Asia Pacific Journal of Contemporary Education and Communication Technology (APJCECT)
ISBN: 978 0 9943656 82; ISSN: 2205-6181
Year: 2017, Volume: 3, Issue: 1
www.apiar.org.au

INVESTIGATING THE ROLE OF BIM IN CONSTRUCTION PROJECT CHANGE

Chen, Bing
The University of Hong Kong, China
Email: bingchen923@gmail.com

Abstract

Changes in construction projects are common and inevitable in the construction phase. In face of these changes, project participants need to make sense out of the equivocal or uncertain situation through interactions with others, i.e., collective sense making, in order to achieve consensual interpretations with actionable meanings as a response to the change event, which is critical to successful management of construction project change. However, the diversity of project participants results in differences in understandings of various signals, and thus, difficult convergence of consensual interpretations. Material artifacts and practices, acting as "cognitive aids" and "boundary objects", facilitate the exchange of individual provisional interpretations and expedite the development of consensual interpretations. Considering the increasingly wide application and implementation of Building Information Modeling (BIM) which has the potential to provide more informative and readable material artifacts for collective sense making in construction practices compared with traditional ones, understanding its role in construction project change is very important. Despite occasional acknowledgments and labeling regarding BIM as boundary objects in existing literature, the theoretical basis and corresponding empirical evidence are still underdeveloped. Based on the literature review, from distributed cognition perspective, a conceptual framework is developed to investigate the influencing mechanism of BIM-related material artifacts on collective sense making, serving as a basis for further empirical test. There are two parts in the conceptual framework: i) BIM-related material engagement influences collective sense making effort and capability, moderated by trigger conditions of a construction project change, and ii) Collective sense making effort and capability influence consensual interpretations of the variation order.

Keywords: Material Engagement; Collective Sense Making; Construction Project Change.

1. Introduction

Changes in construction projects are common and inevitable (Shipton, Hughes & Tutt, 2014; Sun & Meng, 2009; Hwang & Low, 2012). Only a few engineering projects are ever completed exactly as out in the initial plans. On one hand, the complexities and uncertainties embedded in the project entity and realization process and the limited time of planning phase lead to imperfection of the initial plans (Shipton, Hughes & Tutt, 2014; Love et al., 2002). As project proceeds, people have a deeper understanding of the project, some changes may be made (Senaratne& Sexton, 2011). On the other hand, there are also uncontrollable external factors causing construction project change such as differing physical conditions or changes in legislation, especially during the construction phase (Winch, 2010).

In face of these changes, where relevant, project things are unfamiliar or unexpected, and the planned path is interrupted, people start to consider "what's happening", (i.e., interpreting) change issues and then think about "what do I do next", (i.e., planning the probable action)

in response to the unexpected change event (Weick, Sutcliffe & Obstfeld, 2005). The process that individual develops plausible meaning of what occurs and create rational order of their world is sensemaking(Weick, 1995). Dealing with construction project change needs not only individual sensemaking efforts but also joint efforts of collective sensemaking where individuals exchange their provisional interpretations and try to agree upon a consensual interpretation of change issues and a course of action presented in the variation order (Senaratne & Sexton, 2011; Maitlis, 2005).

During the sensemaking process, consistent with physically distributed cognition perspective, people may make use of some material artifacts and practices, e.g., drawings and models (Stigliani & Ravasi, 2012), to assist their individual cognitive work to understand, evaluate and represent the proposed change programme (Hutchins, 1995). Moreover, as mentioned before, dealing with construction project change needs collective sensemaking efforts of a group of participants, who may come from different disciplines and organizations. The diversity of participants forms boundaries and exaggerates the distinction in perceptions and understanding of the change issues included in the variation order, resulting in difficult convergence of the consensual interpretation (Fellows & Liu, 2015). In this regard, material artifacts and practices, apart from being "cognitive aids", can act as "boundary objects" to support the exchange of provisional interpretations across heterogeneous parties and expedite the development of consensual interpretations on the variation order among group members through conversations and collaborative work (Rafaeli, Ravid & Cheshin, 2009; Bresnen & Harty, 2010).

Traditional material artifacts and practices that help people make sense of construction project change can be 2D drawings, Gantt chart, and etc. It is uneasy for a layman to read and understand them. Besides, they provide neither real-time data of the project execution nor quick and rich information of the proposed alternatives (Hartmann et al, 2012; Chavada, Dawood & Kassem, 2012). Nowadays, with the introduction and development of Building Information Modeling (BIM) which has the potential to provide more useful material artifacts and practices, e.g., 3D models, as-planned, as-built progress report, and etc. to help people understand and evaluate the current situation of the project and impacts of the proposed change alternatives. BIM is a process involving sets of material practices through which BIM models (material artefacts), rich in building information, are generated and managed by project participants using relevant BIM software (Eastman et al., 2011). BIM has been labeled as "boundary objects" to serve as communication and collaboration platform providing a common referent around which different stakeholders interact, align their work, and create shared meaning of the same thing (Alin, Iorio & Taylor, 2013).

Despite occasional acknowledgments and labeling of the role of BIM-related material engagement in collective sensemaking and its outcome, i.e., consensual interpretations (Stigliani & Ravasi, 2012; Whiteman & Cooper, 2011), the theoretical basis of the influencing mechanism and corresponding empirical evidence are still underdeveloped, especially in the context of construction project change (Fellows & Liu, 2015).

Hence, the aim of this research is to explore how material engagement influences collective sensemaking and consensual interpretations of a construction project change, considering the introduction and implementation of BIM. In order to achieve this aim, this research intends to develop a theoretical model to investigate the influencing mechanism.

2. Construction project change

2.1. Construction project change and variation

The definition and provisions of construction project change in this research are based on International Federation of Consulting Engineers("FIDIC") contract forms since the establishment of procurement system and standard construction contract forms in China

learn from FIDIC (Chan, Wong & Scott, 1999). The term associated with change made to the project in FIDIC Conditions of Contract for Construction is "variation". Variation means "any change to the Works, which is instructed or approved as a variation", including changes in quantities, quality and other characteristics, levels, positions and/or dimensions, omission and addition of the works, and also the sequence or timing of the project execution (FIDIC, 1999).

Compared with "variation", construction project change is a broader concept. On one hand, before being confirmed and instructed as variations, there are potential changes to the project, which is needed to be investigated, evaluated, defined and planned (Shipton, Hughes & Tutt, 2014). Also, there are minor changes that do not necessarily constitute variations in terms of contents of variation under FIDIC (FIDIC, 1999).Because this research intends to explore the stage that potential changes have not been ultimately confirmed as variations, the terminology of "construction project change" is chosen instead of "variation". But, things need to be clarified here is that it is the major potential change that this research intends to investigate, which will become a variation once confirmed or substantially happened. Variation has been chosen as the research scope of construction project change for the following reason. Always, the impacts of variation, especially "significant variation" on the project is so great that the assessment and approval of the variation require joint efforts of different parties, including engineer, employer, contractor, and designer (Winch, 2010). Different parties, from different professional disciplines and driven by different interests, form boundaries and exaggerate the distinction in understanding of the issues in the variation order (Fellows & Liu, 2015). Such context is where collective sense making and development of consensual interpretations with the support of objects comes into effect.

Construction project change can be precipitated by various causes, including external environmental factors (e.g., unforeseen ground conditions and changes in legislation), organizational factors (e.g., changes in employer's organizational strategy) and project-independent internal factors (e.g., design errors, omissions) (Sun & Meng, 2009). Such causes show that construction project changes arise from unexpected events, which are inevitable since construction project entity and realization process are complex and uncertain in nature and macro-environment and organizational issues cannot be controlled and predicted accurately. When such unexpected conditions or events occur, project organizations need to make responses in time, deciding whether and how to make alteration to initial project plans. This type of construction project change is reactive change as a response to unexpected events.

In response to unexpected events, some changes are required to be made to meet the basic venture objectives or legal requirements while in other cases, changes are not mandatory(i.e., elective) but have the possibility to enhance the project if implemented (Senaratne & Sexton, 2011). So far more attention has been paid to the required change in construction literature. However, elective change is also important since it may have beneficial impacts on the project and related stakeholders (Shipton, Hughes & Tutt, 2014).For example, Ibbs et al. find that some construction project changes can actually save money in their empirical research of variations documented on 67 projects (Ibbs et al., 2003).

Other classification of construction project change encompasses pre-fixed change and post-fixed change according to the time of occurrence, and beneficial change and detrimental change in terms of types of impacts (as shown in Table 1).

Table 1: Types of Construction Project Change

Criterion	Construction Project Change	
Initiation Nature/ Responsiveness of change	Reactive Change Unplanned, unexpected. The response is after the occurrence (Burnes, 1996)	Proactive Change Expected before it occurs, therefore necessary actions are taken (Burnes, 1996)
Need for change	Required Change Must be implemented to meet the basic venture objectives or regulatory/legal requirements (Senaratne & Sexton, 2011)	Elective Change Have the potential to enhance the project, but are not required to meet the original goal or regulatory/legal requirements (Senaratne & Sexton, 2011)
Time of occurrence	Pre-fixed Change Occurs during design development (Lazarus & Clifton, 2001)	Post-fixed Change Occurs during construction process (Lazarus & Clifton, 2001)
Types of impact	Beneficial Change Accelerate completion, reduce cost, improve the efficiency or value to the Employer of the completed Works (FIDIC, 1999; Weick & Quinn, 1999)	Detrimental Change Reduce valuetotheEmployerofthecompletedWorks, orhave othernegative impact on the project (FIDIC, 1999; Weick & Quinn, 1999)

In brief, it is the **reactive change** triggered by unexpected events occurring in the construction phase of projects (i.e., **post-fixity change**) that is the main focus in this research. And although required change and detrimental effects attract more attention in construction project change literature, this research will maintain a balanced attitude towards them since elective change have the potential to be a beneficial change to the projects.

2.2 Construction project change and change management

Since construction projects are delivered by project organizations, some perspectives from organizational change theories can be borrowed to explore construction project change. But, heedful attention should be paid when applying organizational change studies to analyze changes in construction projects as changes in construction projects is a type of task-related change while organizational change is broad domain covering cultural change, strategy change, and etc. The nature and characteristics of different types of change are not always the same.

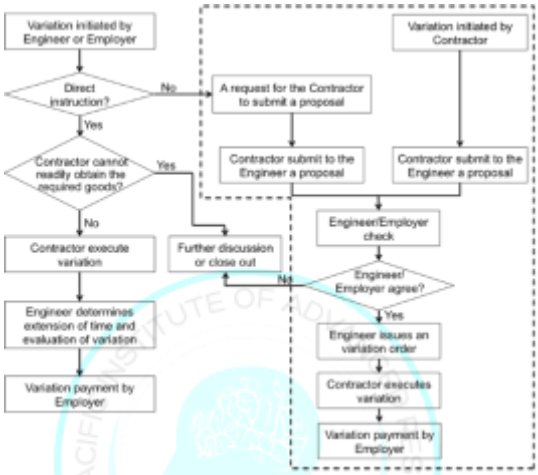
In organizational change theories, considering the rate of occurrence, changes can be broadly grouped into episodic change and continuous change. “Episodic change” is the assembly of organizational changes that are unusual, discontinuous and intentional (Weick & Quinn, 1999).Some later researchers have challenged the idea of “episodic change”to describe all organizational changes and introduced “continuous change” to represent a pattern of endless modifications in work processes and social practice in some aspects of organization, e.g., organization culture, strategy, human side and etc.(Dunphy & Stace, 1993). Since construction project change are task-related changes and are triggered by unexpected events as significant discontinuity interfering the intended progression of work, they belong to episodic change.

Change management literature suggest that episodic change can be managed by planned approach, e.g., Lewin’s three phases of unfreezing, movement and refreezing(Lewin, 1951), Bullock and Batten’s “exploration, planning, action and integration” four-phase model (Bullock & Batten, 1985), and etc. In the same way, construction project change can be initiated and managed by planned approach in order to avoid a ‘chaotic’ response. Similar to change process model presented by leading “planned change” scholars, construction project change management literature also develops some generic “N-steps” change process models[24, 25]. Although N-Steps change management system has been criticized for oversimplification and lack of deep insights (Shipton, Hughes & Tutt, 2014), they have

ISBN: 978 0 9943656 82; ISSN: 2205-6181
Year: 2017, Volume: 3, Issue: 1
www.apiar.org.au
acknowledged the importance of promoting a balanced culture to construction project change and implied that potential changes should go through a process of heedful evaluation and planning before eventually determined, instructed and implemented.

Under FIDIC, for potential changes, there are three ways to initiate a variation (FIDIC, 1999) (refer to the details in Figure 1). It is the ways in which a contractor's proposal is needed that is the focus in this research since in such cases, all major parties of a project have to participate in the change management process to make sense out of chaos together and develop a consensual interpretation of a variation order as response to the unexpected change event (Senaratne & Sexton, 2011).

Figure 1: Variation Procedure



3. Sense making

3.1. Triggers for sense-making and construction project change

Interruption in individual ongoing activities can trigger sensemaking according to Weick (1995). Louis and Sutton (1991) identified three types of trigger conditions of interruptions which enable actors to shift from automatic processing to active thinking, including novelty, discrepancy and deliberate initiative.Novelty means a situation that is unusual, unique, unfamiliar or previously unknown. Discrepancy means a disruption where there is a significant difference between expectations and reality. The third condition consists of deliberate initiatives made by internal or external requests for a higher level of deliberate attention (Louis & Sutton, 1991; Osland, Bird & Gundersen, 2007). Under these trigger conditions, existing situation will become equivocal (or ambiguous), which means there is multiple and conflicting interpretations, or uncertain, which means absence of any interpretation about the future (Maitlis & Christianson, 2014). People actively involve in sensemaking efforts in order to reduce the equivocality or enact novel interpretation (Weick, 1995).

In construction project, there are unexpected events as significant discontinuities along the construction process that will trigger sensemaking and require agreements among project stakeholders, e.g., material or technological innovation, changes in legislation, differing underground conditions, and etc. (Shipton, Hughes & Tutt, 2014; Fellows & Liu, 2015).Unexpected is used to describe events that happen unplanned or absence of events that should have happened based on the initial plan (Geraldi, Lee-Kelley & Lutsch, 2010). The conditions of these unexpected events often manifest as novel things stand out of the ordinary, discrepancy between what is expected and what is reality and deliberate initiative

by others' explicit requirement of cognitive attention to the change issues (Chaudhry, Coyle-Shapiro & Wayne, 2010).

3.2. From individual sense making to collective sense making

The sensemaking process is argued to begin within individuals' heads and occurs when people encounter discrepant cues that did not fit the existing mental model very well, so they make sensemaking effort to enact plausible interpretations, which can enable action, and feed back to reshape their mental model (Maitlis & Christianson, 2014; Klein, Moon & Hoffman, 2006).

However, as people inevitably live in specific social network or organizational context, sense-making will not stop within one's head and remain static; instead, individual cognitive process and outcome will be further influenced by the social context. That is to say, individual's cognitive process and achievement can be extended beyond the boundaries of the skull through interactions with the other cognitive agents, consistent with socially distributed cognition perspective (Hutchins, 1995; Salomon, 1997).Sense-making can be viewed as a social construction process that is carried out within the context of social interactions. When the individuals are involved in a group to make sense of some ambiguous or uncertain events or situations together, they exchange individual temporary interpretations and try to create and agree on inter-subjective consensual interpretations that allow coordinated action through cycles of interpretations and action, i.e., collective sense-making (Weick, Sutcliffe & Obstfeld, 2005; Stigliani & Ravasi, 2012).

3.3. Sense-making process and interpretation

No matter talking about sensemaking at individual or group level, sense-making generally incorporates three sub-processes: information gathering, interpreting, and action (Thomas, Clark & Gioia, 1993; Daft & Weick, 1984).From the information processing perspective, information gathering involves acquiring information from external or internal environment to seek cues/signals for sensemaking. Interpreting involves the act that fit the information into some structure to carving out meaning from equivocal and uncertain cues(Fellows & Liu, 2015; Thomas, Clark & Gioia, 1993).Connecting cues and cognitive frames will generate interpretations, as the outcome of sensemaking process. The interpretations can have a semantic function as an explanation of "what's happening?", and a performative function pointing out "what should I do next?" (Weick, Sutcliffe & Obstfeld, 2005; Maitlis, 2005). When sensemaking transited from individual level to collective level, a group of people involve in the iterative process of sensemaking and sensegiving through conversational practice, individuals exchange their provisional interpretations and try to agree upon one consensual interpretation (Daft & Weick, 1984). In other words, consensual interpretation is the output of collective sense making.

Regarding action, in organizational sense making research, viewing from macro level, action can be defined as any significant changes in ongoing organizational practices (Fellows & Liu, 2015). However, viewing action from macro perspective fails to take diversity nature of group members into account. "Information exchange" was then introduced by Comfort and Kapucu to represent action in micro practices (Comfort & Kapucu, 2006).

Interpretations and action, which are both important components of sense making, are always twining together and shaped by each other. According to Weick (1995), "Sense making is a way station on the road to a consensually constructed, coordinated system of action". In other words, interpretations of certain circumstances will serve as a springboard for action, while failure to construct consensual interpretation of specific situation can hamper effective collective action; often, the consequence is reduced performance. In turn,

action also shape interpretations in the way that action taking generate new cues or stimuli for sensemaking (Maitlis & Christianson, 2014).

3.4. Collective sensemaking effort and capability

To date, many research on collective sensemaking topics is apt to explore the sensemaking process, i.e., how sense is made within a group or a large organization, e.g., the Mann Gulch disaster (Whiteman & Cooper, 2011; Weick, 1993)and in a design consulting firm (Stigliani & Ravasi, 2012). Recent research starts to investigate it at a macro level, link it to its antecedents and dependents. From organizational information processing perspective, Choo develops an organizational knowing cycle model linking organizational sensemaking, knowledge creation, decision making and environment (Choo, 2001).Jensen also considers "sensemaking" as a measurable construct and examine the influence of amount of information and type of communication on collective sensemaking respectively in command teams during military planning (Jensen, 2009).

However, to directly measure "sensemaking" is over-simplified since sensemaking is a complex concept and has various facets. Among the literature trying to measure sensemaking process at a macro level, two operational and measurable sensemaking-process-related constructs, i.e., collective sensemaking effort and collective sensemaking capability have been adopted in this research. Collective sensemaking effort means the frequency that a group of actors involve in a course of reciprocally interactive sensemaking sub-processes (Vlaar, 2008), including information gathering, interpreting and exchange. Collective sensemaking capability has been identified as an important strategic resource for an organization, e.g., in military coalitions (Jensen, 2009; Smart & Sycara, 2013), to react to the environmental changes quickly. Although both collective sensemaking effort and capability are based on three sensemaking sub-processes, collective sensemaking capability stresses the quality and performance of this series of activities while collective sensemaking effort is reflected in the frequency and quantity of sensemaking activities.

4. Material engagement in sensemaking

4.1 Material artefacts and practices as boundary objects

Traditional research on sensemaking has considered this process as an intellectual cognitive process and turned a deaf ear to its sociomateriality (Orlikowski & Scott, 2008). It is only until recently that senesmaking studies started to pay attention to material engagement in sensemaking and acknowledged that material artifacts and practices are important "sensemaking resources" (Shariq, 1998). Material engagement is reflected in the extent to which material artefacts used and material practices involved in individual cognitive or social activities (Malafouris, 2004). Material artifacts, which refers to purposively made products of human action perceived by the senses, are created aiming at satisfying a need or solving a problem (Gagliardi, 1990). And they cannot be separate exactly from human beings and human practices since they need to be perceived and endowed with corporality and physically by people in practices. Thus, artifacts are in themselves materially produced, assembled, elaborated and utilized in material practices (Stigliani & Ravasi, 2012; Whiteman & Cooper, 2011).

As an individual's mental representation interacts with a material environment rich in material artifacts through material practices, these material artefacts and practices, e.g., models, simulations generated or utilized by people, act as "cognitive aids" and "individual thinking tool" to assist cognitive work (Stigliani & Ravasi, 2012; Rafaeli, Ravid & Cheshin, 2009). Besides playing an important role in individual sensemaking, they can also act as "boundary objects" (Carlile, 2002) or "interactive communication tools"(Rafaeli, Ravid & Cheshin, 2009) when group of people transfer their provisional understandings and try to develop consensual interpretations through conversational practices other interaction

ISBN: 978 0 9943656 82; ISSN: 2205-6181
Year: 2017, Volume: 3, Issue: 1
www.apiar.org.au

activities since collective sensemaking is a social construction process rather than a purely cognitive activity.

4.2. BIM, and material artefacts and practices

During construction project change, traditional material engagement to support cognition canbe Gantt charts, 2D drawings and etc. Actually, it's uneasy for a layman to read and understand them. Besides, they provide neither real-time data of the project nor rich information of the proposed change alternatives (Hartmann et al., 2012; Chavada, Dawood & Kassem, 2012). Nowadays, the introduction and development of BIM have the potential to provide more probably useful material artifacts and practices, e.g., 3D models, quantity takeoffs, as-planned and as-built progress report, and etc.

Before going further in the literature about the role of BIM, it is necessary to clarify the relationship between "BIM", "BIMs", "BIM tools" and material artifacts and practices. According to NIBS, BIM is defined as "an improved planning, design, construction, operation, and maintenance process using a standardized machine-readable information model for each facility, which contains all appropriate information created or gathered about that facility in a format useable by all throughout its lifecycle" (NIBS, 2008).Building Information Models (BIMs) refers to "digital representations of physical and functional characteristics of a facility. A BIM model is a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle" (NIBS, 2012). BIM's here is not confined to 3D building model; instead, it means joint digital objects that can represent and provide information of the facility. "BIM tools" means relevant modeling technologies and software that are associated with producing, communicating, and analyze building models (Eastman et al., 2011).

To link them together, what can be summarized is that BIM is a process involving sets of material practices through which BIMs (material artifacts), rich in building information, are generated and managed by project participants using relevant BIM tools. Thus, BIM-related material engagement in this research is reflected in the extent to which BIMs used and BIM practices involved in sensemaking activities, including information gathering, interpreting and information exchange when a group of people dealing with construction project change.

In the context of "fragmented" construction projects, BIM has been investigated and considered as "boundary objects" in joint activities executed by various participants from different parties (Alin, Iorio & Taylor, 2013), e.g., design coordination (Kim & Grobler, 2009), technical disclosure (Xu & Wang, 2013), and etc. Bresnen and Harty (2010) have reviewed 10 papers related to the topic of the role of objects in knowledge sharing and transformation in construction projects. Despite of the acknowledgement of critical role of BIM as boundary objects in collective sensemaking and collective sensemaking process in joint activities, little is known about how and to what extent BIM-related material engagement influences collective sensemaking process and its outcome, especially in the context of construction project change.

5. Framework development

As mentioned in Chapter 3 and 4, distributed cognition perspective can offer a good lens to view cognitive work in a group existed in socio-material environment. And distributed cognition can be further classified into socially distributed cognition where a cognitive agent interacts with other cognitive agents and physically distributed cognition where a cognitive agent or a collection of cognitive agents interact with the material environment.

This perspective in cognitive science were originally introduced and developed in the mid-1980s by Edwin Hutchins, who investigated a navigation team's cognitive task and nature outside lab in the wild (Hutchins, 1995). The author moves the boundaries of the cognitive unit of analysis out beyond the skin and skull of the individual body and treats the navigation

teams as a cognitive and computational system. From his point of view, individual's cognition cannot be observed directly, but within a socially distributed cognitive system, stepping inside the cognitive system become possible. This idea lays a basic foundation for studying group-level collective sensemaking effort, collective sensemaking capability and consensual interpretation in this research.

Moreover, physically distributed cognition perspective questions the traditional claim of regarding artifacts as an amplifier of individual cognitive ability. Considering two main functions of artefacts that act as information representational media and provide constraints on the organization of action, researchers in distributed cognition maintain that in social activities, material artefacts enhance the cognitive work of a cognitive system that consists of a collection of individuals instead of every individual cognition ability in the group (Hutchins, 1995; Saloman, 1997).

Based on distributed cognition perspective and taking constructs identified in sensemaking theoretic net into account, material engagement and collective sensemaking can be linked. Material engagement in sensemaking serves as information storage and representational media providing raw data and processed information. Then, a trigger condition of novelty, discrepancy or deliberate initiative enables people to consciously start to gather, process and exchange information. And the information is transformed through process-related collective sense making effort and shaped by collective sense making capability. Lastly, information is given actionable meaning by a group of cognitive agents jointly as consensual interpretations.

In this specific research context, to deal with construction project change, the use of BIMs and BIM practices involved will influence the decision making group's collective sensemaking effort and capability, including the effort and capability of information gathering, interpreting and information exchange. In the meanwhile, an unexpected event that precedes construction project change will create a trigger condition of novelty, discrepancy or deliberate initiative for collective sensemaking within the decision making group. The extent of trigger condition will moderate the relationships between material engagement and collective sensemaking effort, and material engagement and collective sensemaking capability. Furthermore, sensemaking-process-related collective sensemaking effort and capability will influence level of agreement, speed of reaching and quality of collective sensemaking outcome, i.e., consensual interpretation. Consensual interpretation here is reflected in the contents of variation order, including description of the variation, causes for the variation and effects on the works, extension of time for completion and evaluation of the (Jaeger &Hök, 2009), agreed and signed by all involved parties. Accordingly, a theoretical framework is established as shown in Figure 2.

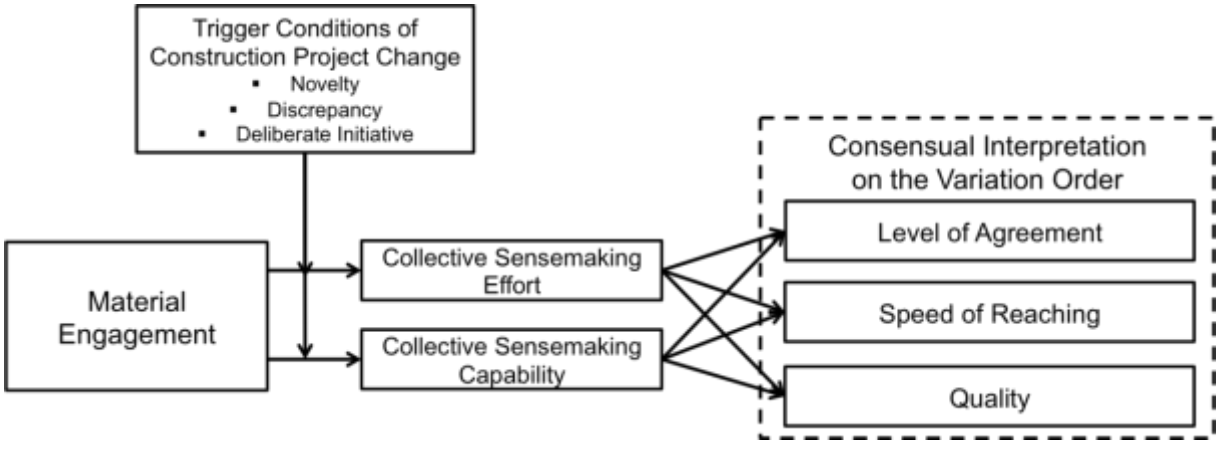


Figure2: Theoretical Model

6. Conclusions and implications

In order to investigate the role of BIM in construction project change, this research develops a conceptual framework based on sensemaking theoretic net from distributed cognition perspective. There are two parts in the conceptual framework: i) BIM-related material engagement influences collective sensemaking effort and capability, moderated by trigger conditions of a construction project change and ii) Collective sensemaking effort and capability influence three characteristics, including level of agreement, speed of reaching and quality, of consensual interpretations on the variation order.

Previous research on role of BIM has been limited to simple labeling, lacking in theoretical base or empirical evidence. This research explores the impacts of BIM on construction project change management process and variation order by applying theories from general change management and cognitive science. The proposed conceptual framework lays foundation for further empirical test. Besides, although there is considerable research on sensemaking in organizational change or crisis, investigation on sensemaking within construction literature is rare, especially in construction project change. This research may contribute to apply sensemaking theoretic net and its related constructs in a relatively new context. Some similarities and discrepancies of sensemaking in different context may be identified after conducting this research.

ISBN: 978 0 9943656 82; ISSN: 2205-6181
Year: 2017, Volume: 3, Issue: 1
www.apiar.org.au

References

i. Alin, P., Iorio, J. & Taylor, J.E. (2013) 'Digital boundary objects as negotiation facilitators: spanning boundaries in virtual engineering project networks',*Project Management Journal*, 44(3), pp. 48-63.

ii. Bresnen, M. & Harty, C. (2010) 'Editorial: objects, knowledge sharing and knowledge transformation in projects',*Construction Management and Economics*, 28(6) pp. 549-555.

iii. Bullock, R. & Batten, D. (1985)'It's just a phase we're going through: a review and synthesis of OD phase analysis',*Group & Organization Management*, 10(4), pp. 383-412.

iv. Burnes, B. (1996)'No such thing as... a "one best way" to manage organizational change',*Management Decision*, 34(10), pp. 11-18.

v. Carlile, P.R. (2002)'A pragmatic view of knowledge and boundaries: Boundary objects in new product development',*Organization Science*, 13(4), pp. 442-455.

vi. Chan, W.K., Wong, K. & Scott, D. (1999) 'Managing construction projects in China—the transitional period in the millennium',*International Journal of Project Management*, 17(4), p. 257-263.

vii. Chaudhry, A., Coyle-Shapiro, J.A. & Wayne, S.J. (2010) 'A longitudinal study of the impact of organizational change on transactional, relational, and balanced psychological contracts',*Journal of Leadership & Organizational Studies*,

viii. Chavada, R., Dawood, N. & Kassem, M. (2012) Construction workspace management: the development and application of a novel nD planning approach and tool.*Journal of Information Technology in Construction*.

ix. Choo, C. (2001)'The knowing organization as learning organization',*Education + Training*, 43(4/5), pp. 197-205.

x. CII (1994)*Project Change Management*. Construction Industry Institute.

xi. Comfort, L.K. & Kapucu, N. (2006) 'Inter-organizational coordination in extreme events: The World Trade Center attacks, September 11, 2001',*Natural Hazards*, 39(2), pp. 309-327.

xii. Daft, R. & Weick, K. (1984) 'Toward a model of organizations as interpretation systems',*Academy of Management Review*, 9(2), pp. 284-295.

xiii. Dunphy, D. & Stace, D. (1993) 'The strategic management of corporate change',*Human Relations*, 46(8), pp. 905-920.

xiv. Eastman, C. et al. (2011)*BIM handbook: A guide to building information modeling for owners, managers, designers, engineers and contractors*. John Wiley & Sons.

xv. Fellows, R. & Liu, A. (2015) 'Sensemaking in the cross-cultural contexts of projects',*International Journal of Project Management*.

xvi. FIDIC (1999).*Conditions of Contract for Construction*. Geneva: International Federation of Consulting Engineers.

xvii. Gagliardi, P. (1990)'Artifacts as pathways and remains of organizational life.' In*Symbols and artifacts: Views of the corporate landscape*, pp. 3-38.

xviii. Geraldi, J.G., Lee-Kelley, L. &Kutsch, E. (2010) 'The Titanic sunk, so what? Project manager response to unexpected events',*International Journal of Project Management*, 28(6), pp. 547-558.

xix. Hartmann, T. et al. (2012) 'Aligning building information model tools and construction management methods',*Automation in Construction*, 22, pp. 605-613.

xx. Hutchins, E. (1995) *Cognition in the Wild*. MIT Press.

xxi. Hwang, B.-G. & Low, L.K. Low (2012)'Construction project change management in Singapore: status, importance and impact',*International Journal of Project Management*, 30(7), pp. 817-826.

xxii. Ibbs, C.W. et al. (2003) 'Project delivery systems and project change: Quantitative analysis',*Journal of Construction Engineering and Management*,129(4), pp. 382-387.

xxiii. Jaeger, A.-V. & Hök, G.-S. (2009) *FIDIC-a Guide for Practitioners*. Springer Science & Business Media.

xxiv. Jensen, E. (2009)'Sensemaking in military planning: a methodological study of command teams',*Cognition, Technology & Work*, 11(2), pp. 103-118.

xxv. Kim, H. & Grobler, F. (2009) 'Design coordination in building information modeling (BIM) using ontological consistency checking',*Computing in Engineering*, pp. 410-420.

xxvi. Klein, G., Moon, B. &Hoffman, R.R. (2006) 'Making sense of sensemaking 1: Alternative perspectives',*IEEE intelligent systems*, (4), pp. 70-73.

xxvii. Lazarus, D. & Cifton, R. (2001) *Managing project change: A best practice guide*. Ciria.
xxviii. Lewin, K. (1951)*Field theory in social science*.
xxix. Louis, M.R. & Sutton, R.I. (1991)'Switching cognitive gears: From habits of mind to active thinking',*Human Relations*, 44(1), pp. 55-76.
xxx. Love, P. et al. (2002) 'Using systems dynamics to better understand change and rework in construction project management systems',*International Journal of Project Management*, 20(6), pp. 425-436.
xxxi. Maitlis, S. (2005) 'The social processes of organizational sensemaking',*Academy of Management Journal*, 48(1),pp. 21-49.
xxxii. Maitlis, S. &Christianson, M. (2014) 'Sensemaking in Organizations: Taking Stock and Moving Forward',*The Academy of Management Annals*, 8(1), pp. 57-125.
xxxiii. Malafouris, L. (2004)'The cognitive basis of material engagement: where brain, body and culture conflate'. In*Rethinking materiality: The engagement of mind with the material world*, p. 53-61.
xxxiv. NIBS, N.I.o.B.S., National BIM Standard - United States. 2008.
xxxv. NIBS, N.I.o.B.S., National BIM Stadard - United States - Version 2. 2012.
xxxvi. Orlikowski, W.J. & Scott, S.V. (2008) 'Sociomateriality: challenging the separation of technology, work and organization',*The Academy of Management Annals*, 2(1), pp. 433-474.
xxxvii. Osland, J., Bird, A. & Gundersen, A. (2007) 'Trigger events in intercultural sensemaking'. In*Academy of Management Meeting, Philadelphia, USA*.
xxxviii. Rafaeli, A., Ravid, S. &Cheshin, A. (2009) 'Sensemaking in virtual teams: The impact of emotions and support tools on team mental models and team performance',*International Review of Industrial and Organizational Psychology*, 24, pp. 151-182.
xxxix. Salomon, G. (1997)*Distributed cognitions: Psychological and educational considerations*. Cambridge: Cambridge University Press.
xl. Senaratne, S. & Sexton, M. (2011) *Managing change in construction projects: a knowledge-based approach*. John Wiley & Sons.
xli. Shariq, S.Z. (1998) 'Sense making and artifacts: an exploration into the role of tools in knowledge management',*Journal of Knowledge Management*, 2(2), pp. 10-19.
xlii. Shipton, C.,Hughes, W. & Tutt, D. (2014) 'Change management in practice: an ethnographic study of changes to contract requirements on a hospital project',*Construction Management and Economics*, 32(7-8), pp. 787-803.
xliii. Smart, P.R. & Sycara, K. (2013) 'Collective sensemaking and military coalitions',*IEEE Intelligent Systems*, 28(1), pp. 50-56.
xliv. Stigliani, I. &Ravasi, D. (2012) 'Organizing thoughts and connecting brains: material practice and the transition from individual to group-level prospective sensemaking',*Academy Of Management Journal* 55(5), pp. 1232-1259.
xlv. Sun, M. & Meng, X. (2009) 'Taxonomy for change causes and effects in construction projects',*International Journal of Project Management*, 27(6), pp. 560-572.
xlvi. Thomas, J.B., Clark, S.M. & Gioia, D.A. (1993) 'Strategic sensemaking and organizational performance: linkages among scanning, interpretation, action, and outcomes (includes appendix)',*Academy of Management Journal*, 36(2), pp. 239.
xlvii. Vlaar, P. (2008)*Contracts and trust in alliances: Discovering, creating and appropriating value*. Edward Elgar Publishing.
xlviii. Weick, K. (1993)'The collapse of sensemaking in organizations: The Mann Gulch disaster',*Administrative Science Quarterly*, pp. 628-652.
xlix. Weick, K. (1995) *Sensemaking in organizations*. Thousand Oaks, Calif.: Sage Publications.
lx. Weick, K. & Quinn, R. (1999) 'Organizational change and development',*Annual Review of Psychology*, 50(1), pp. 361-386.
lxi. Weick, K., Sutcliffe, K. &Obstfeld, D. (2005) 'Organizing and the Process of Sensemaking', 16(4), pp. 409-421.
lxii. Whiteman, G. & Cooper, W.H. (2011) 'Ecological sensemaking',*Academy of Management Journal*, 54(5), pp. 889-911.
lxiii. Winch, G. (2010) *Managing construction projects*. John Wiley & Sons.
lxiv. Xu, N. & Wang, L. (2013) 'Study on Technical Disclosure in Construction Based on BIM.'In *Applied Mechanics and Materials*. Trans Tech Publ.