Exploring the influence of sociohistorical constructs on BIM implementation: An activity theory perspective

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Building Information Modelling (BIM) has been widely acknowledged as a new paradigm to transform the construction industry. However, scholars have acknowledged that neither widespread BIM implementation nor the envisaged systemic changes within the sector have taken place. Despite acknowledging that the industry’s conditions and embedded contexts shape innovation’s diffusion, existing studies have not explored in depth ‘how’ the context might influence the episode of change when a new technology is introduced and new practices accompanying technology and old practices co-evolve. By adopting activity theory, its concepts of contradictions and multiple layers involving the activity system, in this paper we explore the interaction between situated and existing practices or the ‘how’ of implementation, i.e., how the activity system is questioned and redefined in the episode of technological change. Drawing on multiple case studies data, our findings demonstrate that situated practices related to the definition of information requirements, the production and the handover of information were re-enacted following institutionalised sociohistorical constructs (e.g. norms, rules, division of labour) at the industry and organisational levels. The findings provide insights regarding inertia in the transformation of the sector as also deriving from re-enactments of sociohistorical constructs that mediate the institutionalisation of situated practices. Our findings reveal re-enactment as part of the transformation process and contribute to calls for more realistic views on BIM implementation.

Keywords: BIM; activity theory; change management.

Introduction

Building Information Modelling (BIM) has been widely acknowledged as a ‘new paradigm’ in the architecture, engineering and construction (AEC) industry, with proper implementation is expected to enable a range of benefits and the transformation of the industry (Lindblad 2019). In the last years, many countries have started to introduce programmes and new policy for the progressive use of BIM, and there is seemingly no
end to the hyperbole surrounding its potential to revolutionise the industry (Dainty et al. 2017).

BIM is considered as a systemic innovation (Lindgren 2016) – a type of innovation that cuts across traditional discipline and supply chain boundaries and requires changes to the system integration of the project (Hall et al. 2018). Despite the claimed benefits, because these types of innovation cross professional specialisation and redefine how work is done, they are less likely to be adopted in projects in comparison to incremental innovations (Hall et al. 2018). In the case of BIM, despite the promulgated benefits, scholars have acknowledged that the widespread BIM implementation has not taken place (Lindblad 2019) and the envisaged systemic change within the sector has not occurred (Aksenova et al. 2020).

Indeed, the AEC industry is considered a complex social system for innovation, with a range of contextual factors influencing innovations implementation and diffusion (Shibeika and Harty 2015). Past research has already posited that industry’s overall characteristics (e.g. the socio-cognitive environment, the market and production environment and the institutional actors) shape innovation, such as the adoption of information and communication technologies (Jacobsson et al. 2017), making implementation of innovations more complicated (Dowsett and Harty 2019). Despite acknowledging that the industry’s contextual and structural conditions shape innovation’s diffusion and that the industry might be caught in a ‘mirroring trap’ when implementing systemic innovations such as BIM (Hall et al. 2020), existing studies have not explored in depth how industry’s characteristics may influence the episode of change and emerging practices when, for example, a new technology is introduced and the new practices accompanying the technology and the old practices co-evolve. In other words, there is a lack of a deeper understanding on how contextual aspects might
influence the institutionalisation of new practices accompanying technology implementation or the impacts on how the change unfolds. In fact, in the case of BIM, most of the existing BIM discussion has assumed that the BIM discourse and the prescriptions that follow it are readily accepted (Smiley et al. 2014), with an overemphasis on the positive aspects of technology adoption in isolation of the implementation process (Dowsett and Harty 2019). The real influence of context and environment in the innovation process has been ignored in the BIM implementation literature (Poirier et al. 2015). However, exploring ‘how’ embedded contexts influence the unfolding of and institutionalisation of the innovation can provide insights to understand why change has not widespread and happened as envisaged.

Thus, in this paper, we explore ‘how’ aspects within the context of where the innovation is implemented influence the dynamics of institutionalisation of new practices following from the interaction of multiple contexts when these new practices are introduced accompanying new technologies, such as in the case of BIM. Sociohistorical constructs guiding practices may originate simultaneously from, for example, the professional context and the organisational context (Groleau et al. 2012). We draw on activity theory as a practice-based approach and theoretical framework in which the concept of socio-historically anchored contradictions plays a central role (Engeström 2001). In other words, activity theory allows to analyse change as a transformation process punctuated by contradictions, acknowledging multiple contradictions that emerge in projects when new technology and practices are introduced. Also, activity’s theory analytical framework allows to model projects as arenas in which multiple strands of sociohistorical contexts manifest themselves in the performance of activities (Kaptelinin and Nardi 2006), being thus a good framework to explore interaction and subsequent unfoldment taking into account multiple contextual
aspects. Moreover, in comparison to social theories that account for the structural context and that could be used to analyse the episode of change, such as structuration theory, for example, activity theory allows to take into account not only the role of human agency, but also the role played by technology (Groleau et al. 2012). Analyses of activity systems have been applied by past studies to capture the processes involved in organisational change, identify systemic contradictions and tensions that shape episodes of change and identify guidelines for designing interventions (Yamagata-Lynch 2010).

By adopting activity theory to account for the tension between and the coexistence of emergent BIM practices and institutionalised practices from embedded contexts we aim to address the calls for more research exploring the real nature and dynamics of change associated with BIM implementation (Çidik et al. 2017, Akintola et al. 2020) and more critical views on the practices that are being normalised through policy discourse (Dainty et al. 2017). In other words, the analysis of the activity system within the episode of change allows to identify systemic contradictions and tensions that shape the episode of change, interactions that emerge and ultimately may also provide insights which can be used to input the design of future interventions.

Past research has already acknowledged the effects of the context on the translation and routinisation of management initiatives, positing that understanding change in project-based contexts requires recognising the complex counterpoint between change initiatives and the existing project context (Bresnen et al. 2004). Thus, we apply activity’s theory concepts of contradictions and multiple layers involving the activity system to explore patterns of interaction between situated and existing practices and on how the activity system is questioned and redefined in the episode of technological change. The findings also help to extend the understanding of the
conditions surrounding implementation beyond the acknowledged critical success factors for BIM adoption and implementation by existing literature, such as the availability of qualified people, training, client demand, top management support, cultural change, etc., (Antwi-Afari et al. 2018; Awwad et al. 2020). Moreover, as previously mentioned, although previous research has already acknowledged that structural characteristics from multiple embedded contexts influence the adoption and implementation of innovations such as BIM (Poirier et al. 2015; Jacobsson et al. 2017), the patterns of interaction identified through the lens of activity theory sheds light on aspects related to dynamics of the institutionalisation of the innovation. The findings provide a more detailed view of the process of challenge emergence - when new tools and process are implemented - resolution and persistence as part of the transformation of the project activity system (Groleau et al. 2012), helping to explain why the transformation of the sector has not occurred in the envisaged pace and way. Also, although activity theory has been previously applied by construction management scholars (e.g. Gade et al. 2019; Akintola et al. 2020), we extend its adoption by exploring some of its unexplored principles to analyse unexplored aspects of the practical implementation of BIM, i.e., the ‘how’ of implementation.

The remainder of this paper is organised as follows. The next section provides an overview of the literature on innovation and change within the AEC industry including BIM implementation and the theoretical framework based on activity theory, which lays the theoretical foundations for the research design. The research method is then presented, followed by the analysis of the project activity system, contradictions and identified sociohistorical constructs influencing implementation unfolding. The paper ends with a discussion on the contributions, limitations and suggestions for further research.
Theoretical background

**Innovation and change in the AEC industry**

Scholars have acknowledged for a long time that change and transformation of the AEC industry, specially driven by new technologies, is quite slow when compared to other sectors (Jacobsson *et al.* 2017). The AEC industry has been considered as conservative and reluctant to change and adapt to external environment’s requirements (Gustavsson 2018). The project-based nature of construction activity, the complexity of construction work, and the fragmented and dispersed nature of construction organisations are some of the factors that make change difficult to achieve (Bresnen *et al.* 2006). Organisational and structural characteristics of the AEC industry posit challenges that are related to, for instance, the inter-organisational nature of construction projects and firms that cause innovations to have ripple effects over multiple spheres of influence, the tensions between the unique and changing project processes and firms’ standardised processes and the double-edged project-based learning which is found to be problematic and difficult to capture (Harty 2005; Shibeika and Harty 2015). The socio-cognitive environment, market and production environment and institutional actors within the industry also influence in the adoption of innovations and change (Jacobsson *et al.* 2017).

Moreover, it has also been acknowledged that, given such structural and organisational characteristics, some types of innovation and change are even more difficult to implement (Hall *et al.* 2018). Innovations that reinforce and align with the existing industry’s characteristics diffuse faster than systemic innovations which are holistic and relational to their nature and require coordinated change of processes by multiple firms (Lindgren 2016). Scholars have posited that systemic innovations are one-third as likely to be adopted in AEC projects in comparison to incremental
innovations that fit within existing discipline and structural characteristics (Hall et al. 2018). These types of innovation, however, are claimed to be the ones which often offer superior system-wide gains in performance (Hall et al. 2018).

Aiming to understand the implementation of such types of innovation, empirical research has focused on identifying factors that influence its diffusion. Those include organisational variety, degree of interdependence in tasks and boundary strength between trades and span (Taylor 2006; Lindgren 2016). Harty (2005) has also identified that established roles, distinct disciplines and traditional cultures provide implications for systemic innovations implementation. Organisation of work in phases with clear boundaries is another factor hindering systemic innovations diffusion (Hartmann et al. 2009). Hall et al. (2020) have also pointed out that norms, standards and regulations have institutionalised over time until the construction industry has found itself caught in a ‘mirroring trap’, and the knowledge about design, engineering and construction are deeply embedded leading to resistance on attempts to innovate at the system level (Hall et al. 2020).

Despite previous research has acknowledged the influence of a range of factors on systemic innovation diffusion, understanding ‘how’ the contextual characteristics within the AEC influence the practical implementation of systemic innovations seem to be limited. In other words, while it is relevant to understand the factors related to adoption and diffusion, diffusion in and of itself does not equal legitimation of new practices (Scott 2014). Understanding how legitimisation occurs in practice is relevant to better understand how the change process takes place and requires exploring the dynamics through which the change unfolds. But as pointed out by Dainty et al. (2017), there is still a small body of academic research examining the ‘real-world’
implementation of BIM processes in organisations and projects, the systemic innovation under analysis in this research, as discussed next.

**BIM adoption and implementation**

Calls for productivity improvement and changes in the way the construction industry delivers its products and services have led to a host of new initiatives within the sector in recent years, including the use of new technologies (Bresnen et al. 2006). One of such initiatives has been the mandatory use of BIM in projects as a policy shift that many countries, such as the UK, have started to introduce.

The literature on BIM adoption and implementation has grown considerably in recent years, along different streams of research including both technical and managerial aspects. Along the management stream, there are studies examining both BIM adoption (which refers to the decision to make full use of BIM) and BIM implementation (which occurs once BIM is put into use). The terms, however, have often been used interchangeably (Ahmed and Kassem 2018). Despite that, implementation and change related to BIM has been recognised as complex, and scholars have started to acknowledge that actually, BIM has led neither to a systemic change nor to a business transformation within the sector (Aksenova et al. 2019).

A range of studies have identified factors affecting BIM adoption and implementation. Those include factors related to technology, such as failure in technology support, interoperability challenges across project lifecycle, complexities involved in adopting new tools (Vass and Gustavsson 2017; Oraee et al. 2019). Lack of resources, skills and training, and changing working practices (Vass and Gustavsson 2017) are other frequently mentioned barriers for successful implementation. In terms of contextual factors, existing studies have highlighted that the dynamic and fragmented nature of the construction industry, lack of contractual standards, different
organisational structures in multidisciplinary teams, and culture of the industry as hindering implementation (Oraee et al. 2019). Poirier et al. (2015) identified four embedded contexts mediating the BIM adoption and implementation process: the organisational, project, industry and institutional contexts.

While the influence and relevance of a range of factors, including contextual factors, have been recognised, less is known about their effects on how innovation implementation unfolds. However, exploring how implementation process takes place and unfolds in practice and its complexities may provide more answers to the recent observations on the lack of change and business transformation within the sector (Aksenova et al. 2019). As highlighted by Fox (2014) and Akintola et al. (2020), the literature is still limited in explaining the actual change process related to BIM and to systemic innovations in general. Few studies, however, started to emerge applying practice-based approaches to investigate some aspects related to dynamics of the change, as outlined next.

**BIM implementation through the lens of social theories**

Since scholars started to acknowledge the need for research with a more realistic view of the conditions for BIM implementation (Miettinen and Paavola 2014), some studies applying practice-based theories have started to emerge. Practice-based theoretical lenses such as the ones provided by structuration theory, activity theory and actor-network theory (ANT) have been applied in few studies to explore micro-level change processes related to BIM (Table 1). These theories have been viewed as promising in terms of supporting a better understanding of what happens in projects, what practitioners do, and the practical rationalities involved in their actions (Floricel et al. 2014). Indeed, these social theories offer a more grounded approach to understanding activities related to innovation, as in the case of BIM implementation (Harty 2008).
These three theories are particularly useful to investigate BIM implementation because they emphasise the role of actors and their interactions in creating and maintaining the properties of organisations and projects (Floricel et al. 2014).

The application of ANT is relatively recent, but it is widely used to understand organisational change following the implementation of information systems (Lindblad 2019). Through the lens of ANT, BIM implementation is conceptualised as the creation of an actor network, and this theory enables the analysis of how different actors are influenced by new technology implementation and how their roles and relationships change (Lindblad 2019). BIM is viewed as a translation process whereby actions are taken to create an actor network around BIM (Lindblad 2019).

Applications of structuration theory explore the effects of the relationship between structural conditions and agency on attempts to introduce change. Structuration theory, however, is still rarely applied in the context of projects. Bresnen et al. (2004), for example, applied it to explain the diffusion of new management initiatives in construction firms. Through the lens of structuration theory, the authors found that the take-up of new management practices could be significantly influenced by attenuated links between construction firms and distributed project management practices. With regards to its application in the context of BIM implementation, very few studies apply the structuration lens to understand the change process. Among them are Morgan (2019), who used structuration theory to demonstrate that BIM adoption is facilitated by a mutually constitutive relationship between the user, firm and institution. Morgan’s (2019) findings showed that the diffusion of BIM in a firm takes place through a combination of actions involving investment and leadership support, standards and policies and training and skills development. Papadonikolaki et al. (2019) adopted a
structurational view of BIM-based collaboration and explored the interplay between structure and agency of collaboration.

Although ANT takes into account technology as a non-human actor which in its involvement in the network influences all other actors in their link to the network and consider multiple actors involved, it does not account for embedded contexts in the innovation process. On the other hand, while structuration theory accounts for the context and allows to explore how pre-existing representations at the level of the broader social field and specific representations to the project context, it is difficult for structuration theory to reconcile the structural properties of technology and human agency (Groleau et al. 2012).

Another lens that has emerged on BIM implementation investigation and that account for the previously mentioned limitations is the one provided by the activity theory framework, which examines situated practice and considers both its material and social dimensions as well as its embeddedness in multiple socio-historically extended contexts (Groleau et al. 2012). However, as is the case for structuration and ANT, only a few studies have applied activity theory in the context of BIM research. Among those, Gade et al. (2019), for example, used activity theory to analyse the design process and investigate the consequences of using BIM tools in a collaborative building design setting. Akintola et al. (2020) explored organisations that had implemented BIM within their organisations and multi-organisational projects and used activity theory to examine how professional work practices evolved. Their findings reveal dynamics between and within the interconnected system of actors, objects, tools, rules and roles. Maki and Kerosuo (2015) applied the activity theory approach to study actual BIM use in site managers’ daily work.
Although the previously mentioned studies have used the activity theory framework to study details of practices and the activity system, the dynamics of BIM institutionalisation following the interaction between existing and new BIM practices have not been explored through the lens of the activity theory framework, i.e., those studies do not reveal much about ‘how’ the implementation process takes place. The analysis of the activity system, however, offers an opportunity to explore the tensions among the sociohistorical constructs that originate from multiple sources and to guide project practices via a study of evolving work practices during a change episode (Groleau et al. 2012), allowing to explore the effects of socio-historical constructs on how the institutionalisation of BIM occurs. The application of the activity theory framework is extended here to cover the impact of sociohistorical constructs on how change unfolds, leading us to challenge the perceptions of BIM enactment as a linear process (Dainty et al. 2017) and contributing to the understanding of the possible reasons on why the envisaged change has not occurred (Aksenova et al. 2019).

**Activity theory and the conceptualisation of BIM projects as activity systems**

Activity system analysis supports a systematic and systemic approach to understanding human activities and interactions in relation to their context, and how individuals, activities and the context affect one another (Yamagata-Lynch 2010). Activities are collective and motivated by the need to transform an object (the motive behind the activity) into desired outcomes. Thus, the outcome of an activity system is the end result of the activity. The goal of the activity gives sense and direction to actions, which are carried out by the subjects (individuals or groups) and which are oriented towards specific or finite goals. Actions, which are intentional, are mediated by tools, which include material artefacts and are the resources for the subject in the activity. Engeström (1987) also recognises that activity systems involve rules and norms, division of labour
and the community as interrelated elements that influence the activity. Rules and norms, formal or informal, affect how the activity takes place. The community is the social group to which the subject belongs while engaged in the activity and is composed of individuals sharing an interest in and influencing the unfolding activity (Groleau et al. 2012). The division of labour refers to how the tasks are shared among the community.

As highlighted in past research (Akintola et al. 2020), a project activity system is driven by the communal motive of delivering a built asset at the end of the project to satisfy the client’s needs and achieve the overall business outcomes (Figure 1). BIM is about producing and managing digital information efficiently, with the aid of digital technologies, to inform decision making over the project lifecycle. Adoption of BIM technology and information management process is driven by the perception that BIM improves productivity for service providers while enabling them to meet clients’ constraints of time, quality and budget better than they could using CAD (Sacks et al. 2018). Thus, BIM tools and information management processes have emerged to achieve a specific set of desired outcomes within the activity system and solve existing ‘contradictions’, at the same time that its introduction generate new tensions.

Figure 1 around here.

The activity system’s subjects are the project team members involved in carrying out the activity (actions and operations). As noted by Engeström (2001), different individuals speaking in different voices take the leading subject position in the activity at different moments, depending on the action being performed. The community and the environment in which the activity is carried out includes, for instance, the client, asset operators and maintainers, users, statutory bodies, government and professional
bodies. Different individuals influence the unfolding activity at different moments. The tools mediating the activity include discipline-specific tools, documentation, team knowledge and collective tools (e.g. a common data environment [CDE]). The division of labour is redefined with the emergence of new roles (e.g. individuals undertaking the information management function) and the redistribution of responsibilities within the project.

The formal and informal norms and rules governing the performance of the activity include the new BIM-related standards and specifications, the procurement/delivery approach, new contractual agreements/obligations, new guidelines and new protocols as well as the existing pre-BIM formal and informal, implicit and explicit rules and norms governing the project activity system, which coexist with the new ones. All the previously described elements frame the different actions that compose the BIM project activity system and are articulated by the participants. Table 2 summarises how those elements mediate interactions within the activity system.

Table 2 around here.

Activity theory can be summarised via five principles (Engeström 2001), and two of those principles are considered here in the exploration of BIM implementation. The principle of multi-voicedness of activity systems allows to account for projects as embedded in different social contexts. This principle posits that activity systems consist of communities with multiple points of view, traditions and interests. The activity system carries multiple layers and strands of history engraved in its artefacts, rules, norms and conventions, which may be a source of both trouble and innovation (Groleau et al. 2012). The other principle addressed here is related to the central role of contradictions as
sources of change and development (Engeström 2001). According to the conceptualisation of contradictions (Engeström 1987), contradictions can be divided in four levels, which are generally collapsed into one generic contradiction by scholars exploring the framework (Groleau et al. 2012), but which are considered separately here to address the unfolding of the implementation process. We conceptualise BIM implementation as an attempt to solve a primary contradiction within the project activity system, as previously described. When BIM is introduced into the project activity system, the tools and practices are integrated into existing tools, rules, and division of labour to realise the object. The new tools and practices, however, are embedded in its own sociohistorical context, introducing new voices, traditions, and interests within the activity system that interact with the existing ones. Drawing on those principles, the institutionalisation of BIM in practice can be further explored, as outlined next.

**Methods**

Scholars have posited that more empirical research through case studies is needed to avoid simplistic explanations of innovation patterns in construction (Orstavik 2014). Indeed, understanding how contextual factors influence how the implementation of systemic innovations unfolds in practice required a naturalistic research design, meaning that operating within the context was necessary to have access to and make sense of the subjective and socially constructed meanings. Thus, an interpretive philosophy and case-study strategy were chosen, as case studies are powerful research approaches to explore a phenomenon within its context (Saunders et al. 2012). Case studies are also a relevant strategy to gain a rich understanding of the processes being enacted (Eisenhardt and Graebner 2007), as aimed in this study.

The UK was selected was the best setting to explore the practical implementation of BIM because it has been considered as a highly mature country on
BIM adoption (Kassem and Succar 2017). The units of analysis were defined as construction projects in which the BIM Level 2 mandate - as set up by the UK’s government in 2011 - has been implemented, which included implementation across all stages. A multiple-case design was chosen because of its capacity for demonstrating replication. The cases were chosen considering theoretical replication (Saunders et al. 2012; Yin 2014), meaning that the cases were selected to identify if they predicted contrasting results or if the influence of the contextual factors repeated across the cases.

Seven construction projects from two different client organisations were analysed longitudinally. We selected projects from the same context that were fully applying what was previously called BIM Level 2, in order to analyse projects that adopted the same approach to BIM, applied the same practices, and shared the same wider context. In other words, as the goal was to identify patterns on the interaction between existing contextual aspects and new BIM practices, we selected cases that had a similar context – similar types of projects in terms of complexity (institutional buildings – school and university buildings) and in terms of the approaches followed in the project (e.g. plan of work), and similar type of client organisation and organisational context (organisation that owns and operate the estate).

The client organisations, however, differed in their motivation for BIM adoption. One of the client’s organisation started to implement BIM in its projects mostly because of technical reasons, and the other organisation is a public sector client and implemented BIM as part of government’s mandate. Because we aimed at exploring the interactions between existing sociohistorical constructs and new BIM practices and understand its effects on implementation independent on the motivation for adoption, we selected projects where BIM implementation was driven by different reasons. Past
research has suggested that BIM implementation and project teams’ actions are affected by the motivation for adoption (Papadonikolaki 2018).

Multiple data collection techniques were employed to collect data on enactment of the BIM level 2 approach across the stages of the project. Observations of meetings, (shadowing of project stakeholders), semi-structured interviews, document analysis and secondary data analysis constituted the bulk of our data (Table 3), through which we documented the performance of practices as part of the activity system as they took shape through interactions during different stages of the projects. All data collected were transcribed and compiled. The software NVivo 12 was used afterwards to support data analysis.

Table 3 around here.

The observations covered a fourteen-month period and involved participation in six of the seven projects considered in this study. For these six projects, the first author was embedded inside the client organisation and could directly observe the projects’ work (i.e. playing the role of observer-as-participant, Bryman and Bell 2011). For instance, the first author attended project meetings, BIM coordination workshops and design review meetings. Notes were taken during and after the meetings to document details of how and under what conditions the work practices unfolded.

There is, however, a limitation related to collecting data through observations in projects. It is difficult to observe an entire project process, as contract periods are typically lengthy and sometimes it is not possible to gain a whole-project view. Therefore, interviews were conducted to collect extra information about work practices in stages of the projects that had been completed before the data collection started.
The interviews covered questions about each stage of the project lifecycle, including actions taken to implement what constituted the BIM Level 2 approach in the respective stage and how work has been carried out. For the other client organisation and respective project, for which it was not possible to collect direct data through observations of daily work (only by attending some meetings), we mainly documented the performance of activities through interviews and workshops with project team members. The data collection for all cases was supplemented by document analyses, as previously mentioned. As recommended in the activity theory literature (Yamagata-Lynch 2010), we applied multiple data-collection strategies and triangulated the data to increase validity. In other words, we triangulated data from different sources to understand how the implementation unfolded, following what has been recommended by the BIM Level 2 approach, and how practices have been enacted. For example, regarding production of digital information, we triangulated data on how information has been produced and exchanged gathered through interviews with discussions on the data exchange processes during meetings. In terms of definition of information requirements, we triangulated the data gathered through interviews on how those requirements were defined with analysis of the project documentation. Thus, by combining different sources, we had an in-depth understanding on how implementation took place.

Table 4 around here.

Before starting the data analysis, an analytic strategy was defined as recommended by Yin (2014). The analytic strategy chosen consisted of working the data from the ground up, which means closely examining the activity system and
enactment of the BIM Level 2 approach without prior theoretical propositions. Previous research looking at practical enactment of practices has also adopted an inductive reasoning as the one adopted in this study (e.g. Bromley et al. 2012; Groleau et al. 2012). A content analysis of the transcribed data was undertaken. First, we coded the data by considering the practices that it was referring to (i.e. definition of information requirements, production and delivery of information and handover of information) and the explanation related to how the practice was enacted, in a chronological order following implementation across the project stages. We reconstituted the activity system by looking at the data using themes from the activity theory framework, i.e., tools, rules, division of labour, etc. Then, we took the data grouped across the lifecycle stages and focused on analysing the change within the project activity system. By taking the concept of contradiction as an analytical tool (Groleau et al. 2012), we analysed the contradictions that emerged within the project activity system because of BIM introduction. In the change process, not all changes create tensions within the existing activity system, but we focused on those that created tensions to explore how those tensions have been solved and the implications on how implementation occurred, as shown in the following sections. We then analysed the transformation of the activity system and how the tensions have been solved, i.e., we analysed how the wider sociohistorical context became manifest in the contradictions and how they influenced the process through which the situated practices following the implementation of BIM Level 2 have been reconstituted by the project members. Sociohistorical constructs are related to aspects from embedded contexts, as identified by previous research (Poirier et al. 2015) and considered in this research as being the organisational and industry contexts. Moreover, within the analytic strategy, we also employed a cross-case
synthesis technique to identify patterns on how those contextual aspects influenced enactment.

Regarding the quality of the research design, according to Easterby-Smith et al. (2018) the criteria to assess the validity of a qualitative research design involve the consideration of multiple perspectives, including access to the experiences of those involved in the research setting. We considered the perspective of multiple project team members in the interviews and by collecting data through observations, i.e., by having direct access to the real experience of those involved in the research setting. The multiple-case research design provides the basis for theoretical generalisation as the findings are observed across all projects, independently of the client organisation and motivation for adoption. Construct validity of the data was verified by having multiple sources of evidence and by having a draft of the case study reports read by key project members (contractors’ and clients’ information managers/BIM coordinators involved in the projects) (Yin 2014). With regards to reliability of the research design, transparency is demonstrated by references to the data (e.g. quotes of the interviews illustrating the findings discussed next), and replication is addressed here by describing the research strategy in detail.

**Results and findings**

*BIM implementation and contradictions within the project activity system*

The practices that take place in a project activity system are accounted for by the existence of habitual scripts that dictate the order and type of practices in projects. These practices are framed by the existing tools, rules, norms, conventions and the established roles arising from the division of labour that come from different embedded contexts. When new information processes and technologies are
introduced into the project activity system as part of BIM, there are changes in the practices/scripts. As shown in Table 1, new division of labour, new rules and new tools mediate interactions within the project activity system. In other words, BIM implementation initiates a series of transformations through which the conduct of activity within the project activity system is redefined. The analysis of how BIM has been enacted revealed tensions that confronted long-standing practices, as outlined next.

_The emergence of a new division of labour._ Data revealed that the emergent division of labour and changes in the way that tasks are traditionally distributed created tensions that endured over projects’ lifecycle. For example, in terms of changes on the way stakeholders interact because of new roles, more involvement of facilities managers in the information production and delivery practices as required for the production of a fit-for-purpose information model, for example, created tensions within the client organisation and between the lead contractor and the client organisation, as highlighted by a digital engineer for one of the projects (project 05) of organisation’s A:

“When producing information, facilities managers were coming to us for what they wanted, rather than through their own team, which sometimes blurs the lines about who should be doing what, and when”.

Conflicts also emerged regarding the redistribution of responsibilities through which the parties strive to achieve the object of the activity system, for example, in the production of the information models, as highlighted by a project manager (organisation’s A project 03):

“I think there was some confusion where we’d expect the design team to update the model if there were any design changes, but there were also the expectations it
would be updated so it was the correct level of detail by the end of the project. But then the onus seems to be coming back to the main contractor to update a consultant’s information. It’s not ours, so there is some conflict there and it hasn’t been as smooth”.

While it is acknowledged in the literature that effective multidisciplinary collaboration through BIM requires changing the roles for all project stakeholders, re-organising collaborative processes, new contractual relationships and a shift in mind-set of parties (Akintola et al. 2020), analysis of enactment confirmed that, in practice, real implementation is mediated by contextual aspects that may lead to enduring tensions and reproduction of long-standing practices. Similar tensions occurred for conflicting new rules with the existing ones, as discussed next.

*The emergence of new rules and norms.* The implementation of BIM Level 2 is related to a range of standards (e.g. PAS 1192 suite of standards) and associated rules and norms that aim at guiding how practices are conducted to realise the object and how different parties interact. Moreover, as widely known, BIM also requires a collaborative approach. Data confirmed that the coexistence of new rules and norms based on collaboration and existing rules and norms focused on more linear work activities (e.g. from the plan of work) and functional specialities and ways of working where participants view themselves and services they provide independently (Matthews et al. 2018), even for more collaborative delivery methods, led to enduring tensions, as highlighted by a digital engineer when talking about interaction in the design and construction stages (organisation’s A project 05):

> Once they’ve done their element, they won’t then come back to it. So how can you overcome that? I suppose you have to get them to keep coming back to it and say, “Well, this is what we had to change of what you did, because of these reasons.” I think, maybe, there’s a resistance to that, from their end, in that they have their
ethos. This is how they implemented that, that is the reason, and they’re not really too bothered about how someone else might do it and update the models.

Tensions between new rules and norms and rules institutionalised at an organisational level also emerged, as for example, in the case of organisation’s B existing rules to appoint contractors and the new emerging rules to appoint them based on their BIM capabilities:

“We get criticised if we don’t allow smaller contractors onto our frameworks. So, we can’t allow BIM to be a pass/fail kind of thing in our projects”.

Thus, data revealed that, project team members, when enacting the situated practices where there were tensions, interpreted the new rules as a reproduction of the ones existing within the activity system. In other others, although there were new rules, standards, roles, etc., established, the unfolding of implementation has been influenced by institutionalised practices. The new tools introduced to support the realisation of the object of the activity system also created tensions, as described next.

The introduction of new tools. Data revealed that new tools introduced to support the realisation of the object and that mediate the interactions between the subject and community led to tensions over the project lifecycle stages. Previous research has already posited that lack of interoperability is a major inter-organisational challenge for BIM implementation (Vass and Gustavsson 2017). Data revealed that tensions were created because of interoperability issues related to the use of new tools and the modelling approach adopted, as highlighted by an information manager (organisation’s A project 01):

“ If you’ve got your building modelled as it is with the tool used before, you can’t just press a button and put it into your thermal modelling software because the software won’t understand any clashes, so you need and certain M&E
consultancies have developed scripts that basically take this rather complex model of a building and turn it into something that can be digested by the thermal modelling software and then to do something”.

The institutionalised ways of working, focused on linear and functional work activities, contributed to each discipline to concentrate on the use of the most appropriate tools for its specific work activity without strictly considering next uses of the information model. Indeed, in face of tensions, it was observed that existing sociohistorical elements played a role on how the implementation unfolded, as discussed next.

**Interaction between situated practices and institutionalised practices**

The analysis of practical enactment revealed patterns of interaction within the project activity system. Particularly, patterns through which situated practice replicated existing institutionalised practices could be observed. Through the re-enactment of sociohistorical constructs from both industry and organisational contexts, we observed how the project activity system was questioned and redefined through the episode of change. Although there were situated practices that challenged existing ones, replacing those, and practices that were accommodated with existing ones in the project activity system, data revealed that a range of situated practices reproduced an institutionalised practice at the industry or organisational levels, confirming the influence of embedded contexts and its sociohistorical constructs. In other words, the findings highlight aspects of the institutionalisation of situated practices, as illustrated next.

*The influence of the industry context*

The data revealed many instances where situated practices were enacted following institutionalised sociohistorical constructs at the industry level (i.e., norms, rules,
division of labour and tools), such as codes of conduct, resources distribution, professional work as part of bodies of knowledge, as shown in Table 5.

Table 5 around here.

In terms of information requirement specifications, BIM implementation leads to a change in the project definition practices at early stages of the project because information requirements also need to be identified alongside other conventional project definitions. For the physical asset delivery, the existing industry code of conduct recommends involving key stakeholders in the process (e.g. a soft-landing champion) to ensure that the design optimises operational performance. The institutionalised plan of work also suggests that the built asset operators are consulted.

With regards to the definition of the information requirements, the information users, especially during the operational phase, are supposed to be consulted and get actively involved. However, traditionally as per codes of conduct, the facility manager’s effective involvement in the asset data-management process commences at the handover phase (Alnaggar and Pitt 2019). The definition of information requirements in a BIM context therefore involves a new division of labour in mediating interactions, with new responsibilities among stakeholders. Our data showed that the institutionalised codes of conduct and division of labour that coexisted in the project influenced the way in which the action of defining information requirements was enacted. For both organisations and respective projects, the definition of the information requirements was performed following the industry’s institutionalised code of conduct.

For organisation’s A projects, the information requirements were developed by an internal team with the support of external consultants and in consultation with some
major contractors, and it did not actively include all information users, as would be expected. Yet, it was claimed in the BIM project documentation that asset managers were consulted. The lack of involvement of the final users of the information resulted in issues during information production (i.e. it influenced the way in which BIM was institutionalised in organisation A’s projects), as noted by a digital engineer:

> In my opinion, the content of the client’s current employer information requirements still needs the client’s expertise adding to it. I think a lot of it is written by BIM consultants, and it needs someone to look through it from the client’s eyes and say, “Actually, no, we do not want this. We do want that.” Because there have been times where we have said, “Well, this is what you have asked for,” and the client has said, “I did not realise that.”

The non-involvement of facilities managers and the re-enactment of the then-current division of labour and rules/norms impacted the deliverables and outcomes, as noted by a BIM coordinator:

> We came to the end of the project, and then we had meetings with the facilities management team who did not necessarily want all the COBie data, they just wanted certain bits of it, and they did not want it in the format that they were going to be given.

Moreover, the business behaviour in the construction industry is generally considered risk averse (Akintoye et al. 2012). The data revealed that the risk-averse culture prevalent in the industry led to an overspecification of information requirements by the consultants in charge of the information requirements definition for organisation A’s projects, as noted by a digital engineer – also because these requirements were not defined strategically:

> They tended to ask for nearly all of the information, but then people might come in later and say, “Actually, I don't want to know about everything; I just want to know about these things.”
Poirier et al. (2015) has already identified that successful implementation is dependent on alignment of organisations’ business strategy and its BIM implementation strategy. In the case of organisation’s B project (project 07), although the organisation had a strategy in the definition of the information requirements, the same risk-averse behaviour as part of the institutionalised informal norms was reproduced by the contractor of organisation B’s project 07 when producing information, as reflected in its self-reporting of practice:

A very diligent contractor and design team will be putting forward all that information, you know. It’s easier and better to strip something out and filter it for an end user than it is to then go back and find that information. If you’ve got access to it, put it in.

Another example of action related to the practice of definition of information requirements that was enacted under the influence of the industry’s sociohistorical constructs involves the definition of information production methods and procedures. Organisation A identified a range of BIM uses over the project lifecycle stages and included the different required uses in the BIM documentation. Based on those uses, the client established an anticipated level of definition and specified that suppliers should review it for adequacy during their appointments. This requirement for suppliers to review the pre-defined definition level for their appointments followed the institutionalised way of working and the division of labour at the industry level, without considering the entire project lifecycle and possible interdependencies between stages. Indeed, as previously mentioned, traditionally, projects comprise of a set of related linear work activities and participants often view themselves and the services they provide independently of the project, neglecting partially, or even totally, existing dependencies (Matthews et al. 2018). However, defining and reviewing the level of definition by
only considering the specific appointment of the supplier and without considering the interdependencies between the stages or taking into account that a model handed over at one stage will be used by another party in subsequent stages created issues in the later stages of the projects, as noted by an appointed party for one of organisation A’s projects:

There has been lots of rejiggling in this project. And this is related to the way that they had set things out … that was the main issue.

Clearly, the institutionalised division of labour at the industry level influenced the way in which the information production methods and procedures were defined by the client and reviewed by the appointed parties, consequently impacting the way information was produced in the subsequent stages. Indeed, each discipline in the construction industry has become dedicated to the optimisation of its own function, with a limited focus on understanding the project as a whole (Jacobsson et al. 2017).

The project information model was then developed by the projects’ lead-appointed parties and task teams, following the model master information-delivery plan and task information-delivery plans. However, each appointed party produced and delivered information focused on its appointment and following the institutionalised professional interpretive schemes (e.g. the way that activities are performed as part of the identity of industry professionals). Indeed, the fragmented structure of the construction industry leads to vertical fragmentation, involving parties engaged in self-interested behaviour (Hall et al. 2020). However, as previously mentioned, successful BIM implementation involves moving away from fragmented functions to create a multidisciplinary environment where new
workflows and deliverables are managed for a project’s entire life. This did not happen in organisation A’s projects, with project stakeholders highlighting that each discipline focused only on its own appointments and followed its way of working. Organisation B’s main contractor for project 07 also highlighted that designers have an institutionalised way of working following their “design ethos”, which has an impact when working on a BIM project, even in a design-and-build contract, as in the case under analysis. According to the main contractor:

You have a lot of designers on all projects, not just this one, who will say, “Our as-built records will be the final construction issue.” Which means if anything changes during construction, there is a change of control process, and it’s got to go through with that, whereas BIM, fundamentally, works in a different way. As soon as there is a change, the designers need to make allowances for that, make the changes, but it is not what they are doing.

Additionally, because of the vertical fragmentation and institutionalised manner for resource distribution in construction projects, appointed parties were resistant to engaging in other stages outside of those they are appointed to, as noted by a BIM coordinator (organisation A’s project 04) when talking about the way that designers worked on the project:

They tend to only get money up to a certain point. That’s just the way contracts work. So naturally, they’re less inclined to continue with the same level of advice or design that they have previously done.

Moreover, the implicit norm of exchanging information also influenced the way that the project team worked on one of organisation A’s projects, with some stakeholders still relying on information exchange by email, despite having a CDE, as pointed out by a BIM coordinator:

When exchanging information, they just want to email, because that’s what they’ve known how to do, and share information.
A technical advisor (TA) (project 07) also confirmed that despite having a CDE, information exchange and discussion occurred following the standardized way of working:

Even though we’ve all got access to the contractor’s CDE, it’s actually not the place where that discussion is actually typically taking place. It’s still taking place in workshop environments and across those emails. It’s quite useful having the emails as well, because you’ve got a record of the correspondence.

Additionally, it is important to highlight that some of BIM’s claimed benefits could not be achieved because of the way that practices were enacted. For projects of both organisations, project teams reported increases in cost, for instance, associated with updating models when variations had to be incorporated. Essentially, the same process of managing variations when producing only 2D information was followed, as noted by a project manager (project 07):

The other lesson we’ve learned from the process, it might not be at this stage where you’ve got appointing and appointed parties, the management of variations, the expectation of variations, the costs were a surprise. I mentioned this earlier, as we were faced with additional variation costs because of the time and effort they needed to update the BIM model for the variation regarding what was already agreed.

Finally, regarding information handover, the implicit norms also ended up being reproduced such as with the handover of O&M manuals along with the asset information model (AIM), as highlighted by a TA when explaining to the final user what they would get at the completion of the project as established in the contract (project 07):

You are still going to have a set of O&M manuals, because it’s still contractual to make one and you will probably need it.
Thus, clearly, industry’s formal and informal norms and rules and the division of labour that coexist in the project and are part of institutionalised practices were reproduced when conflicting with the new ones associated with BIM. These sociohistorical constructs at the industry level, however, were not the only ones influencing how the situated practices have been institutionalised, as mentioned previously. The organisational context (e.g. the client’s organisation context) also played an important role, as discussed next.

The influence of the organisational context

The data revealed that the organisational context of the stakeholders involved in the practices, especially the client, on which rules and the division of labour were based, also influenced the process through which subjects reconstituted their work practices, as shown in Table 6.

Table 6 around here.

With regards to the definition of information requirements, as previously discussed, in the case of organisation B, the project information requirements were also defined by the client in consultation with external contractors and with the support of third-party consultants. Organisation B does not operate its estate; although it is the asset owner, the asset is handed over to third-party users/operators at the end of the project. These users and the respective facilities managers are traditionally not involved in the action of defining the information requirements, because, by following the traditional way that the client develops its projects, they are neither known during early stages of the project nor are they usually involved in project specifications, even if known. Thus, the practices of specifying
requirements itself changed to incorporate information requirements but continued to be framed by the old elements of the project activity system (division of labour and norms) at the organisational level, as highlighted by the asset user when talking about challenges in a BIM project:

The way the project documentation was set up assumes that the information requirements are specified based on the final user’s needs, when actually it is mostly the client’s vision, again, which may not reflect the final user’s needs in terms of building operations and following the practices that each final user follows to maintain the buildings.

Indeed, the existing institutionalised authority relationships involved in mobilising power (reflected in the way that the interests of different groups were represented in the project) influenced the way that information requirements were defined for organisation B’s project 07. The same occurred for organisation A’s projects. Due to power relationships and the existing organisational structure, facility managers were involved more at handover instead of during the early project stages.

Another practice within the activity system modified by the introduction of BIM is the establishment of the project information standards. This action also requires the involvement of asset users and maintainers because it requires information on the CAFM systems that will be used during the operational phase in order to specify the information production methods and procedures. The definition of information standards requires considering the exchange of information between the client and the asset operators and maintainers, and the means for classifying information, which requires input from asset operators. For organisation B, as previously mentioned, the organisation was not going to operate the buildings post-completion. The organisational context, with its particular norms and division of
labour, precluded the definition of the means of operating the asset during the early stages of the project. For instance, during the specification stages, there was no definition of the CAFM software that would be used by the asset operator. The action remained within the bounds of the institutionalised structure and ways of working and did not change to include considerations of information exchange, use of information during the operational phase, or data transfer to the CAFM system. Thus, information was produced following general standards and resulted in rework for the CAFM provider and the lead-appointed party at the end of the project.

Moreover, the institutionalised way of assessing bidders’ technical capabilities (based on the current division of labour) was also reproduced when evaluating the BIM capability of organisation B’s project. The same people who evaluated the technical capability of tenders to deliver the physical asset were the ones evaluating BIM capabilities, even though they did not necessarily have BIM knowledge, as highlighted by a TA:

From my personal point of view as well from the TA team, I would expect that not all of your internal TAs would have experience necessarily with delivering BIM projects. When you put a BIM question into your evaluation matrix, are you actually asking people who don’t have the skill sets to actually evaluate the answers to that question? You have to expect a level of competence for somebody who is scoring that.

Regarding the production and delivery of information, the data revealed that the existing design review approach continued to be followed in organisation B’s projects (i.e. it did not change to incorporate aspects of data drops and the review of the information delivered to support decision making, following the Plain Language Questions and according to the new rules):

Rather than a sit-down singular session where we go, “This is the 3D model. These are specific answers to particular plain language questions,” for example, it was
actually much more of a holistic process. The design review process that would have been done on a traditional scheme really didn’t change in that regard.

The TA also noted that the technical review itself followed the institutionalised way of doing it (i.e. in 2D) as a client’s specification in the contract:

The technical review was on a 2D basis. From a contractual point of view, our scope as TAs, our appointment is to review those contractor’s proposals, but to do that on a 2D output.

Other institutionalised sociohistorical constructs at the organisational level also influenced the production and delivery of information. The institutionalised mobilization of power at organisation A, for example, influenced the way that the project team communicated during the production of information, with facilities managers going directly to the main contractor, as highlighted by a contractor’s information manager:

The communication between the client’s management team – so their project managers, who are a third-party company – and the facilities team seems to be very sporadic, as an internal thing. They are coming to us for what they want, rather than through their own team, which sometimes blurs the lines about who should be doing what, and when.

The previous examples of the practices part of the BIM project activity system enacted under the influence of sociohistorical constructs demonstrate that implementation of situated practices related to BIM is clearly not as straightforward as assumed, and it needs to account for the interplay between the new elements of the BIM activity system and the elements within the existing project activity system that is embedded in organisational and industry’s contexts. Indeed, it has been recognised that although adaptations have been made to institutionalised codes of
conduct at an industry level, for example, the development of the UK’s new digital plan of work (developed in response to the need to adjust to emerging digital processes and disruptive technologies), institutionalised practices within the UK’s construction sector have existed for decades and are embodied within the working practices of everyone involved in the built environment. By shedding light on the influence of multi-level sociohistorical constructs on the unfolding of practices when implementing BIM, the contributions to existing literature and practice are outlined next.

**Discussion: The influence of multi-level sociohistorical constructs on the unfolding of situated practices associated with an innovation implementation**

Our analysis of contradictions in the episode of change related to BIM implementation intends to contribute to existing literature in the following ways. First, although previous research has acknowledged the influence of multiple embedded contexts in the innovation process, our findings provided the conceptualisation of re-enactment of existing practices from embedded contexts in the process of interaction with situated practices. The findings reveal the influence of two embedded contexts differently, by showing how those embedded contexts with their own sets of rules, norms, roles and tools conflict with the situated practices and influence their legitimisation. The data reveals insights on the dynamics of institutionalisation of situated practices, especially regarding the influence of organisational socio-historical constructs which may vary from project to project. Thus, the findings reveal inertia in the transformation of the sector as also deriving from those re-enactments, which may vary across projects, and that mediate the institutionalisation of situated practices. In alignment with Dainty *et al.* (2017), our findings challenge the perception of BIM implementation as a linear process.
From the perspective of the industry context, while previous research has shown that the construction industry’s socio-cognitive environment (Jacobsson et al. 2017) and existing institutional logics (Linderoth 2017) shape the way that project team members work, their actions and the adoption of new technologies, this study’s findings reveal industry-related aspects associated with “how” institutionalisation of new practices takes place. Previous research has asserted that, in a change episode, certain dimensions of the industry can potentially align with specific features of technologies, implying that certain applications will be more rapidly adopted than others if this alignment occurs (Jacobsson et al. 2017). Linderoth (2017) found that the influence of existing institutional logics weakens if actors perceive that a technology can solve problems in daily practice. On the contrary, if those actors perceive that a technology creates discomfort, they use arguments based on the existing institutional logic to avoid its use (Linderoth 2017). The data revealed that, actually, when there is a conflict between coexisting elements within the project activity system, the new practices associated with the innovation may be enacted under the influence of existing sociohistorical constructs, even if actors perceive the innovation as beneficial.

In a recent study, Hall et al. (2020) argued that the construction industry has found itself caught up in a mirroring trap, where knowledge about design, engineering and construction are deeply embedded in individuals’ actions. One implication is that project teams are unable or unwilling to take up systemic innovations that offer benefits but do not align with the existing industry structure (Hall et al. 2020). Aligning with this argument, the findings revealed aspects through the lens of the activity system framework that can be seen as part of this mirroring trap. But the findings also showed that the reproduction of prevailing rules, norms and divisions of labour was not necessarily a conscious decision, also corroborating findings from broader management
literature that decoupling between a formal policy and current practice may also occur unintentionally (Gondo and Amis 2013). Regarding organisation A’s projects, for instance, although BIM Level 2 was adopted and accepted as valuable by the client and project stakeholders, they unconsciously enacted the actions following existing socio-historical constructs at both the industry and organisational levels. Papadonikolaki’s (2018) findings revealed that project networks motivated by internal BIM adoption drivers implement BIM more collaboratively and flexibly, while this study’s findings show that even when the internal motivation is high, enactment may follow institutionalised ways of doing and established rules, norms and division of work.

Moreover, previous research has showed that embedding new practices in project-based organisations is influenced by a complex interplay between structural conditions within organisations and existing project management practices (Bresnen et al. 2004). This study aligns with Bresnen et al.’s (2004) view by showing that there may be a conflict between multiple-level sociohistorical constructs and elements of the BIM project activity system, which in turn influenced how new practices were enacted. The data also revealed that certain sociohistorical constructs not only influenced the enactment of a specific situated practice and its outcomes, but had an effect on multiple and consecutive practices such as in the definition of information requirements and then the production and delivery of information requirements. But differently from Bresnen et al.’s (2004) findings showing that well-established ways of working provided more immediate templates than the wider initiative trying to be implemented, because the institutionalised mechanisms were perceived by project managers as contributing more directly towards the completion of the tasks, the analysed data revealed that the re-enactment of existing practices and related sociohistorical constructs occurred not only because it was perceived as the most effective way of completing tasks. Re-enactment
occurred simply because the sociohistorical constructs had been shaping actions for a long time.

Finally, from a practical perspective, by conceptualising re-enactment when implementing new practices, the findings reveal the need for institutional designers of built environment interventions to account for how industry’s embedded rules, norms and division of labour will interact with the innovation when it is implemented, when designing such interventions. From an organisational point of view, sociohistorical constructs within organisations’ practices and how those will interact with new practices should also be considered by practitioners. As pointed out by Dainty et al. (2017), the deterministic transformation agendas that have permeated the industry often fail to account for the structural challenges which await such prescriptions. By looking at real implementation, our findings suggest that, actually, implementation of BIM is framed by project stakeholders' pre-existing practices and embedded sociohistorical constructs. Existing research has posited that, to fill the gap between built environment policy design and implementation, policy should be co-designed by stakeholder communities and experts (Foxell and Cooper 2015). The findings, however, suggest that, to implementation be effective, more emphasis should be given to the context of implementation and interaction between the new practices aimed at being institutionalised and the existing ones.

**Conclusion**

This paper has attempted to provide evidence of a key issue when embedding an innovation such as BIM in construction projects: the influence of sociohistorical constructs on institutionalisation of practices. By adopting the activity theory framework, the central message that emerges is that institutionalisation of BIM practices cannot be assumed to be straightforward and it should account for
multiple contexts. Most existing research on BIM adoption and implementation tends to decontextualise and overgeneralise the findings. By highlighting the influence of the organisational context, it is clear that case-specific actions envisaging a change in the institutionalised organisational division of labour, rules and norms, for instance, are necessary. At the industry level, as previously mentioned, interventions aiming to frame the implementation of new initiatives need to account for the conflict and interplay between the new and old and be more prescriptive in order to avoid the intentional and unintentional reproduction of sociohistorical constructs when enacting the situated practices.

This study, however, did not attempt to showcase the specific strategies and actions necessary to avoid such a reproduction of sociohistorical constructs, which could thus be a topic for further research. It is limited to the application of activity theory principles in order to extend their use in BIM implementation investigations, and it is specific to the context of the analysed projects. But as pointed out in the literature, activity theory is a more descriptive approach than a method applied to changing practice, and it is application on this research is limited to demonstrating patterns of interaction when there are contradictions between existing and situated practices, in order to provide more details on how implementation of such innovations takes place. Moreover, we considered contradictions that emerged between sociohistorical constructs at the industry and organisational levels and situated practices, without taking into account the project context in terms of delivery approach, which has been highlighted in the literature as influencing BIM implementation. Specific tensions that emerge may vary depending on the delivery approach employed, as well as the type of interaction. Our sample consisted of different delivery approaches and, despite that, we observed patterns across the
projects on sociohistorical constructs from both embedded contexts (organisational and industry) in terms of rules, norms, tools and division of labour that clashed with situated practices and thus were re-enacted. Further research could look at specificities related to each delivery approach.

Finally, although activity theory was applied in this research and in previous BIM studies, the current understanding of BIM implementation within an organisation’s projects can still be enhanced by the activity theory framework. Existing research can be extended by expanding the use of the principles of historicity and the expansive transformation of the activity system, for instance. Multiple and sequential BIM projects within the same client organisation could be analysed and the transformation of the BIM project activity system could be explored against the history of its local organisation. The expansive transformation of the BIM project activity system could be studied, highlighting the multiple cycles of transformation and contradiction resolutions.

References


Table 1. Studies applying social theories to investigate BIM implementation.

<table>
<thead>
<tr>
<th>Social theory</th>
<th>Approach to change</th>
<th>BIM studies</th>
<th>Positive aspects to BIM implementation’s exploration</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actor-network theory (ANT)</td>
<td>By considering a project as a dynamic set of relations and associations that transcends organisational boundaries, ANT provides the opportunity to follow the elaboration of projects regardless of borders or predefined structures. Change can be analysed by taking into account the broad set of relations in the network.</td>
<td>Lindblad (2019)</td>
<td>ANT enables the analysis of how different actors are influenced by the implementation and how their roles and relationships change. Materiality (e.g. technologies) is strongly represented in ANT by the assumption that nonhuman actants also play an active role in project processes.</td>
<td>ANT informs study of issues, efforts and actors involved in developing and reshaping projects through BIM, but it is limited in the consideration of influence of structure</td>
</tr>
<tr>
<td>Structuration theory</td>
<td>Structuration can be used to explore why organisations and projects fail to change. From this perspective, projects can be conceptualised as shaped by pre-existing representations that guide actions.</td>
<td>Morgan (2019); Papadonikolaki et al. (2019)</td>
<td>Through the concept of duality of structure that actors produce and reproduce the institutionalised social structures that persist over time and space and provide guidelines for action, structuration theory can support the explanation of change in both organisations and projects. The 'institutional realm' of structuration theory which is a historical accumulation of beliefs, norms, power, and interests that generate the institutionalised social order and that plays a central role in explaining the transformation process, however, is not in depth explored by existing BIM studies.</td>
<td>Structuration theory does not take into account materiality, which is necessary in studies of BIM implementation</td>
</tr>
<tr>
<td>Activity theory</td>
<td>Activity theory explores the conduct of collective practices, and can be used to explore change by considering multiple elements that frame the activity system.</td>
<td>Mäki and Kerosuo (2015); Gade et al. (2019); Akintola et al. (2020)</td>
<td>Activity theory's principles of contradictions and multiple strands of sociohistorical contexts offer an opportunity to explore the tensions among the sociohistorical constructs that originate from multiple contexts and the situated practice in a episode of technological change, but those principles have not been explored by existing studies</td>
<td>Activity theory is criticised for being a descriptive approach.</td>
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Table 2. Mediating elements and interactions within the BIM project activity system.

<table>
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<tr>
<th>Mediating elements</th>
<th>Interactions</th>
<th>Subjects–object</th>
<th>Subjects–community</th>
<th>Community–object</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rules and norms: BIM standards, protocols</td>
<td>New rules guiding how the subjects conduct the tasks to accomplish the object</td>
<td>New specifications and guidance that project stakeholders adhere to while engaging in building the physical asset and the digital model and that guide their interactions</td>
<td>New rules that govern how individuals, who share an interest and influence the unfolding activity, should interact with the object</td>
<td></td>
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<tr>
<td>BIM discipline-specific tools and project tools</td>
<td>New BIM tools supporting the realisation of the object</td>
<td>New tools, such as a CDE, mediating the interaction between the subjects and the project community, including the client</td>
<td>New tools supporting the relationship between the key stakeholders in the community and the immediate goal of the project activity system such as tools for engagement with end users</td>
<td></td>
</tr>
<tr>
<td>BIM roles and responsibilities</td>
<td>New responsibilities that subjects have when accomplishing the object</td>
<td>New roles and responsibilities change the way stakeholders interact</td>
<td>New organizing processes and redistribution of responsibilities through which multiple parties strive to achieve the object</td>
<td></td>
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<tr>
<td>Source</td>
<td>Details</td>
<td></td>
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<tr>
<td>Project documentation¹</td>
<td>Review of the EIRs, asset information requirements (AIRs), BIM execution plan (BEP), digital handover documentation, project contracts, protocols etc.</td>
<td></td>
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<tr>
<td>Intranet</td>
<td>Access to CDE and internal intranet system (organisation A)</td>
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<tr>
<td>Interviews</td>
<td>Semi-structured interviews with project team members. Questions related to their work, challenges faced, actions taken, technologies used etc.</td>
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<td></td>
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<tr>
<td>Meetings</td>
<td>Attendance at project team meetings, design review meetings, BIM workshops, internal meetings, informal meetings, construction operations building information exchange (COBie) deliverables meetings</td>
<td></td>
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<tr>
<td>Other observations</td>
<td>Shadowing the computer-aided facilities management (CAFM) provider in the tagging process (organisation B)</td>
<td></td>
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</table>

¹ The analysed projects followed the principles of BIM Level 2 according to the UK government mandate, so the terminology adopted follows the PAS 1192 suite of standards (British Standards Institution 2019).
<table>
<thead>
<tr>
<th>Organisation</th>
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<tbody>
<tr>
<td>Organisation A</td>
<td>Project 1</td>
<td>Project manager (client), project manager (contractor), facilities manager, information manager (client)</td>
<td>Technical design</td>
<td>6h40</td>
</tr>
<tr>
<td></td>
<td>Project 2</td>
<td>Project manager (client), project manager (contractor), information manager (contractor)</td>
<td>Handover and close out</td>
<td>2h25</td>
</tr>
<tr>
<td></td>
<td>Project 3</td>
<td>Project manager (client), project manager (contractor), information manager (contractor), architects and workshop with all stakeholders</td>
<td>Construction</td>
<td>6h40</td>
</tr>
<tr>
<td></td>
<td>Project 4</td>
<td>Project manager (client), BIM coordinator (contractor)</td>
<td>Operation (project completed)</td>
<td>2h20</td>
</tr>
<tr>
<td></td>
<td>Project 5</td>
<td>Digital engineer (contractor)</td>
<td>Handover</td>
<td>45 minutes</td>
</tr>
<tr>
<td></td>
<td>Project 6</td>
<td>Project managers (client), information manager (client), facilities managers</td>
<td>Concept design</td>
<td>3h55</td>
</tr>
<tr>
<td>Organisation B</td>
<td>Project 7</td>
<td>Client’s technical adviser (TA), project manager (client), project manager and information manager (contractor), facilities operator, CAFM provider and individual responsible for the digital transformation strategy (client)</td>
<td>Construction</td>
<td>11h</td>
</tr>
</tbody>
</table>
Table 5. Examples of sociohistorical constructs at the industry level influencing the enactment of actions within the project activity system.

<table>
<thead>
<tr>
<th>Action influenced by sociohistorical constructs</th>
<th>Sociohistorical constructs</th>
<th>Activity system elements</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Definition of information requirements</strong></td>
<td>The way that stakeholders traditionally get involved in projects. Consultants and contractors are the ones who originally define requirements, and the conventions that asset managers usually get involved in at the handover stage</td>
<td>Division of labour, implicit norms</td>
</tr>
<tr>
<td>Industry’s risk-averse culture leading to overspecification of requirements and/or a broad specification to ensure that everything is covered</td>
<td>Implicit norms</td>
<td></td>
</tr>
<tr>
<td>Project participants providing services independently of the project and not considering interdependent stages</td>
<td>Division of labour</td>
<td></td>
</tr>
<tr>
<td><strong>Information on production/delivery</strong></td>
<td>Institutionalised professional work as part of the identity of industry professionals and the fragmented nature of work</td>
<td>Implicit norms, division of labour</td>
</tr>
<tr>
<td>Institutionalised way that resources are distributed (e.g. lead-appointed parties are paid for specific outputs at certain points)</td>
<td>Rules, division of labour</td>
<td></td>
</tr>
<tr>
<td>Institutionalised way of conducting some process such as exchanging information (e.g. by email)</td>
<td>Implicit norms</td>
<td></td>
</tr>
<tr>
<td>Institutionalised way of conducting some processes such as design reviews</td>
<td>Rules</td>
<td></td>
</tr>
<tr>
<td>Institutionalised way of conducting some process such as managing variations</td>
<td>Rules</td>
<td></td>
</tr>
<tr>
<td><strong>Information handover</strong></td>
<td>Institutionalised way of handing over information (e.g. delivery of operation and maintenance [O&amp;M] manuals)</td>
<td>Rules</td>
</tr>
</tbody>
</table>
Table 6. Examples of sociohistorical constructs at the organizational level influencing the enactment of actions within the project activity system.

<table>
<thead>
<tr>
<th>Action influenced by sociohistorical constructs</th>
<th>Sociohistorical constructs</th>
<th>Activity system elements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Definition of information requirements</td>
<td>Representation of the interests of different groups</td>
<td>Division of labour, norms</td>
</tr>
<tr>
<td></td>
<td>Decision making regarding asset operation</td>
<td>Division of labour, norms</td>
</tr>
<tr>
<td>Invitation to tender</td>
<td>Selection of contractors</td>
<td>Division of labour, rules</td>
</tr>
<tr>
<td>Information production/delivery</td>
<td>Communication between parties</td>
<td>Division of labour, norms (power mobilization)</td>
</tr>
<tr>
<td></td>
<td>Established workflows (e.g. design review process)</td>
<td>Rules</td>
</tr>
<tr>
<td></td>
<td>Established workflows (lack of incorporation of the data review produced to answer the plain language questions [PLQs] and data drops)</td>
<td>Rules</td>
</tr>
</tbody>
</table>
Figure 1. The project activity system and its elements.
Figure Captions

Figure 1. The project activity system and its elements.