



Collaboration in BIM-based construction networks: A bibliometric-qualitative literature review

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Abstract

BIM-based Construction Networks (BbCNs) are teams comprising members from several specialist organisations to undertake BIM-related tasks on BIM-enabled projects. Fostering collaboration within BbCNs is a top priority for construction project managers, yet no explicit body of knowledge has focused on investigating the relevant research gaps in knowledge. The present study intends to address this gap by plotting the storyline of relevant research studies in the last 10 years (2006–2016). A “*Collaboration Pentagon*” consisted of context, process, task, team and actor as the theoretical lens is created through integration of relevant frameworks. The study draws upon a bibliometric analysis of 1031 studies on BIM alongside the outcome of a qualitative evaluation of a total of 62 carefully selected papers on collaboration in BbCNs. The findings reveal that the scholarship on collaboration on BIM-enabled projects has predominately focused on technology as one antecedent of collaboration while project-related and managerial antecedents have remained under-researched. Moreover, though enhancing collaboration necessitates inclusion of all influential antecedents, studies with such an all-inclusive perspective are rare. The study contributes to the field through this inclusive *Collaboration Pentagon* and by providing a systematic and objective evaluation of available literature on collaboration in BbCNs and uncovering respective gaps.

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1. Introduction

As one of the most influential innovations in construction industry, BIM is capable of supporting project management in procurement, construction, pre-fabrication and facility management areas (Bryde et al., 2013). Eastman et al. (2008) defined BIM as an integrative technology with “parametric intelligence” that alters the digital building representation process throughout

the lifecycle. BIM is a “multifunctional set of instrumentalities for specific purposes that will increasingly be integrated” (Miettinen and Paavola, 2014). Thus, BIM could be defined as a methodology with technological, agential and managerial components. BIM-enabled projects are typically handled by BIM-based Construction Networks (BbCNs) comprising members from specialist organisations, contracted to execute BIM-related works (Grilo et al., 2013). The ability to enhance collaboration within these BbCNs has been a selling point for BIM (Cao et al., 2017). However, maintaining collaboration among geographically separated members coming from multiple disciplines and organisations in BbCNs has proved problematic (Volk et al., 2014; Liu et al., 2016) and thus worthy of further investigation.

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There exists a growing interest in exploring the factors affecting collaboration in BbCNs (Shafiq et al., 2013), yet anecdotal evidence still refers to knowledge gaps in the Body of Knowledge (BOK) on collaboration in BbCNs (Mignone et al., 2016; Alreshidi et al., 2016; Liu et al., 2016). To this end, no explicit BOK has systematically assessed the specific literature on collaboration in BbCNs, but have focused on the extended BIM BOK instead, e.g. (Zhao, 2017; Santos et al., 2017). This is a major barrier to identifying directions for research on any topic, which might end up either in overlooking central aspects or duplication of efforts (Yalcinkaya and Singh, 2015). From a Project Management BOK (PMI, 2013) perspective, this study unravels the contribution of BIM scholarship in the areas of integration management, communication management and stakeholder management.

With this in mind, conducting systematic review studies to spot gaps and discover core research requirements becomes highly relevant (He et al., 2017). This study aims to analyse the scholarship on collaboration on BbCNs. As such, the study maps and analyses the state of existing publications on collaboration on BbCNs. The resulting accumulated knowledge will uncover patterns and relationships between concepts that have remained hidden within the literature on the topic. Additionally, the findings will produce evidence to inform, guide and improve future research on the topic. The paper is structured as follows. First, the background and relevant research on collaboration on BbCNs is presented. Next, the relevant research methods to address the research aim are defined. The findings of the study are presented and discussed against relevant literature in the subsequent two sections. Finally, the ensuing section concludes the study by summarising key points and outlining implications for scholarship and practice.

2. Collaboration on construction projects

According to the seminal study by Wood and Gray (1991), “collaboration occurs when a group of autonomous stakeholders of a problem domain engage in an interactive process, using shared rules, norms, and structures, to act or decide on issues related to that domain”. Thomson et al. (2009) expounded on the foregoing definition and stated that collaboration requires negotiations among the parties involved to jointly create rules and structures for mutually beneficial relationships. Collaboration is not defined in the same way across disciplines (Thomson et al., 2009; Bedwell et al., 2012). For management-related fields, collaboration is seen as a relationship structure that follows effective management (Bedwell et al., 2012). This also holds true for the construction management field, as discussed below.

Collaboration, which is tightly attached with effective management, is deemed a central element of success throughout the lifecycle of construction projects (van Gassel et al., 2014; Suprpto et al., 2015). Collaboration on construction projects is closely linked with communications and seamless information exchange among stakeholders (Pryke, 2004; Hughes et al., 2012; Xue et al., 2010; Walker et al., 2017). With the advent of web-based applications and propagation of information technology (IT) into construction activities (Hosseini and Chileshe, 2013), the nature of

collaboration has undergone a radical change in recent years (Lee and Yu, 2012; Grilo and Jardim-Goncalves, 2013). In essence, computer-based collaboration has become the norm for contemporary construction projects where team members are scattered across several locations (Niknam and Karshenas, 2015; Solihin et al., 2016) but use shared databases (Lee and Yu, 2012; Hu et al., 2016; Alreshidi et al., 2016). With the rise of BIM as the state-of-the-art technology to foster collaboration (Chen and Hou, 2014; Singh et al., 2011; Solihin et al., 2016), BbCNs have become the centrepiece of collaboration on construction projects (Grilo et al., 2013; Mignone et al., 2016; Liu et al., 2016) as discussed next.

2.1. BIM-based Construction Networks (BbCNs)

Members of BbCNs typically come from different disciplines, each one with a particular set of skills to enable BbCNs of fulfilling project requirements (Grilo et al., 2013). Yet, goal attainment and success in BbCNs relies upon members working collaboratively and project data being seamlessly shared across all involved organisations (Love et al., 2011; Bassanino et al., 2013; Merschbrock, 2012; Kuiper and Holzer, 2013; Hosseini et al., 2016). As stated by Ashcraft (2008), a BIM-enabled project without collaboration means nothing but “scratching the surface”. This has highlighted the crucial role of access to interoperable tools and packages for BbCNs (Grilo and Jardim-Goncalves, 2010; Hu et al., 2016). Many scholars have highlighted the necessity of framing the project environment and shifting common practices to foster collaboration among BbCNs members (Merschbrock, 2012; Poirier et al., 2016; Grilo and Jardim-Goncalves, 2010; Alreshidi et al., 2016). Nevertheless, collaboration on construction projects and BbCNs is a multifaceted complex phenomenon manipulated by a variety of factors (Poirier et al., 2016; Alreshidi et al., 2016). This necessitates looking into the problem by including all antecedents of collaboration (Merschbrock, 2012; Poirier et al., 2016; Alreshidi et al., 2016).

2.2. Theoretical lens

Research into collaboration has been an active field across a wide range of disciplines and industries over the past decades, which has mobilised agential and societal perspectives (Giddens, 1984; Porpora, 2013). The major factors acting as antecedents of collaboration in different industries have been asserted in the seminal study by Wood and Gray (1991). As such, several investigators have attempted to define generic antecedents for collaboration to be used across different industries and sectors. As an example, Alreshidi et al. (2016) argued that collaboration antecedents fall within two broad categories: technical and socio-organisational factors. Bedwell et al. (2012) discussed that collaboration antecedents are associated with task attributes, environment, temporal features, structural attributes and entity characteristics with different weights in influencing collaboration, depending on the settings under investigation. Moreover, according to the Co-Spaces Collaborative Working Model (CCWM) by Patel et al. (2012), collaboration antecedents are categorised into context, tasks, support, interaction processes, individuals, teams

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