

The Enhancement of Design Business Operation Using LOD 350: The Case of China

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Abstract

The lack of coordination in design practice is the cause of many problems in design business operation, and possible failure or delay in project delivery. The role of design manager is becoming important in design practice because of the necessity to manage complex design information. Level of Development (LOD) has been introduced to guide development of the BIM model and to help the control of information in building projects. This paper focuses on design companies in China with the aim of finding which features of LOD 350 will increase design coordination, enhancing design performance and improving design business operation. The paper also finds that increasing coordination between the design management team and the business management team can increase the efficiency of communication.

Key words: Design management, LOD 350, Design Business Operation

1. Problems and Introduction

Research shows that lack of coordination challenges the design operation process (Deutsch, 2011). Inefficient coordination in design practices is a common problem, and this lack of coordination causes numerous difficulties in building projects, such as delay in design, repetition of the same tasks and errors in design (Levy, 2012). This lead directly or indirectly to an increase of cost in design, for example, increasing utility bills and increasing employee working time. Therefore, it is very necessary to study the optimization of the design process in design practices, despite the existence of Building Information Modelling (BIM). Research has shown that BIM could help Small Medium Enterprises (SMEs) in their Returns on Investment (ROI) but this is not going to be the panacea (Kapogiannis, 2018), so there is opportunity to explore how to improve the design process through digital construction.

Building design consists of three phases: Schematic Design, Design Development and Construction Documents (Unifomat II, 1999). Following the design stage, there is requirement to submit construction documents in both graphical and non-graphical formats (ISO 19650, 2018). Different levels of development (LOD) are found in each phase of BIM models (See Figure 1) and can help to avoid BIM models containing too much information (Holzer, 2015). Research has found that LOD aims to create collaborative cultures for people, processes and technology (Kapogiannis, 2018).

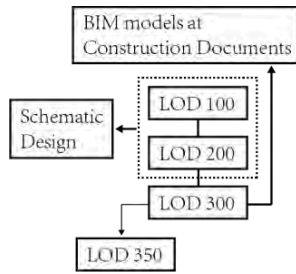


Figure 2 Level of Development (By Authors)

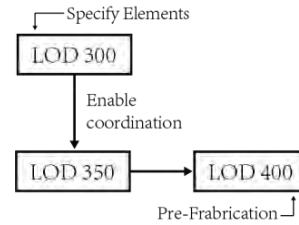


Figure 1 Role of Different LOD

This LOD specification (2018 Version) argued that LOD should evolve with project development (See Figure 2), with each LOD contributing to the construction project. Although LOD 300 has specified elements in the BIM model, coordination of the elements is not well addressed. LOD 350 aims to establish a relationship between model elements to improve design documentation, which will help design managers to improve design information coordination.

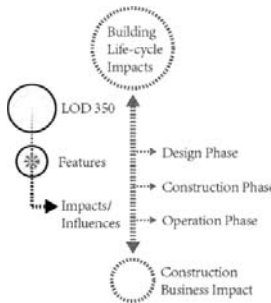


Figure 3 Role of LOD 350 (By Authors)

The quality of design management impacts on construction and facility management (Lou et al, 2019). It could be argued that lack of precise data could lead to inefficient process, despite the use of Common Data Environment (CDE), BIM software, Networks etc. The precision of a good model, according to ISO19650, is strongly linked to precise data: generic, approximate, accurate, and actual. With current LOD 350 specifications, it remains unclear why and how this level of detail will impact design practice and design business operation; therefore, this paper will investigate those features of LOD 350 (See Figure 3), and study how these features can improve working coordination in design companies. Due to length constraints, this paper will not validate the results.

2. Research Methodologies

The research is aiming to investigate and identify features of LOD 350 that could potentially improve the operation process of design practices by using secondary data and systematic review analysis. The literature review looked at fifteen fields relating to Architecture, Engineering and Construction (AEC) Industries. These papers comprehensively cover most aspects relating to construction projects and can be categorized into three parts: Design, Technologies and Business. The design element is primary in finding efficient design management solutions; the technologies element will find how to use advanced technologies to improve design management; and the business element will find business operation strategies under BIM implementations.

This paper reviews literature in current related technologies to explore advanced solutions, then finds what design of business operation is required. Literature review of the technology element finds solutions to link the design practice and business operation. Based on literature reviews, the research finds three fields in the design stage which highlight the importance of LOD: Design Planning, Sustainable Design and Quantity Survey. Also, two elements of business have accentuated LOD: BIM management and Business Interoperation.

Table 1 Major Reference Materials and Documents.

	British Standard	ISO Standard	US standard
Objects Classification	UniClass	ISO 12006-2:2015	UniFormat II/CSI UniFormat
			OmniClass
Process Guide	BS EN ISO 19650-1:2018		US National BIM Standard
	BS EN ISO 19650-2:2018		Version 3

COBie	BS 1192-4:2014		
LOD Specifications	BIM Forum LOD Specification 2018 version (Updated Annually)		
	Major Reference Materials		
BOOKS	BIM Handbook, 2 nd Edition		
	Managing the Building Design Process, 2 nd Edition		
	Building Design Management		

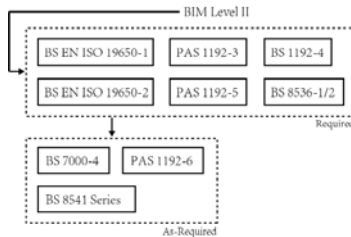


Figure 4 BIM Standards

Findings are mainly based on secondary data published by world recognized organizations such as NIBS, BSI and ISO (See Table 1), as well as on a series of standards in BIM Level II implementation strategies as listed by BreAcademy (2019) in their training in Hong Kong (See Figure 4). Other reference materials include relevant books, journals and conference papers. The results of this paper have not been validated, and further research will be conducted.

3. Finding results

Problems occur during the information model design operation process when different levels impact on decision making, work collaboration, business operation and operational management (Deutsch, 2011). The paper finds that features of LOD 350 will improve design practice and impact to design companies' business operation, although there is a gap in design collaboration across different disciplines due to inefficient communications. The focus, therefore, is on Building Design Management, Building Information Modelling (BIM) and Level of Development (LOD) in the Chinese building design market, with the aim of finding solutions to make improvement.

3.1 Building Design Management and BIM

Design practice needs IT management to improve project coordination and collaboration (Emmitt & Ruikar, 2013). Design management needs efficient information and communication flow, not only within the design team but also with clients and external specialists (Tunstall, 2006). BIM is a methodology to increase collaboration in design practice for improving building project development (Eastman et al. 2011). Emmitt and Ruikar (2013) argued that BIM is a solution to make a single model for communication and coordination and, as a new working process, highlights the role of design managers with efficient knowledge and technology management.

Gray and Hughes (2012) argued that the efficiency of communication needs to be understood and well addressed at different levels across design practice. Prior to the schematic design stage, a well-organized project brief is important. The design brief is the start of design information production, and a brief list of project needs helps designers to develop the building concept (Gray and Hughes, 2012). Farr (1965) pointed out the role of design management is finding suitable people to successfully accomplish design tasks on schedule. UK BIM level II regulates how project information needs to be managed, first with information requirements, leading to the information model. According to ISO 19650-1 (2018), Information requirements consist of Organizational Information Requirement (OIR), Project Information Requirement (PIR) and Asset Information Requirement (AIR), while information models consist of Project Information Model (PIM) and Asset Information Model (AIM).

AIM is the result of compiling building property information for construction management and PIM is built for assisting AIM in project management through building detailed information (ISO 19650-1, 2018). This paper finds these information requirements can address better information management. The design process needs efficient information coordination at each level for making design performance effective (Tunstall, 2006). Clear information requirements can guide each design

phase to satisfy the perspectives of owners, users and societies (ISO 19650-1, 2018). The design manager can use these information requirements as tools to link the design team and clients to establish efficient communications. Design needs management due to the complexity of building projects, and the role of the design manager is very important (Eynon, 2013). Efficient communication with clients will increase design performance (Gray & Hughes, 2012).

Since clients are not always experienced in building projects, the design manager acts as a bridge to link design teams and clients, requesting information and informing updates. A building design project is a multi-disciplined collaborative process including the participation of architects, structural engineers, system engineers and sub-contracted specialists (Tunstall, 2006). The paper finds that in order to deliver the design on schedule, each discipline needs a lead designer for quality control and a design manager for information coordination. Gray and Hughes (2012) argued that the participation of clients will decrease after the project brief. However, this paper finds that clients still need to be involved in the project to inform on updates (eg. budget change), thus, involvement among Design Team, Design Manager and Client are equally important.

Research shows that the quality and efficiency of design management impacts on the construction business (Bryde, 2008). Although the design business is not as complex as the construction business, it is important and is depends on the quality of design management. BIM provides a solution that enables design collaboration through information interoperation and management, which aims to increase design efficiency and enhance project performance (Eastman et al. 2011). This paper has found that LOD specifications provide information guidelines for the design manager to control and organize design development. It is important that design management should efficiently coordinate those design tasks and people working on tasks through choosing the appropriate technology tools.

It is concluded that the building design project is a highly collaborative processes that requires involvement and efficient coordination and management between the Design Team, Design Manager and Clients. BIM enables the design manager to efficiently establish coordination through disciplines. Design management needs to organize both human resources and design tasks, adopting information requirements through the information delivery process, ensuring that those working on the design project have the correct task information and produce the correct documents. The design business operation is depending on the performance of the design practice, satisfaction of clients and time-consuming efficiency. Design companies can improve business operation through improving building design management by adopting advanced skills.

3.2 Features in Level of Detail 350 in BIM

LOD specification is updated by the BIM forum annually. Elements in LOD are referenced upon CSI Unifomat (2010) and OmniClass (2019) Table 21 (see Figure 5). Therefore, these two documents are the main secondary sources for studying object classifications in this paper. UniFormat (2010) is created for classifying built elements through the project lifecycle, and OmniClass (2019) is for making a standard system for classifying construction-related information in the United States. UniClass has been introduced in the United Kingdom with the same purpose. These three documents categorize elements in design practice.

Dividing problems into manageable, small pieces can help design managers to better coordinate the project and thus make design companies more successful (Farr, 1965). Building Information Modelling (BIM) can increase integrated design delivery (Deutsch, 2011), but this paper finds that there is still a need for specific solutions to efficiently accomplish design tasks. LOD provides design practice guidance in the information accumulation during different phases and contributes to BIM models (Ibrahim & Hamzeh, 2016). Different LOD levels can contribute to each project stage, enabling an elaborate building process and efficiently assessing building performance (Lattifi et al, 2015). This paper finds LOD 350 features can help the design manager to coordinate design information more efficiently

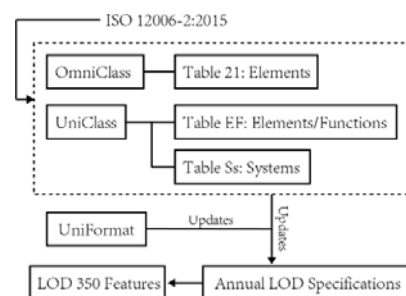


Figure 5 LOD 350 Elements Sources

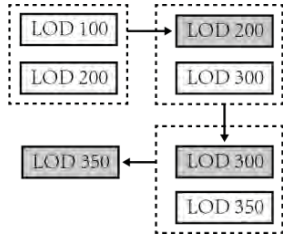


Figure 6 LOD Relations

Each level includes previous LOD information (BIMforum, 2018), and features from previous levels are inherited by the next level (see Figure 6). This paper finds element properties in different LODs are defined differently for the accuracy of elements. Furthermore, according to the research, high levels of LOD enable the design manager to assess design performance, for example, Honic, Kovacic and Rechberger (2019) argued that Material-passport based on BIM contains required information during the design process and improves optimization.

This paper finds that features of LOD 350 allow the design manager to clearly assign design tasks. The increase of collaboration contributes to project design performance (Aguilar, Vonk & Kamp, 2019), and this leads to improvement in the design business operation. Element properties (see Figure 7) consist of Spatial, Compositional, Experimental and Administrative (ISO 12006, 2015). Features of LOD 350 have the potential to impact the design lifecycle; for example, Abou-Ibrahim and Hamzeh (2016) have introduced the concept of LOD matrix in lean design management.

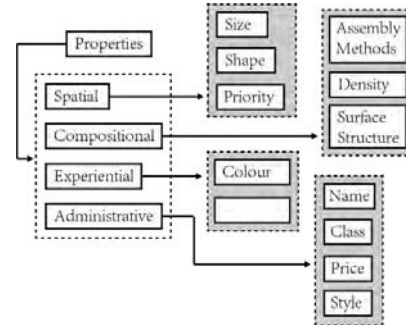


Figure 7 LOD Properties

Information needs to be managed during the project delivery process, and this information has been categorized into Asset Information Management, Project Information Management and Task Information Management (ISO 19650-1, 2018). This paper finds design management must combine features of LOD 350 and information management. Properties contained in LOD 350 fall into two categories: functional and non-functional (ISO 12006-2, 2015). Functional properties need to be managed under Task Information Management while non-functional properties need to be managed by Project Information Management, according to the findings of this paper. The design manager must manage all information relating to the design process in order to improve design efficiency.

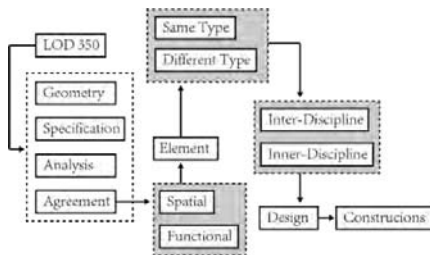


Figure 8 LOD 350 Characteristics

The paper finds interactions between elements consisting of both inner discipline and inter discipline (see Figure 8). Ganiyu, Egbu and Cidik (2018) argued that knowledge management is important during BIM implementation - hence, building design management should organize the existing knowledge in information management. The researchers find that the extent to which 350 level will impact design business operation is unclear and requires further research.

It is concluded that LOD 350 can improve design management in Task Organization, Discipline Collaboration and Information Coordination. LOD 350 features will improve the design practice, according to the findings of this paper, because they enable design managers to better control, assess and evaluate design development. Adopting a high level of detail such as LOD 350 can provide the design team with an efficient solution for organizing design information, avoiding missing data and increasing design qualities through the management of both inner and inter disciplines. This research has found that adopting technologies (eg. BIM) and improving design management will enhance design performance, and improved design performance will make the design business operation more successful.

3.3 Business Operation of Design Practice

Many Chinese design companies have multi disciplines, which include architecture, structure

engineering and system engineering, and they will sub-contract third part specialists to take special designs (eg. glass curtain walls). Expenditure needs to be considered to maintain companies' business operation, for example, the salaries of employees, utilities bills and transportation fees. This paper finds that employee salaries and printing of design documents are the highest cost in the design business operation. Experienced architects and engineers demand high salaries, and high-quality colour printing is expensive. Deutsch (2011) argued that the adoption of advanced management and technologies, and transforming the environment, is not easy. However, there is a realization that BIM will improve information management, for example, Zandieh, Kani and Hessari (2016) argued that an integrated model is important for cooperation between disciplines because the design process is very complex. Kapogiannis (2018) has proved digitalization can improve those operation performances in Small to Medium Enterprises. The quality of model is significant for BIM implementation because this will affect functional purposes in further management (Reddy, 2012) This paper finds that advanced management strategies such as adopting LOD 350 will enhance business performance

Design companies in China are mostly functional organizations. Functional organizations are efficient in management but might cause conflicts between functions (Schaufelberger, 2009). First is the board of director, then the president (normally in charge of technical management). The general manager is responsible for managing internal affairs (eg. salaries, travel expenditures). Each discipline has a lead designer (also known as chief engineer) who is responsible for controlling design qualities. The existence of a design manager is not new, but is important for design coordination nowadays (Eynon, 2013). Porier, Forgues and French (2014) argued that if the Architecture, Engineering and Construction (AEC) industry increased interoperability, the BIM process would progress more efficiently. Schaufelberger (2009) discussed what each management process in an organization should focus on to improve business operation. Eastman et al (2011) argued that BIM will transform the design practice and Deutsch (2011) argued that making an impact on society is important before BIM is widely adopted. This research finds that each administrative position should participate in the design business operation to achieve business success. Eynon (2013) argued that design managers are responsible for the management of risk, human capital and information delivery in design companies. Tunstall (2006) argued that design documents should transfer design ideas in ways that would enable construction. This paper suggests design companies need efficient strategies to help design management, and enable design delivered on schedule and of high quality.

In conclusion, improving management, both in a company's organization and in the design practice will help the design business operation because the business's income is from client payments. Design companies need innovative management strategies to improve their organization management (eg. BIM) and adopt advanced technologies to enhance their design performance (eg. digitalization). Since the design practice requires input involving multiple disciplines, it is important that design managers can coordinate the design practice, manage information flow and delivery, and avoid unnecessary errors. The more efficient the completion of a project, the more resources can be put into other projects, thus leading to greater profits and a successful business operation.

4. Discussion

This research is aiming to improve design information coordination and to improve design business operation. Findings from Design Management, LOD 350 and Design Business Operations indicate that LOD 350 features will impact on the design business. It is found that poor information coordination during process and delivery is caused by a lack of clear strategies. Building designs need a design manager to accurately control the flow of information, establish communication with clients and avoid errors which delay design delivery. This paper finds each LOD 350 features will contribute to the design business, thus, both design and business managers can reference these features to improve management. Building projects are increasingly reliant on information management; Ademci and Gundes (2018) argued that projects in modern society have increased in complexity and hence there is an increased demand for integrated BIM models in project operations. Through research, this paper finds that LOD 350 could enhance design business performance due to the interactive character of its elements.

Table 2 Impacts of Non-Functional LOD 350 Properties to Design Practice

		Design Management		Design Team		Business Management
		Design Manager	Lead Designers	Architects	Engineers	
According to ISO 12006-2:2015(E)	Administrative	Name	Yes	Yes	Yes	Yes
		Style			Yes	
		Class	Yes			
		Price	Yes	Yes		Yes
	Spatial	Shape			Yes	
		Size			Yes	
	Compositional	Weight				Yes
		Density				Yes
		Surface structure			Yes	

Gray and Hughes (2012) found that business operation in design companies is organized into Design Management and Business Management. Design Management comprises a design manager and design team, while each discipline in the design team has a lead designer. The lead designer is responsible for design quality control and the design manager is responsible for information coordination, according to RIBA. The major inputs in the design business are human resources (eg. architects, engineers, specialists) and capital resources (eg. computers, printers, projectors), thus, business managers are responsible for eliminating waste, which compliments Lean Construction (Koskela, 2018, et, al). This research finds that each feature of LOD 350 will impact on each role in the design business (see Table 2). The design business can be divided into design management, design team and business operation. Architects and Engineers are two of the most important roles in the design team, each with different responsibilities. This research finds that there are three categories of LOD 350 features which contribute to design management: Administrative, Spatial and Compositional. Despite this, only two features can be found that impact on the design business operation; further research will be carried out to explore if other features will contribute to business performance.

This research also finds that the functional properties of LOD 350 help design managers to manage design tasks and control design information. Lead designers from each discipline can also benefit from these properties. Project design consists of different stages, and the role of different management positions will focus on different areas (Gray and Hughes, 2012). For example, business managers will focus on the project brief and design delivery in order to promote business. The lead designer focuses on project development and construction documents in order to make the design suitable for construction and operation (Emmitt and Ruikar, 2013). The design manager needs to focus on an entire stage to ensure that information is delivered from stage to stage in order for the design to be complete, on schedule and of good quality (Tunstall, 2006). Those features found in the table can be categorized into qualitative and quantitative characteristics, and this paper finds that quantitative features can be combined with qualitative ones. Thus, the features can be integrated to impact both the design practice and the design business.

It is concluded that, so far, this paper finds features of LOD 350 can help design companies in two aspects: Design Management and Business Management. Improved design management can enhance design performance which can have a positive social impact (eg. environmental, commercial), while improved business operation will raise company profit that can help companies' long-term development (eg. hire more skilled people, purchase more advanced equipment). This research finds that the impact

of LOD 350 on business operation starts in programming and planning because these stages prepare the design project. Features of LOD 350 enable information flow in a coordinated way during schematic design, design development and construction drawings, which solves the research problem of this paper. There are still many other reasons for inefficiency in design coordination, thus, more research will need to be done.

5. Conclusions

This paper has found solutions to solve problems relating to inefficiency in design coordination. According to the findings, features of LOD 350 will help design managers to improve information process and delivery during design practice. Furthermore, it is found that LOD 350 will not only help design managers, but also business managers in design companies to enhance business operation through efficiently managing capital inputs. Inefficient coordination in design practice can be solved by improving information and technology management as this allocates resources (both human resource and capital assets) appropriately, thus leading to improved success in design business operation.

To summarize, features of LOD 350 will enhance building design performance and impact on design business operation. The results have not been validated due to the limits of this research; thus, further research will focus on validating those findings. This paper is a partial study from a PhD topic, so more in-depth research will be conducted in the future. The methods used to validate these results will be case studies, questionnaires and surveys. The contribution to knowledge of this topic is to find solutions to improve design coordination and enhance the performance of design business through combining design management, levels of development and technological innovations.

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