CIB World Building Congress 2019
Hong Kong SAR, China
17 – 21 June 2019

Integration and Collaboration for Smart Planning, Design and Construction

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Abstract

The need for integration and collaboration has been widely acknowledged in the construction industries across the Globe. These calls have their roots in the numerous critical reviews of the industry, starting with Bossom (1934) and the Simon Report (1944) in the UK. McKinsey's 2017 Report is more recent. Despite the passage of time, the core of the appeal remains surprisingly similar, and the low levels of performance persist.

The prevailing business model that relies on temporary contracts, and the insistence on treating its symptoms, e.g. adversarial relationships, lack of trust, usually by advocating technological solutions such as BIM, result in the decades-long need to repeat these calls. It is counterintuitive to delivering truly 'Smart Cities', which requires integration and collaboration horizontally and vertically across Project and Urban Governance Systems.

This paper argues that even if technological solutions such as BIM are adopted at scale, they will not result in a more collaborative and better integrated industry, because the adoption problem is fundamentally considered as a linear process of technology adoption. BIM and other potentially transformative initiatives should be conceptualised and implemented as high technology management (Zeleny, 1986) in order to deal with the unique set of challenges and exploit the opportunities associated with working in interdisciplinary teams across organisational and institutional boundaries, and thus to make collaboration and integration common-practice.

This paper evaluates the current BIM initiatives in the UK. This evaluation is based on Zeleny's framework, which is applied using secondary data. First, the plethora of calls for collaboration and integration are reviewed. A brief discussion of the conceptual aspects of high technology management follows. The Conclusions present the key barriers to high technology management: the structure of the industry, its narrow search scope, and its focus on experiential learning, and on incremental change at the project level.

Keywords: high technology, organisational adoption, strategy

1. Introduction

The need for integration and collaboration has been widely acknowledged in the construction industries across the Globe. In the UK, these calls have their roots in the numerous critical reviews of the industry, starting with Bossom (1934) and the Simon Report (1944). McKinsey's 2017 Report, which is a Global call for transformation, is more recent. Despite the passage of time, the core of the appeal remains surprisingly similar, and the low levels of productivity persist.

The prevailing business model that relies on temporary contracts, and the insistence on treating its symptoms, e.g. adversarial nature of the relationships, lack of trust, usually by advocating technological solutions such as BIM, result in the decades-long need to repeat these calls. It is counterintuitive to delivering truly 'Smart Cities', which requires integration and collaboration horizontally and vertically across Project and Urban Governance Systems.

This paper argues that even if technological solutions such as BIM are adopted at scale, they will not result in a more collaborative and better integrated industry, because the adoption problem is fundamentally considered as a linear process of technology adoption. BIM and other potentially transformative initiatives should be conceptualised and implemented as high technology management (Zeleny, 1986) in order to deal with the unique set of challenges and exploit the opportunities associated with working in interdisciplinary teams across organisational and institutional boundaries, and thus to make collaboration and integration common-practice.

First a review of the calls for transformation in the industry is provided. Then, the current focus on technology adoption to bring about the necessary changes is critically evaluated. Zeleny's (1986) notion of high technology management is proposed as an alternative approach to utilising technology in bringing about transformational change. Initiatives such as the UK Government's approach to encouraging BIM adoption and Bryden Wood's proposal to utilise open source platforms are evaluated using Zeleny's notion.

2. The Industry Reports: a literature review

Having observed a much more efficient building industry during his time in the USA, Bossom (1934) pioneered the conceptualization of design and construction as a process that relies on effective collaboration between all the relevant parties on his return to the UK. He also characterized the UK construction industry as wasteful and adversarial ahead of other commentators such as Latham (1994) and Egan (1998).

The Simon Report (1944) was mainly concerned about the placement and management of contracts with regards to their potential in improving the efficiency of the industry. It also highlighted the increase in specialization which lead to the need for temporary contractual arrangements. It advocated prequalification for tender and recognized the impact of lowest price tendering on the quality of the built facilities and on the number of claims for variations. A more collaborative approach to design and construction with earlier contractor involvement, was suggested as a solution to these problems.

The Banwell Report (1964), which was commissioned in 1962 when the Emmerson Report (1962) was published, is arguably the next milestone for calling for change within the industry. It was mainly concerned with team relationships, construction contracts and other construction documentation, such as bills of quantities. The traditional separation between design and construction was once again highlighted. The industry was criticized for its entrenched positions, leading to this separation, and operating with a lack of speed and purpose. It advocated a common form of contract for building and civil engineering works but this suggestion was not supported by industry bodies such as the Joint Contracts Tribunal. The Potts Report (1967) which was published to implement the recommendations of the Banwell Report (1964) did not gain momentum either.

Tavistock Institute's 1966 Report characterized management in construction as an attempt to systematic and centralized task management. It has also highlighted the tensions between the structure of the organization of the Project Coalition (Winch, 2010), and the processes through which this coalition would deliver the projects. This report acknowledged that the uncertainty associated with highly inter-dependent tasks, and the pressure of completing the tasks would culminate in an informal organization that had reshaped the original structure and processes.

Several other industry reports were published between 1970 and 1993. They are listed in Table 1. In the main, these reports aim at improving the industry by considering the issues from different perspectives. They joined those published since the Bossom Report (1934) in terms of their limited influence on the industry practices that continued to be dominated by the market forces. For example, the Finniston Report is concerned with the low status of the engineering profession in the society and recommended new educational standards and a National Engineering Authority. The Manual of the BPF system for Building Design and Construction was the British Property Federation 's response to the recession at the time. It reviewed the way its members procured construction contracts in order to establish the causes of delays and cost overruns in building projects. It identified competitive tender as the main vehicle for securing value for money and design and build contracts as the type of contract that had the best record in terms of cost and time. However, the BPF report criticized D&B projects designed by contractors for low levels of design quality and proposed that the initial design should be developed by a design team under the control of the client.

Table 1: Industry Reports Published between 1970 and 1993

Source: Designing Buildings Wiki(no date)

1970	Large Industrial Sites, National Economic Development Council
1975	Wood Report, The Public Client and the Construction Industries: the report of the Building and Civil Engineering Economic Development Committees Joint Working Party Studying Public Sector Purchasing.
1978	The PIG Report: Project Information - its content and arrangement. A report and proposals on the way forward, by the Project Information Group (PIG) of the Department of the Environment NCC Standing Committee on Computing & Data Co-ordination.
1980	Sir Montague Finniston, Engineering Our Future: Report of the Committee of Inquiry into the Engineering Profession, HMSO.
1983	The British Property Federation Manual of the BPF system for building design and construction.
1983	Faster Building for Industry, National Economic Development Office (NEDO)
1988	Faster Building for Commerce, National Economic Development Office (NEDO)
1993	Latham, Trust & Money

The Latham (1994) and Egan (1998) reports are relatively more recent additions to the plethora of publications that called for the transformation of the industry. Constructing Excellence (no date) states that the Latham Report (1994) "set the starting point for the most recent change agenda in the industry".

Latham (1994), once again, labelled the industry as 'adversarial', 'ineffective' and 'fragmented'. It placed the Client at the centre of the transformation of the industry. It argued that Clients were best placed to foster collaborative working practices through partnering arrangements. In this context, the onus was placed on the Government as the largest procurer of construction to become 'the best practice client'.

The principles of partnering did not catch on beyond the first tier of the supply-chain. The uptake was slow even at that level. Hence, the Labour Government commissioned Sir John Egan to undertake a review of the industry. This review culminated in the Egan Report (1998), which introduced the notion of 'lean thinking', and identified It identified five drivers for change:

- committed leadership,
- focus on the customer,
- product team integration,
- quality driven agenda,
- commitment to people.

The 2000s witnessed the publication of further reports. Some focused on Accelerating Change (Strategic Forum for Construction, 2002) within the industry; another on Modernizing Construction (NAO, 2001) by improving public sector procurement and management of new construction, refurbishment and repair and maintenance. Developing a Strategy for Sustainable Construction (Strategic Forum for Construction, 2008) was also on the agenda as a result of the realization that building activity and operation of buildings had a significant impact on the environment.

Wolstenholme (2009) was commissioned by Constructing Excellence to establish what progress had been made since the publication of the Egan Report (1998) a decade previously. He considered the industry to be moving in the right direction, but highlighted that it had fallen well short of Egan's targets. The review of the industry KPIs for the 9 years preceding this report showed that 10% increases had been achieved in terms of productivity, and turnover and profitability. However, the report concluded that the impact of a strong economy during this period may well have resulted in these improvements rather than the changes that were advocated by Egan. Predictability had seen a 20% increase. The other four KPIs, i.e. capital costs, construction time, defects, accidents, had witnessed either a 10% or a 20% decline. Wolstenholme (2009) identified Business and Economic Models, Capability, the Delivery Model, and the Industry Structure as 'key blockers' to progress. The report concluded by arguing for the adoption of a wider perspective of the built environment, going beyond the current focus on the construction phase, in order to deliver true economic value in a low carbon economy.

The recent Farmer (2016) and McKinsey Global Institute (2017) reports identified similar issues in the UK and Global construction industries respectively. In both reports, the fragmentation of the industry, low levels of capability and of investment in technology and innovation; poor project management and execution practices; and the misaligned contractual structures and incentives were identified as the causes of the productivity problem. Collaboration, increased investment in innovation and technology adoption, enhancing the capability of the workforce, and improving project execution and delivery were among the solutions that both reports suggested for dealing with the "intractable productivity problem" (McKinsey Global Institute, 2017), largely echoing Wolstenholme's (2009) recommendations.

3. Is Technology Adoption a Vehicle for Industry Transformation?

Despite these calls for a fundamental rethink from business models to the delivery model, technological solutions such as BIM, have, on their own, been hailed as key solutions to the industry's perennial problems, e.g. low productivity, fragmentation, lack of collaboration and innovation.

Construction 2025 stated that "only through the implementation of BIM will we be able to deliver more sustainable buildings, more quickly and more efficiently". The technical objectives of the Challenge reflect a similar position.

On the contrary, evidence highlights that focusing on technology in isolation is unlikely to yield the expected transformation. For example, 58% of the respondents to NBS's 2018 BIM Report state that the UK Government's 2016 BIM Level 2 mandate 'has not been successful' or 'not successful at all'. Less than one fifth agree that 'the construction industry is now delivering on [it]'. Increasing levels of adoption have been reported (74% adoption in 2018) but there is less confidence in the anticipated project efficiencies. Only 52% of the respondents agree that BIM adoption increases the speed of delivery. Other studies have shown that BIM adoption has not resulted in collaboration across the disciplinary boundaries (see for example Volk, Stengel & Schultmann, 2014; Liu, van Nederveen & Hertogh, 2017).

The industry KPIs corroborate these findings. Although there have been some improvements in cost and time predictability of the design and construction phases to 2016, only 41% of the projects as a whole were completed on time. Time predictability of design, which had arguably benefited from high levels of BIM penetration even before April 2016, decreased from 53% in 2015 to 48% in 2016. The McKinsey Global Institute's 2017 report identified "an intractable productivity problem".

All this evidence leaves little cause for optimism that the continuing emphasis on technology, whether it is BIM or digital manufacturing, will independently yield the aspired transformation. The root-causes of the challenges should be eradicated. A robust understanding of the conditions for technology adoption and novel approaches to nurturing them in this adversarial, fragmented industry are needed.

The substantial body of work in this area, highlights the importance truly collaborative business models, e.g. platform businesses (Christensen, Altman, McDonald et al., 2016); and for a move from hierarchical co-ordination (management) to self-management of mutually interdependent professionals, when the new technology "changes the nature of tasks and their performance, interconnections and nature of physical, energy and information flows, the skills required, the roles played, the styles of management and coordination, even the organisational culture" (Zeleny, 1986). Hence, it is necessary to envisage BIM adoption not as adoption of *technology*, which will only allow the industry to do the same thing in essentially the same way but more efficiently, but as adoption of *high technology*, which allows to do things differently and to do different things through collaboration and integration.

4. High Technology Management: appropriate lens

Zeleny (1986) differentiates high technology (HT) from any other form of technology because HT "affects directly the nature and organization of tasks to be performed". They also lead to reintegration of knowledge that is currently distributed at different hierarchical levels of an organization, i.e. management and labour. Unlike the past technologies, which served to enhance efficiency and specialization, HT supports a 'multi-functional' worker. A symbiosis between the man and the machine is envisaged where the relationship itself, rather than the man or the machine in isolation, enhances the outputs.

Zeleny (1986) identifies three components of HT: hardware, brainware and software. Hardware is the physical/logical plant (e.g. machine, equipment). It is the means of carrying out the tasks. Software is the set of rules, guidelines, algorithms that are necessary for using the hardware, and the know-how on how the tasks should be carried out. Brainware is the know-what and the know-why of technology which facilitates decisions on what to employ, how, when and why. These components are "embedded in a complex network of physical, informational, and socio-economic relationships" (Zeleny, 1986). This network is called technology support network, which also encompasses the

organizational, administrative and cultural structures.

5. Current Approaches to Facilitate Collaboration and Integration in the UK: BIM or otherwise

The hype around BIM transforming the industry and facilitating collaboration is still buoyant. What is missing is evidence, going beyond the perceptions of practitioners, to establish whether the "transformational opportunities demonstrated through the Level 2 BIM programme" (HM Government, 20165) have materialized or not. The UK is not alone in this lack of evidence-based evaluation (Vass & Karrbom Gustavsson, 2017).

This author argues that, so far, BIM adoption in the UK has mainly been envisaged as one of technology adoption, with a focus on efficiency gains, although the rhetoric refers to transforming the industry through collaboration and integration. The ultimate goal is to deliver industry level efficiencies that Construction 2025 called for, e.g. 33% lower costs and 50% reduction in both emissions and delivery time. This approach is in stark contrast with *high technology* adoption (Zeleny, 1986).

Against this background, much of the effort for adoption is spent at the project delivery level, which creates significant barriers to sustaining momentum given the temporary nature of projects and teams. It also means that BIM needs to be aligned with the *current* practices and procedures in the adopting organisations, rather than facilitate the redefinition of the nature and organization of tasks to be performed. Hence, the opportunities that BIM adoption could offer in terms of transforming the industry are not utilised.

Moreover, aspirations for collaboration across disciplinary and organizational boundaries are difficult to achieve. One reason is the the persistent fragmentation of the industry, which necessitates the use of temporary, and often adversarial contracts to build the project teams for design and delivery. Such contractual arrangements raise questions about data, and therefore model, ownership. These issues are generally circumvented by authorizing different levels of access to different project actors to the models, curtailing the opportunities for collaboration across disciplinary and organizational boundaries across the breadth and depth of the supply-chain.

The transformative potential of initiatives such as BIM can only be exploited, if the uptake of technologies is viewed as a substantive change to existing routines, and managed according to the principles of high technology management, which are briefly outlined in the previous section.

In this context, the building and maintenance of the technology support network should be considered as the starting point for successful transformation. The "complex network of physical, informational, and socio-economic relationships" (Zeleny, 1986) should come to the fore as part of establishing new ways of doing business by designing a new and better system, which "promote[s] self-reliance, self-service, innovation and creativity". The *tasks* (or activities) that are to be performed by individuals and *flows*, i.e. the entities to which these tasks are applied (whether they are other people or machines), are the two key components of this network. *Flows* normally span organizational boundaries. The tasks and flows cannot be separated because the ultimate goal is to achieve system productivity, and not task or flow productivity in isolation.

However, the UK's approach to BIM adoption at the industry level has followed the opposite strand. Rather than allowing the market to define new practices and routines, the quasi-governmental agencies took the lead by publishing a series of codes of practice, starting with BS 1192:2007-Collaborative production of architectural, engineering and construction information in 2007. The BIM Task Force published its BIM Strategy in 2011, and called the Government to help the industry to realise the benefits of BIM. The Government mandate for April 2016 came later in the same year.

These attempts have been limited to digitizing the existing processes, rather than redefining them.

Following on from this strand, adoption has mainly been considered at the project level. The Digital Plan of Works (DPoW, see Figure 1) that was published in 2013, is one piece of evidence to support this argument. It presents management and information processes that run concurrently, along the sequential stages of the RIBA Plan of Works. It could be argued that the common data environment that encircles these stages is part of the technology support network, but there is little consideration of how this environment can be enacted when the project coalition is brought together through temporary contracts, data ownership issues have not been resolved, and over 95% of the companies in the industry are micro-businesses.

Moreover, DPoW implies that there is a single 'Project Information Model' (PIM) which is kept up-to-date throughout the project life-cycle, ready to be transferred to the Client as the 'Asset Information Model' (AIM) at the end of the Handover Stage (Stage 6). The experience in practice is very different to this notion of seamless flow. A relatively recent Innovate UK-funded project provided evidence that the design consultants, who were employed using a NEC3 contract, were reluctant to sign off the PIM as an *as-built* model because they had no means of establishing whether the contractors fully adhered to the construction drawings. Hence, they were only prepared to sign off these models as '*last-issue for construction*', raising issues around the reliability of the PIM as an AIM.

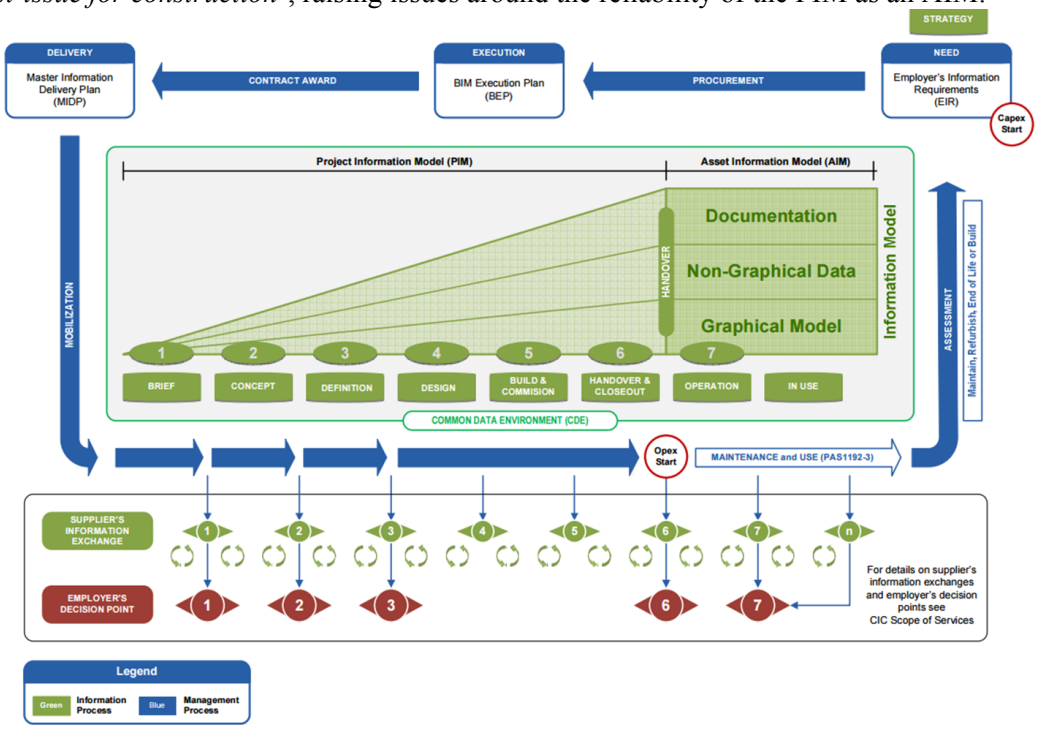

Figure 1. Digital Plan of Works
Source: BIM Level 2 (2013)

This brief overview has demonstrated that the UK Government's approach to BIM adoption in the UK is unlikely to bring about the transformation that is required for collaboration and integration that many reports have called for since the 1934 Bossom Report. However, the limited but notable exceptions may provide some impetus for the industry to change course.

One of these exceptions is Bryden Wood's (2018) proposal of "digitally enabled" platforms as a way of achieving the UK Government's targets for cost effectiveness, productivity and timeliness of delivery. They argue that the industry is ready to harness the potential that platforms inherit, mainly because "digital tools that would support a manufacturing-led approach are in place". They define "platform construction" as "an integrated, digitally-enabled logistics process bringing together components and sub-assemblies". Popular examples of platforms come from the automotive and

software/smart phone industries (see for example Christensen et al., 2016, and Gawer & Cusumano, 2013). The chassis of a car is the platform on which its different components, e.g. the engine, are assembled. The iPhone is a platform for many apps, which directly deliver services such as Uber to customers.

Bryden Wood (2018) offer an "initial view on those platforms that would be most commonly useful, and the type of assets that they could serve." They also illustrate that platforms can be blind to asset type. For example, a bedroom and a treatment/consulting room are located on the same platform because their physical dimensions, level of complexity and performance requirements, e.g. privacy, are similar. The development of platforms is the starting point. It is envisaged that open source platforms would enable all types of projects and organisations, including small projects and SMEs, engage in innovation and benefit from the learning from major projects, which would be incorporated on the platform.

Bryden Wood (2018) clearly proposes a different approach to the design and delivery of built assets. In this respect, it is a welcome contribution to the debate on the transformation of the industry. However, this contribution, in its current form, does not include concrete suggestions as to how this idea can be implemented in practice. Open source platforms, as the key vehicle for implementation, is not even at its infancy, given the current practices in the industry. Moreover, the publication itself acknowledges the issues around the "capability" and the "capacity" of the off-site market. It is envisaged that "a digital marketplace for construction" that will facilitate a different payment mechanism linked to components either leaving the assembly line or being installed will play an important role in the utilization of platforms. There is also a suggestion that components assembled on platforms would be more readily re-purposed or reconfigured at end of life or as an asset's needs evolve in the Circular Economy. How these ideas will be operationalized remains to be seen.

Furthermore, Bryden Wood (2018) states that the platform approach is "typified by 'continual improvement' -the components are improved or expanded over time by incorporating lessons learnt and innovations in materials science and manufacturing processes." Zeleny (2012) strongly opposes "continuous improvement", because it fits in with the existing technology support network rather than creating a new one. He proposes "*discontinuous improvement* leading to high technology, disrupting the old ways and old interest, lifting up human spirit and advancing human condition in leaps and bounds". He lists Distributed Co-creation, Open-source innovation and Co-ware; and Social-network Organization among the emerging new technology trends, which exemplify "*discontinuous improvement*". In the former trend, the product is co-created with the customer who plays a role through providing and sharing feedback. Creative resources of customers, consumers and users are tapped into. In the Social Network Organisation, the focus is on coordinating the flows and tasks across the organizational and professional boundaries, rather than the ownership of workers and their specialist knowledge. Perhaps the industry-wide adoption of the platform approach could become discontinuous improvement if social network organisations that focus on the coordination of flows and tasks also emerge as enablers of integration and collaboration.

6. Conclusions

This paper reviewed the plethora of reports that called for a transformation of the construction industry in the UK. It critically evaluated the UK Governments current approach to BIM adoption as a vehicle for integration and collaboration. This approach has been classified as technology adoption, which focusses on improving the efficiency of existing processes, rather than developing new practices and routines through "*discontinuous improvement*". The paper also argued that Zeleny's (1986) approach to High Technology Management should be adapted for new technologies to deliver the transformation that reports since 1934 have been calling for. Recent developments such as Bryden Wood's (2018) call for the development and adoption of platforms for asset delivery and management have been identified as notable exceptions, which could inherit the potential to transform the industry. However, the structure of the industry, its narrow search scope, and its focus on experiential learning,

and on incremental change at the project level, remain to be key barriers to bringing about such changes.

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