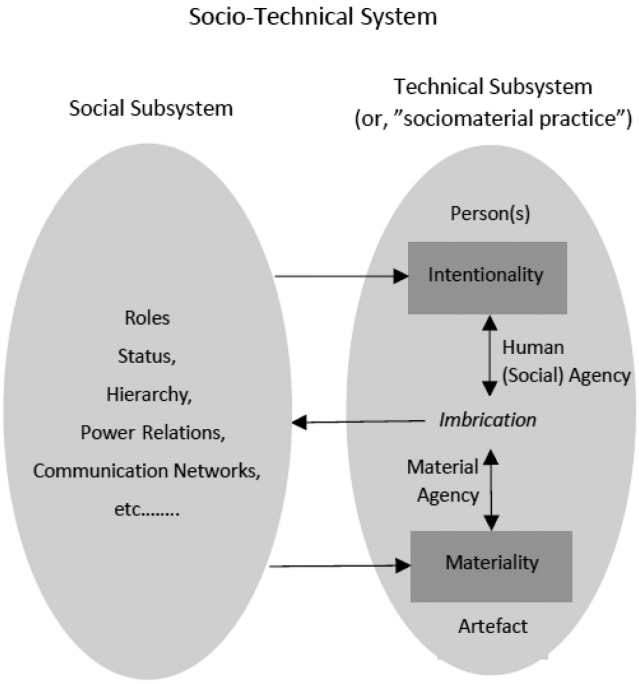

Figure 1. Potential Relationship Between Materiality, Sociomateriality and a Socio-Technical System (Leonardi, 2012, p43.).

new technological innovations are made and out of which material properties. The Sociomaterial-Designer can design an artefact, but cannot design sociomaterial practices. Sociomaterial practices emerge in practice and, therefore, cannot be designed. However, the design of artefacts will condition the sociomaterial space for interaction, since when enacted in practice, the artefact becomes part of what constitutes the sociomaterial practice. Not knowing what future sociomaterial practices will look like, the Sociomaterial-Designer will begin the design practice by paying attention to what is available visibly, namely the current sociomaterial practices of existing artefacts (Bjørn and Østerlund, 2014).

3. Example: Drywall installation – a product development process

Our example builds on interviews with two informants from a global supplier, and we got material and insights about a product development process on the mounting and assembly process of gypsum walls. The assumption is that the mounting and assembly of gypsum walls include challenges related to automation (technical aid), ergonomics, environment, and efficiency. Despite the use of technical aids, the gypsum board installation process involves manual handling of boards, for instance in small spaces where there is not enough room for technical aids or when working in height, where boards or pieces of boards have to be carried and lifted into the right position on a scaffold. The purpose of the product-development projects was to study the value chain, mapping an internal development process in retrospect, based on methods and the materials on two drywall installation projects. We have had access to reports and presentations, as well as videos and transcribed interviews.

The emphasis is on the involved industrial designer from the supplier's development department, whose practice and sociomaterial agency we look into. The industrial designer

gained her knowledge from interviews, and subsequently, some of the interview points were demonstrated to her. She filmed and asked question about the process and the technical aid. E.g., she analysed the tool for lifting plasterboards by observing and participating in craftsmen's practices, processes, collaboration and artefacts, an interaction she has documented on video.

The focus was partly on their use or non-use of technical aids, and the reasoning, as well as on what is important to the foreman, team leader and apprentices and what constitutes pain points in their everyday work. The purpose was to qualify the core assumptions and describe and understand the gypsum wall mounting and assembly processes in practice, with specific insight into the use of technical aids, which were "new" for the drywall installers. In addition to technical aids, they knew from a previous project, a prototype of a new technical aid co-developed by them with other stakeholders was tested. The foreman for the drywall installers in the above development project describes his practice:

"I have read all the descriptions and looked at all the drawings and examined what could be the smartest choice. Should we pick one type of plasterboards or the other kind of plasterboard, and try to reduce the number of plasterboards. Try to minimize steel profiles, so it becomes less complex, and if we can simplify, so it is easier to understand on the construction site. Because the next problem you got, is to have many different types of plasterboards inside. They take up space on the floor, and then you can't get around with your scaffold towers, and your ladders and your lifts. So it's about keeping the number of material groups down." (Foreman for the drywall installers).

The new artefact the drywall installers were asked to apply was an ergonomic tool for lifting plasterboards from the material stack and place it on the wall. Over a more extended period, the ergonomic tool was tested and improved on the site by the drywall installers and the developer of the device. The lifting tool is mounting plasterboard on the wall, and the drywall installers and the developer discuss. While mounting is going on, a drywall installer grasps the transverse arm which holds the plasterboard and says: "Look, it's more stable than the previous one. This makes the plasterboard much easier to mount".

The industrial designer investigated internal reactions and interactions throughout the development project as a reflection of the challenges for their product and systems. One piece of feedback from the installers was: *fewer, improved products; optimized packaging and delivery, and thought out (and tested) processes for how to handle them.* The products should

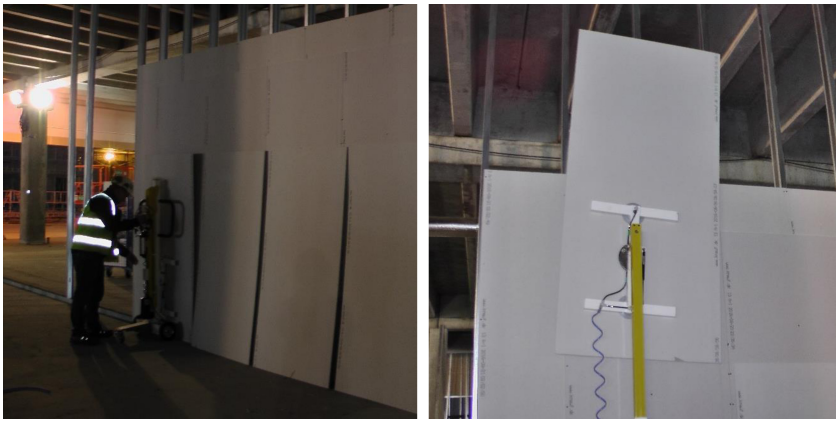

Figure 2.
Prototypes of New Ergonomic Tool (Technical Aid) for Lifting Plasterboards.

have improved ergonomics (lighter, smaller) and better installer-friendliness (pre-marked, pre-cut (tapered edges). Another challenge was the way some of the products (plasterboards) was packed and delivered. For instance, in one of the projects, the plasterboards came from a factory in Spain (the supplier has several fabrics all over Europa), were the plasterboards were packaged with every other board facing the wrong way. This resulted in 50 % extra lifts pr. stack of gypsum. There are many more examples about entanglement in practice.

4. Discussion informed by sociomaterial perspectives

The example above is created from the industrial designer's data collection, she has a "user-centered" approach, and she is cleverly applying ethnographic fieldwork methods. Despite the industrial designer's thorough research on the assembly process, the supplier was not able to obtain the knowledge and bring her observations into play in their design and business development. In our discussion we argue that her user-centred approach can be enriched by bringing sociomaterial entanglement in play. The reason for this is to understand and work towards more entangled material, solutions, services, and work practice. From a sociomateriality perspective, the analysis lacks a broader understanding of the drywall installer's technical subsystem (sociomaterial practice).

Using a sociomateriality approach, this paper zooms in on automation in practice from a supplier's perspective. For instance, the sociomaterial practice (technical subsystem) is imbrication between the human (social) agency and the material agency. In this case, the human agency was affected by the fact that the work was organised in teams which divided the process into three tasks: (1) marking up and setting up the steel, (2) first side and insulation, and (3) closing. Each function was taking approximately the same time which resulted in a continuous logistic process. As material agency (artefacts), the drywall installers were using traditional tools such as a knife, tape measure, pencil, screwdriver, pallet lifter, drawings, and descriptions (assembly instructions).

However, it requires a cross-sector collaboration between communities of practice which not only involves the drywalls installers and their installing of plaster boards. According to Leonardi (Fig. 1), the sociomaterial practice influences the social subsystem through the two elements intentionality and materiality. Impact occurs through the project's organisation and relations (architect, engineers, contractors and material suppliers), design and technical solutions (including the choice of materials), material supplier and material supplies, time schedules, building site, and overall logistics. For instance, installation of walls in the two cases is a result of a collaboration process based on industry-specific norms and standards as well as the product's characteristics, which are adapted to the individual project's framework and organisation. Products have evolved over the years as a result of increased fire and sound requirements, a better understanding of how the craftsman can handle the plaster board's size and weight, a process where fastening of the plaster board with nail and hammer is changing to screw and screwdriver, etc. A project's framework means, e.g., building functions, volumes and time- and economic factors. Organisation in this context is the drywall installer's dependence on the construction project's workflow for setting up a plaster walls, which means coordination between him, the electrician, the plumber and the painter.

The Social Subsystem is likewise affected by the imbrication between the human (social) agency and the material agency. Supplier, consultants, and the developer of the new tools are all part of the interaction in the drywall installation, an experience which can be used in the next projects and for further development work.

5. Conclusions – further research

The agency of the Sociomaterial-Designer is both social and material but her actions are still driven by her intentionality and power to transform/change practice (Socio-Technical Systems). The Sociomaterial-Designer can help to understand and make innovation happen when doing automation in construction, as the center of innovation in construction processes, she works all day with practice together with practitioners, focusing on material arrangements as located not only in practice, but also in the artefacts. Sociomateriality specifies that when we study the technical artefact, it cannot be understood outside of the practices in which it becomes enacted. To get this insight, we can benefit from the Sociomaterial-Designer, with her sociomaterial perspectives on the shaping of technical artefacts. She can help the supplier of construction materials in understanding different professional practices and the transformation to utilize smarter tools, which takes more than an industrial design approach, it is more like co-design or co-creation.

But how do we take into account all of these sociomaterial phenomena in all their complexity in automation in construction? This is still a work in progress, and it holds a lot of potentials for research and even more for the agency of a Sociomaterial-Designer. The question we shall pursue in our further research is how the Sociomaterial-Designer will impact the epistemology of professionals in construction – this will enable a lot of further questions and investigations. Methodological questions also have to be solved.

The supplier is now working on a project together with a robot company, designing an automated system for drywall installation (we, the researchers, are invited to participate in this project). The supplier would like us to develop their understanding of automation in construction and product development, to give them a deeper understanding of the context of usage of their products. Our aim is to help them to understand and create sociomaterial design and agency. We also plan to design experiments with co-design.

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