



Incorporating Building Information Modeling, Lean Construction, And Quality Control: A Study Based On Chinese Construction Engineering

Du Hongxia^{1*}, Aiman Al-Odaini²

^{1*}Research Scholar, Lincoln University College, Malaysia

² Lincoln University College, Malaysia

Email: hongxia@lincoln.edu.my

Citation: Du Hongxia & Aiman Al-Odaini (2024), Incorporating Building Information Modeling, Lean Construction, And Quality Control: A Study Based On Chinese Construction Engineering, *Educational Administration: Theory and Practice*, 30(4), 9509– 9514
Doi: 10.53555/kuey.v30i4.4417

ARTICLE INFO

ABSTRACT

Poor quality control, unfulfilled client expectations, and inadequate rules have hurt China's construction sector. How-to issues hinder Chinese building quality improvement. Building information modelling & lean construction increase quality. Lean & BIM can't address all construction issues. Combining lean building with BIM yields efficient results. Few high-quality lean construction-BIM links exist throughout the building process. Visual management, unified structure development, & BIM/lean building design administration are the key academic topics. Especially with "growth," quality is frequently disregarded. Little research exists on this topic. The study shows that BIM and lean construction increase building quality. Despite China's tremendous expansion, there is little study on how lean construction and BIM might enhance construction quality. Lean construction or Building Information Modelling (BIM) might assist China's construction business if executives learn about quality-driven interactions. Researchers must study more to finish our understanding. For these reasons, lean construction and data modelling project quality studies should be addressed. The project's focus on creating site connections was ended.

KEYWORDS: *Building Information Modelling (BIM), Design management, Lean construction, Quality Control, Chinese Construction Engineering.*

INTRODUCTION:

Recently, building project management has relied increasingly on Building Information Modeling (BIM) to improve outputs and stakeholder integration. BIM is a global construction project management standard. BIM is important to the construction management of projects, although no literature review has investigated this. This article discusses BIM and construction project management development (Adam et al., 2020). Researchers discovered 166 peer-reviewed Web of Science articles after filtering. Results demonstrated that the 2010 construction project management literature still introduced BIM. This research emphasis has been maintained by China, the US, England, & Australia since 2017. BIM in building management of projects literature is expanding beyond scheduling to encompass sustainability (Papadonikolaki et al., 2019), lean construction, and optimization. 5 network clusters were linked to project management topics. Integration, time, and expenditures dominated BIM topics in construction project management. BIM improves project activity growth, unlike traditional project administration literature, which concentrates on planning. Implementing/executing is the most mentioned process category (Papadonikolaki et al., 2019).

As elsewhere, China's building sector employs BIM for operational & commercial advantages. Despite its importance, China has scant evidence of BIM usage beyond the aforementioned. Building information modelling is hard for Chinese builders. This research investigates the Chinese building industry's BIM adoption motives (O'Loingsigh et al., 2014). This study includes many crucial elements in a prominent innovation paradigm, the technology-organization-environment (TOE) research model. Research models BIM technology's effects on an organization's adoption or operations. BIM's technical, organizational, & environmental benefits impact its adoption, studies reveal. Three innovations distinguish these results. Three

variables affecting BIM adoption in China are analyzed using the TOE paradigm. Several parameters may be evaluated in complete BIM adoption research (Andújar-Montoya et al., 2019). Engineering consulting and construction organizations conducted a survey-based operational inquiry. Consulting engineers and construction businesses manage building projects. Engineering consulting & construction firms are excellent advocates and executors for owners. This study enhances the results and provides a more complete picture of BIM users. This study examines BIM literature data using a complex partial least-squares methodology. The method is well-known in various academic disciplines but overlooked in engineering and construction management (Andújar-Montoya et al., 2019).

BACKGROUND OF THE STUDY:

As a foundation of China's economy, the construction sector has grown at an unparalleled pace. Chinese construction GDP reached 19.35 trillion yuan in 2016, accounting for 6.66% of the country's GDP (Sinchew, 2017). In 2017, the Chinese construction sector employed 61,576,100. Although large, the Chinese building sector is weak, notably in quality (Liu, 2015). Construction quality appears to be a concern for every nation, but China has especially significant issues. China's numerous quality-related mishaps have cost lives and property. 46% of consumers report quality defects (Xinhua, 2013). To address quality issues, the Chinese government switched from inspection to statistics to complete quality management in buildings. However, building quality remains poor. In recent years, the Chinese government has used BIM and lean construction to enhance construction quality. BIM's clash detection capability has been extensively used in China to enhance building quality (Liu, 2015). China has also used lean construction ideas to improve quality for years (Wen, 2000). Good construction quality eliminates faults, provides value, and meets customer expectations. Chinese building quality is improving in certain areas.

BIM is a new construction method that digitally designs and builds structures. Sacks, Radosavljevic, and Barak (2010) define BIM as parametric objective modelling that displays construction data and simulates. Virtual development of onsite structures is convenient. BIM has gained popularity in China despite its recent arrival. The Chinese Construction Industry Association found that 55% of construction businesses have heard of BIM but just 15% employed it in their projects. BIM was used in 40% of Chinese projects in 2016 (Lu, 2018). The Ministry of Housing and Urban-Rural Development of the People's Republic of China predicts that 90% of new projects will use integrated BIM by 2020. Some BIM functionalities are being tested to enhance building quality (Lu et al., 2017).

THE PURPOSE OF THE RESEARCH:

BIM is a complex, 3D-based model technology that shows a facility's physical and functional qualities. This illustration helps explain spatial organization, planning, architecture, and administration. Academics and corporations are interested in BIM, LC, and PHC. Researchers have paid little attention to LC & BIM in PHC projects. This paper examines China's primary healthcare (PHC) BIM and LC implementation. China has the world's biggest population and housing market, as reported by (Fang et al., 2023). Despite massive government funding for PHC in China, only a few hospitals use BIM and LC.

LITERATURE REVIEW:

This chapter presents the results of the literature review on building information modelling (BIM), lean construction (CCM), and construction quality. A thorough analysis of the evolution of quality management for construction is conducted in the first part to ascertain the need to improve the quality of buildings in China (Andújar-Montoya et al., 2020). The researchers explored how lean construction may be used to enhance the quality of construction. The final part delves into possible methods for enhancing quality that are driven by BIM. To enhance the quality of construction, the fourth part provides a detailed evaluation of current studies on merging BIM and lean construction (Sun et al., 2015).

Having a clear understanding of what quality means is essential for improving building quality. The first step in comprehending quality is to provide a precise definition of the term, although this is easier said than done. "Quality is conditional, subjective, and perceptual" (Heigermoser et al., 2019). Judging quality is more subtle than determining whether a project was completed on time and under budget. Quality judgments are also susceptible to visual cues (Mellado, and Lou, 2020), and researchers from diverse backgrounds may arrive at various conclusions on what constitutes high quality (Mellado, and Lou, 2020). Researchers have long sought to provide a meaningful definition of quality. The term has been defined differently by different academics and professionals in the field of construction over the years, but no one definition has been able to gain consensus (Heigermoser et al., 2019).

QUESTION OF THE STUDY:

- i. What is the correlation between lean construction & the BIM approach?

RESEARCH METHODOLOGY:

There has been little investigation into the quality-based relationships between CIM and lean building practices. By engaging in exploratory inquiry, one may uncover new and interesting truths. This research thus relied on exploratory methodologies. After reviewing the current literature, it is clear that this area needs further research. To go into uncharted territory, qualitative research is a powerful tool. Case study analysis and the administration of questionnaires are two methods for gathering expert opinions. Researchers have a fighting chance of succeeding if they use these strategies. The results of a literature review dictate the methods, processes, and approaches to data collecting that are used in a research project. The following study provides the justifications for each research strategy and looks at the results of these picks. Table 1 details the research methods of the study.

Table 1: Summary of Research Methodology

<u>Researchmethodology</u>	<u>Adoptedinthisresearch</u>
<u>Researchphilosophy</u>	<u>Realismontologyandinterpretivismepistemology</u>
<u>Researchapproach</u>	<u>Qualitativeresearch</u>
<u>Researchdesign</u>	<u>Casestudyandsurvey</u>
<u>Datacollectiontechnique</u>	<u>Datacollectiontechniquesincasestudy</u>
	• Documentation • <u>Directlvobservation</u> • Interview
	<u>Datacollectiontechnique insurvey</u>
	<u>Interview</u>

• Research Design:

To get to the bottom of things, researchers employ the study design to effectively collect data. Researchers use study design to decide on the approach that they use and the strategies they use for data collection and evaluation. There are several ways to do research. Research designs that are often employed include action research, study designs, experiments, case studies, & surveys.

• Data Analysis:

A theme analysis was performed on the interview data obtained from the case study. Even researchers without experience were not scared off by the prospect of working with complex qualitative data since this method is so easy to understand. A complete and detailed evaluation of the data may be achieved by using a theme analysis framework. To do this, researchers carried out the following procedures.

Examining the collected data.

To answer these two questions, researchers need to look at all the data researchers have and see whether it supports the theory. The next part was to go into the concepts of interview analysis of data that was used to analyze the transcripts of the interviews. To highlight the most important "details," researchers now take notes.

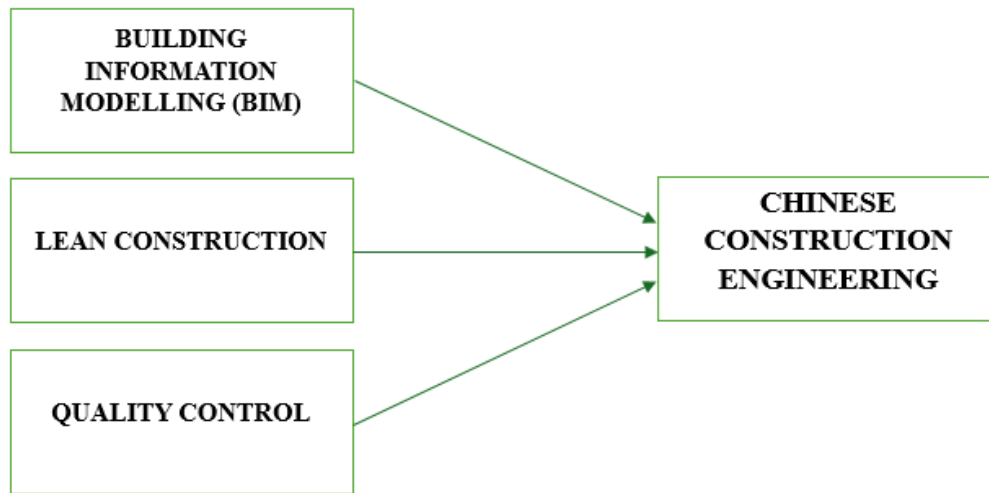
Primitive Code Creation

In theory, one might "identify the codes" using a manual technique or software like NVivo. Researchers conducted our investigation using a manual method. Pencils, highlighters, and Post-it notes to take notes, they were used. To identify keywords, researchers recorded the audio recordings. It was critical to expose all possible codes. Everything linked to a particular code was brought together.

At this stage, researchers started to organise the many codes into manageable groups in quest of direction. To help them zero in on the most important details, they made use of a mind map. Before analysis, the codes were recorded there. The themes were retrieved and shown on A3 paper. Researchers were able to get a holistic view of the scenario's overall "themes" by arranging these sheets on the wall.

It's beneficial to review the key elements once again.

Furthermore, this could have been the point at which academics first started to group the various codes into potential themes. Through the use of mind mapping, the core ideas were uncovered. The A3 paper was used for coding documentation, analysis, and theme development. Everyone had a better grasp of the overall "themes" after seeing these papers displayed on the wall.



RESULTS:

In their investigation of the connections between quality-focused lean construction approaches and quality-focused building information modelling (BIM), the researchers collected interview data. For this research, 22 experts were selected to participate in in-depth interviews. The interviews were place in China. Additionally, researchers were interested in participants' perspectives on the connections between quality-focused lean construction approaches and quality-focused building information modelling (BIM). By recording, analyzing, and summarizing the interviews, researchers were able to glean the necessary information.

• Findings from Survey:

Both Table 1 and Table 2 display the interview data. There is a connection of 17 between quality and strategy, and 11 between quality and execution. These results provide the groundwork for a comprehensive model of interactions.

Table 1: The Quality-Based Strategic Interactions between Building Information modeling (BIM) Systems and Lean Construction Theories

No.	The quality-based strategic interactions	Agreement level	Literature review	Survey
1	Proactive quality defect prevention culture - Visualisation	18 of 22		x
2	Proactive quality defect prevention culture - Simulation and calculation	22 of 22		x
3	Conversion to a quality-based mindset - Visualisation	13 of 22		x
4	Conversion to a quality-based mindset - Simulation and calculation	15 of 22		x
5	Conversion to a quality-based mindset - Collaboration	15 of 22		x
6	Decentralised control- giving authority to worker- Visualisation	21 of 22		x
7	Decentralised control-giving authority to worker -Simulation and calculation	22 of 22		x
8	Decentralised control-giving authority to worker- Dynamic	20 of 22		x
9	Decentralised control- giving Authority to worker- Integration	22 of 22		x
10	Customer quality requirements – Dynamic	21 of 22		x
11	Customer quality requirement – Collaboration	22 of 22		x
12	Customer quality requirements – Coherence	19 of 22		x
13	Pull-based quality management – Visualisation	19 of 22		x
14	Pull-based quality management – Collaboration	18 of 22		x
15	Pull-based quality management – Integration	22 of 22		x
16	Continuous quality improvement – Dynamic	17 of 22		x
17	Cooperation and communication – Collaboration	22 of 22		x

Table 2: The Quality-Based Interactions of Lean Construction Methods with Building Information Modelling Software

No.	The quality-based implementation interactions	Agreement level	Literature review	Survey
1	Last planner system-BIM-based design joint inspection and technical disclosure	22 of 22		x
2	Last planner system-BIM-based construction plan simulation and optimisation	22 of 22	x	x
3	Last planner system-BIM-based quality information management	21 of 22	x	x
4	Visual management-BIM-based dynamic template display	20 of 22		x
5	5S management-BIM-based visual construction layout	20 of 22		x
6	Kanban-BIM-based information management	16 of 22	x	x
7	Kanban-BIM-based quality inspection	19 of 22		x
8	Standardisation-BIM-based dynamic template display	22 of 22		x
9	Standardisation-BIM-based quality information management	18 of 22		x
10	First run study-BIM-based construction plan simulation and optimisation	22 of 22		x
11	Concurrent engineering-BIM-based clash detection	22 of 22		x

The interview data is used to present an overview of how lean building and building information modelling (BIM) work together to enhance quality. Eleven connections were made for quality-based implementation, and seventeen were made for quality-based strategic linkages. Several interactions have been confirmed by earlier studies. Many examples can be found in the literature (Shi, 2015; Liu & Shi, 2017), such as high-quality information management, LPS, & BIM-based building design optimization and simulation. The majority of those polled supported the transactions that were investigated. However, several examples were dismissed or even cast into doubt by some academics. In this chapter, researchers go deep into the relationships between these ideas. There are ten links between quality-based lean construction approaches and quality-based building information modelling software. Based on their unique traits, the encounters were divided into two categories: strategic and execution. The groundwork for expanding these connections into a framework that includes two separate forms of interaction is laid out in this chapter.

DISCUSSION:

A total of 17 quality-focused strategic relationships and eleven execution-related interactions were found in the research. Our understanding of lean construction & Building Information Modelling (BIM) is enhanced via these quality-improvement interactions. It would be beneficial if researchers could summarize the encounters based on the poll results. The purpose of this article is to improve the quality of construction in China by detailing the findings of an investigation into the connections between building information modelling (BIM) and lean construction. The methodology used is the foundation of our investigation. Researchers enhanced the use of lean concepts and building information modelling (BIM) software. To connect data modelling with lean construction, a simple matrix was used. This approach allowed us to establish a new study framework to examine how building information modelling (BIM) and lean construction (LC) work together to raise the bar for building quality in China. Based on the results of the study, a two-pronged strategy for participation was developed. While one researcher compared and contrasted BIM deployments with quality-based lean construction theories and practices, the other looked at how these were related to BIM. To raise the bar for Chinese construction quality, experts are crossing their fingers that this new framework sparks further investigations into the advantages of lean methodology and building data modelling. Preparation and execution are the two main components of this system. When used at the level of strategy, frameworks bring attention to the interdependencies among various parts. Among the quality-first BIM techniques and lean construction mindset. Researchers used a matrix approach to assess several quality-based construction lean theories at a more macro level. Additionally, quality-focused BIM techniques were compared using a column-wise strategy. The different parties' strategic exchange data were incorporated in every cell of the matrix. Take a look at the table below to get a brief idea of what's in each cell. The two frameworks, strategic and operational, were indistinguishable. Each cell in the matrix represented a connection between quality-based BIM and quality-based lean construction approaches.

CONCLUSION:

This article lays out the process of developing and testing the suggested framework of quality-oriented lean or BIM interaction. Eleven interactions concern the execution and seventeen concern the quality-based approach in the two-tiered interaction matrix. Because of the clear explanation, the reader has an easier time understanding the interactions. The center of attention here is an interaction framework. For this framework, researchers were relying on the findings from our interviews and case studies. This study aims to enhance project quality by studying the links between building information modelling (BIM) and life cycle costing (LC). To improve the quality of China's buildings, future research should focus on lean construction techniques and building data modelling. It is possible to use this model to examine how lean building practices impact BIM.

REFERENCES:

1. Adam, M., M. Hofbauer, and M. Stehling. 2020. "Effectiveness of a Lean Simulation Training: challenges, Measures and Recommendations." *Production Planning & Control* 32 (6): 443–453.
2. Andújar-Montoya, M. D., A. Galiano-Garrigós, C. Rizo-Maestre, and V. Echarri-Iribarren. 2019. "BIM and Lean Construction Interactions: A State-of-the-Art Review." *WIT Transactions on the Built Environment* 192: 1–13. doi:10.2495/BIM190011.
3. Andújar-Montoya, M. D., A. Galiano-Garrigós, V. Echarri-Iribarren, and C. Rizo-Maestre. 2020. "BIM-LEAN as a Methodology to save Execution Costs in Building Construction—An Experience under the Spanish Framework." *Applied Sciences* 10 (6): 1913. doi:10.3390/app10061913.
4. Fang, Y., Gao, S., Jiang, Y., & Li, S. (2023). BIM and lean construction in prefabricated housing construction in China. *International Journal of Lean Six Sigma*, 14(7), 1329–1353. <https://doi.org/10.1108/ijlss-03-2022-0059>.
5. Heigermoser, D., B. G. de Soto, E. L. S. Abbott, and D. K. H. Chua. 2019. "BIM-Based Last Planner System Tool for Improving Construction Project Management." *Automation in Construction* 104: 246–254. doi: 10.1016/j.autcon.2019.03.019.
6. Liu, H., 2015. A study of construction enterprise competitiveness based on stakeholder cooperation (In Chinese). Thesis (PhD). Beijing Jiaotong University.
7. Liu, J. and Shi, G., 2017. Quality control of a complex lean construction project based on KanBIM technology. *EURASIA Journal of mathematics, science and technology education*, 13(8), pp.5905-5919.
8. Lu, L., 2018. The construction information modelling (BIM) development status and trend analysis in 2018. [Online]. Available at: <https://www.qianzhan.com/analyst/detail/220/180117-04a9a109.html>. [Accessed 11 April 2018].
9. Lu, Y., Z. Wu, R. Chang, and Y. Li. 2017. "Building Information Modeling (BIM) for Green Buildings: A Critical Review and Future Directions." *Automation in Construction* 83: 134–148. doi: 10.1016/j.autcon.2017.08.024.
10. Mellado, F., and E. C. Lou. 2020. "Building Information Modelling, Lean and Sustainability: An Integration Framework to Promote Performance Improvements in the Construction Industry." *Sustainable Cities and Society* 61: 102355. doi: 10.1016/j.scs.2020.102355.
11. O'Loingsigh, M., A. Hore, B. McAuley, and J. Deeney. 2014. "Aligning BIM and Lean Methodologies within the Capital Works Management Framework in Ireland." *Computing in Civil and Building Engineering* (2014), 1522–1529. doi:10.1061/9780784413616.189.
12. Papadonikolaki, E., C. van Oel, and M. Kagioglou. 2019. "Organising and Managing Boundaries: A Structural View of Collaboration with Building Information Modelling (BIM)." *International Journal of Project Management* 37 (3): 378–394. doi: 10.1016/j.ijproman.2019.01.010.
13. Sacks, R., Radosavljevic, M. and Barak, R., 2010. Requirements for building information modeling based lean production management systems for construction. *Automation in construction*, 19(5), pp.641-655.
14. Shi, G., 2015. Research on quality control of construction project based on lean construction and BIM technology. (In Chinese). Thesis (M.A.). Tianjin University.
15. Sinchew, 2017. Development of Chinese construction (in Chinese) [Online]. Available from: <http://www.sinchew.com.my/node/1618817> [Accessed 31 May 2018].
16. Sun, C., S. Jiang, M. J. Skibniewski, Q. Man, and L. Shen. 2015. "A Literature Review of the Factors Limiting the Application of BIM in the Construction Industry." *Technological and Economic Development of Economy* 23 (5): 764–779. doi:10.3846/20294913.2015.1087071.
17. Wen, B., 2000. The zero defects management of Crosby (in Chinese). *Chinese quality inspection*, 7, pp.63.
18. Xinhua, 2013. Research: House buyers focus on building quality but have no confidence to 'rights protection' (in Chinese) [Online]. Available from: http://news.xinhuanet.com/house/suzhou/2013-08-07/c_116853073.htm [Accessed 15 April 2015].