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The Safety Dance: Challenging BIM Conformity

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Abstract

BIM is considered a key component in the construction industry's ongoing improvement agenda, providing safety enhancements through more streamlined design, works planning and monitoring, and opportunities to communicate and collaborate using virtual modelling information. As such, BIM is presented as a digital solution that will help save construction from its most pressing problems. However, while BIM undoubtedly plays an important role in various pre-construction and construction-stage safety processes, something is missing. A pervading techno-optimism conceals uncertainties around the extent to which BIM can really inform and support site safety practice. A more comprehensive understanding of BIM is required, one that accounts for the nuanced social and material aspects of everyday site work, that considers how practitioners make sense of their work and how BIM reconfigures safety practice. Drawing on initial ethnographic fieldwork findings, the concept of atmospheres is leveraged alongside an appreciation for the complex network of people, objects, spaces, and affective and sensory experiences on site, to shed light on the dynamic interconnections between BIM and site safety. Such hitherto underexplored factors in the operationalisation of digital solutions must be considered to better understand how BIM shapes safety practice. As such, a call is made to critically examine current perspectives of BIM and their role in these uncertain times of industry transformation.

Introduction

In the field of construction digitalisation and safety, BIM is regarded as an enabler in site safety performance, through opportunities for more efficient design and planning of works, model-informed discussion, and for testing and training (Health and Safety Executive, 2018). The interest in leveraging BIM and other digital tools stems not only from the construction industry's efforts to improve safety performance, but also a wider policymaking culture of promoting BIM to solve a range of problems including productivity, collaboration, predictability and attracting new talent (Farmer, 2016). Thus, the position that increased BIM implementation leads to safer outcomes on site is a popular industry belief. This techno-optimism is widely reflected in the literature with various studies underpinned by the

assumption that BIM brings benefits through its capacity as a collaborative 'single source of truth' (SSoT) mechanism, and that identifying barriers to adoption will further improve safety performance (Enshassi et al., 2016; Marefat et al., 2019; Swallow and Zulu, 2019). Yet as the unintended consequences of technology for construction worker health and safety are being critiqued by some (e.g., Sherratt et al., 2023), so too must the use of BIM.

BIM for safety

BIM is frequently treated as a purely objective information and decision-making tool in quantitative and/or algorithm modelling approaches to safety improvement, such as Lu et al.'s (2021) development of an Autodesk Revit plug-in or Zhang et al.'s (2015) use of automated safety rule-checking. Such studies may well help designers reduce safety hazards at pre-construction stages, contributing obvious benefits to site safety. However, doubts around the supposed objective neutrality of BIM will inevitably be raised when investigating the social and organizational implications of these design decisions later in construction stages. Additionally, we must recognise that site work exists beyond planned-for activities; work as planned is not always work as done (Hollnagel, 2014: 102). Safety knowledge and learning is developed in situated, social practices (Gherardi and Nicolini, 2000) which are too often disregarded in works planning due to their unspoken and 'out of sight' nature (Tutt et al., 2013). Failing to acknowledge such circumstances risks an over-reliance on pre-construction stage technologies, like BIM, to solve site safety issues far in advance of works taking place. Building on his own earlier critique of technological totalitarianism (1998), Green reminds us in his more recent arguments on the 'Unfulfilled Dreams of Technological Optimism' (2023: 329) that BIM is one in a long line of policy-hyped deterministic innovations. If only BIM could be fully and widely mobilised, so the argument goes, eventually construction will be saved from its most urgent problems.

A further issue lies in the special attention given to BIM by top-level decision makers who are often more or only aware of prevailing industry discourse rather than on-the-ground practice. As the hype for digital technologies becomes further embedded in discourse, the allure of BIM becomes standard and thus ultimately beyond reproach, resulting in an enforced embedding of BIM in practice. It is therefore crucial to examine how the rhetoric around early intervention with BIM plays into the reality of site safety practice, whether BIM really can be a neutral factor in safety planning and indeed whose interests it serves.

In addition to using BIM for safety planning and design processes, it is also leveraged for worker safety monitoring at later project stages, for example in conjunction with mobile apps (Hossain et al., 2023), Bluetooth location detection (Park et al., 2017), passive Radio Frequency Identification (RFID) (Costin et al., 2015), and spatiotemporal global positioning systems (GPS) (Golovina et al., 2016). However, as Forsythe (2014) stresses, BIM-based safety systems technology should not be privileged for its own sake over the goal of human

safety. We must critically consider how affective aspects of site practice are shaped by such systems, for example in mistrust, excessive dependence or apathy towards the technology (ibid.). Further questions also need to be asked around personnel surveillance and potential leveraging of digital data to substantiate uncaring, self-interested or even exploitative management activities (Ivory et al., 2023).

This paper contributes to an emerging critical discourse around the unintended consequences of BIM, and especially those which seek to understand the way in which it structures power relations between actors, and what this means for the outcomes it shapes (Dainty et al., 2017; Sherratt et al., 2020). Such perspectives suggest that with regards to digital technologies, site safety is not only shaped by directly targeted BIM-based tools and processes, but also, importantly, is indirectly shaped by more nuanced aspects of BIM implementation. However, an increasing use of BIM potentially encourages collection and scrutiny of only those data that are more easily identifiable and measurable by management, rather than data associated with the more elusive and complex social activities that constitute site practice. As such, rather than examining whether increased BIM adoption directly leads to changes in safety perspectives, practices and accident rates, here we seek to understand how digital tools are inadvertently shaping factors associated with safety, such as trust and authority, and indeed to what extent these tools can be relied on for safety related planning. We do not aim to prescribe better uses of BIM for safety practice, but instead to spark a distinct debate around the ways that BIM reconfigures site work and associated relationships, perceptions and sensitivities. Instead of accepting the proposition that BIM is a neutral information and planning management system offering safety benefits, we would also ask how it might be used as a tool of control, whether it entrenches already existing disjunctions, and how it affects and is affected by feelings around technology use. BIM is neither a neutral nor a passive actor, but one that is enmeshed with emotional labour, shaping social practices and outcomes. While the affective implications of BIM have been explored in relation to construction design practice (Vitry et al., 2020), we ask the same for on-site safety practice. Thus, we critically examine the wider operationalisation of BIM, including the unplanned outcomes of the resulting power relations that its implementation structures around it, to better grasp its implications for safety. Thinking around such unintended consequences on safety practice is a necessary corrective to the BIM-optimism which currently pervades both the sector, and the academic literature.

An Atmospheres Methodology

To more comprehensively understand the role of BIM in site safety, we draw on ethnographic fieldwork data, as part of the lead author's PhD research. The fieldwork was carried out over a six-month period in the construction stage of a multi-million pound commercial office design and build project in the UK. The project implemented '3D' BIM in

accordance with ISO 19650 standards. Autodesk BIM 360 served as the management platform, which all main contractor site managers regularly used via tablets and laptops. Participant observation and short conversations were held with participants working from operative to management levels for the main and sub-contractor firms on site.

The concept of atmospheres are employed to reveal further insights on the dynamic nature of the construction site, a space which ultimately comprises irrational human behaviours as well as state-of-the-art digital technologies (Forsythe, 2014). Construction sites are multi-sensory spaces, full of continually changing sets of people, objects, sights, sounds, materials, and even smells and tastes. An 'atmospheric approach' accounts for this multiplicity of "phenomenological and sensual elements, and the social and cultural contexts in which they are consumed, interpreted and engaged with emotionally as well as affectively" (Edensor and Sumartojo, 2015). When thinking through atmospheres, a blurring occurs between spaces and bodies, subject and object, between what is atmospherically experienced and sensed on the one hand and what might be expressed and produced on the other, and thus between the researcher themselves and what is being researched (Madsen, 2017). This may lead to questions around methodological bias and calls for more 'objective' or quantitative measures, which some studies of place experience/atmosphere have included for, such as biosensing devices (Canepa et al., 2019; Paiva et al., 2023) or place attachment scales (Lin and Lockwood, 2014). While this particular project does not employ such measures, it does attempt to widen its scope beyond purely representational, reflexive participant accounts, to consider pre-conscious aspects of embodied experience (Hill et al., 2014). Using an atmospheric lens in construction management studies is novel, yet enables researchers to consider important emotional states (Sumartojo, 2023) and how the construction site feels - temporally, spatially and materially - to the people within it.

While 'vibe' or 'ambiance' are often paid significant design attention in construction's end product and its marketing, whether that be a dwelling, office, classroom or other, there is a curious absence of such purposeful atmosphere design for the construction site space itself. However, we explore the shifts between such (even unintentional) designed atmospheres and atmospheres that emerge as they are co-produced by bodies on site, to help us think about change in terms of safety and the digital. In particular, attuning to atmospheres of 'hanging around', antagonistic hierarchy and managerial performativity, sheds light on the ways that BIM – as digital information collection, access, and planning - plays into how site workers understand their role and practise safety. Instead of making recommendations for enhanced use of BIM, we pose critical questions that encourage further reflection around the dynamic and sometimes disordering interrelations between BIM and site atmospheres.

Reflecting Site Realities

Next, we elaborate on three ethnographic episodes that highlight the inability of BIM technology to accurately reflect or predict the reality of working on site. As the fieldwork played out, each of these episodes was notable for its atmospheric qualities, with the lead author attuning to atmospheres through sensorially experiencing the action on site. Thus, three distinct episodes are presented to allow for a focus on those particular contextual elements which drive the emergence of atmospheres.

The first episode sets out an unfolding atmosphere of boredom and explores the capacity for BIM to capture and thus respond to the nuances of quotidian site practice. The second looks at the atmospheric qualities of meaningful social interactions to further question BIM as a 'source of truth'. The final episode examines how the use of BIM in an atmosphere of surveillance drives particular behavioural changes, especially those of managers. Each episode therefore challenges BIM as neutral and objective technology, putting into question the extent to which BIM can 'transform' safety practice.

Hanging around

While BIM is used daily at a high level to plan and monitor project safety, the ordinariness of everyday site work at an individual, micro level, is all but invisible within BIM-collected information. When a site activity is recorded as complete in BIM-enabled projects, there is often a wealth of accompanying visual, textual and specific measurable data 'attached' to the record, such as progress and completion photos, descriptions of works issues, and permit and compliance documentation. While harnessing such a great quantity and variety of data for analysis and decision making may seem impressive, the overall picture portrayed by these data does not reflect the often-harsh realities of site. Other overlooked data are critically missing from the frame.

On a cold, early-winter Friday morning on my fieldwork site, I spend some hours with a couple of steel decking workers who are due to complete their works that day, and leave the site for good. They are unable to finish their final task, a tiny and easy five-minute detail on the uncovered roof level, until another exercise requiring crane time is completed by a team of steel erectors working for the company which subcontracts the steel deckers. This ultimate task is the only thing stopping the deckers from heading to their vans and driving home, potentially the difference between a satisfying short journey or a Friday afternoon rush hour ordeal. The pair's frustration and boredom in waiting for specific resources to become available is evident. For one, they are so bored, they are willing to spend extended periods talking to me about their work and their personal lives. Usually I'm lucky if I can catch them for a minute or two at the smoking shelter or as they leave the canteen and head back onto site. I would typically expect to see them in pairs moving large metal sheets into

place, or operating heavy power tools, hunched over and steadily moving down the edge of a steel sheet, or stretching their arms from a ‘cherry picker’ basket to secure safety netting to the steel frame. They are almost always on the move.

The fact that their bodies are now more or less still, only rubbing their hands, swaying slightly from side to side, or shaking a leg in an effort to warm their cold, numbed bodies, speaks to the difference in pace of work. It’s not yet happened but I know, from experience and from their constant glances over to the steel erectors, that the moment they are able to leap into action to finish their work, they will. Earlier that morning I had found them attempting to fix the problem themselves, lying prostrate across the not-yet-concreted decking with only a thin sheet of corrugated plastic separating them from the frosty metal below. One of the deckers isn’t even wearing a coat. Instead, he clings onto the sleeve-ends of his two not-especially thick sweaters, pulling them taut against his clenched, swollen fists. Declining my offers to fetch extra clothing or cups of tea, they are determined to stay outside in near-freezing temperatures to complete their last task at the very earliest opportunity. They’re used to this sort of thing, they tell me. I continue talking to the deckers for an hour, eventually not able to bear the cold any longer. Stiffly and carefully, I waddle down several flights of stairs and head back to the site office where my hands and toes throb for ten minutes before regaining proper feeling. I wonder how on earth tradespeople manage to do any kind of detailed work in these kinds of conditions.

The atmosphere of boredom while waiting to complete a job involves a change in the way that bodies usually move and interact on site. Without the mental or physical distraction of manual labour, they move less, hang around, chat, crack jokes and voice meaningful frustrations about their shared experiences of long commutes between weekday ‘digs’ and partners and children at home. They become numb from the cold and simultaneously more aware of their own corporeality and passing time. Moreover, concentration levels ebb and flow, rubbing up against a peculiar sense of being on edge every time a glance is made in another direction to survey the ‘crane time’ situation. Against a backdrop of relentless pressure for productivity and progress, the waiting around seems unspeakably wrong whilst at the same time, entirely expected. “There’s always something,” one of the deckers tells me, noting that this felt contradiction is normal on all jobs.

Such sensory and affective experiences, their “felt quality both in terms of touch and manipulation of bodies, tools, objects and materials, and in the socially experienced, learned and shared skill of the work” are central to safety awareness and learning (Tutt et al., 2013). However, they not only stand in striking contrast to, but are completely absent from data-driven BIM software which instead records ‘neutral’ project progress information such as the decking detail being completed. The atmospheres that emerge in completing these decking works, their associated experiences, bodies, and historical and socio-political drivers, are entirely missing from the BIM documentation perspective. If atmospheres are inherently

invisible and incorporeal (Canepa, 2023), entangled in a difficult relationship with representational description, the impossibility of BIM to capture and classify such data becomes clear. This begs the question: How can BIM-based data analytics drive decision-making on safety practice when it does not in any way encapsulate the 'messiness' of construction work?

Antagonistic relationships

The appeal of BIM as a 'single source of truth' also fails to reflect the inherent complexities of hierarchies and relationships on site. What appears as a relatively simple piece of recorded safety data, such as blustery weather stopping crane lifts, might conceal significant information about the way that people work together. For example, on a particularly dismal early afternoon on my fieldwork site, daylight is already starting to recede and the wind picks up. Pooled water ripples, safety signs bearing the main contractor's logo flap against the gates they are affixed to, and loose gaffer tape ends twitch with each sudden change in wind direction. The steel erecting gang stops work, 'winded off' due to high wind speeds recorded by the crane driver. One of their team communicates the crane driver's confirmation to two main contractor site managers who stand on their astro-turfed second storey portacabin terrace, looking down over the site. A short but impassioned dispute ensues between the steel erectors and site managers, the latter pointing to a windometer atop a nearby apartment building and surveying surrounding sites' cranes to see if they too have stopped operating. The site managers are questioning the wind speed because their mobile weather apps appear to state a strong breeze at most. The managers shout their doubts to the steel erectors who stand inside the site works boundary on the other side of a wire fence, their feeling of betrayal made visible as they pull and push at the fence and ask why their words aren't accepted as truth. One steelworker leaves the area in frustration, noisily 'tidying' scaffold clamps away by hurling them into metal storage containers as he walks away, while his colleague remonstrates the managers for upsetting him. He strides towards the turnstile to leave the site works area, then passes through the second turnstile to remove himself entirely from the site space, standing on the pavement outside site for a few minutes to cool down. I consider going to see if he's OK, but I decide against it. He probably needs some space, and besides, I was standing with the site managers when the incident occurred so I worry that my proximity to them has associated me with the antagonisers.

In this episode, the inclement weather and the managers' confusion over which technology is providing them 'the truth' shifts the atmosphere from a common mood of 'getting on with it' despite changes to machine availability, to an intensity that damages working relationships. Elements of trust between direct subcontractor colleagues and distrust of 'the hierarchy' (as they referred to the main contractor), circulate to produce an atmosphere of

antagonism. Indignation is pronounced through aggressive body movements, contorted facial expressions, shaking heads, making noise and relocation of the body to outside the work world. Even the safety fencing separating the works area from the non-works area on site, which the workers peer through and tug at, ironically works to produce an atmosphere in which trust is eroded. Although the values around staying safe on site are actually shared by both teams, their differing positional heights during the incident is a rather unfortunate contributor to a sense of misalignment. Furthermore, the managers' obvious body movements to check multiple sources, including phones, tablets, other cranes, wind gauges and even rippling puddles, as well as their audible questioning tones exacerbate the issue.

Such atmospheric qualities of site relationships, including misunderstandings around values and feelings of distrust and dissatisfaction – all inherent qualities of safe working practices - are not and cannot be captured by BIM based technologies. Given these examples, it is then rather ironic that data drawn from such technologies might then be considered a 'single source of truth' and used for safety review and decision-making. This raises the significance of asking how, or indeed if, otherwise unrecorded sensory and affective experiences can be captured within the data, and who gets to collect and control it. What if, no matter the level of BIM sophistication, the technology will never be capable of telling a complete story of what it is to work on site, but will instead only ever reflect just one of its realities? If "the 'pervasive quality' of a particular situation 'gets inside us' and orients us towards particular actions and expressions" (Edensor and Sumartojo, 2015), can BIM really be used to inform future safety-related planning if its data has absolutely no understanding of what it means to feel trust, upset, confusion, subordination or other meaningful experiences?

Surveillance and performativity

Next we turn to the manner in which BIM reshapes otherwise unremarkable events into noteworthy demonstrations of performative management practice when used as a surveillance tool for compliance. On the fieldwork site, several subcontractor workers tell me of their awareness of being watched, often signalling the main contractor's site office with directional eye movements or hand gestures and pointed facial expressions. One steelworker who's been working in the trade for almost forty years points out that historically there would be only one main contractor site manager checking works on site, whereas now a number of site managers are in charge of a variety of works packages. He comments that this change has led to 'bitchy' game-play in the managers' competition for recognition, telling me that they unnecessarily find safety related faults with subcontractor works and blow small issues out of proportion because a 'perfect week' cannot possibly be recorded. Instead, as the steelworker sees it, the managers need to demonstrate to each other and to their own managers that they are resolving problems, which leaves him feeling powerless to push back. While walking away, he ends our conversation with what I feel at

the time to be a very gloomy prediction, that the situation will get worse before it gets better.

In the context of an industry which increasingly holds big data in high regard, the management tactics described by the steelworker are undoubtedly connected to the data-centric, surveillance atmosphere driven by BIM. At a project level, the obsession with monitoring encourages certain types of data to be collected such that main contractor project teams may demonstrate the resolution of 'tricky challenges' and thus be recognised and rewarded at project, regional or national levels. Individually, management careers can also be advanced by aligning with current technological trends and rhetoric espoused by more senior, powerful actors in the firm (Green, 1998). Such pedantic management behaviours as those described appear absurd to subcontractor workers, whose own labour, utterly connected to their bodies, tools and materials, stands in jarring contrast to the drive for seemingly immaterial data-driven recognition. The assumption that site work is inherently unsafe, where 'something must go wrong', also runs counter to the theory that the vast majority of work is actually safe because people adjust to working conditions and apply their competence accordingly (Hollnagel, 2014: 137).

While designed atmospheres of BIM for safety surely point to reassurance and care, at least a small part of how BIM actually plays out in site safety practice involves pretence and opportunism through a process of technology 'hacking' of sorts. In this episode, monitored bodies feel the intrusion of site managers' movements and technological artifacts, yet do not respond viscerally. Instead, they disengage, baffled by the artificiality of overdoing safety data capture for self-interested concerns. The atmosphere of safety surveillance is underpinned by certain bodies' constant drive for self-improvement as well as others' cynicism around digital data collection, working to undermine main contractor authority and obscuring genuine safety concerns. The process of managerial application of power through supposed corrective surveillance, along with the internalisation of such discipline, evokes Foucault's prison-Panopticon metaphor (Galič et al., 2017). Although in our example the workers are well aware of who their disciplinarians are, they do not share the same access to the technologies of discipline and are never quite sure what is being recorded and exactly how it is being used. The pervading atmosphere of surveillance is sensed by those who are observed and its continual re-emergence in various forms, times and spaces becomes a normalised aspect of site work, partially resisted by workers communicating concerns with each other, yet still shaping a reluctant submission to management control.

Acknowledging that technologies are not purely deterministic, but are instead part of an assemblage of sensory and affective experiences, personal histories, future hopes, ambitions and more, we therefore question the reliability of BIM for site safety surveillance. Though certain management tools may give the impression of control and coherence, they may actually hold little objective meaning or relevance for their intended purpose (Sage et al.,

2010). In an atmosphere of decreased respect and confidence in those who set the rules, perhaps the steelworker's ominous forecast does not seem so improbable after all?

Conclusions

In conclusion, there is a need to re-think BIM as a mechanism for reproduction of site realities and a tool for future facing decision making. BIM is intended as way of producing site atmospheres of certainty, productivity and progress through more predictable, tractable and streamlined ways of working. Yet as its features expand and its rollout becomes the norm, its already-existing embedded power structures become more capable of being exploited.

As with any big-data technology, BIM requires a variety of good quality data as well as high volumes of data if it is to be utilised as a robust decision-making tool. However, its capacity to capture the everyday realities of site practice is glaringly unfeasible, not least because the time and care required to even attempt collecting such data would be impossible given the squeezed 'efficient' project programmes we so commonly now see. Together with the temptation to gather ever greater amounts of data under the assertion that 'data is the future', this leads to a complete disregard of the meaningful experiences of those very people whom the system is supposed to serve. As noted by my bored and frustrated steel decking participant, a disordering 'something' will always arise in construction work. Regardless of BIM levels or expertise, its intended atmospheres will be disrupted by affective intensities that can only be vaguely captured, accessed and represented by the technology.

It is therefore necessary to problematise data-driven safety strategies not only in terms of data analytics, security and ethics, but also by reckoning with the nuances of working in a gradually digitally transforming industry. Without such scrutiny, the continued unchecked use of BIM for safety risks undermining hitherto well understood, effective safety practice. The mobilisation of ever-evolving technologies, and what their use means for practice, management and various stakeholders, is incredibly complex, and warrants further attention from both BIM researchers and industry practitioners. In such uncertain times, it is paramount to question the BIM orthodoxy, to focus not only on specifying future use of BIM, but to reflect critically on the power effects and relationship between unrelenting BIM-optimism and the reality of what it means to work on site.

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