The Implementation of Building Information Modelling (BIM) in Construction Industry: Case Studies in Vietnam

Ngoc Quyet Le, Michael Er, and Shankar Sankaran

***Abstract*—The research introduces the combination of Diffusion of Innovation Theory and Activity Theory to investigate the current implementation of BIM in Vietnamese context. Data was collected through three large AEC firms (Architect, Engineering, and Construction) to present the comprehensive understanding of BIM practices in the construction industry. Qualitative approach was employed with the use of semi-structured interview to examine respondents' perspectives of their daily BIM activities. Interpretive abductive strategy was used to interpret and transform everyday beliefs and meanings into social scientific knowledge that matches Diffusion of Innovation Theory and Activity Theory. Key findings were mediating forces affecting the BIM implementation including tools, rules, division of labour and contradictions among elements in the activity system.**

***Index Terms*—Activity theory, BIM implementation, diffusion of innovation theory, vietnamese AEC firms.**

I. Introduction

Building Information Modelling (BIM) has been the subject of much research in the construction industry. There are a number of researchers that eulogizes the benefits of BIM in areas such as cost reduction, time saving, enhanced communication, and control [1], [2]. Other authors proposed the application of BIM to 4D, 5D, 6D…nD [3]-[5]. These studies have generally been conducted in developed countries or in single discipline areas such as application to facility management, architecture, and structure etc.

The Vietnamese Government has mandated the use of BIM for all government and large construction projects (such as high-rise buildings) by the year 2020 [6]. In terms of economic development, Vietnam is considered a periphery country [7] and typical of most developing countries have a low level of technological knowledge [8]. To date the impact of this Government's requirement upon the construction industry in Vietnam has yet to be explored. Further, although

BIM is a well-known construction support tool and has been reportedly being in use in Vietnam since 2009, there is no existing reports of its current state of practice [9].

This research aims to explores the current state of BIM implementation into the construction industry of the peripheral country of Vietnam. Two theories are used to assist in the interpretation and analysis of research data collected. Diffusion of Innovation Theory is a well-known and used theory which emphasises the channels of communication in the process of innovation adoption whereas Activity Theory is concerned with interrogating the work activity and factors of mediation.

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II. Theoretical Framework

A. Diffusion of Innovation Theory (DOIT)

The DOIT seeks to explain how innovations are accepted and adopted by social groups [10]. Innovations can be ideas, behaviours, or objects that the social groups perceive to be new and will in some manner create social change. Construction firms that are accustomed to traditional way of leadership and responsibility are generally slow to alter [11], and BIM acting as catalyst for change in construction industry [12].

Rogers [10] developed a framework that describes the adoption process within a society (see Figure 1). The diffusion of an innovation into a social group occurs as a five-stage decision making process. It occurs over a period of time through a series of communication channels among individual members of the group. As an increasing number of individuals within the social group adopt the innovation, the more palatable the innovation becomes for the rest of the group. Five stages are summarised as below.

1) Knowledge: the individual is first exposed to an innovation but lacks information about the innovation and is uninspired to seek any more information
2) Persuasion: the individual in interested in the innovation and actively seeks out more information about the innovation
3) Decision: the individual takes the concept of the change and weighs the perceived advantages and disadvantages. The individual also makes a decision about adopting the innovation or rejecting the innovation.
4) Implementation: the individual employs the innovation to varying degrees depending on the situation. This is a testing stage and the individual is determining the usefulness of the innovation and may need further information about it.
5) Confirmation: the individual finalizes their decision about continue use of the innovation. This stage is both intrapersonal (may cause the individual to be conflicted about deviating from the status quo) and interpersonal with the group confirming that the innovation in the better choice.

As showed in Fig. 1, the first three stages including knowledge, persuasion and decision (pre-implementation stages) were explained in detail with a number of factors

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affecting the organisational decision of taking innovation into practice. The implementation stage and confirmation stage, however, were not fully taken into account because they depend on situational applications of each organisation. Innovation practices in generally and BIM implementation in particular are lacking of empirical evidences within the construction fields and in the developing country context [13][14]. This paper, hence, intends to contribute the Vietnamese case studies of BIM practice to construction innovation discipline's knowledge through the lens of AT which dedicates to investigate mediating forces that drive changes in community [15], [16].

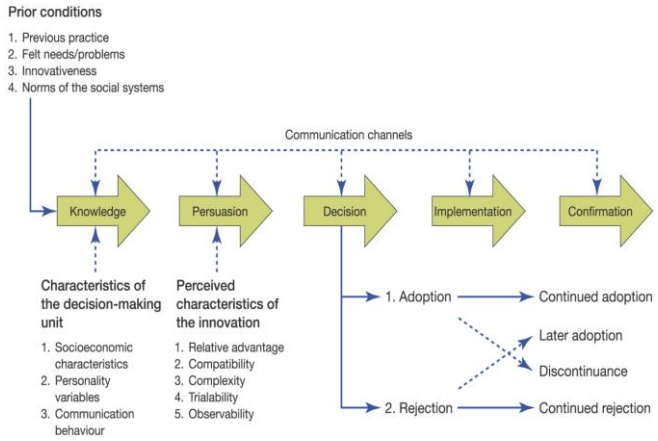

Fig. 1. Innovation adoption process.

Another key element of DOIT is the effect that communication has upon acceptance and use of an innovation. Two sources of communication channels that were emphasised in DOIT are innovation champions who lead the changes and change agents who facilitate changes among following adopters [10].

B. Activity Theory (AT)

This study was informed by the third generation Activity Theory by Engestrom [15]-[17] as a lens to frame the activity system of implementing BIM in construction companies (see Fig. 2). The first and second versions of AT was originated within the cultural historical tradition of Russian psychologists namely Lev Vygotsky and Alexei Leont'ev (1979-1981). Traditional AT framework only involved three principal elements that are Subjects (actors engaged in the activity), Tools (instruments used in the activity) and Objects (the targets of the activity). The theory notes that the work activity is mediated by previous perceptions and behaviors (a historical cultural background of actors) and motivated by objects that take the form of tools as a medium of action in order to obtain desired outcomes [15]. However, outcomes of an activity system are not always desired results but possibly unexpected results that were transformed from the interactions among the AT system's elements [18]. In the third version of AT, Engestrom [17] added three more elements that concern with social factors – namely rules (cultural norms and regulation governing the performance of an activity), community (environment or social context in which the activity is being carried out) and Division of Labour (hierarchical structure of activity – roles and responsibilities of actors in the activity system).

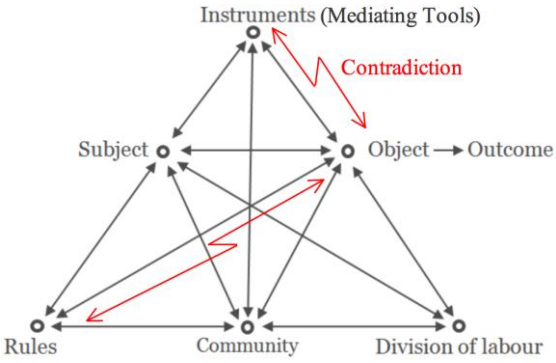

Fig. 2. The third generation of activity theory.

Another key concept of Engestrom's AT is contradiction that occurs when there is tension between elements in an activity system. For example, a contradiction such as a breakdown in the activity where a tool is used inappropriately or in an unanticipated manner [19]. Such contradictions, however, should be seen as a source of change and development rather than problems or conflicts [15]. The identification of contradictions in an activity system could help actors to focus their efforts on the root causes of tensions to make proper decisions on change [16].

C. Combination of DOIT and AT to Examine BIM Practice

As said, AT is a supplement to DOIT in terms of providing empirical evidences of innovation implementation and confirmation stage through case studies in developing country context (Vietnam); whereas DOIT assists AT's analysis with the concept of communication channels (e.g. innovation champions and change agents) that facilitate the activity of BIM implementation. Characteristics of the innovation (BIM) and decision-making units/ actors (construction companies) also support AT to interpret the motivation of participants' actions.

In the activity system of implementing BIM, subjects are AEC firms working on the objects of innovation of technology and business process in order to obtain desired outcomes- i.e. the approved design documents in conformity to current local standard and regulations (rules). The Vietnamese social context (community) where BIM is implemented is characterised by its fragmented nature, particularly the lack of innovation leadership driven by the Government and the widely spontaneous deployment of BIM adopters [9], [14]. The roles and responsibilities of participants (division of labour) engaged in the activity of BIM practice rely upon projects' requirements and vary from company to company.

III. Methodology

Qualitative approach was used to develop a comprehensive perspective of BIM adopters regarding their current state of BIM implementation. Data of the research was collected by semi-structured interview through three case studies - the first was a design consultancy company, the second was a MEP engineering company, and the third was a contracting company (see Table I). All of selected cases are large scale companies and BIM leaders in AEC industry. To maintain

confidentiality, names of companies and respondents were put into codes.

TABLE I: RESPONDENTS' PROFILES IN VIETNAMESE AEC INDUSTRY

Respondent	Position	Major	Exp. years	Exp. BIM tool
Design Consultancy Company (A)				
R1A	Director	Architect	30+	0
R2A	Deputy Director	Structure	30+	0
R3A	Head manager	Architect	15+	5+
R4A	Head manager	MEP	15+	3
R5A	BIM manager	HR& business	5+	0
R6A	Modelling leader	Architect	5+	5+
R7A	BIM member	Architect	3	2
R8A	BIM member	Architect	5+	4
R9A	BIM member	Architect	1	3
R10A	BIM member	Architect	1	3
MEP engineering company (B)				
R1B	Director	MEP	20+	0
R2B	BIM manager	Civil engineer	15+	0
R3B	Modelling leader	MEP	10+	5+
R4B	BIM member	Energy analysis	10+	5+
Contracting company (C)				
R1C	Head manger	Civil engineer	15+	0
R2C	BIM manager	Structure & PM	10+	0
R3C	BIM member	Structure	5+	3
R4C	BIM member	MEP	5+	3
R5C	BIM member	Architect	5+	3
R6C	BIM member	Structure	5+	3
R7C	BIM member	Estimator	5+	3
R8C	BIM member	Architect	5+	5+
R9C	BIM member	Infrastructure	5+	5+

Applying the interpretive abductive strategy, lay concepts identified from semi-structured interviews will be analysed by theories of DOI and AT to generate them into technical concepts that match such theories. In other words, everyday meanings and languages from social actors 'accounts will be interpreted and transformed into scientific social accounts connected to popular social theories [20].

IV. FINDINGS AND DISCUSSION

A. Findings

The themes illustrating how BIM is implemented in subject AEC firms are presented below in Table II.

TABLE II: COMMON THEMES OF PRESENT BIM PRACTICE

Respondent	Lay concepts	Technical concepts	Common themes
R1A, R2A, R1B, R2B, R1C, R2C	"BIM is still in a trial...CAD is widely used in most of work".	Interoperability problems (contradiction)	Hybrid system of CAD & BIM
R5A, R2B, R2C	"BIM team is established to mediate the BIM implementation."	Mediating tool	The role of BIM team is not clearly defined
R3A, R4A, R3B, R1C	"People are in the habit of using fake-licensed software…affecting our IT capability."	Social norm (rules)	Violated copyright
R7-10A, R2-9C	"we feel isolated within our company."	Contradiction between tool and division of labour	Distrust among BIM adopters
R1A, R2A, R5A, R2B, R2C	"we do not have any plan to extent our BIM team…instead, we find BIM-allies to cooperate."	Mediating tool	Risk-sharing strategy
R1-5A, R1-2B, R1-2C	"Clients get used to trust household names for large projects…fame and reputation are what owners need not innovation itself."	Social norm (rules)	Feeling of guarantee
R7-10A, R4B, R3-9C	"Main contractors are innovation champions and should bring sub-contractors with them."	Division of labour	Innovation starts from bottom-up of construction process
R5A, R2B, R2C	"no matter what innovation we use, the outcomes must confront to old criteria of the Government."	Contradiction between rule and object	Building codes slow to change to meet new technology and process
R1-5A, R1-2C	"as an implicit rule, almost 50% of project's profit is used for lobby … affecting the innovation motivation."	Corruption as social norm (Rules)	Low motivation to diffuse innovation
R2A, R5A, R3B, R2C	"old and experienced people are senior managers now but they cannot use BIM tool; whereas youngers are good at software but less practical experience."	Division of labour	Mismatch between professional knowledge and BIM technical knowledge
R5A, R2B, R2C	"People do not intend to share BIM knowledge and self-apply BIM in different ways."	Social behaviour (Rules)	Silo BIM knowledge
R5A, R2B, R2C, R3C	"site managers have absolute power of what happen on site. Head office (BIM team) cannot interfere much in distant construction sites' work."	Division of labour	Unsuccessful bring BIM to sites
R1-5A, R2B, R1-2C	"People talk about BIM too much whereas their real capability is only around architectural models built by Revit."	Social norm (Rules)	Afraid of losing face

B. Discussions

The common themes will be rearranged into proper categories (technical concepts) and explained by DOIT and AT. Analysing the activity of construction professionals in the BIM field in Vietnam has uncovered several mediating forces (e.g. tools, rules, division of labour, and contradictions) which influences the implementation of this new tool into the

construction design and build industry. The adoption process is mapped with DOI evidence of consistency with the theory however there are also some interesting departures that are discussed below.

1) Mediating tools

a) BIM team

Through case studies, it is found that a BIM team was established as a change agent to help AEC firms mediate their BIM practice. These teams are responsible for BIM technology implementation and charged with overseeing processes such as research and development, training for staff and sub-contractors, provision for technology extension, and cooperation with outside parties. The variety of tasks require different skills such as research, coding, communication, and collaboration that do not likely fit any current kind of job description of Vietnamese construction professionals. This leads to the confusion of how BIM-based employees perceive their roles in professional community.

The decision-making units (directors and senior managers) also feel confused when systematically arrange BIM team in their existing organisational structure due to the lack of BIM knowledge. Their secure solution was to set up BIM team as separate unit from other departments to minimise its negative effects (e.g. conflicts) on the whole system. However, the separation in the organisational structure limited success of the BIM implementation with the BIM team members identifying a lack of resource support for their work from other groups.

b) Risk-sharing strategy

An interesting revelation was that the organisations did not have a long-term implementation strategy and managers admitted that they "don't have any plan to extent the size of BIM team in the next few years" and intended to "just keep watching and seeing the market".

The Government's BIM mandate has recently issued since the end of year 2016 [6]; as yet there has been no official guidelines, national standards, and incentive to deploy BIM focused projects [9]. In addition, BIM is not a single technology but compose both new management process and a cluster of new technologies (e.g. Revit, Tekla, and Naviswork)[21]. The ambiguous innovation leadership and the complexity in use [10] make BIM not a top priority of organisational business plan. The organisations, hence, are looking for BIM-competent partners (e.g. outsourcing, and sub-contractors) to share risks in implementation process rather self-develop their full BIM services.

2) Rules (social norms, behaviours, and regulations)

a) Violated copyrights

Differently from developed countries, the entry cost of BIM software is not a big concern of AEC firms in Vietnam as they are used to work around intellectual property issues by using fake IT licenses [14]. The national legal framework of copyright has been not stringent to bind infringers [22]. This phenomenon might mediate the initial access to new technology of poorer economies in the short term, however, it threatens their sustainable development of Information Communication Technology (ICT) in the long term [23], which affects the intensive implementation of BIM beyond basic uses. It is revealed that AEC firms simply used unlicensed BIM tools and copied the standards laid out by American software providers Autodesk regardless the conformity with Vietnamese standards. As long as the social norm of "free raider" is not addressed, the local IT capability has been underdeveloped and unable to fill the gap between western innovation and local context – Construction industry has to struggle to reconfigure their BIM implementation in order to comply with Vietnamese codes.

b) Feeling of guarantee

It is an implicit acknowledgement that BIM is more appropriate for complex and large scale projects [24] [25]. With large capital investment for such projects, owners were insisting on using "large household name" consultancies and contractors who did not use BIM software whereas there were many SMEs (small to medium enterprises) who did. The fear of failed projects overshadows the innovation laggard so that ongoing demand for large firms' services to be more dependent on their reputation and ability to deliver projects irrespective of the use of BIM systems.

Top managers of large AEC firms admitted that SMEs might have more advantage to transform from old CAD system to new BIM system due to their agility (i.e. neat and compact organisational structure)[26]; however the rise of BIM based SMEs does not change the market share due to clients' need of security. The BIM competent SMEs have to accept to be sub-contractors of large companies for survival. This explains why large AEC organisations are implementing BIM at slow progress despite currently bustling activities of BIM applications.

c) Low motivation to diffuse innovation (BIM)

It is discovered that locals perceive the corruption as a natural part of enterprise. Corruption is considered a social norm attached to daily business relationship [27]. This phenomenon derives not only from discretion of officials but rather rule-violating behaviour of the related parties (i.e. business sectors) [28]. The indication from AEC firms 'managers was that in order to win or be awarded a project, the organisations had to pay a third party to lobby the government or developer. As the result, the motivation to innovation is inhibited because whether the design is in a BIM format or 2d CAD, it is less significant than the capitol spent on the lobbying with respect to being awarded the contract.

d) Silo-BIM knowledge

Research found that the boundary of inter-organisational communication is the key factor affecting the diffusion rate of BIM practice. There are two reasons for this phenomenon. Firstly, the fragmented nature of construction projects makes the BIM collaboration difficult [29]. A complex project is considered a multi-discipline environment involving different parties with each adhering to their own industry standards - that negatively impacts the BIM's knowledge sharing among them [30]. Secondly, the conservativeness of "large household name" company is holding back its ability to collaborate in BIM-focused projects. Large companies intend to be leaders taking control in BIM process despite their insufficient BIM capability in comparison with other SME partners.

e) Afraid of losing face

The interrogation of data exposed that "saving face" is one of cultural forces which mediate the BIM execution. The BIM capabilities of Vietnamese construction organisations are sometimes misrepresented in order to avoid embarrassment [31]. The commitment to the introduction of BIM systems into the case study organisations is questionable as large AEC firms have overstated their actual BIM use to confirm their leadership in the market.

3) Division of labour

a) Innovation begins from bottom up of construction process

Unlikely common thought that design consultancy firms, especially architects have clear advantages in leading BIM implementation due to their experience in using software platform and traditionally, construction process begins with a design phase [32]. The research uncovered that main contractors who engage in the later project phase are innovation champions driving BIM forward. Most of interviewed design professionals (architect and engineering) expect an increase in design fees because the efficiency they can make through BIM application and claim to be paid accordingly. Nevertheless, national regulation regarding design fee ceiling has been not updated to meet designers' demand that reduces their motivation of innovation adoption.

Contractors, however, are best placed to lead the use of BIM on projects because they can easily convert 2d drawings taken from designers into 3d models in order to check clash visually and automatically. Contractors traditionally working on "low tech" approach without using advantaged BIM design system might perceive BIM "ease to use" rather than design professionals. This finding is consistent to DOIT [10] which argued that "observed benefits" and "less complexity" of innovation are two key factors mediating the adoption.

b) Mismatch between professional knowledge and BIM technology knowledge

It is posed that senior managers who have responsibility for determining the direction of BIM practice within their companies are likely to be richer in discipline-special skills but most have little or no skills with BIM software, whereas recent graduates and younger team members tended to have better BIM-technical and broader technology skills but lacking of practical experience (see Table I). The unbalance between professional knowledge and BIM technology knowledge resulted in the inefficient communication among BIM team that impedes the BIM implementation.

c) Unsuccessful bring BIM to site

Another mediating factor hindering interest with the use of BIM systems materialises around the division of design and construction activities. Site managers conventionally have absolute power on the whole building process - making decision of whether adopt BIM design models. People on site tend to be less educated rather than office staff, working by experience and, hence, posing higher degree of resistance to change [31]. Research found that BIM implementation is around basic applications such as clash detection, rough cost estimation, and shop-drawing release that are mostly executed by BIM team with less support from site teams. The end user, construction personnel working on the building site have been not actively engaged in BIM process.

4) Contradictions

a) Hybrid system of CAD and BIM

As there is no common format to mediate multi- BIM software's interoperability [33], the tension between the object of intensive use of BIM and the tools' ability occur in the activity system. To solve the interoperability problems, AEC firms are using hybrid system of CAD and BIM that consider whether BIM or CAD matches which specific parts of their business for flexible implementation.

b) Distrust between BIM adopters

The separation from the core business operations created a sense of isolation and frustration within the BIM team as they felt they had little impact or support for their work. Their implicit contribution to BIM focused project management was not appreciated by other colleagues because BIM team did not take responsibility in any specific-discipline but lean to general support of knowledge management. The BIM job descriptions have been not well defined among industry [34].

c) Building codes slow to change to adapt innovation

BIM managers of examined AEC firms complained that the object of diffusing BIM has never been achieved if the Government does not change their old assessment of designs which still relies on the traditional "paper based" approach. Much information is miscarried and then misinterpreted when AEC firms try to transform their digital models' data into official paper forms. In other words, using new technology and process to produce "old" outcomes. The Government did not take the proper leadership on innovation and is a key force hindering implementation as they have not explicitly outlined what these requirements are.

V. Conclusion

The research identified key mediating forces that influence the current state of BIM implementation in Vietnamese AEC industry. Most surveyed construction professionals confirmed to continually adopt BIM but keeping the gradual pace of adoption and waiting for the market's signal rather than intensifying BIM applications.

Ongoing work on this research will extend the range of interviews, with additional participants in Vietnamese AEC firms. The research found that BIM team works as a tool (change agent) facilitating BIM implementation but there is a contradiction between BIM team's roles and organisational structure. The next paper aims to find a "proper model" for organising BIM team in the existing system's operation.

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