Ordering in disguise: digital integration in built environment practices

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ABSTRACT

The digital integration of built-environment practices aims to bridge a large variety of organizations to improve building delivery and operation. However, recent research on building information modelling (BIM) reported organizational challenges arising from digital integration. This suggests a need to develop a critical perspective on digital-integration-driven organizational change. Adopting a practice-based approach, this paper exposes the practice-level phenomenon responsible for the ongoing change to develop a critical understanding and enable better interventions. The concepts of 'simplification' and 'systematization' of digital integration are developed from previous literature and then used to explore and interrelate the practice-level experiences of digital integration (i.e. the experience of the change from within) and the emerging patterns of interactions (i.e. the picture of the change from outside) in a BIM-enabled design project. The concept of 'ordering in disguise' is proposed to capture this phenomenon. It shows that practitioners experience digital integration as various task-specific instances of unresponsive technology. However, they are unaware that their ongoing efforts to accommodate it actually further reinforce digital integration's simplification and systematization. This makes the unresponsiveness of technology harder to challenge, and ultimately forces the organization to change and adapt to it. Implications for management of practice are outlined.

KEYWORDS: building information modelling (BIM), digital technologies, organizational management, socio-technical, technological change, technology policy

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INTRODUCTION

The organisation of the built environment is based on interactions between a large number and variety of material, social, and organisational entities within a time frame set by a wide variety of purposes. 'Building Information Modelling' (BIM) and 'big data' have the ambition of taming this complexity within the digital realm through the digital integration of data to improve building delivery and operation. The dominant academic literature and key practical guidance documents on BIM identify industry problems as poor communications, poor information recording, and poor integration based on the lack of collaboration to make the case for BIM adoption (e.g. Azhar, Khalfan, & Maqsood, 2012; British Standards Institution, 2013; Eastman, Teicholz, Sacks, & Liston, 2011; International Organization on Standardization, 2016; Oh, Lee, Hong, & Jeong; 2015). Such publications see BIM as the solution to these problems through its capabilities of communications based upon digital data integration among various stakeholders involved over the life-cycle of buildings. 'Digital integration of data' refers to the technological capability of exchanging, relating, analysing and synthesising numerous data sets and data models that are created by a variety of sources, for a variety of purposes, at various times (Pagano, Candela, & Castelli, 2013).

However, recent empirical research on BIM has reported opposing results by pointing out the organisational changes and challenges raised due to digital integration (Dossick & Neff, 2011; Harty, 2008; Whyte & Lobo, 2010; Whyte, 2011). Other studies have suggested that the digital shift in built environment practices needs to be understood beyond the effects on individual projects or companies. These studies have considered the wider context that includes, for example, shifts in perceptions of the life cycle of buildings (Love, Matthews, Simpson, Hill, & Olatunji, 2014), professional roles (Sebastian 2011), and even the meaning of 'professionalism' (Jaradat, Whyte, & Luck, 2013) in the built environment. Thus, there has been an ongoing effort by both the practitioner and research

communities to make sense of the nature and effects of the changes that digital integration has brought about. Much of the existing critical literature on BIM and organisational change is mostly descriptive in explaining what has been changing in terms of organising the built environment and why, but it falls short in theorising the underlying mechanisms that drive and shape this change. As a result, practitioners, managers, and policy-makers lack concepts for making better sense of the nature and dynamics of the ongoing change, and therefore cannot intervene effectively in it.

This paper adopts a practice-based approach (Feldman & Orlikowski, 2011) to inquire into and develop theory about the practice-level phenomenon that is responsible for the digital-integration driven change at different levels of organisation in the built environment. As argued by Sandberg and Tsoukas (2011), such an approach can expose 'the logic of practice'; and thus, reveals the changing dynamics of practicing in relation to digital integration. This enables the development of theory for the practical management of change based upon practitioners' perspective. According to the practice-based approach, all change that can be identified at various levels of organising are actually continuously produced by subtle shifts in everyday communications and actions of practitioners. Therefore, the paper uses data from an in-depth study of practices in a BIM-enabled design project. Four interdisciplinary events from the project are analysed in order to investigate how and why digital integration of design practices changed practitioners' everyday, mundane interactions. It distinguishes the lived experiences of practitioners (i.e. *within* lived practices) from the discourses and processes that make the context in which they operate (i.e. *outside* lived practices but surrounding them), importantly suggesting the mechanisms that connect these.

The paper develops the concepts of 'simplification' and 'systematisation' of digital technology from previous literature in technology and organising, and then uses these for analysing the events. The analysis will show that digital integration disrupted practice because it could only provide a single and

simplified version of reality while different design practitioners needed various different systems of working. As a result, the actual content, scope, and procedures of digital integration were ongoing and fundamental concerns to all parties, but experienced differently depending on how much their individual needs were recognised. This suggests that simplification and systematisation of digital integration were experienced by the practitioners as a continuing struggle to deal with the unresponsiveness of digital integration to the everyday 'messy' practices of multidisciplinary design. Thus, the organisational contexts of interdisciplinary practices were shifted and interdisciplinary interactions were reformed accordingly. This phenomenon, through which digital integration drove the change in practices, is conceptualised as 'ordering in disguise' because digital integration did not explicitly determine what practitioners must do and how, but worked through, variously, constraining or promoting individuals' courses of action. This resulted in an organisational change that practitioners could hardly control.

The paper suggests that digital-integration driven transformations are not directed to effectively bridging different perspectives of various stakeholders as promoted. It concludes that positive change through digital integration requires reflective and active management at multiple levels of organising the built environment. The new concept of 'ordering in disguise' captures a key phenomenon that needs to be considered to enable such a change in the built environment and multidisciplinary practices elsewhere; and hence, advancing theory on organisational change and its management.

DIGITAL DRIVEN CHANGE FROM THE PRACTITIONERS' PERSPECTIVE

Tsoukas and Chia (2002) identify that research in organisational change poorly acknowledges everyday practices due to the difference between how change looks from *outside* and how it is experienced

from *within*. This distinction provides the theoretical framework of the paper. Hence, this section reflects on this distinction with a critical discussion of the abstract concepts of 'organisation' and 'organisational change', and how these relate to the practitioners' point of view. The concepts of 'simplification' and 'systematisation' are then developed from previous literature on technology and organising to be used as the analytical lens of the paper. This is followed by a brief review of the work on BIM and design work in construction, and showing how the concepts are implicit in recent critical studies in order to fine-tune them for analysis and discussion.

Organisation and organisational change from practitioners' perspective

Sandberg and Tsoukas (2011) criticise organisational and management theories for failing to adequately recognise the actual practices (i.e. 'the logic of practice') that are studied due to their assumptions based on 'scientific rationality'. They suggest that this is because 'scientific rationality' and 'practical rationality' are different in their basic ontological-epistemological assumptions, and that this difference leads to divergent understandings of the relation between theory and practice. The authors claim that 'scientific rationality' assumes a world made of separate, distinct categories of entity (i.e. people, professions, technologies, organisations, etc.) with distinct, fixed characteristics; and hence, it explains organisational phenomena by establishing general cause-effect relationships between different categories of entity to improve practices. Therefore, 'scientific rationality' sees theory as the *de facto*, stable, and refined version of what is happening in practice, and thus relies on abstract concepts (e.g. technology, organisation, organisational change, and so on). However, these are, in fact, absent from the dynamic, everyday, speech and actions of practitioners. This limits the application of such theories because in practice, all situations are experientially unique, and consideration of situation-specific circumstances between various entities are crucially important.

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Sandberg and Tsoukas (2011), following work by Heidegger (1927/1996), Bourdieu (1990) and Schatzki (2002), show how 'practical rationality' embraces the idea that all situations are experientially unique, and thus acknowledge a dynamic, contingent view of rationality. This kind of rationality rejects predictions based on general cause-effect relationships between distinct, universal categories of entity. Instead it focuses on exploring situation-specific interrelations between entities because it is those unique interrelations that enact 'the logic of practice', and thus drive daily, mundane interactions in practices. In this view, 'theory' becomes *explanatory*, rather than being *assertive*, so that it becomes "a systematic way of approaching a given subject matter" (Stern, 2003, p. 187) that has to be considered with respect to a relational whole (Sandberg & Tsoukas, 2011).

According to Orlikowski (2010), developing organisational theory that captures 'practical rationality' requires a philosophical orientation about the constitutive role of practices in producing organisational reality. This suggests that structures of organisational life are rooted in, and continuously (re)-produced through the ongoing interactions between practitioners and events in daily, mundane practices, and so organisational structures and routines don't have an existence of their own (Orlikowski, 2010; Schatzki, 2001). As pointed out by Orlikowski (2000); Feldman and Pentland (2003); and Nicolini (2009), they are only 'patterns of interactions' that develop and remain due to the courses of action being repeated in practices, and so they only exist when seen from a distance and in abstract terms.

In a similar way, research into organisational change generally sees it as an abstract concept but Quattrone and Hopper (2001); Saka (2003); Meyer, Gaba, and Colwell (2005); and Appelbaum, Habashy, Malo, and Shafiq (2012) challenge this with a consideration of empirically observable organisational practices which reveal that the ongoing change is both experienced and reproduced. Tsoukas and Chia (2002) explain that the problem with research in organisational change, that neglects

everyday practices, is that their adoption of a 'synoptic' view of change which sees and explains change from *outside* and as a series of static positions. They claim that this causes the distinguishing features of the studied change to be lost from view, because change is work-in-progress, it "is the reweaving of actors' webs of beliefs and habits of action to accommodate new experiences obtained through interactions" (p. 567). Pollack (2015, p. 45) comments that, "…practitioners …focused on the localised history of an organisation, typically as a way of providing context for the organisational change they were relating". Other literature on digital-technology driven organisational change uses adjectives such as 'subtle' (Suchman, 2007), 'unnoticed' (Ciborra & Lanzara, 1990), and 'invisible' (Bowker & Star, 2000) in describing the experience of change of practitioners who go through it. These adjectives suggest that, at the practice-level, practitioners do not experience, or perform, based upon static, clear, or complete pictures of an organisation-in-action. Rather they are largely preoccupied with completing their daily tasks through everyday interactions during which their mundane speech and actions shift based on shifted organisational contexts (Ciborra & Lanzara, 1990).

Tsoukas and Chia (2002), acknowledge the difficulty of inquiring into the shifting flux of reality from *within* when adopting a practice-based view. Mackay and Chia (2013) suggest that the focus should be on investigating the unfolding of practices to reveal the contingent logic formed by the simultaneously evolving environmental factors and individual people's actions. This practice-focused definition of organisational change suggests that it can and should be understood from *within* (i.e. at practice-level) through an investigation of interactions. Thus, a focus on interactions in practice can yield insight into the experiences of practitioners, or in other words into the changes in 'logic of practice', which ultimately shape and drive the organisational change that can be observed from *outside*. It is this difference between the experience of change from *within* and its resulting picture from *outside* which is explored in this paper as it poses the main challenge of organisational research

but also configures the opportunity for better understanding and intervening in organisational change for positive outcomes.

Simplification and systematisation of digital technology

What is needed to explore the experience and performance of organisational change from *within,* and relate it to the resulting picture of change from *outside,* are concepts that capture the unfolding and path-dependent nature of organisational practices. Previous practice-based studies of technology and organising, propose relational concepts such as affordances (Hutchby, 2001; Leonardi 2011), sociomateriality (Orlikowski, 2007), adaptive structuration (DeSanctis & Poole, 1994), imbrication (Leonardi, 2011), and appropriation (Dourish, 2003; Leonardi & Barley, 2010) to capture the technology-driven change as an unfolding and path-dependent process along which technology use and social interactions develop in an interdependent way. These concepts provide an overall explanation of the constitutive role of technology in organising, and therefore explain the general process of technology-driven organisational change. However, they do not engage with the direction of the change, hence do not provide a nuanced or critical understanding of the changing logic of practice or the experience of practitioners. The concepts of 'simplification' and 'systematisation' of digital technology used in this paper also constitute an analytical lens to capture the unfolding and path-dependent nature of organisational practices, because they allow exploration of practice-level experiences in relation to developing patterns of interactions. However, additionally, this analytical lens enables a critical edge by showing the direction of the ongoing change. These concepts refer to the reductionist and fixing aspects of digital technology, and are implied in previous work, which are reviewed here.

As shown in Beynon-Davies (2011), technologies are fundamental in creating systems of representations which drive the patterns of communications and performances that constitute

recognizable and meaningful practices. Kallinikos (1995) implies that simplification is inherent to technology, by pointing out its fundamentally representational nature. He argues that technology reduces the complex and synthetic character of the world to limited domains through its limited and selected objectification (Kallinikos, 1995). In line with Beynon-Davies (2011), he further argues that, therefore, technologies indeed "…represent detached and decontextualized systems of work" (p. 117); thus, also implying that systematisation accompanies simplification as a result of the ongoing 'limited and selective objectification' of technology. In a similar line of thought, Suchman (2007) implies both simplification and systematisation of technology through her argument which claims that digital technologies operate through a 'planned action model'; and thus, they are restricted to perform only a limited number of actions in fixed orders. This corresponds to a simplified and systematised version of what happens in real world following 'situated action model' which is characterised as contingent and complex (Suchman, 2007). Although digital integration of data has significantly increased the variety, pervasiveness, and outreach of digital technologies, Pagano et al. (2013) state that digital data integration always requires some sort of schema matching and schema mapping among the parties involved; thus, implying that simplification and systematisation are also inherent even when a variety of operations are digitally integrated. Moreover, as suggested by Constantiou and Kallinikos (2015), and Whyte, Stasis, and Lindkvist (2016) even when working with unstructured 'big data', making a purposeful use of it requires simplification and systematisation.

The organisational consequences of simplification and systematisation of technology are also present in this body of research. Kallinikos (1995) claims that simplified and systematised version of reality embedded in digital technologies impose their own material and behavioural requirements and as a result change work habits and the nature of formal organisations. According to Suchman (2007), simplified and systematised 'planned action model' of digital technologies, together with their

interactive but opaque interfaces, create problematic situations due to the unresponsiveness of technologies to unfolding situations, and this directs practices in certain ways. This resonates with Dechow and Mouritsen (2005) who show that, although there is a degree of freedom in establishing the terms and logic of digital integration, in the end these fundamentally reflect a simplified version of what is happening in reality, and eventually incurs a hard-to-evade 'techno-logic' which imposes a certain way of practicing by systematically shaping organisational priorities and procedures. Hanseth and Monteiro (1997) and Kallinikos (2006) consider this argument from a wider perspective, and suggest that the terms and logic of standardisation for technological compatibility, which would drive simplification and systematisation in a digitally integrated environment, underpin the basis for further standardisation of technologically-connected organisations and their future work processes. This resonates with Bowker and Star (2000) who empirically show that categories and standards that underpin an information system continuously foreground a limited and simplified version of the complex net of interrelations among the practices that engage with it; thus, reshaping the future of these practices. In a later paper, Star and Bowker (2007) deduce that those whose needs and perspectives cannot be formally represented within the defined categories of an information system, would be significantly silenced, and thus disadvantaged in relation to their activities concerned with the information system. Knights and Vurdubakis's (2005) argument about digital integration's apparently contradictory consequences is relevant here as their view of digital integration as organisation and disorganisation implies disruption to existing practices and establishment of new ones constituted by the simplification and systematisation of digital integration.

Organisational challenges of BIM

There is a growing body of organisational research on BIM and interdisciplinary design work that exposes the shortcomings of the trivialised view of digital integration which sees organisational

challenges triggered by digital integration as misapplication of technology to design tasks. Examples from this critical body of literature will be reviewed and related to the concepts of 'simplification' and 'systematisation' in order to further ground them through the literature that focuses on built environment practices.

Harty (2005; 2008) shows that built environment practices are characterised by social, material, and organisational variety and complexity making them hard to represent and integrate digitally, thus implying the inherent simplistic approach of digital integration in representing the complex interrelationships in built environment practices. In line with this argument, findings of Whyte and Lobo (2010) suggest that digital integration does not facilitate existing courses of interactions leaving them intact, but rather reshapes them to a form of organising that involves prescribed processes, stage-gates, and top-down, hierarchical forms of sign-off and control; thus, implying that a simplistic version of reality needs to be systematised to be viable in complex organisations.

Moum's (2010) argument that the logic of information processing of BIM technologies is 'formal and linear' can be seen as another expression of simplification and systematisation because it implies that BIM suggests a univocal view of multidisciplinary design, which is simplistic, as well as BIM's process rigidity, which suggests systematisation of the simplicity. This interpretation is implied in her argument that BIM technologies cannot accommodate the dynamism required for design improvement and innovation, and this may lead to a bias in the way design process works. This line of thinking echoes with the findings of other critical research into BIM and organisation. Among them Whyte (2013) highlights shortcomings of formalisation of construction design through digital integration by exposing that designers cope with the complexities of the physical world through testing their design from multiple perspectives, and integrated technologies are limited in these terms. Also Neff, Fiore-Silfvast, and Dossick (2010); and Dossick and Neff (2011) argue that centralisation and integration of design

data produces over-determination and inflexibility in design, and make it harder to embrace multidisciplinary design settings which require synthesis of multiple perspectives. Dossick and Neff (2010); and Neff et al. (2010) further establish that closer technological coupling between different design practitioners with goal conflicts can make interdisciplinary work more difficult, thus supporting the idea that digital integration's representation of practices is simplistic and systematic, making inherent organisational challenges more complex and harder to solve.

Other studies identify that the mismatch between diversity and complexity inherent in design practices and BIM's limited representation of them cause practitioners to spend extra effort to keep integrated technologies up and running in the face of messy, everyday practices. Whyte (2011; 2013), for example, argues that working with digitally integrated technologies requires undertaking processes outside of core design-tasks; and therefore, the success of an integrated technological infrastructure is always fragile and only ever partly accomplished (Whyte, 2013). Similarly, Çıdık, Boyd, and Thurairajah (2014) show that the set-up and operation of digital design data integration include significant extra advanced planning followed by ongoing negotiations and re-confirmations regarding the accountability of the integrated data. Consequently, the concepts of simplification and systematisation also provide an explanation of the additional effort required in digitally integrated practices by implying that simplistic and systematised operations of technology need to be continuously adjusted to the complexity of real world practices. When seen from this perspective, Jaradat et al. (2013)'s finding becomes more striking as they suggest that the ongoing efforts to keep the digital systems functioning can create new roles and forms of accountability which can be in conflict with historically established practices.

This review of the literature in BIM and organising exposes that digital integration reflects a simplified and systematised view of interdisciplinary design practices, against their inherent complexities and

dynamism. However, although simplification and systematisation can be inferred from the findings of previous research; how they work in practical situations, affect the experience of practitioners, and thus transform the 'logic of practice' are not established within the current literature. This decreases the chance of informed interventions to steer the wider organisational change driven by digital integration. Therefore, this paper will analyse the interdisciplinary interactions in four practical situations in order to develop an insight into the practical mechanisms through which simplification and systematisation effect the logic of practice. This will enable an understanding of how and why digital integration transforms mundane 'sayings and doings' of practitioners, and thus produces and drives the wider organisational change in the built environment based on its simplification and systematisation.

METHODS

Investigation of digital-integration driven organisational change is challenged by the different appearances of organisational change from *within* and from *outside* (Tsoukas & Chia, 2002). The adoption of a practice-based approach (Gherardi, 2012; Nicolini, 2012; Orlikowski, 2010; Schatzki, Cetina, & vonSavigny, 2001) is particularly suited to address this difficulty given its fundamental assumption that organisational stability, order, structures are rooted in, and continuously (re)-produced through the ongoing interactions in practice (Feldman & Orlikowski, 2011; Schatzki, 2001). This indicates that any change that is identified in the structures and order of organisations are actually rooted in the transformations in everyday, mundane 'sayings and doings' of practitioners. Consequently, the practice-based approach can explore the differences between how organisational change is experienced and performed from *within*, and how it looks from *outside*, as well as offering insights into how these are connected. Following Nicolini (2009), the outsider perspective is established through zooming-out to dominant discourses, discussions and routinised processes that

reflect the patterns of interactions developed in the project in response to simplification and systematisation of digital integration. On the other hand, the insider perspective zooms-in to the unfolding 'sayings and doings' of the practitioners in individual events in order to develop an insight into the changing experience of practitioners due to simplification and systematisation.

Key to the analysis for such an inquiry is the adoption of a relational epistemology (Emirbayer, 1997) in which the practice-level activities and organisational-level order are mutually constitutive, and the local practices and global organising are inter-connected. This suggests that, while patterns of interactions, which appear as order and stability, are rooted in and continuously (re)-produced through everyday practices. At the same time, though, these patterns become resources for meaning-making in practices, thus 'ordering' the subsequent interactions by defining the space of possible meaningful interactions. They are experienced by the practitioners as the 'context', or, in their words, as the feeling of 'what to do' and 'what ought to be done' (Nicolini, 2012). This epistemological assumption allows bridging the organisational change as experienced from *within* (i.e. from practitioners' eyes) and the resulting picture of organisational change which can be identified from *outside* (i.e. in abstract terms). Thus, the structure and ordering are resources for practitioners to make sense of unfolding situations, and give practitioners a certain direction in their actions and interactions. At the same time, actions that are performed as responses to unique situations shape the context for subsequent activities through challenging or reinforcing the existing context, and determine future outcomes; as encapsulated by the concept of 'path dependency' (Greener, 2002).

The research used empirical data collected as part of a larger research project investigating a BIM-enabled new built project, involving a UK educational building in its detailed design stage. Observational data were collected through passive observation (Rosenthal & Capper, 2006) of twenty-three face-to-face project meetings over a period of ten months. These meetings involved: regular

fortnightly design coordination meetings, focused and one-off design coordination workshops, and model-coordination and clash-detection meetings. Each of these meetings lasted from one to one-and-a-half hours. Conversations before, and after the observed meetings were also held with the practitioners to validate the researcher's understanding of the situation-specific experiences of the observed practitioners. In addition, four open-ended interviews were conducted with the representatives of the mechanical and electrical engineering (M&E) consultancy and architect companies to gain better insight into the model development and its use in individual offices.

The organisations involved did not allow the recording of the observed meetings. Therefore, the observational data were recorded in field notes and the reflections on these were supported by the interviews and informal communications. During the observations, the researcher's attention was directed towards capturing two main kinds of phenomenon to reveal 'the logic of practice' as suggested by Sandberg and Tsoukas (2011). These were (i) revealing 'entwinements' as the logic of practice (i.e. how recurring aspects of the observed practices are re-produced over time); and (ii) revealing the logic of practice through 'temporary breakdowns in communication' (i.e. how confusions about 'what to do', and 'what ought to be done' were noticed, evaluated and solved). The field notes were turned into reflective explanations based on the original notes and other communications with the practitioners.

The events presented here are selected from the wider pool of similar events observed in the project that showed aspects of entwinement and temporary breakdown in communication. They are selected with the consideration of exposing a variety of seemingly different situational contexts which involved different kinds of design tasks. The aim is to expose how the earlier established concepts of simplification and systematisation are inherent in digital integration and displace the context for each of these seemingly different design situations; thus, leading the practitioners to transform their

performances in certain ways. The point being made is that, when seen from the practitioners'

perspective, the four events look distinct and inconsequential as practitioners merely see negotiations

of tasks with different opportunities and burdens. However, the analysis of the four seemingly

different events reveals the commonalities between them, and thus enables a discussion that

produces knowledge on the practical mechanisms that drive digital-integration driven organisational

change. A joint exploration of contextual and experiential levels through the lens of the concepts of

simplification and systematisation, allows the research to reveal the shifted contexts which frame the

experiences, and therefore the 'sayings and doings' of practitioners. This involves, first, presenting the

particular interdisciplinary interaction patterns that expose the shifted project-level context; and

then, presenting the interactions that took place in four events in a more detailed way with reference

to their shifted situational contexts. Ultimately, the description of findings aims to reflect the

connections between the shifts in the contexts, upon which practitioners based their understandings

of 'what to do' and 'what ought to be done', as well as resulting actions which further reinforced the

shifted contexts.

The discussion establishes the concept of 'ordering in disguise' to highlight the lack of awareness by

practitioners regarding how their reactions to particular, task-specific instances of unresponsive

technology are driven by the shifted contexts in which simplification and systematisation become

organisational requirements. The practitioners experience unresponsive technology, interdisciplinary

conflict, and extra work; but not seeing the simplification and systematisation explicitly. The

practitioners' responses, including taking the opportunity to negotiate for personal advantage,

produce and drive the organisational change which is what is observed from *outside.*

DIGITAL INTEGRATION IN PRACTICE

Zooming-out to Organisational Coordination

The observed project was a design-and-build educational building in which the design, and hence the financial risk of the construction works were transferred to the main contractor. The project was ambitious in its use of BIM. At the outset, the project aimed to develop a fully coordinated integrated model consisting of various discipline-specific models to use it as the baseline for further model-based cost management, scheduling, construction as well as for operation and maintenance purposes. The client had a BIM-literate estates team. The design team also had working experience in BIM. Therefore all were aware of the step change needed for digital integration.

In order to coordinate this new way of working, the project needed a system which was established through detailed conventions for model-based working (e.g. responsibility matrices for the objects in the model, naming conventions for object families etc.) as well as a detailed Employer's Information Requirements document describing the parameters for each of the objects in the model to be provided by specified stakeholders. This information was mainly documented under a BIM protocol which was part of the contract both for the main contractor and the novated designers so that it was strictly followed. A specific commercial shared modelling platform (MP) that had architectural, mechanical-electrical-plumbing (MEP) engineering, and structural engineering packages was dictated by the client. These were all aspects of simplification through standardisation, and systematisation through protocols that were imposed on the project.

Two surprising results arose. Firstly, although the design and construction teams held numerous face-to-face coordination meetings during the detailed design stage, the model coordination/ clash detection meetings (MCMs) were kept separate from design development meetings. This separation was a significant organisational differentiation in the project. Secondly, the models were rarely used or referenced in design development meetings, which mainly featured discussions around individual documents such as published drawings, schedules etc. These results demonstrated the degree of

segregation of activities between model development and design development. Thus, MCMs were technology focused meetings attended mostly by people with technology focused roles (apart from the architect) who normally did not attend design development meetings. The technological terms such as 'objects', and 'worksets' that were used in these meetings also reflected the technological orientation of the meeting, and differentiated it from design development meetings. MCMs were mainly concerned with the alignment of model development and design development which implied that they involved two main types of activities. First there were the activities to inform design decisions through the interdisciplinary use of technological capabilities offered by the MP (e.g. automated clash detection). Second there were the activities to establish the modelling approaches that had to address both the needs of multiple parties, and the requirements of the software in holding the design information as anticipated (e.g. naming conventions, object responsibility matrices, level of detail in the model, clash detection rules etc.). The MCMs thus had effects on structuring how the design process could operate.

Zooming-in to Coordination in Practice

The differentiated contexts of model development and design development activities, and the simplification and systematisation required by the digital technologies disrupted practice-level interactions, thus created a series of incidents. These were investigated by studying the detailed interactions that took place in MCMs. Four such events from practice are described where entwinements between design work and model work, and temporary breakdowns could be identified and explained by the effects of simplification and systematisation of digital integration in practice. The events are named after the shifted contexts within which they took place in order to emphasise the association between the shifted context and the unfolding of interactions. The first involved a shift in previous interdisciplinary working allowing the architect to use the digital integration to argue for their

system of working. The second involved a shift in discipline-specific practice where the digital integration forced an unnecessary accuracy in modelling. The third involved a shift in the context of the work of the designers due to the introduction of modelling requirements for future asset modelling outside the need for design development. Finally, the fourth involved a shift in the designers' and contractors' work created by the demand that the design data integrate with the data from the construction site.

Event 1: Shifted context of interdisciplinary design interactions

The M&E sub-contractor adopted a design process in which the design was developed outside of MP. This was heavily criticised because it reduced the value of model-based design development and made detailed model-based coordination not possible. In one of the meetings, the modelling manager of the M&E sub-contractor was criticised for delaying the modelling of the lights in the atrium area which were needed by the architect for the detailed coordination of the ceilings in that area. Representatives of the main contractor and M&E consultant backed the representative of the architect in his demand. The modelling manager of the M&E sub-contractor said that his team would not model the lights in that area, and reminded a previous instance in the project when their team modelled some M&E services at a specific part of the building for detailed coordination as requested by the architects, but then the architect subsequently amended that part of the architectural model, thereby wasting all that modelling effort. He further reminded that coordination could be done through overlaying 2D M&E drawings on the plans in the architectural model. However, his arguments were rejected by the others in the room who claimed that MP was a design development tool and must be used as such. This was followed by a long speech delivered by the modelling manager of the M&E sub-contractor in an upset fashion, in which he explained how MP was not geared up for the M&E discipline. He referred to the long processing times that the MP took to re-calculate the model after each small change to

the model when the services were modelled as closed and calculated systems; and therefore, how his team was initially modelling their design in another software and then exporting it to the MP. Others in the room claimed that only the geometry was needed for interdisciplinary coordination purposes but not closed, calculated systems. However, this was indeed in contradiction to their general expectation that MP was a full design development tool. The modelling manager of the M&E sub-contractor replied saying that the accuracy of those calculations was essential in their design development process, and therefore his site team expected to have all the modelled systems closed and calculated in the model. The discussion ended with the modelling manager of the M&E sub-contractor's promising that his modelling team would prioritise the model coordination needs of the architect, although it was impossible to respond to all of the modelling requests made so far at the same time.

This event reveals a long-standing conflict between the competing workflows and priorities of the architect and M&E sub-contractor. However, this time it was negotiated through the arguments around digital integration. This shows how digital integration shifted the context of the interdisciplinary design interactions by providing different opportunities and constraints for different disciplines but could not accommodate them all. This resulted in establishing new ways of working over time. The M&E sub-contractor adopted a different system of work attracting continuous criticism whereas the architect was leading the model-based design determining its procedures. Consequently, at that moment of temporary breakdown, the 'simplification' and 'systematisation' of the MEP design required by the package used for digital integration became an opportunity for winning in the competing views by providing an argument about the legitimacy of different systems of work. Here the architect's system of work (which was also backed by the main contractor) was imposed on the M&E sub-contractor, thus needs of the architect were framed as technological necessity. Rather

ironically, later in the project, when the ceilings started to be installed on the site, the ceiling design needed to be re-documented in several 2D drawings with a much finer level of detail and measurements from the site, as the installation tolerances on the site made the setting-out details included in the model irrelevant. This final situation marks how the system of work induced by digital integration was a 'simplified' version of complex reality considering some aspects while neglecting others.

Event 2: Shifted context of discipline-specific design work

The project utilised the automated clash detection feature of the MP but this was a constant struggle. The main difficulty arose because of the need to differentiate between detected clashes that were simply due to undetailed modelling, and those that were due to clashing design which would cause a real problem during the construction. The software could not make this distinction as it used 'simplified' and fixed rules to check the geometry of the objects in the model. 'Systematisation' of modelling approach was then required to cope with this rule-based system involving strict interdisciplinary naming conventions for the objects in the models in order to more easily filter the thousands of automatically-detected clashes. In addition, the team used the software feature which enabled the 'approving' of a clash in the model, indicating that it was not a real design clash but just due to non-detailed modelling; this feature was needed to compensate for the technology's 'simplification' of the design work. In this respect, the ideal of a clash-free model was never achieved but only a clash-managed model, in which practitioners by-passed the 'simplification' of digital integration to make it useful in achieving clash-free construction.

In one of the meetings, after the initial clash detection, excessive in-discipline clashes were found in the architectural model. This caused anguish in the team who had already been overwhelmed with the initial numerous clashes. When investigated, it was found that a considerable amount of these in-

discipline clashes were between the objects modelled under the 'furniture' and 'internal walls' families. The representative of the architect re-assured the team saying that the clashes between the furniture and internal walls were normal at that stage because the locations of most furniture were not finalised yet. The design manager of the main contractor criticised the architect saying that he should not have exported the unfinished worksets for clash detection. However, the architect claimed that he needed to check the location of some of the furniture with other disciplines' design. Getting upset with design manager's criticism, the representative of the architect explicitly questioned the purpose of model-based working by stating that the real aim of model-based working must be to achieve clash-free construction, not a clash-free model at all times, because this was against the nature of design development. He further stated that if these 'normal clashes' caused an additional cost on the site, his company would be happy to pay for them. However, the design manager of the main contractor responded to this statement by reminding him that design models are not only discipline-specific design documents but would also be used for construction and operations, and therefore the targets and procedures in place were needed to be followed strictly to satisfy the multiple requirements sought from the digital models.

In this event, the 'simplified' and 'systematised' nature of the MP created a temporary breakdown in which one of the normal aspects of the architectural practice (i.e. workflow and design performance criteria) were questioned and re-interpreted. This put the architect's needs in conflict with the main contractor's and client's long-term benefits. Thus, the limitations of the technology created a prioritisation expressed as 'long-term benefits' but this was against the architect's operational needs.

Event 3: Shifted context of working as a designer

The client planned to use the information models for the operation of the building, and therefore was very much involved with the process of model development. In one of the meetings, the

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representative of the client brought an Asset Information Matrix (AIM), and asked the design consultants to create a new 'workset' in their models with the parameters specified in the AIM. These parameters were arranged according to the client's asset management system and classifications, and were different from the parameters required in the design models. The design manager of the main contractor expressed his concerns about this, because he thought that the parameters specified in the AIM might not be suitable for the design models which were mainly produced for the construction works.

This exposed the additional 'systematisation' required by the client's representative against the immediate one. Although the client's representative re-assured everyone saying that it should not be a problem, the design team supported the design manager. They decided that the situation was not as 'simple' as it seemed and that they needed to hold further ongoing discussions to fix naming conventions and well-defined linkages between the two worksets in order to make sure that both design, and maintenance worksets functioned properly.

This event involved members of the design team being exposed to a shifted context in which linking design and maintenance stages was possible through a 'simplified' and 'systematised' technological link (i.e. new model parameters). When this happened, the modelling practices were already entwined around a different 'simplified' and 'systematised' version of organising, and therefore it was not possible to accommodate easily the new requirements. However, the request came from the client expressed as a necessity of digital integration, and therefore the members of the design team were forced to re-structure their system of work to ensure that the two 'simplified' and 'systematised' versions of organising were coordinated.

Event 4: Shifted context of the relation between design and construction

In a mid-project meeting, the client representative informed the design team that a software extension to the existing MP was to be used in the project so that the site works and design models could be linked to avoid re-work during the production of the as-built models. Three months later, a meeting was held for the coordination of the handover of the as-built models to the client. In this meeting, it was revealed that there were some inconsistencies between what was modelled and what was built. The client representative stated that a laser scan of the building would be handed to the design consultants for them to upgrade their models to be as-built models with a maximum tolerance of 35mm. The discussions in the meeting were concluded with the decision that the design consultants would first list the incorrect parts in their discipline-specific models, and then discuss these parts as a team before making any corrections. This discussion was necessary because changing a part in a model to match the as-built situation could disturb the other parts of that and/or other discipline-specific models due to numerous parametric connections which represent the 'simplified' and 'systematised' form of the complex design intent. Consequently, the design team agreed to come together to look at all identified errors, and decide upon which ones to correct and which ones to leave. This resulted in the term 'model snag' which implied the things that needed to be completed or corrected in the information model; and these were different from 'site snags' which needed to be completed or corrected on the site.

This event shows that the rhetoric of digital integration of design and construction remained even after the initial failure of the 'simplistic' ideal of integrating design and construction through data integration, and thus re-shifted the context to modelling being about an accurate as-built model. This required a whole new digital data integration that was between the laser survey data and design models. The designers knew about the potential problems related to doing changes on the currently integrated dataset (i.e. the existing models), and therefore approached cautiously the situation

considering the troublesome nature of the already embedded 'simplification' and 'systematisation'. This shift required the spending of extra effort and undertaking more purely digital operations by the members of the design team. Eventually the distinct focus and efforts of resolving the problems in the digital realm created a new term (i.e. model snags) representing a new pattern of activities in the project which indeed ironically separated (i.e. instead of bridging) the differences between the digitally integrated design and physically constructed building.

ORDERING IN DISGUISE OF DIGITAL INTEGRATION

Design work in construction requires establishing and maintaining a multidisciplinary organisation that ensures effective interdisciplinary interactions to bridge a variety of expertise. The findings show that digital integration did not remove the continuous need for interdisciplinary interactions, but rather it changed the context of interactions due to its unresponsiveness to the multiple and evolving needs of multidisciplinary practices. Events exposed that the resolution of the resulting challenges to interdisciplinary interactions were also compromised by the inherent simplification and systematisation of digital integration. In these situations, the feeling of 'what to do' and 'what ought to be done', and therefore the courses of interdisciplinary interactions were shifted to accommodate the unresponsiveness of the technology. Observing four different situations unfolding in the same way suggests that it was the ongoing efforts for accommodating simplification and systematisation that underpinned novel patterns of interactions at the project-level. Therefore, while in each of the events the instances of accommodating unresponsive technology were experienced by practitioners as distinct, and task-specific professional issues, such as extra work or new aspects of the normal fraught of interdisciplinary interactions, indeed these were consequential in forming novel patterns of interactions which were mainly concerned with accommodating simplification and systematisation.

As a result, these developing patterns became the context for further interactions within which simplification and systematisation of digital integration were perceived by practitioners as a given.

Due to the inherent problematic nature of digital integration, change must be approached critically. This requires a better conceptualisation of digital-integration driven organisational change which acknowledges practitioners' perspective and role. For this purpose, the concept of 'ordering in disguise' is proposed to explain the fact that, the views of change from *outside* and from *within* are different but that the two perspectives are mutually constitutive and drive each other. The concept is argued to address the central difficulty in grasping and intervening in digital-integration driven change by enabling an association between organisational change and that experienced at practice-level. Ultimately, as will be shown, this can inform actions in steering the organisational change in practice as well as in policy-making and technology development.

Establishing the 'ordering in disguise' of digital integration

The concept of 'ordering in disguise' encapsulates the observation that practitioners, within the flow of their everyday interactions, do not see the change imposed by digital integration due to simplification and systematisation. The simplification and systematisation, in fact, organises the way tasks are presented to the practitioners. The practitioners experience the shifted contexts from digital integration, as feelings of 'what to do' and 'what ought to be done' (i.e. the logic of practice). This is apparent in the findings on the unresponsiveness of technology, and the interactions following on from these. For example, in Event 1 the slow calculation of the digital model of the mechanical system disabled the interactive design and required the modelling sequences to be altered. In Event 3 the existing model could not work with the information requirements of both the construction and

operation stages, thus extra work was required to compose a new model suited to operations and maintenance. Although the struggles and glitches appear to be entirely different to practitioners, the root cause of the change in interactions can be argued to be the imposition of simplification and systematisation from digital integration. The professionals engage in personal and organisational conflict and the real instigator is hidden to their situational experience; thus, emphasising the 'ordering in disguise' nature of the shift.

The essence of the concept of 'ordering in disguise' can be seen in previous work describing digital-technology driven change as 'subtle' (Suchman, 2007), 'unnoticed' (Ciborra & Lanzara, 1990), and 'invisible' (Bowker & Star, 2000). 'Ordering in disguise' grounds these arguments in a practice-based framework by relying on the assumption that practices and organisational structures are mutually constitutive (Orlikowski 2010; Schatzki 2001). This suggests that it is the gap between the experience of change from *within* practices and its resulting picture from *outside,* that led previous research to develop such adjectives about digital-technology driven change. Importantly, the concept highlights the problem posed by this gap in terms of comprehending and steering digital-integration driven change. It emphasises that this gap obscures the continuous effects of simplification and systematisation on the flow of everyday practices, as they are sustained and routinised, and thus, becoming harder to challenge or reverse. Each small event underpins shifts in practitioners' performances which ultimately (re)-produce and further drive the digital-integration driven change at various levels of organising the built environment.

Acknowledgement of continuity and pervasiveness of the 'ordering in disguise' effects of simplification and systematisation on everyday interactions is paramount in critically approaching digital-integration driven change. However, a more detailed understanding of how ordering in disguise works is needed in order to be able to recognise the change from *within*. Such insight will enable a better

understanding of and more effective intervention in digital-integration driven change at various levels of organising the built environment.

Unpacking 'ordering in disguise'

In the studied events, 'ordering in disguise' is implicated through two main mechanisms which are both connected to simplification and systematisation of digital integration. The first has to do with digital integration's disability to accommodate multiple systems of work; and the second has to do with the disability of the digital version of reality to hold relevance in the 'messy' world of multidisciplinary practices.

First, there was an ongoing struggle for agreeing on the system of work that underpins digital integration which was always biased to a certain view because of the inherent need for simplification and systematisation of technological operations. This aspect of digital integration was apparent in all events because each event describes a situation where one or more of the interacting parties perceived opportunities in inscribing their system of work as 'the' terms of the digital integration, often argued as achieving greater efficiency in work (e.g. in Events 2 and 3). However, in all instances this also meant burdens for others whose system of work fell outside the terms of the proposed digitally integrated system of work. Therefore, it can be argued that organisational boundaries become more visible and harder to cross in digitally integrated practices (as reported by Dossick & Neff, 2010; Neff et al., 2010) because of simplification and systematisation which continuously generate interdisciplinary conflicts over the scope, content, and procedures of digital integration. Importantly, the events suggest that those who have more knowledge about, better access to, or are in control of technology can gain advantage in such conflicts merely by setting (i.e. discursively and/or technically) and using a technological argument to legitimise their own point of view. This point resonates with Kallinikos (2006); Star and Bowker (2000); and Bowker and Star (2007) who claim that

the terms and logic of digital integration can create significant advantages and disadvantages to certain parties. However, establishing the lack of awareness of the continuous ordering effects of simplification and systematisation, allows a much more detailed understanding of the problematic operation of digitally-integrated diverse systems of work. According to this, such lack of awareness paves the way for gaining advantage through competition, conflict (e.g. in Events 1, 2), and hard to challenge technological arguments (e.g. in Events 3, 4). Thus, albeit inexplicitly, it continuously fuels disorganisation (Knights & Vurdubakis, 2005) of previous patterns of interdisciplinary interactions as well as gives increasing currency to a simplistic view of multidisciplinary organisation induced by digital integration.

Second is the struggle to maintain the digital version of reality in the face of unpredictably unfolding practices which then require undertaking extra tasks to maintain the digital model. Events 1, 3, and 4 end with the examples of how the perceived advantages and possibilities of digital integration were not realised in practice, and required extra digital work for rectification. Besides, Event 2 shows that significant human intervention was normalised in the practice of supposedly automated clash detection in order to adjust the digital system to be useful. Further evidence of the ongoing struggle was the continuing need for MCMs where constant effort was going into keeping the digital integration up and running as expected. Reading these findings through the lens of 'ordering in disguise' extends works of Whyte (2013) and Çıdık et al. (2014) by establishing the reason why practitioners have to engage continuously in interactions to keep the digital integration up and running. According to this, simplification and systematisation are key to the actual operation of practice as the unresponsiveness of the technology to multidisciplinary work is constant, thus determining the unfolding of work and eventually its organisation. However, every effort towards

keeping the system up and running further supports the simplification and systematisation which created the continuous need for maintaining digital integration in the first place.

This point mirrors Jaradat et al. (2013) who argued that the extra tasks that are required to support digital integration, changes the meaning of professionalism in construction. When seen from the lens of 'ordering in disguise', emerging interactions in digitally integrated practices cannot be seen by default as adding to the quality of multidisciplinary work, as a significant amount of these negotiations are only to keep digital integration up and running. Therefore, this paper raises the question whether the new technology-focused roles and the changing meaning of professionalism in built environment can be seen as positive changes; or whether they reflect wasted efforts to deal with the disabilities of digital integration in the face of complex interactions inherent in the built environment.

There is some evidence in the findings that enables insight regarding the way these two mechanisms of 'ordering in disguise' can be resisted in different situations. For example, Events 2 and 3 expose that it is very difficult to resist against the argument about long term benefits of digital integration, especially by those in authority, due to the remoteness and inaccessibility of the future practices that are claimed to benefit from digital integration. On the other hand, when the digital integration is between the practices that could be undertaken in non-digital ways, then integration tends to be more open to negotiations and settled as a set of digital and non-digital bundles of practices. Similar arguments have been provided by Harty (2008) who claim that the 'relative boundedness' of a digital innovation is critical in determining its implementation and diffusion path. Also Harty and Whyte (2009), and Whyte (2011) claim that 'hybrid practices' emerge when previous practices cannot be substituted with the novel digital ones. These arguments are extended here by the idea that it is the extent of the simplification and systematisation imposed by digital integration (i.e. in terms of both time and variety of practices) which determine the extent of its negotiability in the affected contexts,

thus leading either to new digitally integrated practices that are hard-to-challenge, or 'hybrid practices'.

Intervening in digital-integration driven change

The understanding of 'ordering in disguise' provides approaches to intervening in digital-integration driven change in built environment practices. This understanding shows that it is not just the imposition of complex unresponsive technology that drives the change but also about practitioners' lack of awareness and understanding of the effects of digital integration in the flow of everyday practices. In other words, it is not the technology alone that causes shifts in practices but rather it is the mutual constitution of the technological requirements and the people who see and act upon opportunities, possibilities, and constraints in organisational contexts. This leads to the argument that, when dealing with digital integration, management, policy-making, and technology development can intervene to avoid the damaging effects of 'ordering in disguise' both from *outside* and *within* in an interrelated way.

The argument that system of work of digital integration is always biased to a certain view suggests that active management is required during interdisciplinary interactions to avoid domination or interdisciplinary confrontations that lead to inefficiencies in multidisciplinary work. This explains studies of Dossick and Neff (2010) and Neff et al. (2010) who recommend the need for continuous negotiations or strong leadership in digital integration. Moreover, digital integration must be more subject to informed and open policy discussions to make best use of practitioners' experience and collaborative practices. Thus, there is a need for industry wide critical discussion to reveal the advantages and disadvantages created by certain technological rhetoric, standards, and/or processes which constitute an important part of shifted contexts of digitally integrated practices.

Finally, efforts in managerial, policy-making, and technology development must focus on offsetting the effects of simplification and systematisation in digital tools, and on creating practices which can effectively work with this. Different layers of digital integration can then be considered to give practitioners a flexibility to make informed decisions about the extent of integration that they would opt for. Essential for any intervention is the awareness of 'ordering in disguise' in all aspects of organising that are digitally integrated.

CONCLUSIONS

'Building Information Modelling' (BIM) and 'big data' are heavily promoted and researched as tools to more effectively integrate various organisations within the digital realm in order to produce benefits in building delivery and operation. However, the findings of this study show that digital-integration driven change in the built environment involves 'ordering in disguise' of the necessarily complex interdisciplinary interactions; and therefore, it must be approached critically, regulated openly, and managed practically.

The paper contributes more generally to theory on organisational change and its management through the insights that it enables. It demonstrates that a practice-based approach (Feldman & Orlikowski, 2011; Sandberg & Tsoukas 2011) relying upon a relational epistemology (Emirbayer, 1997) can effectively deal with the problematic nature of organisational change (MacKay & Chia, 2013; Meyer et al. 2005; Tsoukas & Chia, 2002; Quattrone & Hopper, 2001), as it provides a definition that jointly considers the abstract explanations of change and the empirically observable practices that are occurring in it. Based upon this, the concept of 'ordering in disguise' captures the interplay between the experiential and organisational levels, and contributes to theory by articulating the driving mechanisms of organisational change in terms of this interplay. Importantly, this conceptualisation highlights that practitioners lack the awareness of their own role in producing the change because

within practices, the change is experienced as everyday, and task-specific possibilities, opportunities and constraints. Therefore, the concept of 'ordering in disguise' provides an additional awareness, and an explanation of the struggles, of organisational change both for practitioners and researchers. Consequently, the insights enabled herein by the reflections and the concept constitute an important step forward in bridging the gap between the 'theory' and 'practice' of organisational change management; a problem which has been criticised in previous research (Saka, 2003; Pollack, 2015). Further, the paper contributes to theory about the impact of digital technology on multidisciplinary practices by developing and using the relational concepts of simplification and systematisation for a joint and critical analysis of organisational and experiential levels. This exposes that the 'ordering in disguise' of simplification and systemisation by digital operations is fundamental in comprehending the nature, development, and sustainment of digital multidisciplinary practices; thus, paving a way for much needed further critical research as identified by Whyte (2013).

Although the ideas were derived from a limited quantity of evidence and the concepts used are explanatory, these do not limit the contribution of the paper in setting a novel critical perspective to understand digital-technology driven change in the built environment and multidisciplinary practices elsewhere. More studies are required to test the conception proposed in this paper in more empirical contexts in order to develop a further refined understanding of how 'ordering in disguise' works. This will enable a better understanding of digital-integration driven change and a better chance for informed intervention in the ongoing change, surfacing the political decisions at organisational level, and ethical and aesthetic ones at institutional level, with social and material consequences for the practices that rely on them. Therefore, the development of digital technology and its management must involve discussions grounded at ethical, aesthetic and political levels (Star & Bowker, 2007) in addition to the technological and economic ones. For this, more practically-relevant ways of thinking

and talking about the digital shift are needed. This paper takes a step in that direction through introducing the concept of 'ordering in disguise', and encouraging further studies on the gap between lived practices and the policies and managerial approaches in the built environment and multidisciplinary practices elsewhere.

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