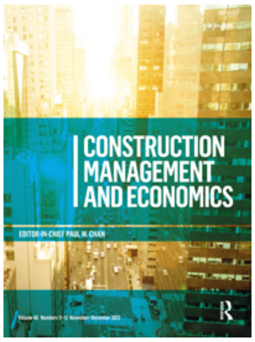

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Unpacking construction site digitalization: the role of incongruence and inconsistency in technological frames

Oscar Lundberg, Daniel Nylén and Johan Sandberg

Department of Informatics, Umea University, Umeå, Sweden

ABSTRACT
Construction site operations often involve multiple actors with substantial variations in assumptions, expectations, and knowledge about technology. This could impair digitalization, which involves development of socio-cognitive environments that foster use of digital technology in new organizational procedures. Nevertheless, construction industry digitalization research has mainly addressed firm-level transformation of engineering phases and focused on technology, largely ignoring challenges arising from cognitive differences among actors at construction sites. Thus, we report a case study of attempts to spark construction site digitalization through a shared information management system (IMS). Applying technology frame of reference theory, we demonstrate how differences within groups among actors' frames (inconsistency) shape group-level frame misalignment (incongruence) and thus digitalization outcomes. The IMS was implemented successfully at the focal firm's headquarter and regional office levels. However, substantial construction site-level frame inconsistency led to misaligned group-level expectations and generated a fragmented socio-cognitive environment that hindered strategic digitalization. In conclusion, socio-cognitive environments at industry, construction site, and group levels recursively shape individual frames, and harmonization of frames is important to realize construction digitalization.

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Digitalization; digitization; construction site; socio-cognitive environment; technological frames

Introduction

Pervasive, combinatory digital technologies trigger new opportunities for digitalization and innovation in the construction industry (e.g. Slaughter 2000, Boland *et al*. 2007, Lundberg *et al*. 2020). However, despite rapidly increasing digital technology investments, the industry is slowly harnessing the benefits (Jacobsson *et al*. 2017) for reasons including project-based logic, fragmented value chains, and monolithic IT-systems (Dubois and Gadde 2002b, Jacobsson and Linderoth 2010, Hall *et al*. 2020). These factors complicate expansion of rigorous internal backbone digitalization to collaborative inter-organizational levels associated with transformation of organizing logics (Sandberg *et al*. 2020).

Construction sites comprise a critical domain where the industry repeatedly fails to envision, implement, and capture value from digital technology due to severe challenges (Jacobsson *et al*. 2017, Morgan 2019). These include multiple heterogeneous actors with diverse specialties, competencies, cognitions, values, and incentives (not necessarily within firms' remits), which require alignment for significant technological adoption (Orlikowski and Gash 1994, Young *et al*. 2016). This study explores challenges associated with such micro-level actor heterogeneity facing expansion of digitalization to a collaborative inter-organizational level at a construction site (treated as an inter-organizational operational domain where distributed heterogenous actors engage in collaborative efforts to realize an envisaged physical product).

Research focused on innovation and renewal has contributed important insights on digitalization processes in the industry (Slaughter 2000, Bygballe and Ingemansson 2014, Havenvid *et al*. 2016), but mainly from a technical test and implementation perspective (e.g. Chau *et al*. 2004, Kim *et al*. 2013, Van Berlo and Natrop 2015, Braun and Borrmann 2019). Digital technology's relationship to social and cognitive factors during digitalization has received much less attention in construction research despite ample evidence of the critical role of socio-technical challenges in the

CONTACT Oscar Lundberg Oscar.lundberg@umu.se Department of Informatics, Umea University, Umeå 901 87, Sweden

high failure rate of IT-implementation projects (Sayer 1998, Dwivedi *et al*. 2015). Moreover, past research on construction digitalization that considers such factors mainly focuses on firm-level operations and industry-level outcomes (e.g. Boland *et al*. 2007, Shibeika and Harty 2015, Jacobsson *et al*. 2017, Lavikka *et al*. 2018, Morgan 2019), while micro-level conditions and intermediate outcomes of applying digital technology in practice (Orlikowski 2000, Arvidsson *et al*. 2014) have been largely ignored.

Understanding digitalization as a socio-technical process that leverages digital technology's capabilities to develop new organizational procedures (Yoo *et al*. 2010, Brynjolfsson and McAfee 2014), we argue that digitalization processes are enacted in construction practices through digital technology application. To elucidate digitally enabled construction industry transformation, we thus need to expand understanding of digital technology's adoption and use in practice. To this end, we complement research focused on industry-level outcomes by addressing (empirically and theoretically) micro-level phenomena. Specifically, we address the following question: How do differences within and across groups (inconsistency and incongruence, respectively) in technological frames (Young *et al*. 2016), i.e. assumptions, expectations and knowledge about technology (Orlikowski and Gash 1994), shape the socio-cognitive environment and hence affect construction site digitalization? For this, we draw on data collected in a qualitative case study (Yin 2009) of attempts by a large Scandinavian construction firm, *cCorp* (fictionalized name), to spark construction site digitalization through an inter-organizational Information Management System (IMS). We examine technological frames of actors involved in a small construction project and their IMS uses to identify implications for construction site digitalization. We also apply technology frame of reference theory (Orlikowski and Gash 1994, Young *et al*. 2016) to analyse actors' descriptions of technology and its capabilities, perspectives on why the technology was implemented, and understanding of its use.

We find that while the IMS was successfully embedded in organizational routines and practices at cCorp headquarters and regional office-level, cCorp did not realize desired strategic digitalization outcomes at construction site level. Instead, a fragmented socio-cognitive environment with misaligned expectations, appropriation and resistance towards digital technology emerged from potently interacting within-group frame inconsistency and between-group incongruency.

Theoretical background

Construction site digitalization

The construction industry has used digital technology for processing information (e.g. spreadsheeting), simple automatization (e.g. process automation), and design architecture (e.g. computer-aided design) for decades. In early stages, technological constraints restricted efforts to scale digital technology capabilities within and outside firms' boundaries. However, due to exponential growth in computational capacity (Brynjolfsson and McAfee 2014) along with its evolving and pervasive nature, digital technology nowadays offers firms vast opportunities to (re-)combine its capabilities (Yoo *et al*. 2010, Nylén and Holmström 2015). Success in such combinatory efforts requires understanding that digital technology systems are *not* self-contained units with fixed meaning and relations, but loosely coupled and infrastructural (Yoo *et al*. 2010, Baskerville *et al*. 2020). Hence, they can be exploited in multiple ways and value paths through design and use combinations (Henfridsson *et al*. 2018), producing generative conditions which increase complexity (Sandberg *et al*. 2020). Firms that experiment with digital technology's capabilities – including construction firms (e.g. Boland *et al*. 2007, Lundberg *et al*. 2020) – may acquire diverse opportunities for process, product and service innovations (Yoo *et al*. 2010, Nylén and Holmström 2015, Nambisan *et al*. 2017). However, despite increases in digital technology investments, the construction industry is still slowly harnessing infrastructural and combinatorial benefits (Morgan 2019, Hall *et al*. 2020).

To realize digitalization benefits, *digitization* is required, i.e. conversion of information from physical, analogue to digital formats (Tilson *et al*. 2010), e.g. drawings on paper to portable document format (PDF). This technical process provides preconditions for various organizational changes, but does not guarantee their occurrence. Therefore, after successful *digitization* of operations firms must proactively engage in *digitalization* – the socio-technical process of leveraging digitized aspects to develop new organizational procedures (Yoo *et al*. 2010, Brynjolfsson and McAfee 2014). At construction site level, such procedures include digitally-mediated routines, improved coordination of multiple actors through digitized information, and establishment of digital relationships between human actors and key physical objects (Tilson *et al*. 2010, Yoo *et al*. 2010, Baskerville *et al*. 2020).

In most previous construction digitalization research (mainly addressing firm-level operations and industry-level outcomes), major concerns are digitalization of the design-engineering process and the role of building information modelling (BIM) (e.g. Papadonikolaki and Wamelink 2017). Digitalization's practical implications at construction sites have received little attention, possibly because of the highly physical inter-organizational procedures, and diversity of both individuals and cognitive schemas. Instead, construction site studies mostly focus on aspects of project management efficiency, such as project managers' roles (Grill *et al*. 2019), risk and safety management (Sherratt *et al*. 2013), or layout planning (Lam *et al*. 2007). Those that consider digital aspects tend to focus on the technical element (digitization) (e.g. Chau *et al*. 2004, Kim *et al*. 2013), particularly by testing BIM for diverse purposes (e.g. Van Berlo and Natrop 2015, Braun and Borrmann 2019). Ways to leverage digitized information at construction sites by developing new organizational procedures to improve project delivery need further investigation (Bråthen and Moum 2016, Whyte 2019). Socio-technical analysis of construction site digitalization remains scarce, and primarily focuses on industrial characteristics and their dynamic effects on digitalization in efforts to understand systemic change and digitalization outcomes (Hall *et al*. 2020). However, examination of heterogeneous individual actors' sensemaking processes, feelings, and abilities is also needed as they affect new information systems' adoption and use (Linderoth 2017). Moreover, construction site actors are often rooted in different firm cultures, and thus likely to differ in cognitions, values, and incentives that are not necessarily aligned, although they all may potentially affect technological adoption (Orlikowski and Gash 1994). Hence, we focus on micro-level actions and how construction site professionals perceive, understand, and use technology in their everyday work (Orlikowski 2000, Arvidsson *et al*. 2014). Such analysis may be crucial for elucidating construction site digitalization, due to project-based logic, fragmentation (Dubois and Gadde 2002b), and need for collaboration of multiple heterogeneous actors with different specialties and competencies (Bygballe and Swärd 2019).

Incongruence and inconsistency in technological frames

Human actors draw on cognitive structures, interpretive schemes (Giddens 1984), scripts (Gioia 1986), or mental models (Schein 1992) to make sense and process new information (Weick 1995). Cognitive structures (*frames*) help actors to understand consistent problems but may also constrain their cognitive responses to new or inconsistent information. For example, since digitalization involves implementing, adopting, and leveraging new technology, it activates actors' frames and actions to contextualize the technology (making it useful and meaningful, or not) (Arvidsson *et al*. 2014, Nambisan *et al*. 2017). Depending on the context and associated actors, this may result in inconsistent information triggering cognitive inertia in individual actors that subsequently spreads within organizations through their interactions (Orlikowski and Gash 1994). Thus, attention to individual actors' frames (and their effects on collective and organizational belief systems) is required to understand the *socio-cognitive environment*: the "broader belief system […] that shapes the beliefs and ideas of individual actors (i.e. their interpretive frames) and thus influencing their actions" (Jacobsson *et al*. 2017, p. 614). We argue that the socio-cognitive environment spans multiple interdependent (society, industry, firm and group) levels. Thus, we extend this unidirectional (environment-to-actor) perspective by conceptualizing the relationship as bidirectional and the socio-cognitive environment as *being shaped by* aggregate effects of individual actors' frames on the broader belief system (particularly within construction sites) and *shaping* actors' frames, thereby influencing their actions.

To understand the mutual shaping of frames by individual actors and the socio-cognitive environment during construction site digitalization, we apply the concept *technological frames* (TF): the "subset of members' organizational frames that concern the assumptions, expectations, and knowledge they use to understand technology in organizations" (Orlikowski and Gash 1994, p. 178). Orlikowski and Gash (1994) recognize three TF domains: the *nature of technology* (actors' understanding of technology, including its potential, functionality and capabilities); *technological strategy* (actors' perceptions of the motivation and vision behind the new technology, and why it should be implemented); and *technology-in-use* (actors' everyday use of technology and consequences of its use). These domains are broad and have varying relevance (cf. Olesen 2014), so scholars have defined additional frame domains and contents (cf. Davidson *et al*. 2004).

The three TF domains indicate context dependency, and facilitate interpretative analysis of the understanding, perceptions and use of technology of actors at various organizational levels, e.g. designers, managers and suppliers (cf. Davidson *et al*. 2004, p. 479). Thus, we apply TF theory to address actors' use, experiences, and interpretation of digital technology in efforts to illuminate micro-level frame *(in)consistencies* and *(in)congruences* that shape the socio-cognitive environment and hence affect construction site digitalization.

Congruent frames are not identical but aligned "on key elements or categories" and related in structure (common categories) and content (similar values regarding those categories). *Incongruent* frames refer to differences in "expectations, assumptions, or knowledge about some key aspect" (Orlikowski and Gash 1994, p. 180). They often occur when actors have different interactions and experiences with technology, which may lead to different understandings of how and why it is used (Davidson 2006), triggering misaligned expectations, resistance, scepticism, and poor technology appropriation (Orlikowski and Gash 1994). TF studies have shown that frame incongruence may vary depending on institutional culture, power relations (Barrett 1999), and across frame domains (Davidson 2002). Most have focused on incongruence *between* social groups, but *inconsistency* (differences in frames *within* social groups) may modulate effects of between-group incongruence on IT-enabled change over time (Young *et al*. 2016). Thus, we apply both frame inconsistency and incongruence notions to explore effects of variation in actors' cognitive frames on construction site digitalization.

Research methods

We conducted a qualitative exploratory case study (Yin 2009), with an interpretative approach (Walsham 1995), of attempts by the Swedish company *cCorp* (fictionalized name) to spark construction site digitalization through an IMS. To facilitate understanding of the context (the socio-cognitive environment in which it was implemented, and inter-organizational relations involved) we followed a small, prefabricated module construction project from planning to handover (November 2018–May 2019). We sought to obtain rich insights from multiple data sources and illuminate theoretical concepts (Yin 2009), thus analytically generalizing our empirical findings to theory, rather than statistically to a larger population (Lee and Baskerville 2003).

Case description

cCorp is a leading Scandinavian manufacturer that provides "prefabricated housing elements to an intermediary builder" (Steinhardt *et al*. 2020, p. 488) and an on-site project manager to oversee the builder's work. Final products range from detached houses to apartment complexes and retirement homes. cCorp's annual turnover is around 3000 million SEK, and since inception it has delivered more than 150,000 buildings, establishing a legacy in sustainable wood construction. The firm has headquarters, three manufacturing plants and approximately 30 regional offices in Sweden.

In 2016, the firm's R&D department initiated a digital project to improve how information was shared during a construction project. The outcome was what we call an Information management system (IMS). The IMS is a web-based solution built on the SharePoint platform, developed by in-house staff at cCorp's headquarters together with an IT-consultancy firm. IMS' main purpose was to provide one integrated cloud-based point of contact for each project where subcontractors could access updated information and that notified affected actors of any changes. The manager of each construction project invites actors to access a dedicated project sub-space (after they create an account with e-mail and other contact information), assigns them roles, then the IMS automatically notifies them via e-mail if role-relevant information (e.g. a construction drawing) changes. For example, when a change in a drawing affects electrical wiring, the contractor responsible for electricity should be notified but not necessarily the land and foundation contractor.

The IMS was in a post-implementation phase when we conducted the study. The construction site activities we followed in the focal project lasted 16 weeks from module delivery to occupation of an eight-unit apartment building and five rowhouses . It involved engineers from cCorp headquarters, managers from the regional office and manufacturing plant, and eight subcontractors working on-site (Table 1). We investigate in detail how the construction project actors framed the IMS in terms of three principal aspects: the nature of technology, its strategic purpose, and its use effects.

Data collection

Following Yin (2009), we used multiple data sources (Table 1) to investigate individuals' and social groups' technological framing of the IMS. Between November 2018 and December 2019, the first author conducted 23 semi-structured interviews (average length, 63.5 minutes, audio-recorded and subsequently

Table 1. Data sources.

Location	Interviews	Observations & documents
Regional department	Project developer 1 (PD 1) Project developer 2 (PD 2) Local business developer Project manager 1 (PM 1) Project manager 2 (PM 2) Customer relationship manager	Interactions before and after interviews Presentation of initial findings Project documents, timeline, customer strategy documents. 6 h observations 800 separate notes
Headquarters	R&D manager IT manager IT & business developer Design engineer Production design engineer Static engineer	Manufacturing plant tour Digital strategy documents 6 h observations 1000 words notes
Manufacturing plant	Manufacturing plant manager Manufacturing plant production manager Manufacturing plant technician manager	Manufacturing plant tour Informal conversations and observations 2000 words notes 4 h observation
Construction site	Machine and supply Carpentry firm CEO Carpenter Scaffolder Ventilation contractor (VC) Land and foundation contractor (LFC) Painter Electrician	Project meetings 7 observations at the construction site 18 h observation 1800 words notes 23 photos
Total: 23 interviews, 34 h observation, 5600 words in notes, 6 policy documents, 23 photos.		

transcribed) with actors at four cCorp sites: headquarters, a regional office, a manufacturing plant, and the construction site. The interviews followed an exploratory interview guide using the predefined themes: background, (digital) work practices and routines, including IMS usage and implications. In addition, the first author compiled a 5600-word field note diary during observations at the four locations of: informal discussions before and after interviews, manufacturing plant tours, presentation and discussion of initial research results, demonstration of the IMS, and key construction site events (project meetings, customer visiting days, delivery, and mounting). Additional data sources (such as project description, strategy documents, and customer journey documents) were collected at each location.

Data analysis

The data analysis followed an abductive approach (Dubois and Gadde 2002a). First, we familiarized ourselves with the data and inductively coded it to identify important quotes of relevance to our research question that we then aggregated into thematic codes (Braun and Clarke 2006). We then reflected on the resultant thematic codes in relation to relevant literature. During this analysis process, we identified salient patterns related to socio-cognitive aspects. Second, in our iterations between theory and the empirical material we identified the technological frames (TF) reference theory as useful in analysing and exploring relationships between them. Specifically, we organized the thematic codes and raw data according to definitions of the three TF domains provided by Orlikowski and Gash (1994) (see Table 2).

Third, to identify frame incongruences between groups (Table 3) we considered, summarized and compared results concerning frames of individuals of three social groups: *developers* (at headquarters), *internal users* (at the regional office and manufacturing plant), and *external users* (subcontractors). Then, inspired by Young *et al*. (2016), we compared frames of individuals within each group to characterize frame inconsistency (Table 4). Through this iterative process, we found frame inconsistency (within groups) and incongruency (between groups) associated with unclear strategy, context of use, technology access, and variation in digital competence. In accordance with our micro-level contextual focus, comparison of the frame inconsistencies and incongruences revealed a fragmented socio-cognitive environment with bidirectional (actor-environment and environment-actor) processes that hindered construction site digitalization.

Findings

In late 2016, cCorp sensed an urgent need to address high on-site production error rates. Increases in production rate and numbers of actors involved in each project had rendered prevailing practices of distributing project-related information through e-mail and phone calls unsustainable. Therefore, cCorp initiated a project to improve project-level information gathering resulting in the IMS implementation.

Table 2. Data analysis example.

Raw data	Thematic codes	TF domain; category
It is not good enough. We want our work orders to be there [IMS]. When you write the time on your work order, you can also change the status of that order. So, it will be like different colours with different names on it then, ongoing or ordered or executed. Then you could just change the status of the person who has received the work order. *(VC, subcontractor).*	IMS potential Technological constraints	*Nature of technology*
It [IMS] started as a publishing system, to create PDF's of our drawings and put them somewhere that everyone knew had the latest versions […]. It has grown, and received several players, both internally and externally. *(R&D manager, headquarter).*	Focal point	
I still think it [IMS] is good because it's reasonably large, easy to understand, you see the information that concerns you for one project. *(LFC, subcontractor).*	Value creation Adaptive information	*Technological strategy*
I don't need to keep track of all protocols, self-checks and documents and send out them to everyone via mail. If a document's updated, everyone's notified in their mail. So, if there's a revision no-one should miss it. *(PM 1, internal user).*	Administrative efficiency Automatization	
I don't really know if it [IMS] is updated all the time. We builders have another communication: "Will the house be there that day? Or is there a new decision? Should we send people there yet?". They [cCorp] must keep track of that. *(VC, subcontractor).*	Trust issues	*Technology-in-use*
It's a bit sensitive using [smart]-phones on the construction site with customers around. *(Electrician, subcontractor).*	Environmental dependencies	

Table 3. Observed frame incongruence between social groups.

TF domain	Groups	Frame incongruency illustrations	N
Nature of technology	*Developers* vs. *internal users*, and *external users*	• The IMS is an evolving publishing system used by the regional office, manufacturing plant, and subcontractors with the potential to generate learning insights for next-generation IMS (Developers). • It's a standardized DMS used by all involved actors in a construction project with the potential to change communication with external actors through automated information flow (Internal users). • It's a centralized information retrieval system used by manufacturing plant and regional office staff, and subcontractors (External users).	1
Technology strategy	*Developers* vs. *internal users*, and *external users*	• The IMS was implemented to reduce high error rates, change project workers' behaviour, and obtain learning insights for the next-generation IMS (Developers). • It was implemented to improve information exchange between project actors (by serving as a focal point for all project-related information), and the internal document system (Internal users). • It was implemented to improve retrieval of information such as construction drawings, thus increasing potential to work uniformly (External users).	2
Technology-in-use	*Developers* vs. *internal* and *external users*	• Despite the underlying platform's technical limitations, the IMS is easy to use, platform-agnostic, and combinable, providing capabilities to rapidly publish and access mutable project information during projects (Developers). • It could be used to manage project information before, during, and after a project through a self-service approach, but there are concerns about its technical performance, relationships between extant IT-systems, low adoption rate and mediocre utilization of its capabilities (Internal users). • It could be used when project drawings changed during a construction project, but there are concerns about being able to use it properly due to environmental factors, unreliability of information in the systems, and its potential to generate extra work-activating information (External users).	3
	Developers vs. *internal users*	• Mirroring information in the ERP system and IMS is necessary, but duplicates developers' work (Developers). • Mirroring information in the system has eased navigation between systems and improved transparency for external users (Internal users).	4

Table 4. Observed frame inconsistency within social groups.

TF domain	Group	Frame inconsistency illustrations	N
Nature of technology	*Internal users*	• The IMS improves how information is written, saved and distributed (PD2) • It constrains creativity especially concerning working with drawings (local business developer).	1
	External users	• The IMS has fostered a more positive attitude to digitalization, and its simple functionalities are important since drawings often change during construction projects (LFC). • cCorp's IMS has insufficient functionalities (less than other firms') and unclear information about when a drawing has changed (Carpentry firm CEO).	2
Technology strategy	*Developers*	• The IMS was implemented to improve users' retrieval of documents whenever they wanted (Design engineer). • It was implemented to decrease administrative workloads (Static engineer). • It will be replaced soon (Production designer).	3
	Developers	• The system's fast implementation could generate important learning outcomes (R&D worker). • Its fast implementation generated technical constraints and maintenance issues (IT-manager).	4
	Internal users	• The IMS was implemented to get away from e-mailing and analogue drawings (PD 1). • It was implemented to ensure that external users' got the right drawings (PM 1). • PD2 agreed with PD1, adding that the IMS allows self-service retrieval.	5
	External users	• The IMS was implemented to enable retrieval of drawings online (Carpenter) • Ditto, but it should work as a communication platform (LFC).	6
Technology-in-use	*External users*	• The IMS lacks appropriate capabilities for subcontractors' communication possibilities and provision of reliable information (VC). • It's a fast system that reaches everyone (LFC).	7
	External users	• The automated push-notice function is smooth (LFC). • The automated push-notices increase stress (Painter).	8
	External users	• The IMS is useful for retrieving drawings and project information (Scaffolder). • There is no need for the IMS (Carpenter).	9
	Internal users	• The IMS clarifies uses of cCorp's existing IT-systems (PD 2). • It has made finding the right documents increasingly difficult (Manufacturing plant production manager).	10
	Internal users	• The system's capabilities could not be leveraged if external users did not adequately use it (PD1). • Its capabilities could not be leveraged if developers did not adequately use it (Manufacturing plant manager).	11

The IMS was launched in 2017 and first deployed for internal users in regional offices and manufacturing plants. Next, regional office users introduced the IMS to external users (subcontractors). This was difficult, because as construction projects progressed internal users had to learn and contextualize the system themselves and manage others' cognitive frames (i.e. train and motivate external users). Hence, a fragmented socio-cognitive environment (i.e. within-group inconsistency and group-frame incongruency) emerged, resulting in mediocre construction site-level utilization of digitized information.

In the following sections, we illuminate developers', internal users', and external users' post-implementation technological framing of the IMS, unpacking the socio-cognitive environment of the focal construction site through analysis of identified within-group inconsistencies then group-frame incongruencies.

Frame inconsistencies within social groups

We identified divergent frames within all social groups, which varied depending on their contextual arrangement, technology access, and digital competence. Here we sequentially address these *frame inconsistencies* (summarized in Table 4) within the groups of developers, internal users and external users.

Developers

Developers at cCorp headquarters consistently described the IMS as an evolving publishing system with technical functionalities allowing fluent publishing and rapid access to mutable project information that would reduce errors during on-site production and hence time spent dealing with complaints. Their vision was to structure project-level documents to provide internal users with better overviews and ensure that external users always have correct information through rapid, automatic updates via smart devices. Hence, the IMS was originally envisioned as a tool for publishing project information, but its role and purpose evolved post-implementation. The R&D manager explained:

> It started as a publishing system. We wanted one common place to publish all documents, especially PDFs of our drawings […] that everyone knew were latest versions. (R&D manager)

Among developers, discussions of the IMS often focused on technological strategy, integrations, and feature improvements rather than socio-technical aspects, such as everyday use and constraints. Some argued that another more sophisticated IMS based on 3D-visualizations would soon replace the current IMS, while other developers commented, approvingly, that it had decreased users' administrative workload (Table 4, N. 3). For example, the static engineer explained that, before the IMS, manufacturing plant managers and other actors were given hard copies of construction project orders and notified of changes through discussions and information issued in multiple e-mail conversations. In contrast, orders and drawings posted in dedicated project spaces of the IMS could be rapidly changed and retrieved by all relevant actors.

Developers consistently described the IMS as a simple hub for publishing pertinent information before and during a construction project that could be easily used on various devices (PCs, laptops, smart devices). One engineer confirmed these consistent frames, saying that developers could combine it with other digital systems (e.g. an Excel-based tool developed by a colleague and used by every engineer to calculate snow-zones and meet various environmental requirements). The high digital competence at the headquarters and the system's combinatory capabilities allowed developers to creatively find solutions to enhance the engineers' efficiency.

An important objective for cCorp's developers is to drive digital transformation by continuously planning, designing, and implementing new digital solutions (the IMS being one of many). Some highlighted that the functionalities prioritized and included in the IMS reflect the project's development and management in collaboration with the external IT-consultant. They argued that the IMS's technological deficiencies were due to cCorps' atomistic project management process, characterized by unclear boundaries, goals, project owners and fast implementation. Inconsistently with the R&D manager's frames, the IT manager said that new functionalities were added during the development process without due consideration of long-term implications. This hindered maintenance of the system's functionalities (Table 4, N. 4) as explained by the design engineer responsible for adding new roles in the IMS:

> Our ERP is synced with [the IMS], transferring data back and forth. So, we have two systems that look alike and do the same thing. We can't kill the first one […] due to the 10-year guarantee period, and to have the ability to go back and look at our data. Thus, we register everything in two systems. (Design engineer)

On a technological strategy level, the IMS was rapidly implemented to test how a publishing system would work in practice. Many developers suspected that issues would emerge post-implementation but believed this would facilitate long-term improvement of the IMS and other digital projects. Another important strategic objective was to change internal and external users' cemented behaviours and non-digital routines. Instead of investing substantial resources in designing a fixed, finalized system, they wanted to give users possibilities to learn and experiment with basic IMS capabilities. However, the rapid implementation also triggered frame incongruency between groups (Table 3).

Internal users

Regional managers and manufacturing plant managers consistently described the IMS as a standardized document management system (DMS) where project actors could share documents. However, there were inconsistencies among the internal users concerning perceptions of functionalities the IMS offered, how they were utilized, and what it should offer. For most regional managers, its core capability was the possibility of publishing information in a shared space, although some noted that these capabilities were not fully or appropriately utilized:

> The idea is that everyone involved in a project, from the building permit office to the architect, the bank, to colleagues at headquarters who make the drawings, and we here regionally are gathered in one place. A future thought is to allow inclusion of customers too. (PD 1)

Most internal users regarded it as a solution to problems caused by subcontractors on-site using outdated drawings in the hard-copy documents and emails distributed by internal users, as illustrated by PD 1:

> [For example, when] an electrician needs electric circuit drawings, he can retrieve them. He knows

> they're the latest versions […]. Everyone [project actors] gets an update from the IMS every morning. […] However, it should be a DMS, and what you see should depend on your role. (PD 1)

Thus, internal users generally recognized advantages of its automation of information production, storage, and distribution, together with self-service features, such as subcontractors' ability to retrieve relevant information at any place and time (Table 4, N. 1). However, some internal users stated that the IMS disrupts construction site operations and reduces creativity, and when discussing the associated technological strategy several other frame inconsistencies emerged. Most noted that the IMS contributed to standardizing document management practices at all cCorp's regional offices. For example, PD 2 said that all regional offices previously had idiosyncratic ways of managing documents via Microsoft Windows' traditional folder system, resulting in extensive e-mailing and administrative efforts to trace documents. In contrast, the IMS provided streamlined access to all project-related information through digitized checklists concerning (*inter alia*) land purchases, sales, production, tenant-owner associations and relevant regulations. According to the customer relationship manager these checklists had improved information availability, particularly retrieval of basic information about specific construction projects, such as actors involved and schedules. In contrast, the business developer (with 30 years' experience) argued that to generate new business cCorp employees should be out in the field, socializing and establishing new contacts instead of hiding behind digital systems (Table 4, N. 1).

Moreover, in their daily work internal users utilized two main IT-systems in addition to the IMS: an enterprise resource planning (ERP) system, and a customer relationship management (CRM) system. Insufficient integration of these systems triggered frame inconsistency, as noted by the quoted design engineer (p. 8). Some internal users argued that the IMS is "just an additional system", which engendered confusion as multiple systems could be used for similar tasks after its introduction (Table 4, N.10). Further, the manufacturing plant production manager noted that while the IMS contained some information relevant to him, it did not help him to identify where and how to find it rapidly. Despite confusion regarding specific roles of the ERP, CRM, and IMS, several internal users stated that the IMS's self-service functionality had significantly improved everyday administrative work. For example, the PM responsible for overviewing on-site construction work commented that he previously had to keep track of all protocols and documents, and send them out individually via e-mail, but following its implementation, "If a document is updated, everyone gets a notification via their mail that there's a new drawing and the old one disappears". PD 1 agreed, highlighting the self-service approach:

> If contractors contact us, we should refer them to the [IMS] because we want to get away from the e-mailing. Instead, we want them to retrieve information from the IMS themselves. So, there's also a way of working that needs to change […] and maybe not spoil our partners. (PD 1)

Most internal users had expected the IMS to improve their communications with external users, but as illustrated in the above quote, external users' low commitment (due to headquarters providing inadequate training) had prevented its full exploitation. They said that they first had to learn the system themselves, then not only train the external users, but also try to motivate them to use the IMS. During the initial implementation, doing all of this simultaneously while trying to control an information-intensive environment was not feasible. As the construction site manager said:

> During the first project, I burst […] I didn't have time to take in the new [IMS], but now if [subcontractors] ask or e-mail, I say they must access the [IMS] instead, then they're almost forced to do so. (PM 1)

External users' low adoption rate was not solely attributed to inadequate training. Other factors, noted by regional managers, included continued use of cCorp's established information exchange methods (e.g. e-mail, phone calls, meetings) and subcontractors' simultaneous need to adopt other construction firms' IMS (with different exchange routines). These managers described frequent needs to remind and cajole external users to retrieve information via the IMS rather than e-mail.

While regional managers highlighted challenges related to external users, manufacturing plant managers revealed another set from an internal perspective (Table 4, N. 11), associated with failure of engineers at cCorp headquarters to provide drawings and other information on time:

> […] when you conclude [during a project meeting] that a document in the system should show what colour [a wall] should be […] but the IMS still doesn't show the colour when we're ready to build that's problematic because we need to order paint from the supplier in time. (Manufacturing plant manager)

External users

Construction site subcontractors described the IMS as a centralized IT-system from which they could retrieve project information (primarily when drawings change). External users are rooted in different firm cultures, with different digitalization experience. Most believed that cCorp implemented the IMS to show that it was keeping up with digitalization trends. Several had been drawn into other partner firms' digitalization efforts and felt vexed. Moreover, there was high variation in overall digital maturity and competence. For example, in their internal operations the electrician still used paper and pencil to report work hours, while the VC used a GPS tracking system to optimize time and resource distribution. This variation in external users' digital maturity generated major frame inconsistencies (Table 4, N. 2). Those with high digital maturity regarded the IMS as having insufficient features and providing unreliable information, thus generating additional work (Table 4, N. 7). For example, the VC felt that the IMS was inadequately updated and lacked crucial features to support subcontractors' tasks and management of time and resources. These subcontractors compared cCorp's IMS unfavourably with systems they had used for other customers. For instance, the carpentry firm CEO declared:

> We think these systems are great. [In the municipality IMS] you can easily get the information out to everyone, you can chat with each other and put up post-its. You get updates all the time […] it's great. However, in the [cCorp IMS], you only get an e-mail like "document X has changed". You have no idea what kind of document it is, and it gets a bit messy. (CEO, carpentry firm)

Some external users, however, argued that cCorp's IMS had a better balance between technical features and information than others (Table 4, N. 2). For example, the LFC said:

> I think it works well. It's nice that everything's gathered at the same place and you get information if there's an update. I have it in the phone […], and it pings if someone changes a drawing. I can directly see if information concerns me. I believe it's crucial because often certain pieces aren't [planned] […] the plan may change over time. (LFC)

Despite the variation in digital maturity, most subcontractors consistently highlighted the IMS's value for retrieving information online, when required, thus solving versioning problems associated with analogue drawings. However, some also noted that the IMS has more potential functions than simply information retrieval (Table 4, N. 6).

While discussing the system's expected value, several external users voiced concerns relating to their physical working environment at the construction site, commenting that digital tools cannot do the work for them: ultimately completing the work correctly in the physical world, on time, and within budget is what counts. Allocating resources for learning the IMS was not a priority. In contrast to the LFC (Table 4, N .8), the painter expressed concerns regarding the balance between digital and physical work

> I'd rather be out on site to make sure the [physical] work [proceeds]. You can use as many smartphones as you want. I feel that if they add more technicalities, I won't have time to get on the site […] every time the phone pings, it may take ten minutes before you return to where you were in work. (Painter)

These inconsistent frames generated "a vicious circle" among subcontractors. If one contractor establish counterproductive frames about the IMS and associated practices, there was a greater chance such frames were communicated within the group, thus affecting collective IMS frames. Therefore, it was easy to fall into the old routines of phone calls and e-mail instead of challenging the frames. Moreover, two of the eight interviewed subcontractors apparently had no access to the IMS, and said they felt no need for it because the required drawings were in their heads, so they continued to work as before, retrieving information through phone calls and e-mail (Table 4, N. 9). When asked about the low adoption rate, external users argued that education, environmental dependencies, and incentives (perceived benefits for themselves) were the key reasons. For example, two stated that they were not offered any proper training, just a link. Another subcontractor strongly confirmed the environmental dependencies and hardware limitations affecting the IMS's adoption:

> It's not easy to scroll and swipe. [The PM] usually says it's better to call because he has a computer. You may want to have a computer or something so you can find out things yourself […] because it's pretty hard to see drawings on a phone […], and if it's minus 20 degrees outside I don't want to flip up the phone, I just call. (Carpenter)

Frame incongruencies between social groups

The analysis reveals frame incongruencies between the three studied groups (summarized in Table 3), associated with variations in their context of use, technological access, and digital maturity. In the following text we sequentially address incongruencies related to the *nature of technology*, *technological strategy*, and *technology-in-use*.

Nature of technology

There is some congruency in TFs of the three groups (developers, internal users, and external users) regarding the IMS's nature. Two groups (internal users and developers) regarded it as a hub for project information, and two (developers and external users) highlighted its utility for *publication*. However, there were clear differences in their descriptions of the IMS (Table 3, N. 1). Much of this frame incongruency was associated with variation in their digital competence and concerned the system's operational purpose (when, where, and how to use it). It was regarded by developers mainly as an evolving tool for publishing drawings, and by regional managers as a *management* tool that facilitated standardization of internal document management in all of cCorp's regional offices. The latter appreciated its use as a hub with digitized checklists and other work routines, while subcontractors largely used it simply to retrieve drawings when they change. PD 2 summarized how they leveraged the IMS in contrast to the other groups:

> We mark start and end times to improve coordination and memory of work processes and reduce vulnerability [risks of error]. (PD 2)

Technological strategy

There were several common categories in all three groups' frames in the technological strategy domain, notably the potential to reduce errors by leveraging digitized and updated drawings to improve coordination. However, there were also significant incongruencies, reflecting differences in descriptions of the system's nature. While developers' strategic aims were to reduce complaints and generate potential learning insights for a next-generation IMS, internal users desired improvement in information exchange and internal document management (Table 3, N. 2). Although developers to some degree indicated that internal and external users perceived the IMS differently from themselves, their frames reflected a view that digital transformation is an important, but long-term strategic process. For example, several revealed that the IMS would soon be replaced by a more sophisticated 3D-based IMS. Seemingly unaware of such plans, internal users focused on ways to improve the current system's adoption rates.

Like developers, internal users highlighted the system's role as a hub for managing project information. In contrast, external users sought improvements in information retrieval, implying perceptions that internal users' role was to *publish* information, while their own role was to *retrieve* that information, so the IMS should facilitate one-way communication rather than information *exchange* between internal and external users. This was incongruent with frames of internal users, who argued that it should improve *communication* on the construction site with subcontractors. In this way, developers' strategy of rapid implementation to test and learn backfired. Both internal and external users argued that the low adoption was mainly due to insufficient training, as reflected in the one-way communication outcome (cf. quotation from PM, p. 9). Internal users argued that the IMS was designed in such a way that it was challenging for them to fall back on established work routines (e.g. e-mailing documents). Fundamentally, they welcomed this because they were highly motivated to change their working practices. However, the lack of developers' involvement during the implementation and training phase was a major obstacle giving rise to incongruent frames. Substantial responsibility for managing the socio-technical change and finding appropriate methods for contextualizing and fully utilizing the IMS landed on the internal users (cf. quotation from PD, p. 9).

Technology-in-use

The context of use varied heavily across the three groups, causing several frame incongruencies around the IMS's everyday use. Developers found maintaining it (e.g. adding new roles and continuously verifying that information was correctly mirrored across cCorp's systems) demanding due to limitations in the underlying technological platform. Internal users found processing the large amounts of project-information time-consuming, but that the ERP's capability of mirroring relevant project information (except internal business documents) in the IMS eased navigation between systems and improved information transparency for external users with retrieval restrictions (Table 3, N. 4). External users said they could not trust the automated role-based notifications or that information in the IMS was fully updated.

Several context-related frame incongruencies reflect differences in the groups' positions in the construction industry's value chain. Many external users struggled to identify *any* value in the IMS, internal users regarded external users' low adoption as the prime obstacle for generating value from it, while developers (the first actors in the value chain, and thus less concerned about other actors' adoption rates) highlighted its ease of use, platform-agnosticness, and associated combinatorial possibilities with other IT-systems.

Variations in the groups' digital maturity and competence also triggered frame incongruency. While external users primarily used the IMS to retrieve drawings, internal users used its checklists for several key work processes, and developers combined it with other systems to generate broader value. Several contextual and digital competence factors caused external users' sporadic utilization, and limited exploration of the IMS to generate value. The few external users with broader digitalization experience believed that it should have more, and better, functions allowing them to communicate information through text, photos and work against digitized orders. External users with less digital experience either appreciated the IMS because it required less interpretation of functionalities and information than other firms' systems or did not use it at all.

Variation in technology access between groups also generated frame incongruency. Internal users and developers operated in a controlled office environment with solid Ethernet connections and large computer monitors. External users mainly operated in the field, so they mainly relied on their smart phones and environmental factors such as the weather constrained their use. Consequently, external users regularly framed use of the IMS as complicated and unnecessary, generating stress and additional work (cf. quotation from the painter, p. 18). They perceived that phone calls and face-to-face interactions were better, faster, and more reliable. The scaffolder contractor summarized the external users' framing as follows: "It's much easier to make a phone call to cCorp. I believe communication with someone you can see is better than sending information online".

In summary, the identified frame incongruences between groups had distinct connections to context of use, technology access, and variation in both digital maturity and digital competence levels. Consequently, deeply misaligned expectations between groups arose that were both shaped by, and shaped, the socio-cognitive environment.

Discussion

Extant TF literature has shown that frame incongruency restricts digital technology adoption and use (Davidson 2006, 2002). However, most studies focus on frame incongruence, while frame inconsistency and the relationship between them have received little attention (for an exception, see Young *et al*. 2016). Our micro-level case study of individual actors' frames in construction site digitalization contributes to theory by revealing origins of frame inconsistencies within groups, and how they fuel frame incongruences between groups. Another theoretical contribution is the demonstration of how the identified inconsistencies and incongruencies affect the socio-cognitive environment and hence digitalization outcomes. The following paragraphs discuss these theoretical contributions then outline the findings' practical implications for managing construction site digitalization.

The findings demonstrate clear frame inconsistency regarding the *technological strategy* underlying the IMS's development and implementation among the developers. Some argued that rapid implementation resulted in a system with technological performance issues, while others held that it provided learning insights for future reconfigurations. This frame inconsistency within the developer group formed and shaped related frame incongruence between all three groups. Internal users argued that the implementation was rushed, and the offered training inadequate, a framing that generated a wake affecting the framing of external users, who also said they were offered insufficient training. Thus, what initially seemed like a developer-group inconsistency spiralled across user groups, generating between-group incongruences and forming a socio-cognitive environment that hindered true digitalization.

Our study confirms Olesen's (2014) observation that frames related to the nature of technology domain tend to converge with frames related to the technological strategy domain. However, our micro-level individual analysis showed that high variation in digital maturity and competence levels within and across groups generated frame inconsistencies that fuelled between-group incongruency in the nature of technology domain, and distinguished elements that influenced respondents' understandings. For example, the findings reveal distinct inconsistency associated with external users' previous digitalization experiences. Some had already experienced various digitalization efforts (within their own firm and/or when collaborating with other large manufacturers), which prompted them to establish their own routines for using digital technology to support their own key work processes. Other external users had just recently experienced basic digitization (from a paper-based to a digital payroll system). The frame inconsistency triggered by high variation in digitalization experience within the external user group influenced the broader socio-cognitive environment, generating frame incongruency between all groups. The IMS was described by developers as an easy-to-use, combinable and platform-agnostic publishing system, by internal users as a standardized DMS (that external users should use to both enter and retrieve important information), and by external users as an information retrieval system mainly used when drawings change. Such frame incongruency resulted in fundamentally misaligned perspectives and expectations of the IMS, hampering socio-technical change. This finding extends unidirectional perspectives on the socio-cognitive environment (Jacobsson *et al*. 2017), showing that it may span multiple interdependent levels and individual actors are not only affected by the environment, but also shape it. Actors' and actor groups' frames can potently permeate the socio-cognitive environment, generating misaligned expectations, and vice versa, that affect digitalization outcomes. Furthermore, frames associated with previous experiences of other firms' efforts (the industry-level socio-cognitive environment) may affect subsequent digitalization experiences (Orlikowski and Gash 1994, Barrett 1999).

In the *technology-in-use* domain, the findings reveal how frame inconsistences related to *context of use* fuelled between-group incongruency. For example, some external users highlighted the challenging relationship between aspects of their physical working environment (e.g. weather, construction project type, and physical work practices) and technology access (small phone screen and unstable internet connection). Others praised the IMS for enabling fast, automatic retrieval of up-to-date information (mainly drawings) (Cf. Bråthen and Moum 2016). As in the previous domain, the technology-in-use frame inconsistency within the external user group generated frame incongruence with the internal users, who used the IMS in an office environment and anticipated that it would change how they communicated with external users. However, due to the working environment's physical characteristics, limited technology access, and varied digital competence, external users did not use the IMS as expected. External users' limited adoption resulted in one-way communications, conflicting with internal users' framing. Here too a bidirectional relationship can be discerned, with individual frames affecting the socio-cognitive environment and vice versa. Misalignments between the working environment and perceptions of technologies' value may severely impair individual-level adoption, and failure to exploit benefits of coordinating multiple user groups' activities through new digitally-mediated collaborative methods. Hence, external users' technology-in-use frame inconsistency generated frame incongruency affecting construction site digitalization outcomes. External users could not contextualize (harness digitized capabilities in their work context) to generate new digitally mediated routines.

Our analysis reveals several ways in which a fragmented socio-cognitive environment with significant levels of frame inconsistency and incongruency can restrict construction site digitalization. From a socio-technical firm-level perspective, cCorp created decent preconditions for digitally driven organizational change by *digitizing* information and providing technical capabilities to produce, retrieve, and display information in a digital format (Tilson *et al*. 2010, Yoo *et al*. 2010). However, several frame misalignments at multiple levels related to strategy, context and competence, hindered acquisition of the potential social and organizational benefits of *leveraging* the digitized information, i.e. *digitalization* (Yoo *et al*. 2010), at the construction site. For example, the key actors (internal and external) at the site did not leverage digital technology to establish new digitally mediated relationships, information *exchange* routines, or work practices to realize broader collaborative inter-organizational digitalization. Instead, established ways of coordinating work (phone calls and e-mails) prevailed, leaving digital technology's combinatory and infrastructural capabilities unutilized.

This research has several implications for construction industry practitioners. While firms can play a central role in organizing digitalization (Morgan 2019), it shows that expanding digitalization to a collaborative inter-organizational level is challenging, and to drive the required socio-technical change for successful construction site digitalization a firm must understand subcontractors' previous experiences, contexts and digitalization-related competence. Papadonikolaki and Wamelink (2017) illuminate the importance of inter-organizational conditions and relations during digital technology integration. We extend these insights by arguing that firms must establish sufficiently aligned frames, contexts and technology *within and across* firm-boundaries. Regarding the former, we found how the lacking integration with cCorp's existing ERP and CRM-systems caused frame inconsistencies among internal users. Construction firms must be wary of the so-called assumption of "green field development": Even in the construction industry, there is a plethora of already installed legacy systems which are weaved into a digital infrastructure with associated entrenched use behaviours. Therefore, any new system must be carefully designed to complement or replace previous systems and features and be integrated with the current digital infrastructure as to avoid suboptimization and duplicate systems (Wimelius *et al.* 2021). As for the latter, firms must also expand their efforts and address *all* users' needs by shifting from a firm-centric towards an inter-organizational mindset. This requires awareness of all actor groups' operational contexts, including technology access and digital competence. Lavikka *et al*. (2018) suggest that scenario planning workshops could enhance sense-making that promotes collaborative relationships among involved actors. We add a socio-technical and socio-cognitive element: as construction site digitalization is a socio-technical process (Yoo *et al*. 2010, Baskerville *et al*. 2020) involving heterogeneous actors with different competences (Bygballe and Swärd 2019), a system-level perspective should be applied, involving all actors. Since digitalization involves multiple incremental refinements in technological design and contextual anchoring, continuous evaluation of performance and usage patterns is crucial. Products, construction projects, policies and rules (contexts), as well as actor constellations (and hence frames) all change. Thus, firms engaging in digitalization should not stop transforming socio-technical arrangements when a particular digital technology is implemented. The findings indicate that stopping a digitalization effort after implementing a single system, hoping that actors can harness digital technology's generativity (Yoo *et al.* 2010), can backfire as frames and technology resistance develop. Instead, we advocate strategical value capture approaches that help users to embed new digital technology in practice and continuous evaluation of both its performance and heterogeneity of actors' frames (which may severely impair success).

Conclusion

Digital technologies will continue to permeate the construction industry with novel digitalization and transformation opportunities. While technological design, development, and alignment are critical factors in digitalization, human actors need to understand the technologies and contextualize their capabilities into their everyday practices to generate value (Nambisan *et al*. 2017). In construction site digitalization, multiple heterogeneous and distributed actors engage in associated sense-making processes simultaneously, but they may establish varying understandings, perspectives, and knowledge (frames).

We extend IS literature (see Orlikowski and Gash 1994, Olesen 2014, Young *et al*. 2016) by applying technological frames in a novel manner based on the construction context. The study corroborates the importance of context (Shibeika and Harty 2015, Morgan 2019), socio-cognitive environment, and interpretive frames during digitally enabled change (Jacobsson and Linderoth 2010, Jacobsson *et al*. 2017, Linderoth 2017). Moreover, it highlights, empirically and conceptually, the importance of micro- (individual- and group-) level frames in addition to industry-level digitalization processes.

This study has important limitations. While the TF lens allowed a flexible interpretative approach, it may have limited sensitivity to other empirical nuances. We encourage exploration of TFs in other inter-organizational phases in the construction industry, including planning, design, and distribution, to strengthen understanding of frames' roles during digitalization in inter-organizational contexts. Besides context, TFs of customers and employees concerning customer-facing systems and frames related to emerging technologies such as virtual reality, augmented reality, and internet of things (which will likely affect the construction industry soon) also warrant attention.

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ORCID

Oscar Lundberg http://orcid.org/0000-0002-8260-7038
Daniel Nylén http://orcid.org/0000-0002-4895-5493
Johan Sandberg http://orcid.org/0000-0003-0602-5404

References

Arvidsson, V., *et al*., 2014. Information systems use as strategy practice: a multi-dimensional view of strategic information system implementation and use. *The journal of strategic information systems*, 23 (1), 45–61.

Barrett, M., 1999. Challenges of EDI adoption for electronic trading in the London Insurance Market. *European journal of information systems*, 8 (1), 1–15.

Baskerville, R.L., *et al*., 2020. Digital first: the ontological reversal and new challenges for information systems research. *Management information systems. MIS quarterly*, 44 (2), 509–523.

Boland, R.J., *et al*., 2007. Wakes of innovation in project networks: the case of digital 3-D representations in architecture, engineering, and construction. *Organization science*, 18 (4), 631–647.

Braun, V., and Clarke, V., 2006. Using thematic analysis in psychology. *Qualitative research in psychology*, 3 (2), 77–101.

Braun, A., and Borrmann, A., 2019. Combining inverse photogrammetry and BIM for automated labeling of construction site images for machine learning. *Automation in construction*, 106, 102879.

Brynjolfsson, E., and McAfee, A., 2014. *The second machine age: work, progress, and prosperity in a time of brilliant technologies*. New York: W. W. Norton & Company.

Bråthen, K., and Moum, A., 2016. Bridging the gap: bringing BIM to construction workers. *Engineering, construction and architectural management*, 20 (6), 751–764.

Bygballe, L.E., and Ingemansson, M., 2014. The logic of innovation in construction. *Industrial marketing management*, 43 (3), 512–524.

Bygballe, L.E., and Swärd, A., 2019. Collaborative project delivery models and the role of routines in institutionalizing partnering. *Project management journal*, 50 (2), 161–176.

Chau, K.W., *et al.*, 2004. Four-dimensional visualization of construction scheduling and site utilization. *Journal of construction engineering and management*, 130 (4), 598–606.

Davidson, E., 2006. A technological frames perspective on information technology and organizational change. *The journal of applied behavioral science*, 42 (1), 23–39.

Davidson, E.J., 2002. Technology frames and framing: a socio-cognitive investigation of requirements determination. *MIS quarterly*, 26 (4), 329–358.

Davidson, E., Pai, D., *et al.*, 2004. Making sense of technological frames: promise, progress, and potential. *In:* Bonnie Kaplan, eds. *Information systems research. IFIP International Federation for Information Processing*. Boston, MA: Springer, 473–491.

Dubois, A., and Gadde, L.-E., 2002a. Systematic combining: an abductive approach to case research. *Journal of business research*, 55 (7), 553–560.

Dubois, A., and Gadde, L.-E., 2002b. The construction industry as a loosely coupled system: implications for productivity and innovation. *Construction management and economics*, 20 (7), 621–631.

Dwivedi, Y.K., *et al.*, 2015. Research on information systems failures and successes: status update and future directions. *Information systems frontiers*, 17 (1), 143–157.

Giddens, A., 1984. *The Constitution of Society*. Berkeley, Calif: California Press.

Gioia, D. A., 1986. *Symbols, scipts, and sensemaking: creating meaning in the organizational experience*. San Francisco: Jossey-Bass.

Grill, M., *et al.*, 2019. The leadership practices of construction site managers and their influence on occupational safety: an observational study of transformational and passive/avoidant leadership. *Construction management and economics*, 37 (5), 278–293.

Hall, D.M., *et al.*, 2020. Mirror-breaking strategies to enable digital manufacturing in Silicon Valley construction firms: a comparative case study. *Construction management and economics*, 38 (4), 322–339.

Havenvid, M.I., *et al.*, 2016. Renewal in construction projects: tracing effects of client requirements. *Construction management and economics*, 34 (11), 790–807.

Henfridsson, O., *et al.*, 2018. Recombination in the open-ended value landscape of digital innovation. *Information and organization*, 28 (2), 89–100.

Jacobsson, M., *et al.*, 2017. The role of industry: an analytical framework to understand ICT transformation within the AEC industry. *Construction management and economics*, 35 (10), 611–626.

Jacobsson, M., and Linderoth, H.C.J., 2010. The influence of contextual elements, actors' frames of reference, and technology on the adoption and use of ICT in construction projects: a Swedish case study. *Construction management and economics*, 28 (1), 13–23.

Kim, C., *et al.*, 2013. On-site construction management using mobile computing technology. *Automation in construction*, 35, 415–423.

Lam, K., *et al.*, 2007. The application of the ant colony optimization algorithm to the construction site layout planning problem. *Construction management and economics*, 25 (4), 359–374.

Lavikka, R., *et al.*, 2018. Digital disruption of the AEC industry: technology-oriented scenarios for possible future development paths. *Construction management and economics*, 36 (11), 635–650.

Lee, A.S., and Baskerville, R.L., 2003. Generalizing Generalizability in Information Systems Research. *Information systems research*, 14 (3), 221–243.

Linderoth, H.C.J., 2017. From visions to practice – the role of sensemaking, institutional logic and pragmatic practice. *Construction management and economics*, 35 (6), 324–337.

Lundberg, O. *et al.*, 2020. Cycles of innovation and alignment in digital transformation: investigating the dynamics of resource recombination in a construction firm. In: *Proceedings of the 53rd Hawaii International Conference on Systems Sciences*, 4346–4355.

Morgan, B., 2019. Organizing for digitalization through mutual constitution: the case of a design firm. *Construction management and economics*, 37 (7), 400–417.

Nambisan, S., *et al.*, 2017. Digital innovation management: reinventing innovation management research in a digital world. *MIS quarterly*, 41 (1), 223–238.

Nylén, D., and Holmström, J., 2015. Digital innovation strategy: a framework for diagnosing and improving digital product and service innovation. *Business horizons*, 58 (1), 57–67.

Olesen, K., 2014. Implications of dominant technological frames over a longitudinal period. *Information systems journal*, 24 (3), 207–228.

Orlikowski, W.J., 2000. Using technology and constituting structures: a practice lens for studying technology in organizations. *Organization science*, 11 (4), 404–428.

Orlikowski, W.J., and Gash, D.C., 1994. Technological frames: making sense of information technology in organizations. *ACM transactions on information systems*, 12 (2), 174–207.

Papadonikolaki, E., and Wamelink, H., 2017. Inter- and intra-organizational conditions for supply chain integration with BIM. *Building research & information*, 45 (6), 649–664.

Sandberg, J., *et al.*, 2020. Digitization and phase transitions in platform organizing logics: evidence from the process automation industry. *MIS quarterly*, 44 (1), 129–153.

Sayer, K., 1998. Denying the technology: middle management resistance in business process re-engineering. *Journal of information technology*, 13, 247–257.

Schein, E. H., 1992. *Organizational culture and leadership*. 2nd ed. San Francisco: Jossey-Bass.

Sherratt, F., *et al.*, 2013. UK construction site safety: discourses of enforcement and engagement. *Construction management and economics*, 31 (6), 623–635.

Shibeika, A., and Harty, C., 2015. Diffusion of digital innovation in construction: a case study of a UK engineering firm. *Construction management and economics*, 33 (5–6), 453–466.

Slaughter, E.S., 2000. Implementation of construction innovations. *Building research & information*, 28 (1), 2–17.

Steinhardt, D., *et al.*, 2020. The structure of emergent prefabricated housing industries: a comparative case study of Australia and Sweden. *Construction management and economics*, 38 (6), 483–501.

Tilson, D., *et al.*, 2010. Research commentary—digital infrastructures: the missing IS research agenda. *Information systems research*, 21 (4), 748–759.

Van Berlo, L.A., and Natrop, M., 2015. BIM on the construction site: providing hidden information on task specific drawings. *Journal of information technology in construction (ITcon)*, 20 (7), 97–106.

Walsham, G., 1995. Interpretive case studies in IS research: nature and method. *European journal of information systems*, 4 (2), 74–81.

Weick, K. E., 1995. *Sensemaking in organizations*. Thousand Oaks, CA: SAGE.

Whyte, J., 2019. How digital information transforms project delivery models. *Project management journal*, 50 (2), 177–194.

Wimelius, H., *et al.*, 2021. A paradoxical perspective on technology renewal in digital transformation. *Information systems journal*, 31 (1), 198–225.

Yin, R. K., 2009. *Case study research: design and methods*. 4th ed. Los Angeles, Calif: SAGE.

Yoo, Y., *et al.*, 2010. The new organizing logic of digital innovation: an agenda for information systems research. *Information systems research*, 21 (4), 724–735.

Young, B., *et al.*, 2016. Inconsistent and incongruent frames during IT-enabled change: an action research study into sales process innovation. *Journal of the association for information systems*, 17 (7), 495–520.