Automation in Construction 69 (2016) 34–43

Contents lists available at ScienceDirect

Automation in Construction

journal homepage: www.elsevier.com/locate/autcon

How to tell if a BIM project is successful: A goal-driven approach

Jongsung Won [a,1], Ghang Lee [b,*]

[a] Department of Civil and Environmental Engineering, The Hong Kong University of Science and Technology, Hong Kong, China
[b] Department of Architectural Engineering, Yonsei University, Seoul 120-749, Republic of Korea

ARTICLE INFO

Article history:
Received 5 July 2015
Received in revised form 21 February 2016
Accepted 22 May 2016
Available online 5 June 2016

Keywords:
Building information modeling (BIM)
Success level assessment model for BIM projects (SLAM BIM)
BIM goal
BIM use
Key performance indicator (KPI)

ABSTRACT

This study investigates the applicability of a success level assessment model for building information modeling (BIM) projects (SLAM BIM). SLAM BIM is a goal-driven method for the sustainable evaluation of a BIM project's success. It was developed on the premise that a project's success cannot be evaluated without first identifying its goals; thus, key performance indicators (KPIs) can vary according to project goal. SLAM BIM consists of five steps for defining BIM goals, uses, KPIs, unit measurements, and data collection forms and processes. To identify appropriate BIM KPIs, the collectability, measurability, and comparability of the candidate BIM KPIs were considered. Data related to schedule, design errors, change orders, response time, and ROI were collected and analyzed in the two projects by using the SLAM BIM process. The validity of SLAM BIM was tested by applying SLAM BIM from the beginning to the end of two construction projects.

1. Introduction

Building information modeling (BIM) implementation is spreading rapidly worldwide and becoming a conventional design and construction practice in many advanced countries [1]. With the increasing acceptance of BIM to improve traditional drawing-based practices, the industry interest has shifted from how to adopt BIM to how to successfully implement BIM in projects.

Previous studies for evaluating BIM projects can be categorized into two parts: (1) methodologies for evaluating the technological or organizational maturity of a BIM project team and (2) case studies evaluating the benefits of BIM projects. Examples of the first category are bimSCORE [2], the BIM Proficiency Matrix [3], BIM Interactive Capability Maturity Model (I-CMM) [4], BIM Maturity Measure (BIMmm) [5,6], BIM QuickScan [7], BIm^3 [8], and macro-BIM adoption assessment model [9]. These studies evaluated the maturity levels of BIM projects without carefully considering whether or not the projects were successful. Although a BIM project with a higher maturity level has a higher likelihood of being accomplished successfully, these methods do not evaluate BIM project success directly. In addition, since these methods are based on lengthy surveys and interviews with project participants after project completion, it is difficult to collect information that accurately reflects all the stages of a project.

The second category measured the BIM benefits of projects through case studies, which contain comparative analyses of BIM vs. non-BIM projects by Giel et al. [10] and Barlish et al. [11] and return-on-investment (ROI) analyses by Autodesk [12], Sacks et al. [13,14], Lee et al. [15], and others [16–18]; however, these studies did not provide appropriate metrics to measure the success or maturity levels of the BIM projects under review. For example, the number of requests for information (RFIs), which is commonly used to measure quantitative BIM effects, cannot be applied in certain cultures, such as South Korea, where it is atypical to formally track RFIs except in special cases.

This study investigates the applicability of a method for evaluating the success of BIM projects called the Success Level Assessment Model for BIM Projects (SLAM BIM). SLAM BIM provides tools to evaluate if a BIM project is successful and to sustainably measure the success of a BIM project. The sustainability of SLAM BIM in this paper means the continuous measurement of the success of multiple BIM projects using the same set of evaluation criteria as well as a collection of evaluation criteria with minimal additional work needed by project participants [19]. To measure the success of a project, the goals should be defined first because the goals are not fixed but vary according to the project characteristics [20,21]. Although existing business management techniques, such as management by objectives (MBO) [20] and the balanced scorecard (BSC) [21], are goal-driven approaches to project success measurement, they do not consider BIM as a factor when determining and measuring key performance indicators (KPIs). SLAM BIM, which is a goal-driven method, was applied to two projects in South Korea to verify its applicability and identify issues related to the measurement of the success of BIM projects.

* Corresponding author.
E-mail addresses: jongsungwon@ust.hk (J. Won), glee@yonsei.ac.kr (G. Lee).
[1] Formerly, Department of Architectural Engineering, Yonsei University, Seoul 120-749, Republic of Korea.

http://dx.doi.org/10.1016/j.autcon.2016.05.022
0926-5805/

In the second section of this paper, we briefly review previous studies on the performance measurement of BIM projects. Then, in the third and fourth sections, we introduce the SLAM BIM process and describe how it can be used and exemplified by two case studies. In the fifth section, we explain the results of the two case studies. Finally, we discuss the lessons learned from this study and present directions for overcoming the noted problems.

2. Literature review

Previous studies evaluating BIM projects can be summarized into two categories: (1) models or methods that evaluate the technological and/or organizational maturity of BIM project teams and quantitatively measure the benefits of BIM projects, and (2) case studies that demonstrate how certain benefits from BIM projects can be measured.

Examples of the evaluation methods, which are referred as a BIM capability evaluation model, a BIM capability maturity model, a BIM maturity model, and a BIM performance evaluation model, include bimSCORE [2], BPM [3], and BIM I-CMM [4] in the U.S., BIM QuickScan [7] and BIM Successvoorspellers [22] in the Netherlands, BIMmm [5,6] in the UK, and the BIm^3 and macro-BIM adoption assessment model [9] in Australia. These methods help participants improve performance by evaluating the maturity and strength of BIM business practices [23,24]. The methods have different goals, evaluation methods, structures, strengths, and weaknesses [7,25–27].

bimSCORE [2] and the virtual design and construction (VDC) scorecard [28] were developed based on BSC to evaluate the success and maturity of a BIM project based on its planning, adoption, technology, and performance. VDC Scorecard comprises two models based on the number of measures and depth of measurements, which are VDC Scorecard Express (22 measures) and VDC Scorecard Full (56 measures). bimSCORE is a commercial version of VDC scorecards developed by Stanford University. bimSCORE provides a service to compare the evaluation results with the results of similar BIM projects, and it proposes improvements using data from the database.

BPM [3] reviews the eight categories for BIM maturity assessment after completing each BIM project as follows: the physical accuracy of a model, integrated project delivery methodology, calculation mentality, location awareness, content creation, construction data, as-built modeling, and facility management (FM) data richness. The maximum BIM maturity score is 32 points. Certification levels regarding BIM maturity are classified into five groups according to the BIM maturity score: working toward BIM (0–12 points), certified (13–18), silver (19–24), gold (25–28), and platinum (29–32).

To assess the maturity level of BIM, BIM I-CMM [29] was developed by the Faculty Information Council (FIC) at the National Institute of Building Science (NIBS) in the U.S. in 2007 [29]. This model, which is based on a concept of the Capability Maturity Model (CMM) in software engineering, analyzes data richness, lifecycle views, roles or disciplines, business processes, delivery methods, timeliness/response, change management, graphical information, spatial capability, information accuracy, and interoperability/IFC support. The certification levels of BIM capability maturity within an organization are classified into six groups: not certified (0–39.9 points), minimum BIM (40–49.9), certified (50–69.9), silver (70–79.9), gold (80–89.9), and platinum (90–100).

Arup [5,6], which is one of the largest construction engineering companies in the world, proposes BIMmm to evaluate structural, mechanical, electrical, and public health aspects of BIM. The four aspects are composed of 21 secondary disciplines, such as lighting, fire, and façade. It additionally provides instruction on how to use collected data to identify gaps in strategies in the current status of a BIM project and make future investment decisions within an organization, including research, training, and software. Furthermore, the results can be used to benchmark the BIM performance of a project against that of others.

BIM QuickScan [30] evaluates the BIM competence of an organization and the scope of BIM implementation in other organizations. BIM QuickScan contains four evaluation categories and 10 perspectives to assess BIM performance: organization and management, mentality and culture, information structure and flow, and tools and application. The ten perspectives are tools, strategy, organization, resources, partners, mentality, culture, education, information flow, and open standards. BIM QuickScan provides measured scores of an organization or a project as well as the highest score of other organizations or projects in terms of each category on the website.

BIm^3, proposed by Succar et al. [31], evaluates five perspectives of BIM projects, such as the BIM capability stage, BIM maturity level, BIM competencies, organizational scale, and granularity levels. It is a triaxial knowledge model comprising BIM fields, BIM stages, and BIM lenses. The user then evaluates the BIM maturity level of a project or an organization and compares it with the maturity level at the targeted capability stage. Each evaluation criterion is evaluated at five levels, 'A' through 'E,' according to subjective judgments of an evaluator working without objective evaluation criteria. These methods evaluate BIM maturity levels effectively; however, they do not address the success of BIM projects quantitatively. Based on BIm^3, Succar et al. [9] improved the methodology for macro-BIM adoption assessment and planning by introducing five new adoption models, matrices, and charts. The five models introduced are composed of (1) nine areas for targeted BIM diffusion assessment and planning, (2) eight macro-components and milestones for assessing and comparing the BIM maturity of countries, (3) three macro-dynamics that clarify how diffusion unfolds within a market, (4) three approaches and nine actions for assessing, comparing, and planning adoption policies across markets, and (5) nine groups of macro-diffusion responsibilities or roles.

Although a BIM project with higher maturity may yield more benefits, these methods do not directly address how successful or beneficial a BIM project is. In addition, they rely heavily on lengthy surveys and interviews with project participants after a project, which may greatly reduce their sustainability. In particular, bimSCORE and BIM QuickScan include more than 50 evaluation factors. To improve evaluation methods, data that can be collected naturally during work processes should be used for evaluation. Furthermore, the methods do not explain the relationship between the purposes of BIM implementation and the performance of a project, since they utilize consistent evaluation factors regardless of the characteristics or BIM goals of the project.

The performance of BIM projects was measured using a VDC Scorecard and BIM QuickScan, but was not measured by the other three models. However, measuring project performance is important because the purpose of adopting BIM is to improve project performance. Setting appropriate BIM goals through considering project characteristics is the first step toward developing BIM execution planning and important for carrying out BIM projects successfully [19,32,33]. Required BIM capability or expected BIM performance can vary depending on the established BIM goals [19,34]. However, most BIM evaluation models evaluate BIM implementation levels without considering BIM goals. Although a VDC scorecard only contains the objectives of BIM implementation as an evaluation factor, it does not provide different sets of criteria and methods that vary according to BIM goals.

Another stream of related studies is generally referred to as BIM ROI studies, most of which were conducted as case studies. Table 1 lists the major BIM ROI studies. Some studies have attempted to measure BIM

Table 1
Previous studies on BIM ROI analysis.

Study	Analyzed BIM ROI
Giel et al. [10,37]	16%–1654%
Gilligan and Kunz [36]	140%–39,900%
Holder Construction [38]	300%–500%
Lee et al. [15]	22%–97%
Azhar et al. [35]	229%–32,900%
PCL Construction [38]	500% ROI
Sen [39]	735% ROI