BUILDING INFORMATION MODELLING (BIM) AS A COLLABORATIVE TOOL IN CONSTRUCTION PROJECT DELIVERY (1)

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Abstract

This development paper briefly sets the scene for the examination of the use of Building information modelling (BIM) as a collaborative tool within the construction industry. The focus of the study is on construction projects in South Africa. The study contemplates that South African construction firms may derive very limited benefits from BIM. They are three reasons for this including (i) limited user competency, (ii) limitations on information exchange and (iii) a lack of clarity in project design.

Keywords: IS/IT, BIM, Collaboration, Integration, Construction, Project

1.0 Introduction

1.1 Background

This development paper sets out the background to a proposed study seeking to examine the key elements that underlie the use of BIM in collaborative integration of construction project delivery in South Africa.

Construction projects often involve uncertainties that exist not only because of the temporal nature of their delivery mechanisms (Zwikael, 2009) but also because of the unpredictable nature of both their supply and delivery networks (Behera et al., 2015) and available procurement routes (Tookey et al., 2001). Studies suggest not only considerable discontinuities between these participants in the delivery process of construction (Cheng and Wang, 2012) but also constantly changing relationships manifested in increased use of design-build procurement methods. Irrespective of the discontinuities and constantly changing relationships between construction project stakeholders, though, their relationship is also characterized by reciprocal interdependencies (Bryde et al., 2013). In addition, relationships between project stakeholders are widely known for their adversarialism (Odeh and Battaineh, 2002). More specifically, contracts are often drafted with the intention of fully transferring as much risk as possible to other project stakeholders (Cain, 2003). This leads to segregation and fragmentation of not only design and planning, but also construction and operations activities (Dubois and Gadde, 2002). These characteristics make the industry among the most complex in existence (Bryde et al., 2013). It also makes the industry prone to performance failure.

Concerns about construction industry performance also extend to South Africa (Aigbavboa and Thwala, 2014; Ojiako et al., 2014). Reports by the South African Industry Development Board (CIDB, 2014) (a statutory body created by the South African government in 2000 to drive industry-wide integrated development strategy) report defects in construction output alongside a continuing decrease in construction client satisfaction.

2.0 Information and collaboration in construction

Information Technology and Information Systems (IS/IT) creates new opportunities and competitive advantages for organizations (Ismail and Yee-Yen, 2015). Similar advantages have been identified for IS/IT in terms of the construction industry (Rivard, 2000). There are many forms of IS/IT being utilized within construction; these include Electronic Document Management (EDM), Electronic Data Interchange (EDI), and Building Information Modelling (BIM). A comprehensive review of their use within construction has been provided by Samuelson and Björk (2013, 2014).

As the literature (Froese, 2010; Samuelson and Björk, 2013, 2014), suggests, the application of IS/IT to construction has predominantly been in either of three ways of which the most recent has focussed on exploitation of the integration capabilities of IS/IT systems. One such IS/IT system that provides such integration capabilities is Building Information Modelling (BIM), currently regarded as one of the most popular IS/IT systems for simulation, visualization, design analysis and the project management of construction projects (Bryde et al., 2013; Lee et al., 2007). Building Information Modelling (BIM) has been defined by Succar (2009:357) as “a set of interacting policies, processes and technologies generating a methodology to manage the essential building design and project data in digital format throughout the building's life-cycle". Due to specific negating characteristics of construction projects (discussed earlier), BIM facilitates effective communication within construction projects by requiring CPOs and project stakeholders to consider and communicate multi-disciplinary concerns, constraints, goals and perspectives, most importantly according to Lee et al. (2007: xix), "…in a 'timely, economical, accurate, effective and transparent way". More specifically, the use of BIM allows for traditional paper-based management of construction projects to be reconfigured into a virtual environment, thus facilitating a level of project management efficiency that is vastly superior (Lee, 2008).

The reality, however, is that with the vast amount of research available (see Bryde et al., 2013; Cao et al., 2015; Eicker and Weeks, 2014; Li et al., 2014), BIM is quickly gaining acceptance within the project management community – particularly as relates to its role in enhancing collaboration within projects. Noteworthy, however, is that while the role of BIM in modelling of collaborative project delivery is generally accepted within the industry, there remains a degree of scepticism towards this in countries such as South Africa. A study undertaken by Smallwood et al. (2012) found that construction practitioners in South Africa were generally sceptical about the collaborative potential of BIM.

3.0 Research method

3.1 Research approach

The study will involve case-study research (Barratt et al., 2011), undertaken in five stages drawn from earlier studies (Stuart et al., 2002). The first stage will involve explaining the specific nature of the phenomenon being examined; in this research context, the role of IS/IT (in the form of BIM) as a tool for collaborative integration in project delivery within the South African construction industry. The second stage will involve presenting a research question *What are the key elements that underlie the use of BIM in collaborative integration of construction project delivery in South Africa*? This question will be structured around "…*what are the key issues*?" (Handfield and Melnyk, 1998:324; Stuart et al., 2002:422). While the third stage of the study will involve drawing on lessons gleaned from a case study involving a project commissioned by the South African Department of Public Works, the fourth stage of the study places one of the authors within the case project via the Construction Project Office (CPO), thus allowing for participant observation. The final stage of the study will involve exploration/codification of a BIM model consisting of a dataset of 66GB, comprising 44,000 items. We show the basis research approach in Figure 1, below.

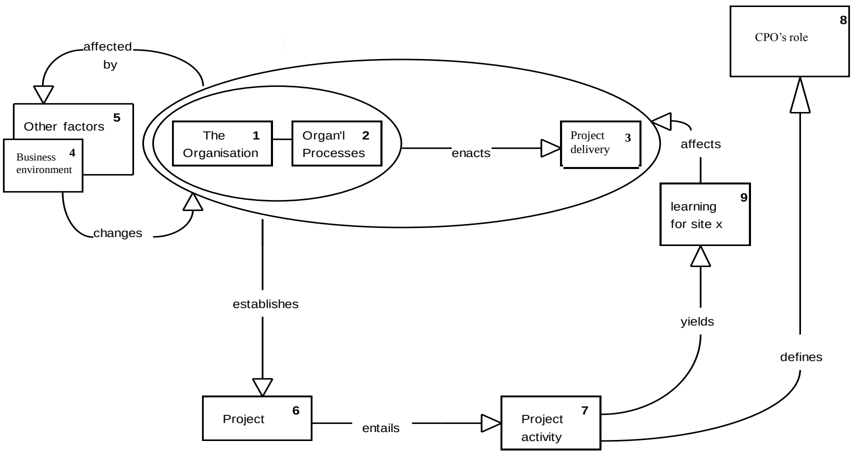

Figure 1. **Research approach.**

3.2 Data analysis

The data analysis will be undertaken in two stages. The first involving examining the BIM model. The second stage of the analysis of data focusses on examining communications between the CPO, project stakeholders and the project team. Figure 2, below shows the outline email density between the project delivery team, with darker colours representing higher densities.

From	To	AR1	SE1	MC	CL1	ME	CE	QS	QS2	SE2	ME2	AR2	CL2
SE1		45		7	2	5	6	15	5	1	0	32	0
MC		87	12		60	16	52	88	18	20	1	247	0
CL1		13	0	7		0	12	15	1	0	1	48	0
ME		6	0	0	0		0	0	1	0	0	15	0
CE		9	2	13	4	0		10	0	0	0	29	0
QS1		20	1	0	3	0	13		1	1	0	75	0
QS2		15	0	6	0	1	1	8		3	0	73	0
SE2		4	0	11	0	0	1	3	1		0	36	0
ME2		0	0	0	1	1	0	2	0	0		3	0
AR1			19	16	37	24	58	72	23	13	1	148	0
AR2		7	0	1	1	0	0	4	0	0	0		0
CL2		18	0	0	0	0	0	0	0	0	0	0	
Key: Architectural Practice (AR); Structural engineer (SE); Main contractor (MC/CPO); Client (CL); Mechanical/electrical engineer (ME); Quantity surveyor (QS); Civil engineer (CE)													

Figure 2. **Communication density.**

4.0 Discussion

Table 1, in highlighting likely discrepancies between model capabilities and actual uses, suggests that developing and altering the BIM for effective collaborative use may itself be best seen as a collaborative endeavour whose challenge should not be underestimated.

Function	Hypothetical model	Actual model
Production of drawings	All drawings are generated from a single model.	Model is used for drawing production, but only the architect's drawings are being generated. Structural input will be undertaken done by importing the structural engineer's CAD drawings and overlaying these in the model.
		Details requested in Request for Information (RFIs) are often hand-drawn sketches and are not generated from the model.
		Project drawings are created in isolated environments, where each consultant generates their own drawings, using different software.
		Sub-contractor drawings are prepared independently. There is no coordination between the drawing sets and the records.
Visualization	Model is used for accurate visualzsation of the finished project, with photorealistic material parameters so that surfaces are rendered accurately.	Modeling is sufficiently undertaken to generate low detail visualizations of the completed project.
		Material mapping is used for component surfaces, but these do not always accurately represent the actual materials.
Schedules	All scheduling is generated by the model.	The model is used to generate door and curtain wall component schedules. Other components are scheduled independently using Excel or Word.
Document control	Full control of documents and revisions recorded in the BIM model.	Document control and recording of revisions are done manually outside the model.
Fields for repeat information	Fields are used to eliminate repeating project information.	Repeating fields are added manually as text fields to the model.
Collaboration with consultants .	All consultants have access to the model and can	Model are operated in an isolated environment,

	incorporate their design information directly.	where information is extracted from the model and sent electronically to consultants, who maintains a separate set of documents
Level of development (LoD)	The model has reached a LoD of 400, with components containing sufficient information for accurate analysis of energy consumption, efficiency and sustainability.	Model components are typically at LoD 200, with elementary information contained within components. The components do not generally contain sufficient detail for any analysis purposes.
4D analysis	Sufficient detail from all project participants is included in the model, with components that represent real world objects. The model may be used to show animated, time related construction scheduling. Clash detection and buildability can be confirmed before the construction of the building starts.	The model do not contain sufficient detail or accuracy for clash detection or scheduling.
5D analysis	The level of development of the model includes components that have accurate supplier cost information. The model can be used to generate quantities of materials with associated costs. The model is potentially used to generate the specification document.	The model is not being used to generate quantities and has insufficient detail or accuracy to do so.

Table 1. Comparison of hypothetical and actual models.

Evidence from the first part of the study is likely to suggests that the model is being greatly underutilised. Further collaborative effort in updating and then communicating alterations within the model will be necessary if the model is to progress beyond offering low level visualisations, towards 4D and 5D levels of analysis. Such collaborative effort may well produce a benign cycle whereby project stakeholders, increasingly impressed by the model's capabilities, come to have growing confidence in it and then perceive further collaborative effort to continually update and communicate worthwhile. Importantly, collaborative effort to update and improve the model to facilitate more sophisticated uses may help instil more collaborative cultures which then permit projects to benefit not just from BIM, but from improved collaboration more generally (e.g. through less adversarial and more consensual approaches to risk transfer).

Considered within these contexts of best practice, emerging statutory requirement, and market competition, the primary BIM governance issue likely to be identified within the present study relates to the situation of the architects within project actor networks. Their network centrality in terms of connectivity to other actors (albeit one of low positional power) entails that architects are best placed to play a central BIM coordinating role – in particular, by ensuring that alterations to drawings based on the model, feed back into the model as matters of urgency so that all project stakeholders become aware of alterations as soon as they are known. This being so, it would become appropriate for governance scrutiny to focus on whether their disproportionate input into BIM might disadvantage more peripheral actors (for example where architects produce and then defend poor designs by withholding acknowledgement that these might create unnecessary risks/costs or operational problems for others).

4.0 Conclusions

This development paper briefly sets the scene for work set to examine the use of Building information modelling (BIM) as a collaborative tool within the construction industry. It is anticipated that the study will find that the limited uptake of BIM within the South African construction industry could be related to three factors: (i) perceived user competency/ability with IS/IT and willingness to exploit parametric functions provided by BIM; (ii) power networks as relate to information exchange, and (iii) clarity in project design. From the perspective of technology adoption, this study will likely posit that the potential utilization of IS/IT as a tool for collaborative integration in project delivery within the South African construction industry is contingent upon a number of factors such as the independence of project delivery teams, IS/IT flexibility which is necessary for interoperability, seen as "…the backbone of collaboration" (Grilo and Jardim-Goncalves, 2010:528) and the fragmented nature of construction. The study concludes by suggesting the need for more institutional efforts by the South African construction industry in terms of making the benefits of BIM more widely More specifically, such awareness initiatives are likely to ensure that an industry-wide consensus on the potential benefits of BIM are reached.

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