# How Important is Inter-organizational Collaboration to the Success of Construction Project BIM Implementation

Wei Lu[1], Dan Zhang[2], Steve Rowlinson[3]

## Abstract

The construction industry is always criticized for lack of collaboration and ineffective communication. Building Information Modelling (BIM) is introduced to the industry as a concept that involves a series of changes on organizational processes, tools, structures and policies, as well as the interaction patterns among individuals and professional groups. Proponents claim that BIM will improve the collaboration performance of project teams. However, the performance of BIM in practice fails to achieve more advantages than traditional projects on efficiency and effectiveness. On the contrary a collaborative working environment could be the antecedent of successful BIM implementation. In this paper, the impacts of BIM implementation on the construction process are underlined and a set of key factors of inter-organizational collaboration are explored. Furthermore, the significance of inter-organizational collaboration across project teams toward successful BIM implementation in the construction industry is also discussed, pointing to future study on collaboration theory from a social-technical perspective to evaluate the BIM performance.

**Keywords: Inter-organizational relationship, collaboration, Building Information Modelling (BIM), construction**.

## 1. Introduction

Professionals intend to optimize their functions with little attention to others' interests, and they are barely interested in understanding the whole process in construction (Love et al., 1998). Dainty et al. (2006) confirmed that this focus on their own interests is the reason for fragmentation i.e. lack of integration from design to project delivery. Thus, participants focus more on self-protection and economic benefit maximization rather than general project performance. Furthermore, increasing fragmentation facilitates the increasing complexity of projects, and brings more difficulties in project management (Kadefors, 1995). The fragmentation within the project organization is the main barrier to project performance. Construction projects are unique due to temporary collaboration amongst parties.

[1] PhD Candidate; Department of Real Estate and Construction; The University of Hong Kong; weilu@hku.hk.
[2] PhD Candidate; Department of Real Estate and Construction; The University of Hong Kong; doradanzhang@gmail.com.
[3] Professor; Department of Real Estate and Construction; The University of Hong Kong; smr@hku.hk.

Professionals own influence on the decision-making, and the goal of the organization is mixed with their own expectations. From Partnering, Alliancing to IPD, multi-delivery methods are adopted through the process in order to optimize such inter-organizational collaboration (Earl 1996). Nevertheless, both academics and practitioners fail to attain satisfactory inter-organizational collaboration, no matter how they tackle the improvement such as changing organizational structure, adjusting contractual items and adopting new technologies.

Wide use of BIM technology in construction industry has not promoted collaborative relationships within organization thus far. BIM becomes one way to cope with cooperation, integration and coordination challenges in the construction industry, however, current use of BIM technology has not promoted collaborative relationships within organization. Collaboration under BIM creates great opportunities, but also creates new issues that need to be addressed and solved. It is ineffective for BIM adoption if each professional still performs under the conventional contract framework. That ignores the inter-relationship between BIM and Integrated Project Delivery (Ashcraft, 2009). It is necessary to consider collaboration before implementing BIM.

## 2. Building Information Modelling

BIM is regarded as a critical factor in fulfilling integrated project delivery. This inevitably leads to the restructuring of project organizations and communication processes. Current project management also needs to be changed in order to facilitate BIM implementation. Although the development of Information and Communication Technology (ICT) has improved significantly in the past decades in construction industry, most of the outstanding issues mentioned earlier are still unsolved since Bowley (1966) identified the problems and issues related to the industry (i.e. lack of integration of design and production). Courtney and Winch (2002) confirmed that over 80% of those factors underlying re-engineering issues could also be found in other countries with equal significance.

BIM as a new concept involves a series of changes and adjustments related to organizational process, tools, structures and policies. Further, it changes the style of interactions among individuals and their organizations. The advent of BIM technology takes one significant step forward towards cooperation and communication logic. Different parties may achieve higher level of collaboration through effective communication in addressing problems, deriving solutions and building trust (Hossain, 2004). Collaboration demonstrates communication and cooperation across parties in the organization (Baker, 1992). Nevertheless, BIM implementation on construction sites has gradually forced project teams into partially unnatural and ineffective administrative work routines due to the inflexibility and fixed nature of the BIM system and process (Wikforss et al., 2007). In that way, the potential of BIM for facilitating collaboration at both inter-personal and inter-organizational levels is constrained under such inappropriate implementation strategies.

By working collaboratively, the project organization could achieve process integration, knowledge sharing and relationship maintenance. Professionalism and geographic dispersal are sources of collaboration difficulties. One of the main functions of BIM is facilitating

professions to achieve integrative and collaborative working. BIM can provide such a condition and platform to optimize the inter-organizational interaction. Nevertheless, the quality of collaboration still needs to be improved. How to promote multi-disciplinary collaboration and how to integrate BIM advantages with better collaboration are the key questions to be addressed. Obviously, it will not be successful without considering social and psychological issues which impact inter-organizational collaboration. They also impact the effectiveness of BIM implementation in a project. Gerber et al. (2012) demonstrated BIM collaboration benefits as follows: "1) Enabling concurrent collaboration—compared to sequential workflows of information generation and analysis; 2) Integrating separate tasks—a shared 3D model can incorporate estimating, scheduling, spatial coordination tasks more effectively; 3) Improving separate tasks—direct use of a 3D model facilitates tasks such as estimating, scheduling, spatial coordination." (pp. 22)

Understanding inter-organizational collaboration is necessary before BIM implementation. Currently, the majority of construction professionals lack sufficient training and BIM knowledge. Few people recognise the necessity of encouraging project teams to collaborate effectively. BIM should break down cultural and organizational boundaries by promoting communication and collaboration. Technophobic personnel are one of the challenges to the successful incorporation of value contribution in the BIM process. Thus the satisfaction of current BIM technology is still low and there is a gap between interoperability and functionality.

Through visualization, BIM may analyse and detect clashes that allow professionals identify the potential risk. At the time that people strongly believe that BIM could provide high efficiency and collaboration with advanced technology platform, but professionals still focus on their own organizations and work fragmentally in construction process. Each member only fulfils minimum responsibilities according to the conventional contract signed before. This constrains the potential utilities of BIM and BIM is adopted as a tool only that creates little knowledge contribution and added value (Dossick and Neff, 2010). BIM provides increasing opportunities for project participants to integrate essential project elements, but it cannot fill the social gaps within inter-organizational relationships. This means that the BIM adoption fails to guarantee a better collaborative interaction in the project. We claim that transformations from traditional projects to BIM enabled projects change the way of providing services and the process of delivering projects. Some changes may do harm to process of collaboration. Inappropriate adjustments and implementation strategies may even cause protectionism and conservatism. Thus inappropriate BIM adoption can decrease the collaboration level and lose the advantages of communication efficiency. Previous studies fail to point out the importance of collaboration across professionals. There is no collaboration issue to be considered before adopting BIM. In other words, BIM could detect the clash by analysing building information, but it could not solve the inter-organizational conflicts. Therefore, we don't consider BIM only as a tool that digitally represents buildings with three dimensions and file all essential databases on a collaborative platform. It is not a tool only but also a set of policies, processes and technologies providing a methodology to collaborate all the essential construction outputs through building's life cycle (Succar, 2009).

The adoption of BIM technology as a goal is to accomplish the critical project objectives such as completion on time and on budget. BIM implementation is expected to close the communication gap and increase collaboration. However, the nature change of construction industry could not be brought along by new technology only (Rowlinson et al., 2010). It is necessary to provide a clear pattern of collaboration in construction and analyse the characteristics of inter-organizational collaboration before we move to BIM enabled projects. We need to find a way to embed this advanced technology in order to better fulfil the vision of collaborative working. Implementing the technology is not a challenge, but how to appropriately adopt the technology is the most difficult issue.

## 3. Collaboration

Collaboration as a word, which the first instance dates from 1860, means working together with others who share common goals and find solutions in order to satisfy all concerned (Kvan, 2000). Mattessich and Monsey (1992) provided a working definition of collaboration as: “Collaboration is a mutually beneficial and well-defined relationship entered into by two or more organizations to achieve common goals. The relationship includes: a commitment to: mutual relationships and goals; a jointly developed structure and shared responsibility; mutual authority and accountability for success; and sharing of resources and rewards.” (pp. 39)

Patel et al. (2012) also defined collaboration as involving two or more people working and interacting within a single task or series of processes. These people worked together towards a common goal. These definitions identify the characteristics of collaboration. The essence of collaboration is common goal, shared responsibility and joint completion at a project level. These characteristics are also the key factors of project success in construction projects. Son and Rojas (2011) explained the evolution of collaboration within inter-organizational networks in the large complex project based team. Xue et al. (2010) claimed collaborative working was recognized increasingly as one of the most important critical success factors in the construction process, and collaborative working became a new management paradigm in the construction community. de Saram and Ahmed (2001) confirmed that collaboration and communication is the key to achieve project objectives. To better understand and analyse it, we examine collaboration in more specific conditions and at different levels.

## 4. Multi-level Collaboration

Kvan (2000) reported that cooperation was used interchangeably with collaboration as seen in the literature. Overuse of “collaboration” on any type of inter-organizational or personal relationship impedes the practical evolution (Gajda, 2004). Czajkowski (2007) argued that although the term collaboration was interchanged with cooperation and coordination, they represented three different levels of formality and structure in the relationship processes in inter-organizational relationships. In practice, few scholars emphasize the differences among cooperation, coordination, and collaboration. Cooperation exists with informal relationships and without common objectives, structure or planning effort. Each organization retains their authority and shares information when it is necessary. There is virtually no risk and the

resources are as separated as rewards; Coordination is more formal than cooperation on relationship issues. Each organization has compatible missions yet still maintains their own authority, but there is an established communication channel. Resources and rewards are both mutually acknowledged. Risks are increased to all participants; collaboration presents a long-term strategic relationship. Collaboration aggregates different organizations into a united structure with one common goal. In this relationship, authority is determined by the organizational structure. To maintain this relationship, it requires effective communication and comprehensive working schedule. Therefore, each organization shares their outcomes and risks although they contribute their own resources and reputation (Mattessich and Monsey, 1992).

Marchington and Vincent (2004) examined inter-organizational relations at three levels: institutional, organizational and interpersonal levels. This distinction allows us to review the factors that encourage collaboration separately.

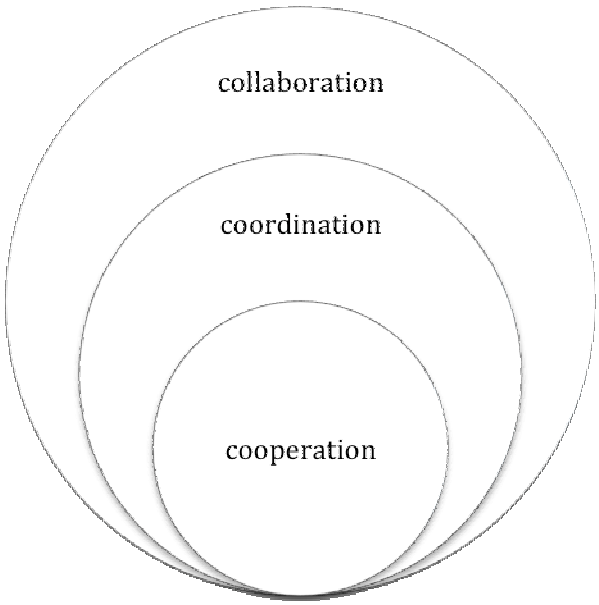


Fig.1 Categorization of Formality of Working Relationship

Phua and Rowlinson (2004a) confirmed that cooperation was vital to construction project success, and they claimed that intra-organizational cooperation was more important than inter-organizational cooperation. Because Intra-organization was more manageable than inter-organization, and individual firm could better control over the work behaviours of their employees in intra-organizational condition. In this paper, we discuss collaboration at project level. Based on the formality of working relationships, we categorize interactions into cooperation, coordination and collaboration (Fig.1). Cooperation allows individuals to share information supporting others for organizational objectives. Coordination is the activities in which different entities share a goal in order to achieve mutual benefit. Collaboration is that different professions give up some degree of independence to realize a shared goal. So the interactions among three categories could be analysed.

Cooperation at the individual level is fundamental to the collaboration. Individual cooperation provides further opportunities of coordination among different parties. Different parties still conserve their independences in the context of coordination. Fragmentations still exist at this level. A collaborative working relationship evolves from individual cooperation to team coordination and then inter-organizational collaboration. Base on the good inter-organizational relationships, project integration is achievable through the construction process.

## 5. Key Factors of Inter-organizational Collaboration

Gajda (2004), adapting figures from Bailey and Koney (2000), argued that collaboration was a journey, not a destination cross the continuum of integration. Anvuur (2008) analysed four types of cooperative behaviour and its impact on the organization. To achieve cooperative behaviour, he also claimed that four essential factors for optimal working relationships in construction, such as common goals, mutual respect, group interaction and support of the authorities and egalitarian norms were needed. Anvuur (2008) also found that contract types decided the nature of cooperation among organizations, some contract incentives may motivate organizations to cooperate, and some may work against the objectives of the project organizations. Mattessich and Monsey (1992) identified 19 factors that influence the success of collaboration based on six categories. Environment, process, structure, communication, purpose and resources are further developed in their study. Phua and Rowlinson (2003) also claimed that culture as a key factor that impacts inter-organizational collaboration. Cultural differences could moderate the contextual variables such as organizational structure. Cultural differentiation leads to inter-organizational differentiation. Better understanding of the influence of culture of organizational cooperation could improve the management of construction projects. Previous researchers identified collaboration factors from a general level rather than any specific industry. Some researchers analyse collaboration factors more specifically in the context of construction projects. Succar (2009) categorized leadership, infrastructure, human resources and products/services into process fields. In his framework, he used these to distinguish among these sub-divisions in order to define BIM stages in detail. Leadership is combined with management decisions, organizational processes and communication activities. Management decisions represent vision and culture; organizational processes represent management; and communication activities include internal and external communications.

## 6. BIM Collaboration Framework

Selected practitioners were invited to participate this research. Emails were sent out to the potential contacts. Eight industry practitioners with more than three years of BIM experience replied and agreed to meet. Face to face interviews were adopted to investigate the impact of BIM implementation and the potential for collaboration improvement. The interviewees were invited from three different BIM enabled construction projects. Based on the literature review, further discussion related to BIM collaboration was developed. A conceptual framework was structured accordingly (Fig. 2). Key factors that facilitate better BIM collaboration are identified.

Through the interviews, most practitioners agreed that promoting collaborative effectiveness of BIM is a systematic issue. It is multi-relational and a dynamic evolution through people, process and technology. Managing a successful BIM enabled project requires an integrated and balanced approach to technology, process, and people.

First, technology as the antecedent is the driver for the whole construction industry to embrace BIM implementation. When the current technology can satisfy practitioners to adopt practically, people may take it on board and enhance it. Technology innovation, as an enabler to improve project performance, provides dramatic improvements in documentation, communication and visualization. Thus management of new technology is crucial to implementation. For better collaboration, current BIM technology could do better such as open standard, interoperability and communication. An open standard may integrate different work done by different professionals. Building information and data is core value and product of project service. Exchange of Building information and data among project participants is crucial to the performance. A standardized exchange protocol is the key to communication through new technology. Communications enhance mutual understanding and information exchange improves communication efficiency. Standard and communication both decide the performance and applicability of BIM technology. In order to take full advantage of BIM, project organizations need to optimize the level of interoperability. Lack of interoperability challenges the acceptance of technology and project progress. Therefore, analyses of standards, communication and interoperability are of major importance in promoting BIM application.

Second, a person is even more important than the technology itself considering successful BIM implementation. Implementing BIM requires changes to organizational culture and process. Individuals who are key players of new technology and execution strategy need supporting management skills. Professional knowledge and personal commitment are critical to successful project delivery. A certain degree of professional knowledge and training are essential at the beginning of BIM implementation. No matter how perfect a technology is, it is only a concept until people decide to adopt it. Incentive strategy could further motivate people to experience new technology more widely. Certain incentives can stimulate individual commitment to project team. The more people involve with new technology, more feedbacks and innovative improvements are provided. Since the technological communication became available, people also need to communicate among project teams. A functional communication path can strengthen the collaboration through sharing knowledge and exchanging ideas. They could strengthen the team relationships through communication and increase the efficiency of BIM implementation. Most of our interviewees claim that good leadership is also important to the success of BIM implementation. Leadership could mean a good BIM manager in a project, or it could be a committed project organization that encourages collaboration.

At last, professionals with efficient resources and state-of-art technology are able to provide services and deliver qualified products. However, process change can lead to negative impacts on the final product. Understanding construction process and optimizing process can reap advantages through productivity and efficiency. When technology is applicable and people master the skills, process needs to be revised according to new circumstances. To

implement a more collaborative BIM, construction project needs a new contract strategy that better fulfils the demands of BIM implementation. We found most of the BIM enabled construction projects are still under the traditional procurement system. This impedes the potential functions of BIM. Besides contract issues, organization structure is another barrier to BIM collaboration. Routinized organization structure may also eliminate BIM's potentials. The rigid structure also constrains individuals' authority. Individuals do not expect to take more responsibility and the organization structure decreases the flexibility of project management. Interviewees also suggest optimizing resources to facilitate team collaboration is crucial to BIM success. Each professional has their own resources and advantages, but sharing resources is difficult. In a word, successful BIM implementation relies on the revolutionary change from all the aspects. Industrial participants should have a clear framework before they could implement collaborative BIM successfully.

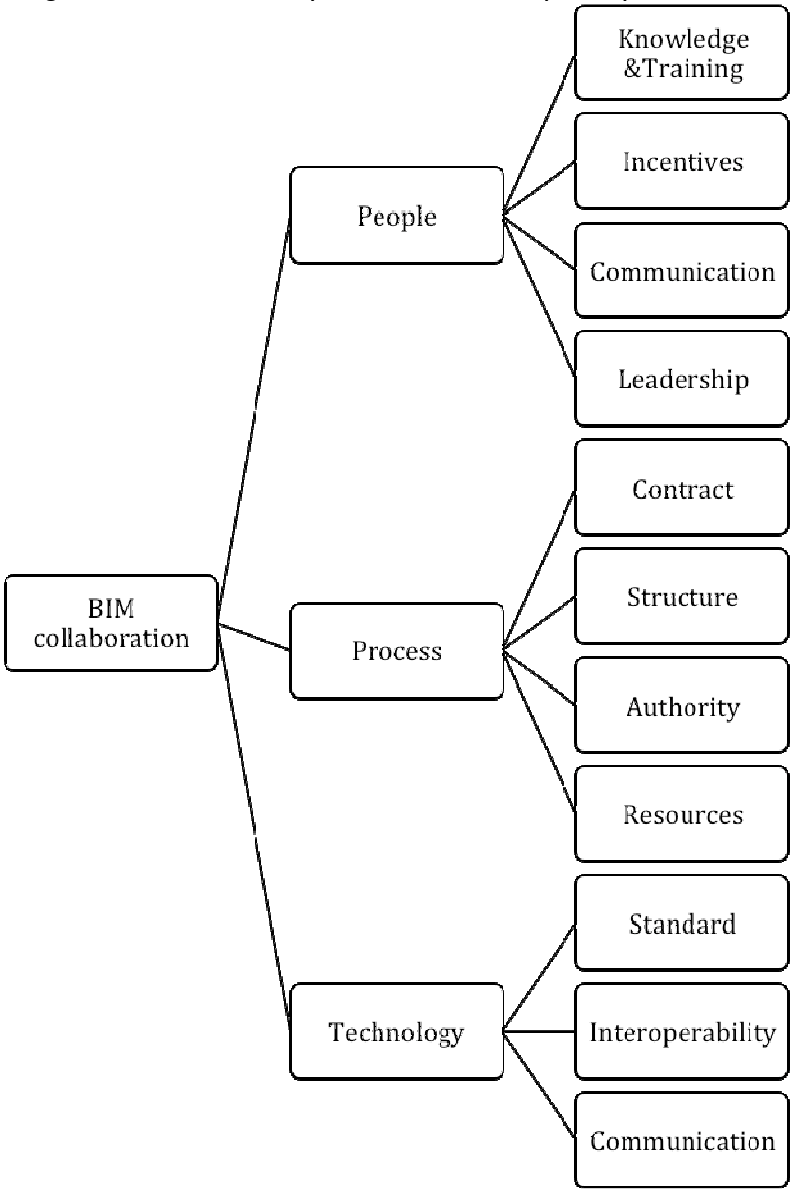


Fig.2 Key Factors of BIM Collaboration

## 7. Discussion and Conclusion

Multi-disciplinary professionals work together so that projects can be executed accurately. Recognizing that collaborative efforts facilitate achievement of organization objectives, researchers and practitioners attempt to set up strategies that foster a collaborative culture among players. BIM implementation breaks the traditional relationships among clients, architects, engineers and contractors. The roles of participants need to be more flexible, interactive and collaborative in the construction process. Collaboration is capable of empowering individuals and connecting fragmented systems in order to address social concerns (Gajda, 2004). The designers traditionally retain their authority and judge the contractor's performance with their initiatives of project success, and contractors always take compliance with the minimum requirement of contract standards. Even though contractors may have superior knowledge of alternative solutions that may benefit the project, they still choose to process the orders conventionally. These adversarial relationships impede knowledge sharing which offers the greatest opportunity to improve project performance. Collaboration is the key to capture that information (Allen et al., 2005). Collaboration in the construction industry is different from other sectors. First, the project organization is a form of multi-disciplinary representatives who have different objectives, goals and cultures. Second, duties and reliabilities are all project oriented in a short term. Partnerships may conflict with each organization's long-term objective. Last, organizations are dynamic. Some representatives may leave before project completion, but impacts of their previous decisions and actions may affect the final outcomes of the project (Kalay, 2001). Greenwood (2012) tested different degrees of collaborative working that is relative to project performance, and he identified that higher level of collaborative working is more likely to produce higher level of project performance and vice versa. Other researchers also opine that working relationships have positive impacts on project performance in terms of construction time, cost and quality (Larson, 1995, Phua & Rowlinson, 2004).

Gajda (2004) identified collaboration as the most highly developed level of integration. Project team collaboration and inter-professional support are essential to BIM implementation. Interactions within the system and the interactions among project participants are the most important aspects to be encountered (Kvan, 2000). Working collaboratively, professionals can share their knowledge and pool scarce resources in order to achieve an objective that would not otherwise be possible to obtain as professionals working separately (Gajda, 2004). Kvan (2000) concluded that collaborative environment could not be created simply with hardware and software tools, and over-reliance on tools was less cost effective use of resources. AIA (2009) claimed that collaboration increased the efficiency, and the adoption of BIM could enhance collaboration. However, it could not guarantee that such collaboration is best for project thinking and primary principles. Hansen and Nohria (2004) identified five advantages of good collaboration including increased profit by expertise sharing, cost reduction by practice sharing, improved decision making by knowledge sharing, innovation by ideas sharing and improved achievability of goals. Thus, collaboration issue is highly important to the success of BIM implementation and to the project performance finally.

Based on the analysis, this research clarifies the importance of collaboration and identifies the relationship between collaboration and BIM implementation success. In other words, collaboration is the key factor in measuring the success of BIM implementation in a project. Therefore, BIM as the vehicle of project delivery aims to integrate project activities rather than be a simple communication and simulation technology. More importantly, few researchers to date have explored the factors that may encourage participants to adopt more collaborative ways of working. Efficient and effective communications are essential to the successful completion of construction projects. However, this finding needs to be qualified by considering the inter-relationships among people, process and technology. Although technology could create a communication environment for virtual users, it may also hinder the sense of cohesion and satisfaction of interaction, and the interactive links are associated with the effectiveness of information exchange.

Projects as temporary social systems in different contingencies and multiple contexts require further demonstrations. Analysing the recursive interplays among actors, organizational structures and technologies are important. First, BIM implementation changes the traditional working process. Second, the organizational contexts constrain the BIM development. So BIM can improve the inter-organizational collaboration, but this advantage can also be constrained by the existing organization context.

Despite the massive investment in BIM, it is impossible to divorce interpersonal and inter-organizational collaboration from the construction process, which is rooted in project success. BIM tends to break the cultural and organizational boundaries by integrating communication and collaborating team participants. Collaboration is able to achieve greater efficiency, but projects need fundamental change to fit into BIM thinking. In this paper, we argue that the study of inter-organizational relationships is important to project success. But it is difficult to generalize a collaboration theory. It is necessary to consider the different levels of collaboration. This research also identifies the inter-relationship between BIM performance and collaboration. Unlike the studies that have been conducted in BIM, it is clear from our research that technology is not the critical issue to successful implementation and project collaboration. It depends on the factors related to people, process and technology as a whole. Further, how to link the project success with innovative technology is demonstrated. In summary, we have argued that inter-organizational collaboration needs to be analysed before considering BIM implementation. Although it is difficult to develop a collaboration model, significant factors could be identified such as contractual issues and organizational structures etc. This study reviews past research on collaboration within social and behavioural contexts. Further exploring the impacts of BIM implementation in a construction project, we identify the importance of collaboration. With the demonstrated relationships between BIM and collaboration, understanding the fundamental issues of collaboration is beneficial to the decision makers in adopting appropriate BIM strategies in future. The study of inter-organizational collaboration could facilitate people reviewing the initiatives of BIM implementation and strategy to further achieve integration.

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