

Key Enablers for Effective Management of BIM Implementation in Construction Firms

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Abstract

In recent years, Building Information Modeling (BIM) has been characterized as a promising tool and approach to tackle the traditional problems inherent in architecture, engineering and construction (AEC) industry. Several AEC firms around the world have deployed BIM to execute their projects. However, the full utilization of BIM has not been achieved yet in mainstream AEC firms and on construction projects. The implementation of BIM is a significant concern for many construction firms as it requires changes in existing business processes to occur. Given the huge financial commitment and multitude of other challenges that a BIM project entails as well as the potential benefits arising from its successful implementation, it is significant to understand what is needed to ensure a successful BIM implementation. Based on a literature review and by using an approach grounded in business process change management theory, this paper aims to provide a better understanding about the enablers of BIM implementation. An enhanced understanding of the BIM enablers could help the organizations to avoid costly errors and mistakes in the process of planning for BIM adoption and implementation and to increase the potential benefits of BIM.

Keywords: Building Information Modelling (BIM), innovation implementation, Construction Management

1. Introduction

The Architecture, Engineering and Construction (AEC) industry has long been criticized for its low productivity in comparison to other industries, and the industry is facing challenges to fulfil clients' expectations and remain competitive. Traditionally, for any construction project a set of design and construction documents are generated largely through 2D CAD-based applications. The result is that the contractor ends up with a pile of 2D drawings that have to be measured and calculated manually in order to get the quantity take off for the project. The on-site planning, assembling of different building components, and coordination of large number of different trades/subcontractors are all difficult tasks to perform with 2D-based workflows. The nature of construction projects is such that they involve a large number of stakeholders and organizations, which require a high degree of collaboration and communication. A smooth flow of information, materials and other key resources is crucial to shorten the lead time and reduce uncertainty. It is the key facilitator for increased team collaboration and providing better value to the client (Titus and Bröchner 2005).

In recent years, Building Information Modelling (BIM) has been considered as an innovative technology and approach to overcome the traditional problems inherent in the AEC industry. BIM is changing the way construction projects are executed. It offers several new opportunities for the optimization of whole construction supply chain through the reduction in reworks, design and construction errors, and by providing reliable and reusable digital information about a building's whole life cycle.

The adoption and implementation of BIM, however also comes with many inherent risks and uncertainties. It is in fact a complex business process for many construction firms to manage it. Some may consider BIM as a mere technological innovation, but it should be re-classified as an organizational innovation (Succar and Kassem 2015). Organizational innovation can be considered as "a means of changing an organization, whether as a response to changes in its internal or external environment" (Damanpour 1991). In other words, organizational innovation refers to a new organizational method for undertaking business practices and/or external relations.

Implementation of BIM as an organizational innovation involves adjustments to the firm's values and culture for its introduction. It also involves significant change in organizational structure and infrastructure. Most importantly, BIM implementation involves a high degree of difficulties because it deals with significant change management and resistance of individuals to embrace the change. Due to these associated difficulties, the full benefits of BIM have not been achieved yet in the mainstream construction projects and firms (Gu and London 2010).

BIM implementation requires a well-planned and coordinated approach with due consideration different aspects of innovation management and implementation (Smith and Tardif 2009). Given the associated difficulties and a huge amount of investment required, a better understanding about the key enablers during the process of BIM implementation is vital. Since BIM implementation involves changing the business processes of construction companies, the

authors believe that business process change theory may provide a better understanding about the key enablers in the BIM implementation. In the following section, the theory of business process change will be further explained.

2. Theory of business process change management

Business process change is defined as organizational initiative to design business processes to achieve significant improvement in performance through changes in the relationships between management, information technology, organizational structure, and people (Kettinger and Grover 1995). According to the theory developed by Kettinger and Grover (1995), “any significant business process change requires a strategic initiative where top managers act as leaders in defining and communicating a vision of change. The organizational environment with a ready culture, a willingness to share knowledge, balanced network relationships, and a capacity to learn, should facilitate the implementation of prescribed process management and change management practices”. In the following sections, the different elements of this theory will be discussed in detail.

2.1 Strategic initiatives

Typically process change starts with strategic initiatives from the senior management team (Kotter 1995). These can happen as a result of reaction to a need or a proactive push to leverage potential opportunities (Earl 1994). Evidence also exists that strategic change, and arguably process change, is often incremental, informal, emergent, and is based on learning through small gains versus being revolutionary and radical. According to Shrivastava (1994), strategic initiatives can be forced on the organization through mandate or pushed through consensus within existing systems of the organization. Alternatively, champions of change could emerge to seek out creative ideas and make them tangible (Tushman and Nadler 1986). They engage in coalition building an information-intensive process of knowledge sharing and persuasion.

2.2 Cultural Readiness

Organizational culture governs how people inside an organization learn, share information, and make decisions. The significance of organizational culture can be best explained in terms of cultural beliefs, values, and norms (Schein 1984). At the highest level, an organization’s beliefs symbolize the interactions between ideas and shape its interpretation of information and how it makes decisions. Value systems relate behaviours across units and levels of the organization, with values being shared by the organization as a whole or by distinct subunits. Values often exhibit a propensity to resist change because of their shared nature (Fitzgerald 1988). At the lowest level, norms are the unwritten and socially transmitted guides to behaviour. Norms that promote change include risk taking, openness, shared vision, respect and trust, high expectation for action, and a focus on quality (O’Reilly 1989). Norms that discourage change include risk avoidance, ambivalence, group think, and excessive competition (O’Reilly 1989). In short, cultural beliefs, values, and norms constitute an organization’s cultural potency to influence behaviour. Thus, leadership that can identify and influence cultural readiness for change can be

a requisite to an effective process initiative. Moreover, open communications and information sharing can promote a common culture and innovative behaviour among people inside an organization.

2.3 Learning Capacity

The major goal of learning is to provide positive outcomes through effective adaptation to environmental changes and improved efficiency in the process of learning. Adaptation involves making appropriate responses to technological changes and learning from other organizations that have achieved the best practices in the industry (Freeman and Perez 2000). Increased efficiency can also be obtained through “learning by doing” (Arrow 1962) and accumulation of knowledge through cross-functional interfaces (Adler 1990). Such knowledge accumulation is also called declarative knowledge (i.e., a body of organized information) and can facilitate learning in a collective manner (Corsini et al. 1996). Higher level learning occurs when members reflect on past learning experiences to discover new strategies for learning. Learning can also be brought about by scanning external information. This can come from organizational employees who constantly review the environment for new developments and opportunities (technology gatekeepers), consultants who span the boundary between the environment and the organization (boundary spanners) and from the end users.

2.4 IT Leveragability and Knowledge-Sharing Capability

IT is an organizational resource which enables the necessary means to accomplish knowledge processing and, hence, induce organizational change (Hammer and Champy 1993). Evidence suggests that IT led projects often fail to capture the business and human dimensions of processes (Markus and Keil 1994). A case is often made for the socio-technical design approach which suggests a mutual, bidirectional relationship between IT and the organization. Such an approach recommends synergy between the business, human and IT dimensions of an organization and could be promoted through cross-functional teams.

Communication technologies have also been proven to facilitate learning and knowledge development through a process of coordinated interaction among individuals. The ability to share knowledge enhances an organization’s tendency to change so that transparent data access empowers individuals and knowledge workers to reinforce one another’s expertise (Nonaka 1991). Thus, information and communication infrastructure and the extent of knowledge sharing can create an environment that facilitates successful business process change.

2.5 Network Relationships

Research indicates that a successful change process requires leveraging of boundaries and relationships and balancing internal and external networks in terms of cooperation and competition (Nonaka 1991). Under most circumstances cooperative, interpersonal and group behaviour results in superior performance (Shaw 1958). However, it is possible that competitive controversy within generally competitive groups can result in greater openness, knowledge and

understanding (Tjosvold and Deemer 1980). In terms of inter-organizational processes, research indicates the benefits of connection with external partners. Organizations that can manage these aspects of competition and cooperation continuously can benefit from employee incentives and to instil change more effectively.

2.6 Change Management Practice

Change management involves effectively balancing forces in favour of a change over forces of resistance (Strebel 1992). Organizations, groups, or individuals resist changes that they perceive as threatening them (Guha et al. 1997). It has been suggested that corporate transformation requires a general dissatisfaction with the status quo by employees who have to change (i.e. a readiness to change), a vision of the future, and a well-managed change process. The change management programme should address required cultural shifts in beliefs, values, and norms. Revolutionary and evolutionary change theorists propose contrasting tactics for accomplishing change which vary depending on the type of employee involvement, communication about the change, and leadership nature. Nevertheless, direct confrontation to forces of resistance will likely only increase resistance capacities. It is, therefore, suggested to use the theories of persuasion in changing attitudes to mitigate resistance and to understand “how” and “what” aspects and persuade the employees toward commitment and cultural assimilation (Melone 1995).

2.7 Process Management Practice

Process management is defined as a set of concepts and practices aimed at better stewardship of business processes (Davenport 1995). It combines methodological approaches with human resource management to improve the outcome of business process change. Successful process management uses process measurement (use of process metrics, process information capture, improvement feedback loop, and process audit), tools and techniques as well as documentation. Evidence also supports the use of team-based structures both for the implementing the project and for designing the new process (Guha et al. 1997).

3. Key enablers for effective management of BIM implementation

As discussed previously, BIM is an organizational innovation and a new approach in construction. The successful adoption and implementation of BIM requires a thorough analysis of different enablers. Based on the theories of business process change management, we have identified the key enablers associated with BIM implementation management which are summarized in Table 1.

Table 1: A summary of the BIM implementation management enablers

<i>Constructs</i>	<i>Enablers</i>	<i>Authors</i>
Strategic initiatives	Support from top management	(Arayici et al. 2011a)
	User's input	(Arayici et al. 2011b)
	Strategic vision	(Khosrowshahi and Arayici 2012)
	Strategic plan	(Arayici et al. 2011b)
	Stakeholder's analysis	(Arayici, Egbu and Coates 2012)
	Cost-benefit-risk analysis	(Mom and Hsieh 2012)
Change management	Rewards and recognition	(Peansupap and Walker 2005)
	User training and education	(Arayici et al. 2011b)
	Supportive supervisor	(Peansupap and Walker 2005)
	Management readiness for change	(Arayici et al. 2011a)
Cultural readiness	Existence of change agents	(Merschbrock and Munkvold 2014)
	Risk aversion	(Succar 2009)
	Early user involvement	(Miettinen and Paavola 2014)
	Open communication and information sharing	(Dossick and Neff 2009)
Learning orientation	Colleague's help	(Peansupap and Walker 2005)
	System expertise	(Eadie et al. 2013)
	Individual competency assessment	(Succar, Sher and Williams 2013)
	Learning-by-doing	(Arayici et al. 2011b)
	Community of practice	(Peansupap and Walker 2005)
	Learning from past experiences	(Arayici et al. 2011a)
Knowledge capability	Developing knowledge management system	(Arayici, Egbu and Coates 2012)
	Use of communication technologies	(Volk, Stengel and Schultmann 2014)
Network relationships	Inter-organizational linkage	(Homayouni, Neff and Dossick 2010)
	Cross-functional cooperation	(Cerovsek 2011)
Process Management	Setting benchmarking metrics	(Coates et al. 2010)
	Tracking benchmarks	(Giel and Issa 2012)
	BIM maturity assessment tools	(Succar, Sher and Williams 2012)

Strategic initiative enablers

Top management support is required throughout the implementation process. Top management must be committed and willingness and actively are involved in the process and allocate valuable resources to the implementation effort. This involves providing the required human resource for the implementation and allocation of sufficient time to get the job done.

Managers should legitimize new goals and objectives. A shared vision of the organization and the role of the new system and structures should be communicated to the employees. New organizational structures, roles and responsibilities should be established and approved and conflicts should be mediated. Policies should be set by top management to establish new systems in the company. Top management of the organization must understand and analyse the sources of resistance and must employ the appropriate set of strategies to counter them.

Moreover, a clear business plan and vision to steer the direction of the projects is required for BIM implementation. A business plan that outlines proposed strategic and tangible benefits, resources, costs, risks, and timeline is essential. This will help keep focusing on business benefits. There should be a clear business model of how the organization should operate behind the implementation effort and a justification for the investment. Goals and benefits should be identified and tracked. The business plan would make work easier and impact on work.

Cultural readiness enablers

Effective communication is critical to BIM implementation. Expectations vary at different levels, so they must be communicated. Management of communication, education and expectations is essential through the organization. User input should be managed in obtaining their requirements, comments, reactions and approval. Middle managers need to communicate importance of BIM implementation. Employees should be told in advance the scope, objectives, activities and updates, and admit change will occur.

A communication plan is important to involve the member with BIM initiative by showing them how it works, how it is related to their jobs and the benefits achieving from it. By doing so, resistant to change can be diminished. Moreover, it would be helpful to establish a communication program that can describe what should be communicated by whom and how often. It may help organizations to propagate their strategy. After implementation of BIM, it is best to publish the outcomes, but these should not be limited to success outcomes but also communication of drawbacks. It will help the future projects to avoid the same mistakes and from the past mistakes.

A champion is critical to drive consensus and to oversee the entire implementation process. They are the agents of change who should spread the BIM philosophy, benefits, as well as weaknesses throughout the organization. Someone should be placed in charge who has the power to set goals and legitimize change.

Knowledge and learning enablers

Knowledge sharing and communication play a pivotal role in alleviating resistance to change and reducing risk and uncertainty. IT tools can facilitate the knowledge sharing process. Another key issue is creating a learning environment through a set of interrelated practices and beliefs within an organisation that enable employees to develop their own skills and learning. In such an environment, employees do not feel constrained by fear of failure and willingly participate in experimentation and risk taking (Klein and Knight 2005). Through “learning by doing”, members can learn how further efficiencies can be achieved through BIM implementation (Arayici et al. 2011b).

Network relationships enablers

Although the training courses provide a wealth of knowledge in BIM initiative, it may not reinforce all the new knowledge and skills required to sustain BIM implementation successful. Throughout the implementation process, companies need to look at external organizations who are successful and leader in BIM implementation and learned best practices and methods from them. Moreover, the organization implementing BIM should work well with external vendors and consultants and/or internal divisions such as R&D to resolve users and software problems. Altogether, these aspects help them to transform from a trained organization to a learning organization.

Change management enablers

Generally, when substantial change occurs inside an organization, the organizational members are afraid of the unknowns and might not realize the need for change. Some organizational cultures are fear based. Mistakes are not allowed, and employees are used to hiding errors. However, BIM as an innovation flourishes in an open and safe environment (Grilo and Jardim-Goncalves 2010) where mistakes are seen as improvement opportunities. Moreover, users must be trained, and concerns must be addressed through regular communication, working with change agents, leveraging corporate culture and identifying job aids for different users. As a part of the change management efforts, users should be involved in implementation processes, should be endowed by tangible or intangible rewards and should be provided with educational and training programs to improve their comfort zone. There should be extra training and on-the-job support for employees and managers during implementation. To meet users’ needs after initial implementation, a support which can be provided either by an external organization such as help desk or internal colleagues is critical.

Process management enablers

Companies that adopt BIM must continuously improve their BIM performances and processes. Maturity assessment tools can be utilized to evaluate an enterprise’s performance in BIM utilisation during the initial stages. Furthermore, process measurement metrics and tools enable them to perform benchmarking. The application of most maturity evaluation tools is to assess the level of BIM performance within an organisation during the initial stages, and benchmarking tools and metrics allow a comparison between one enterprise’s BIM performance and that of

their industry peers. These enable them to benefit from the lessons learned and best practices from other firms and use them for further improvement and modifications in the organisation.

4. Conclusion

The primary objective of this paper was to classify the BIM adoption and implementation enablers. The study identified that BIM is an organizational innovation and therefore needs organizational innovation principles to be taken into consideration. To this end, we believe the theory of business process change management may provide a better insight into the key enablers during the BIM implementation process. The results of this study should assist both practitioners and scholars and provide them with insights on how to better understand and prepare for BIM implementation. Specifically, this study tried to shed light on key facilitators of BIM implementation success that need to be focused for optimising the financial returns from BIM implementation. If any of these aspects are missing during the implementation of BIM, it would be the difference between a successful and unsuccessful implementation effort. However, the degree of influence of these factors may vary in different organizations. The key enablers identified in this study can serve as a checklist that covers the key success factors associated with BIM implementation for AEC firms.

During the BIM implementation process, an organization goes through a major transformation, and the management of this change must be carefully planned and meticulously implemented. We believe providing a conducive change environment supported by a set of change management as well as process management facilitators can help construction firms to better utilize from BIM workflows. Based on the theory of business process change management and through a review of literature, we identified a total of 27 BIM adoption and implementation enablers. The success of BIM implementation heavily hinges on the strong sustained commitment from the top management. An organizational culture where the employees share common values and goals and are receptive to change is most likely to succeed in BIM implementation. Moreover, user training, education and support should be available and highly encouraged. Change agents should also play a pivotal role in the implementation to facilitate change and to leverage the corporate culture. Maturity assessment tools can be utilized for process improvement.

In the next step of this research, we plan to assess the degree of significance of the key drivers identified in the literature and also compare a number of successful and unsuccessful BIM implementation. We are also interested in studying how the perceived importance of these drivers may differ across BIM implementation partners such as top executives, project team members, vendors and consultants. By having a better understanding of the key issues involved in BIM implementation, management and decision makers will be able to make critical decisions, better allocate resources and realize increased benefits from BIM implementation.

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