Exploring BIM implementation: A case study in Hong Kong

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Abstract

Building Information Modelling (BIM) was introduced to the Hong Kong construction industry as a technology-oriented process innovation in the past few years. Improved functionalities and interoperability of software provide a collaborative platform for all stakeholders that will alleviate the fragmentation in the construction industry. However, the high expectations from BIM led to dissatisfaction by users, the nature of the fragmentation itself turns out to be one of the factors inhibiting further successful implementation of BIM.

In this paper, we present a case study that explores current BIM implementation performance in the Hong Kong construction industry. More specifically, we explore whether BIM implementation in Hong Kong is changing the old roles, relationships and working practice paradigms of stakeholders by providing a collaborative working environment on construction sites. Data were collected from ethnographic participant observation and one-on-one interviews within a social network perspective. The evidence shows that visualization tools are powerful facilitators of effective communication across project teams at the technical level. However, the communication techniques themselves in the construction process add little value to the improvement of co-ordination and cohesion in the building team, but the patterns of relationships and responsibilities within project teams have significant influence on the way communication takes place. Due to both team members' reluctance to change and power conflicts during collaboration, human agents mediate the positive influence of BIM on project collaboration to some extent.

Keywords: Building Information Modelling (BIM), inter-organizational relationships, collaborative working, social network analysis, human mediation

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1. Introduction

The construction industry has been widely criticized for its fragmentation (Shirazi et al., 1996, Baiden et al., 2006, Pohl, 1989, Ahmad et al., 1995). This is due to the rational human reflections embedded in the traditional culture of the construction industry over decades (Xue et al. 2010), where participants focus merely on self-protection and economic benefits rather than general performance of project delivery (Latham 1994, Egan 1998, Tang 2000). The increased complexity of construction projects (Gidado, 1996), lack of accurate building information and ineffective communication within project teams (Higgin et al., 1965) are all reasons for the poor collaborative working environment, which leads to unsatisfactory project performance.

Numerous academics and practitioners attempted to construct effective solutions leading to heightened communication and collaboration performance within project teams (e.g. NEC, lean construction, and IPD). In the 1960s, Tavistock Institute's (Higgin et al., 1965) pilot study on communication in the building industry provided a full picture of communication issues in construction projects. Two major problems emerged: lack of accurate building information and communication among stakeholders, which led to inefficient building operations. These primary communication difficulties stemmed from difficulties in clearly defining the roles of resource controllers and the complex interaction of technical, economic and social forces (Crichton, 1966). In their follow-up research in 1966, the concepts of interdependence and uncertainty were proposed as significant characteristics of construction (Crichton, 1966), which were later recognized as two categories of complexity of construction processes (Gidado, 1996).

In the past decades, BIM emerged as an important domain within current information and communication technology (ICT) research. It was promoted for various deliveries and potential advantages: single database, efficient design, effective visualization of clashes, etc. (Ashcraft, 2008, Azhar et al., 2008, Bernstein and Pittman, 2004, Howell and Batcheler, 2004, Hu et al., 2008, Singh et al., 2007). Among these expectations, provision of accurate building information from a single database and provision of service as a collaborative platform are especially attractive solutions to the fragmentation in the construction industry. However, two problems emerge.

First, although there have been numerous research studies on building information modelling, there is no rigid definition of BIM. BIM is considered as "an innovative approach to building design, construction and management" (Autodesk, 2003), enabling the management of building information in different project phrases in the Architecture, Engineering, Construction and Operation (AECO) industry (Gu and London, 2010, Gu et al., 2008). It is a methodology generated from the interaction of policies, processes and technologies; managing the essential building design and project data in digital format through the entire building process (Succar, 2009, Succar, 2010). However, terms ranged from tangible products to intangible concepts such as 'Asset Lifecycle Information System', 'Integrated Model', 'Objective Oriented Building Model', 'Virtual Design and Construction & 4D Product Models' and even 'Integrated Project Delivery' etc. are all adopted to embody BIM. In practice, most BIM users prefer to regard BIM as an advanced software rather than a new approach assissting them to accomplish their work (Holzer, 2011).

Secondly, although BIM was proposed as an innovative solution to the fragmentation of the construction industry, the nature of fragmentation itself turns out to be one of the factors inhibiting further successful implementation of BIM (Gu and London, 2010). The study conducted by Dossick and Neff (2008, 2010) proves that BIM's positive influence on project integration is limited to the technological level; the key to team cohesion is still based on human factors. Observation of current practice of BIM also indicates that a collaborative atmosphere with collective participation and contribution from all stakeholders in a building project will be of great significance (Gu et al., 2008), rather than the innovation itself. In fact, researchers had asserted that improved communication techniques themselves in the construction process will add little value to the improvement of co-ordination and cohesion in the building team, but the patterns of relationships and responsibilities within project teams have significant influence on the way team members communicate (Higgin et al., 1965).

In Hong Kong, proponents claim that BIM has the power to alter and reinforce the collaborative relationships between project stakeholders, rather than a simple technology innovation. However, the project team members broadly accept BIM as advanced CAD. Therefore, we conducted research to explore the reality of BIM implementation in the Hong Kong construction industry. In this paper, some preliminary findings from one case study will be presented and discussed.

2. Methodology

A social network is a social structure comprising components with meaningful social characteristics (Scott, 1991). It is generally defined as "a set of nodes and the set of ties representing some relationship, or lack of relationship, between the nodes (Brass et al., 2004)". The "points" or "nodes" represent individuals, groups or organizations, and the lines connecting these nodes refer to specific types of relationships or flows, such as friendship, kinship, common interest, financial exchange or knowledge flow (Scott, 1991). When represented in a graph, signs (+ or -) are used to indicate positive or negative relations, the directions of the relationships are denoted as arrows (Scott, 1991). In construction projects, formal and informal relationships of stakeholders can be depicted as social networks, the points or nodes represent the stakeholders and the lines indicate the relationships between them. By analysing characteristics of social networks, important information can be explored, such as "who is the key stakeholder to project's success", "How do main contractor and sub-contractors cooperate with each other", "What is the effectiveness of cooperation" and "How does each stakeholder perform?"

Social network analysis is a methodology in terms of social network theories (Kilduff and Tsai, 2003), taking social relationships as its research objective, analysing relational data collected in the social studies, providing both a visual and a mathematical analysis of human relationships

(Chinowsky et al., 2010, Scott, 1991). In the field of construction, research related to social network analysis is gradually increasing because of the wide range of participants that mutually interrelate and collaborate with each other in construction projects (Park et al., 2009). Loosemore had successfully explored SNA as a quantitative tool in the context of crisis management back in 1998; He also suggested that complementary qualitative research should be conducted to enhance understanding by producing reliable accounts of social reality (Loosemore, 1998). Pryke (2004) applied the method to analyse construction project coalitions in the context of partnering relationships. He developed an analytical framework as well as a social network theory of governance of construction coalitions. In this framework, construction projects are conceptualized as multi-layered interdependent networks, through which intra-coalition relationships can be delineated. The author also indicates that the correlations between different networks can provide a measure of the extent to which procurement methods are in transition, or what is often regarded as maturity. Later in his study (Pryke, 2005), this framework was applied to the analysis and formulation of a social network theory of governance, in which network density and centrality are chosen as measurement metrics to investigate the evolution of diverse networks during the adoption process of new procurement system.

In line with the characteristics of the proposed research, a case study approach was adopted. The proposed research is an exploratory study, aiming at investigating a “what” question (what are the impacts of BIM implementation on project teams in current Hong Kong construction industry). Although any of the five strategies: experiment, survey, archival analysis, history and case study can be used to conduct an exploratory study, case study would be the preferred strategy when focus of a study is on “contemporary phenomenon within some real-life context” and when the investigator has little control over events (Yin, 2003). In the proposed research, BIM implementation and its impact on project teams are all contemporary phenomena within current Hong Kong construction industry. Besides, due to limited BIM projects in Hong Kong, none of the other four strategies would be practical for lacking either historical evidence or control over events. In this sense, case study would be the most suitable approach to fulfill the research purpose. Various types of collaborative relationships were expected to be explored through both quantitative and qualitative methods. By delineating collaborative relationships between different stakeholders in the form of networks (e.g. communication network) and analysing the characteristics of these networks, the changes of roles and relationships across project teams were predicted to occur under BIM implementation.

Data were collected from over 4 months of ethnographic participant observation and 5 one-on-one interviews, along with documentation review from a social network perspective. The interviews were conducted with project team members who work with BIM on a daily basis. All the interviews were semi-structured with questionnaires as the fundamental guideline. Before we started interviews, the interviewees were requested to complete a questionnaire with two sections. In the first section, basic information (such as their experience of BIM, their roles in the project etc.) was collected. In the second section, relational data regarding social network analysis were collected.

However, due to the characteristics of the construction project, such as staff turnover, limited time to build trust among team members, problem-oriented collaboration, and contractual concerns over free exchange knowledge (Chinowsky et al., 2008), the implementation of the social network analysis showed a chaotic picture. Nevertheless, some preliminary findings from this case study have provoked discussion about current BIM implementation in Hong Kong.

3. Findings

In this case, BIM is adopted for mechanical, electrical, plumbing and fire safety system (referred to as MEP systems) coordination in the construction stage. The contract relationship exists between a professional BIM consultancy company and the main contractor. In addition to the modelling team in the consultant company's headquarters, a professional with BIM skills is assigned to manage the BIM system on the site with the title of 'BIM manager'. He and another three BIM-coordinators assigned from main contractor constitute the core BIM team in this project.

3.1 Role change

Nominal role change occurs during the BIM implementation process. New positions named "BIM coordinator, model coordinator or BIM manager" emerge from various professions. These coordinators are promoted from drafts man, modeller, CAD supervisor or MEP engineer in the MEP team. They do the same coordination work in the BIM project as they did in previous traditional projects; the role change is nominal with unchanged working content and procedures. In other words, no new patterns of collaborative relationships emerged under this BIM implementation.

On the other hand, the introduction of BIM indeed brought about role change at the project level. For instance, the central role of engineers in a project team is changing. In traditional projects, engineers are responsible for checking section views of drawings and updating all revised 2D drawings in their heads, which makes them the information flow centre and core decision maker. However, BIM models can provide the same information in a more precise way, weakening engineers' central position in the information flow networks. In this case, demand for MEP engineers reduces as the project proceeds. Four MEP engineers are assigned on site when the MEP coordination work starts. With BIM implementation, different professionals in the MEP team get used to relying on the BIM models when they need specific information , instead of searching for information from engineers in the tradition manner. At the end of project, there is only one MEP engineer left on site to supervise the MEP coordination. Nevertheless, it is unrealistic for team members to rely completely on BIM model because BIM can merely visualize the problems rather than solve them automatically. Engineers with rich project experience are still of great importance for the success of BIM projects.

3.2 Embedded norms

Norms indicate patterns of behaviour in a particular group, community or culture (in this paper, the particular group is the project team), accepted as normal and to which an individual is expected to conform. It relates to social norms that are 'customary rules of behaviour coordinating people's interaction with others' (Young, 2007). These are learned through social interactions (Kamau, 2009), arising in either a formal or an informal way; and they exist either in an explicit or an implicit manner (Burnett and Bonnici, 2003).

Before an innovation is completely accepted by a given group, the old working paradigms play the role of inhibitor. Evidence from the case study reveals that some norms embedded in project team members' working routines appeared to be great hindrances to successful BIM implementation. An interesting phenomenon in our third site visiting occurred: A designer from a sub-contractor delivered a copy of her updated drawing directly to one of the BIM coordinators, rather than uploading each revision of the drawings formally to the integrated BIM database for record. This may improve project team members' working efficiency by saving time to submit and download drawings from the database; however, if incidents relevant to the drawings occur later, disputes may arise because of lacking corresponding records in the BIM system as legal evidence. Nevertheless, this embedded working norm (in an implicit manner) is a good example of flexible use of technology. Although we failed to reach this team member for further interview, another interviewee mentioned it as normative behaviour, which happened frequently during team members' daily information exchange. This also reveals that BIM has not been accepted as powerful information storage and exchange system by the construction team.

In addition, professionals' perception and attitude toward collaboration is embedded in their working norms. Even though the clash detection under BIM implementation has reduced the workload of sub-contractors' design team, their staffs' attitude toward revision and submission of drawings is still passive. They believe it is cumbersome to check drawings by themselves, especially when they do not have BIM-related resource support from their own organizations. Hence, they would prefer to wait for the detailed revision list assigned by BIM coordinators and do what they have to do. However, BIM coordinators complain that the revision list is out of their working scope and has been extra workload for them. As one of the coordinators remarked 'Although only BIM coordinators have the permission to update drawings in the BIM software system, staff from sub-contractors can easily find updated drawings and download them from the database. If they can voluntarily repeat this job every day and accomplish possible revisions in advance, the amount of extra work left to us will be reduced considerably; we can focus on coordination and the efficiency of whole process will be improved significantly.' This problem, in his view point, could be solved either by providing the whole project team with a common server or by setting clear regulations to standardize team members' responsibilities and working procedures. He also proposed to set 'green lines' for sub-contractors as sub-deadlines for each revision, the BIM coordinators will then determine whether the updated version can be accepted or not.

3.3 Power of structures

By adopting a social network perspective, our research explored the formal and informal relationships among project teams and their impact on BIM implementation. The data indicate that both of them influence final project performance, but there is a lack of evidence that either one of them is of greater significance than the other.

The formal relationships embedded in contracts and organizational charts engender power conflicts and hierarchical behaviour among team members, but also create an effective mechanism facilitating collaboration. In this case, if any individual starts to exert negative influence on team collaboration, complaints will be sent to senior managers; by reassigning new members, intra-team and inter-team collaboration can be reinforced.

Compared with formal relationships of project team members, their informal network is less powerful during the decision-making process. However, it enables mutual trust building within project team members, and facilitates information exchange as well as knowledge sharing. With favourable social relationships with other team members, a specific individual can take full advantage of the social capital generated from his/her social networks (Oh et al., 2006). This is even more important in the context of construction projects, where rapid turnover of staff is very common.

3.4 BIM capacity

Currently in Hong Kong, most sub-contractors' own design team is neither professional nor efficient; some sub-contractors still need to hire external specialists to assist in the whole design process. The 3D drawing/modelling output is often behind schedule due to their limited capacity when using BIM software, which consequently delays the project schedule. More important, most of them are reluctant to adopt BIM because of its complexity and expensive cost.

In this case, although finalized drawings generated from zero-clash BIM models are distributed to the sub-contractors, installation errors still occurred on site during the construction process. The poor internal coordination of the sub-contractor affects the ultimate performance of BIM. This indicates that excellent organizational capacity of involved stakeholders (especially the contractors) is equally or even more important to the excellent technological capacity in a successful BIM project. Both of them should be listed as essential entry criteria for BIM project bidders. To employ contractors with qualified overall BIM capacity (including both technological aspects and organizational aspects) will then assist the success of BIM projects.. A scorecard method estimating one company's overall BIM capacity to be partner in a BIM project might be useful during the tender stage, for instance.

3.5 Maturity of BIM

Maturity is a core criterion of successful BIM implementation, requiring adoption of BIM through the whole project lifecycle. Common value among stakeholders for shaping the proactive market needs to be created. In this case, people from different parties deem BIM's functionality from various perspectives. Two of the respondents are from main contractors; they state that BIM is efficient and effective for clash detection, for reference, for visualization and for coordination. The other two respondents are from a consultant: one agreed with the former two respondents, believing BIM will provide further convenience to professionals during collaboration; but the other one assumed BIM to be a 3D tool for presentation.

This implies that current BIM implementation in Hong Kong is still in the primary stage of development. Taylor and Bernstein (2009) explored four paradigms of BIM implementation at the firm level: Visualization, Coordination, Analysis and Supply Chain Integration. They assert that different paradigms have different impacts on final project performance. They also suggest that with firm's increasing project experience, these paradigms will evolve along a trajectory from visualization, to coordination, to analysis, and finally to supply chain integration (Taylor and Bernstein, 2009). In this sense, current BIM implementation in Hong Kong is initiating from the preliminary visualization paradigm, and the further success of BIM implementation can be achieved when it evolves along the trajectory to the supply chain paradigm.

4. Conclusions

In this paper, we present a case study that explores current BIM implementation in the construction industry of Hong Kong. More specifically, we investigate if BIM implementation in Hong Kong is changing the old roles, relationships and working practice paradigms of stakeholders by providing a collaborative working environment on construction sites. Data were collected from ethnographic participant observation and one-on-one interviews from a social network perspective. Due to the typical characteristic of construction projects, such as staff turnover, difficulty of building trust within project teams, and contractual concerns etc., we failed to obtain the relational data for a social network analysis at the end. However, the non-relational data collected from this project has provided valuable information of current BIM implementation in the Hong Kong construction industry.

The evidence shows that current BIM implementation in Hong Kong is in the primary stage. In spite of various definitions of BIM in the literature, BIM is broadly accepted only as an advanced technology in the industry. The visualization functions of BIM are effective to facilitate communication across project teams at the technical level. However, the communication techniques themselves add little value to the improvement of co-ordination and cohesion within building teams, but the patterns of relationships and responsibilities within project teams have significant influence on the way communication takes place. Due to team members' reluctance to change and power conflicts during collaboration, human agents mediate the positive influence of BIM on project collaboration.

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