Understanding digital transformations of construction firms: A case from India

Sreelakshmi S, Ashwin Mahalingam
Department of Civil Engineering, Indian Institute of Technology Madras
sreepadam11@gmail.com, mash@civil.iitm.ac.in

Introduction

The construction industry is fragmented and involves many stakeholders. It faces many problems, such as the lack of the right information present at the right time with the right personnel to do the right job. This leads to errors, rework, lack of resources, and eventually cost overruns and time overruns (Iyer and Jha 2006; Yap et al. 2018). Digital technologies bring about innovation, help in work allocation, manage interdependence and focus on coordination. Therefore they have the potential to bring about a remarkable paradigm shift to the global built environment sector for the better. An example of a digital technology is Building Information Modelling (BIM), a simple yet effective medium to aid the management system. BIM is 'a collaborative way of working, underpinned by digital technologies which unlock more efficient methods of designing, creating and maintaining assets'. BIM embeds a 3-dimensional computer model with key asset information that can be used for effective management of information throughout a project's life-cycle – from earliest concept through to operation to demolition (Enegbuma et al. 2016; Kushwaha and Adhikari 2016; Memon et al. 2014; Steel et al. 2012).

Although the technology has much potential to help the industry, the adoption rate is quite low, and there is limited use in practice (Gu and London 2010; Hire et al. 2022; Ullah et al. 2019; Won et al. 2013). It is understood that implementing BIM in construction organizations will involve a lot more than just changing the software currently being used. According to Chan (2018 p. 156), 'there is a deeply entrenched logic in organizing of construction work that drives resistance to technological change and innovation.' For BIM to be adopted across the organization, the company should consider all the challenges related to innovating within the firm, inter-organizational innovation as well as challenges at an industry level. Some findings suggest that new technologies force a change in the existing practices, while few others argue that technologies should adapt to the existing practices (Won et al. 2013). Hinings et al (2018) in their work have stressed the fact that the institutional perspective is considered to be the best lens to understand change and innovation.

Institutions are often taken-for granted, are highly persistent and resistant to change. As actors re-enact institutionally driven practices or routines, these institutions tend to be reproduced and therefore persist. However, institutions, once created, generally tend to change gradually over time. How change processes orient and take root depends on the interactions among different individuals, between individuals and organizations, and between multiple levels across organizations and contexts (Langley et al. 2013). 'The purposive actions of individuals and organizations aimed at creating, maintaining and disrupting institutions', termed as institutional work (Lawrence and Suddaby 2006) helps to identify the mechanisms of change in an institutionalized setting such as construction. In our study, we intend to identify the institutional work associated with the digital transformation in a construction firm. In order to do so we utilize the Virtual Design and Construction framework in conjunction with institutional theory.

Kunz and Fischer (2020) have proposed a Virtual Design and Construction (VDC) framework to emphasize aspects of projects that can be designed and managed. VDC 'is the use of multi-disciplinary performance models of design-construction projects to support explicit and public business objectives'. However, the VDC framework overlooks the processes that need to be carried out in order to implement the VDC successfully. Therefore, this study intends to answer *How organizational change with regards to BIM is achieved and what institutional work triggers the change?*

Research methodology and approach

There is always the question of how to study change. This is because change generally happens gradually over a period, and the signs of routinization may not be readily recognizable. It is easier to understand change through interviews rather than through observations. A case-based approach is followed because there is a need for empirical evidence that can coherently provide in-depth data on the evolution of BIM use. Since the construction industry is project-based this study looks into BIM adoption evolving from projects to projects. An Indian company is considered in this study that has been implementing BIM and other digital technologies for the past fifteen years in various domains. This company has expertise in handling projects such as residential complexes, industrial buildings, airports, bridges, metros, water treatment plants, ports and harbours to name a few. The use of digital technology such as BIM is now extensive in the design phase and is also being utilized in execution phase. There are seven sub-divisions in the firm of which two sub-divisions initiated the use of BIM. Sub-division A (SD-A) handles construction of facilities such as airports, residential complexes, and stadium, and sub-division

B (SD-B) handles the construction of metro rail projects, nuclear power plants and bridges[1]. Hence this firm was chosen for a longitudinal study. The interactions with personnel associated with projects using BIM since 2005 helped to understand the BIM adoption journey.

Interactions with the personnel through interviews can help identify the agents, key events, and other factors that lead to the evolution of BIM within the organization. The findings need to evolve from data inductively and hence there are no ex-ante hypotheses. Interviews are prime data sources as the BIM implementation story is an important entity for project participants who have lived through the project. Using an inductive approach, drawing upon open-ended interviews with the firm's team heads, architects, BIM managers and coordinators, we identified mechanisms that helped in operationalizing BIM in the organization. As this study uses a qualitative and an inductive research, the data and the existing theory is considered in tandem (Acosta and Gond 2021; Gioia et al. 2012; Zerjav et al. 2018). The study is based on the data collected over a period of six months. 20 interviews were conducted with experts, and personnel belonging to all levels of the hierarchy, including the VP, Design heads & BIM managers involved in implementing BIM. The duration of each conversation lasted between an hour to 1.5 hours.

We conducted multiple interviews with our informants and we compared the stories shared by other informants. This helped to enhance the internal consistency and validity of data (Yin 2018). The stories revolved around how organizations decided to go digital and how BIM was utilized in the organization. The informants were encouraged to talk about the workflow, the organization structure, and how BIM affected the existing way of working. The interviews were transcribed and open and axial coding were used to analyze the data(Corbin and Strauss 2008; Miles and Huberman 1994).

Findings and Implications

The evolution of POP models suggested by Kunz and Fischer (2020) are considered for this study zooming in to the relationships between the Product (P- building information models), the Organization (O- intra- and inter-organizational interactions), and the Process (P- change management) that bring change to the organization. Each POP model is project specific. As we observed the firm progress from project to project, we observed changes in the existing practices, be it the objectives from the client, the evolution of the use of 'product'- BIM models,

[1] The name of the firm and the sub-divisions are not mentioned to maintain confidentiality.

the practices in the organization, and related processes. This is explained from an Event-system theory (EST) perspective, which according to Morgeson et al., 'focuses on events, which result in changes in current behaviors and features and the creation of new behaviors, features and events over time and across levels' (Morgeson et al. 2015). Applying EST, we can explain when an event triggers a change in P, O, or P at each point in time and the succeeding POP model that gets improved. Key changes are outlined below:

Evolution of client objectives

Initially, the Indian clients were not aware of the advancements in digital technology and did not mandate the use of the same. However, some international projects required the team to work in the BIM environment. Later on, some of the clients in India had their own BIM teams to guide the project team and laid out very detailed requirements.

Evolution of product model

According to the changing requirements, the product models also evolved. In 2005, the project teams became aware of a new trend in the global construction industry – the use of Building Information Modeling. They were tasked to develop two airports in the cities of Delhi and Mumbai, characterized by complex designs, stringent deadlines, and high coordination requirements. They decided to initially develop a 3D model for visualization and to coordinate the Mechanical, Electrical and Plumbing (MEP) services. Later on, they also released their own BIM manual, based on their experiences, that could be used to set up BIM processes in the future.

As they moved on to the next project, the project team decided to try creating 4D models by integrating 3D models into the schedule. There were requirements from international clients as well. Hence, the models were used for progress monitoring and energy simulations in addition to visualization, quantity take-off, and clash detection. Since execution is mainly carried out using 2D drawings, the project team had to issue the drawings to the execution team.

Evolution of organization design

The organization design is agent-centric, giving importance to the players involved in the evolution. The project teams decided to utilize BIM, which could manage the complex design and meet coordination requirements. Initially, the project team started by seeking help from external forums and assembling volunteers. Some of the volunteers from the project teams were assigned new roles and entrusted with extra responsibilities to coordinate with the stakeholders.

Later on, BIM-specific recruitments were carried out. However, it was only an internal affair, and other stakeholders were not part of the process. Initially, the firm arranged help for sub-contractors and vendors to develop 3D models. Later, some of the vendors acquired the capability and were providing 3D models to the project teams.

The top management later decided to implement BIM after realizing the benefits and observing the trend in the global construction market. To help keep track of the developments, the organization had a team to compile the latest technologies that happen around the world. The top management formed a central BIM team to provide awareness and training to the design teams. Many software developers supported this endeavor by offering solutions and expertise.

Evolution of process model

The process model includes the processes involved in bringing about the changes in the organization. One of the processes was experimenting by working from part to whole and observing the beneficial outcome. Another approach was to create a feel of BIM by convincing and consultations, providing training for developing capability, and setting up a BIM studio. Focused inclusive coordination mechanisms such as digitalizing the workflow, collaborative problem resolution, and collaborative checking and approval were other mechanisms that helped to bring about change. These mechanisms helped to strengthen the inter- and intra-organization dynamics.

Understanding how change is achieved with regard to BIM was our primary objective. Thus, this study provides an example of how an organization is affected by introducing BIM and the mechanisms of change. Understanding the processes associated with BIM evolution is enabled through the micro-dynamics linked to each POP model. As the POP models are getting refined, some of the mechanisms get routinized, reinforcing the idea of digital transformation getting institutionalized. Finally, we notice that these actions induce change by introducing new mechanisms or co-existing with the old. Thereby this study contributes to the current stream of literature on institutional work by identifying forms of institutional work surrounding this change.

Keywords: BIM adoption, VDC, Event system theory, institutional work, organizational change, construction industry

References

Acosta, P., and Gond, J. (2021). “Revisiting Politics in Political CSR : How coercive and

deliberative dynamics operate through institutional work in a Colombian company."

Corbin, J., and Strauss, A. (2008). *Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory*. *Sage Publications, Inc.*, Sage Publications, Inc, USA.

Enegbuma, W. I., Aliagha, G. U., Ali, K. N., and Badiru, Y. Y. . (2016). "Confirmatory Strategic Information Technology Implementation for Building Information Modelling Adoption Model." *Journal of Construction in Developing Countries*, 21(2), 113–129.

Gioia, D. A., Corley, K. G., and Hamilton, A. L. (2012). "Seeking Qualitative Rigor in Inductive Research : Notes on the Gioia Methodology." *Organizational Research Methods*, 16(1), 15–31.

Gu, N., and London, K. (2010). "Understanding and facilitating BIM adoption in the AEC industry." *Automation in Construction*, Elsevier B.V., 19(8), 988–999.

Hinings, B., Gegenhuber, T., and Greenwood, R. (2018). "Digital innovation and transformation : An institutional perspective." *Information and Organization*, 28(1), 52–61.

Hire, S., Sandbhor, S., and Ruikar, K. (2022). "Bibliometric Survey for Adoption of Building Information Modeling (BIM) in Construction Industry– A Safety Perspective." *Archives of Computational Methods in Engineering*, Springer Netherlands, 29(1), 679–693.

Iyer, K. C., and Jha, K. N. (2006). "Critical factors affecting schedule performance." *Journal of Construction Engineering and Management*, 24(5), 757–773.

Kunz, J., and Fischer, M. (2020). "Virtual design and construction." *Construction Management and Economics*, Routledge, 38(4), 355–363.

Kushwaha, V., and Adhikari, M. (2016). "Exploring the Adoption of Building Information Modelling." *International Research Journal of Engineering and Technology (IRJET)*, 03(01), 526–530.

Langley, A., Smallman, C., Tsoukas, H., and Van de Ven, A. (2013). "PROCESS STUDIES OF CHANGE IN ORGANIZATION AND MANAGEMENT : UNVEILING TEMPORALITY , ACTIVITY , AND FLOW." *The Academy of Management Journal*, 56(1), 1–13.

Lawrence, T. B., and Suddaby, R. (2006). “Institutions and Instituional Work.” *Sage Handbook of Organization studies*, S. R. Clegg, C. Hardy, T. B. Lawrence, and W. R. Nord, eds., Sage, 215–254.

Memon, A. H., Rahman, I. A., Memon, I., and Azman, N. I. A. (2014). “BIM in Malaysian construction industry: Status, advantages, barriers and strategies to enhance the implementation level.” *Research Journal of Applied Sciences, Engineering and Technology*, 8(5), 606–614.

Miles, M. B., and Huberman, A. M. (1994). *Qualitative Data Analysis- An Expanded Sourcebook*. (R. Holland, ed.), Sage Publications, Inc, USA.

Morgeson, F. P., Mitchell, T. R., and Liu, D. (2015). “EVENT SYSTEM THEORY : AN EVENT-ORIENTED APPROACH TO THE ORGANIZATIONAL SCIENCES.” *Academy of Management Review*, 40(4), 515–537.

Sage, D. J., and Vitry, C. (Eds.). (2018). *Societies under Construction*. Springer International Publishing, Cham.

Steel, J., Drogemuller, R., and Toth, B. (2012). “Model interoperability in building information modelling.” *Software and Systems Modeling*, 11(1), 99–109.

Ullah, K., Lill, I., and Witt, E. (2019). “An overview of BIM adoption in the construction industry: Benefits and barriers.” *Emerald Reach Proceedings Series*, 2, 297–303.

Won, J., Lee, G., Dossick, C., and Messner, J. (2013). “Where to Focus for Successful Adoption of Building Information Modeling within Organization.” *Journal of Construction Engineering and Management*, 04013014(10), 1–10.

Yap, J. B. H., Abdul-Rahman, H., and Wang, C. (2018). “Preventive Mitigation of Overruns with Project Communication Management and Continuous Learning: PLS-SEM Approach.” *Journal of Construction Engineering and Management*, 144(5), 04018025.

Yin, R. K. (2018). *Case study research and applications: Design and methods*. *Sage Publications, Inc.*, Sage Publications, Inc, Los Angeles.

Zerjav, V., Edkins, A., and Davies, A. (2018). “Project capabilities for operational outcomes in inter-organisational settings : The case of London Heathrow Terminal 2.” *International Journal of Project Management*, Elsevier Ltd, 36(3), 444–459.