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PREVALENCE AND VALUE OF BUILDING INFORMATION MODELING USES IN CONSTRUCTION

ROBERT M. LEICHT, MIAOMIAO NIU, and JOHN I. MESSNER

Architectural Engineering, Pennsylvania State University, University Park, USA

Despite the growth in interest and rapid technological development of Building Information Modeling tools and processes, the adoption of modeling uses to advance construction tasks in the field have been slow in adoption. A list of 30 modeling uses for construction are presented, based upon previous research that develops a taxonomy of modeling uses for construction specific tasks. This research presents survey responses from over 250 industry practitioners regarding the status of industry adoption, perceived value, and level of difficulty to implement for a list of 30 modeling uses specific to construction. Findings highlight the differing perspectives by industry sector and role. In addition to the providing insights into the status of adoption, the paper will introduce the concept of methods as a key differentiator of construction modeling uses that influence their adoption and value in support of construction tasks.

Keywords: BIM use, Survey, Adoption status.

1 INTRODUCTION

The adoption of Building Information Modeling (BIM) has advanced rapidly over the past decade, with Jones (2013) noting the adoption more than tripling in a self-reporting of software use by US design and construction firms. BIM is considered to offer significant potential value for improving information flow and potentially transforming the design and construction process (Fox and Hietanen 2007). Despite the noted potential and the increase in use of software, there is little evidence to suggest the level of adoption and noted value for the array of BIM uses. The goal of this research is to capture the perception of value and difficulty for a subset of BIM uses that are specific to construction, as well as capture the relative adoption of modeling uses from a broad cross-section of professionals.

2 BACKGROUND

Vast potential exists within the use of modeling software for improving the design and construction of facilities. Various terms have been used to address the topic, including virtual design and construction (VDC), 3D computer aided design (CAD), and more recently building information modeling (BIM). While the benefits of using BIM and related tools, there remain challenges in the adoption, and particularly in the handoff between different stakeholders in the project team as well as different phases of construction. The most advanced uses rely upon integration across the supply chain and are the least commonly leveraged opportunities.

Focusing on the opportunity to use BIM geometry and information to support construction, this research builds upon the model uses defined and validated by Jiang *et al* (2016). The developed taxonomy builds upon the five fundamental uses of BIM, as defined by Kreider and Messner (2013): Gather, Generate, Analyze, Communicate, and Realize. A BIM Use is defined as:

> *"A method of applying Building Information Modeling during a facility's lifecycle to achieve one or more specific objectives."*

Given the challenge of handing of models or model information between stakeholders and project phases, this research seeks to both validate the identified model uses in the taxonomy through a broad survey of industry members, with emphasis on those who actively use models. In addition, the relative adoption in terms of use frequency and perceived value and difficulty to employ each model use are also captured to inform the challenges associated with pursuing specific model uses and strategies.

3 RESEARCH APPROACH

To address the goal, regarding the perceptions of value and difficulty, as well as adoption of the array of identified modeling uses, a questionnaire was distributed to a broad list of industry professionals. Once the survey was developed and piloted with the industry advisory board for the project, it was disseminated through several channels to get a wide, but appropriate, audience.

3.1 Questionnaire Design

Using the same questions as originally developed by (Kreider and Messner 2013), the authors developed a concise set of questions to allow respondents to rate three characteristics for each of the listed construction modeling uses using a Likert scale. For each modeling use listed, a definition was made available to the users when they scrolled over the model use term with the computer cursor. In addition to the Likert scale rating questions, several open-ended questions were spread throughout to try to capture potential diversity in the methods which are in place to implement some of the model uses, as well as to attempt to identify any model uses that might not have been captured in the list included in the survey.

3.1.1 Model use 'Status'

The 'status' of the model uses, referring to their adoption within industry, were rated on one of four options: common, rare, near future, and far future. Common and rare suggest the model use is currently available to the industry, and used either frequently or on occasion based on the project context and needs. Near future and far future imply that the model use is not currently, readily available, but that it is expected to be possible. Near future suggests that the model use could be, relatively easily put into practice either through minor software developments or manual workarounds to support the needed information flow or analysis. Far future implies that the model use is not easily implementable, but could be at some point in the future.

3.1.2 Model use 'Value'

The second set of questions for each model use was to rate the perceived value, low, medium or high. These offer insights into the perceptions from the roles and viewpoints of the respondents regarding the potential level of benefit perceived from different points of view.

3.1.3 Model use 'Difficulty'

The third rating then was the perceived difficulty, easy, moderate, or hard to implement. This rating helps inform the research, from the respondent's perspective, regarding the perception of how easy or how challenging a particular model use will be to implement, as well as how much work might be required to the particular benefits or value associated with each given use.

3.2 Survey Distribution

First, the survey was distributed to using an internal list at Penn State to industry contacts familiar and interested in modeling research. This list of approximately 12,000 members was initially emailed in at the initiation of the survey. A reminder email was distributed as the data analysis neared closing, approximately four months later. The second path of dissemination was to ask the advisory board membership to distribute it to their firms and their contacts who would be willing and able to respond. The final source of survey respondents was through Construction Industry Institute (CII) Board of Advisors that suggested survey distribution contacts. A list of approximately a dozen CII firms provided interest and lead contacts to disseminate the survey internally at their firms. 532 respondents took the survey, though only 231 completed the full survey. This suggests a response rate of approximately 4%, based upon the known number of respondents that received the survey.

4 RESULTS

The survey garnered a diverse set of responses. The results will begin with the demographics of the respondents, and then focus on the evaluation of the BIM Uses for Construction.

4.1 Respondent Demographics

As shown in Figure 1, the primary respondents were from construction, but architects, engineers, owners, and consultants were all represented. In addition, Figure 2 shows the breakdown by sector with the largest coming from the Commercial Buildings segment.

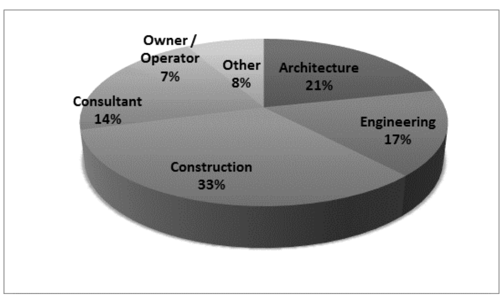

Figure 1. Pie chart showing a breakdown of respondents by discipline.

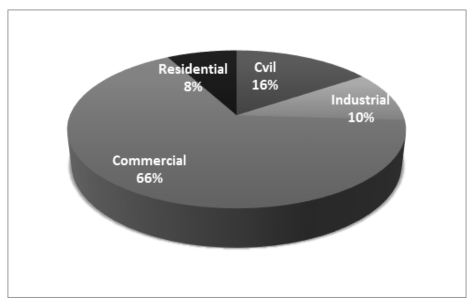

Figure 2. Pie chart showing a breakdown of respondent's industry sector.

Along with having a breadth of roles and sectors, the demographics of the respondents based upon years of industry experience were quite well distributed, as shown in Figure 3.

The most common role of the respondents, regardless of firm or sector, was a CAD or Model Manager, making up 58% of the completed surveys. In addition, Project Managers made up the next largest segment with 33% of the respondent pool.

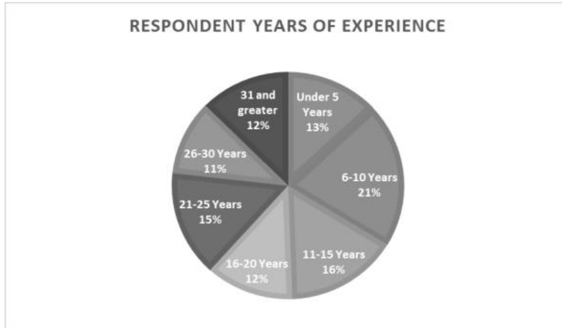

Figure 3. Pie chart showing the distribution of respondent's years of industry experience.

4.2 Adoption Status and Perceived Value

The adoption of the list of model uses were ranked from zero listed as 'Far Future' and indicating that this is not a model use expected to be used until further technological development or processes enabled its use, to three suggesting the model use is commonly applied in projects. The list of uses, as shown in Figure 4, are ordered from the most common at the left, to the least common on the right side of the figure.

The value of the list of model uses were ranked from one, listed as Low Value and indicating that this is not a model use expected to be worth actively pursuing, to three suggesting the model use is of high value for construction. The list of uses, shown in Figure 4, are ordered based on the adoption status, with the perceived value aligning for some uses, but notably different for others.

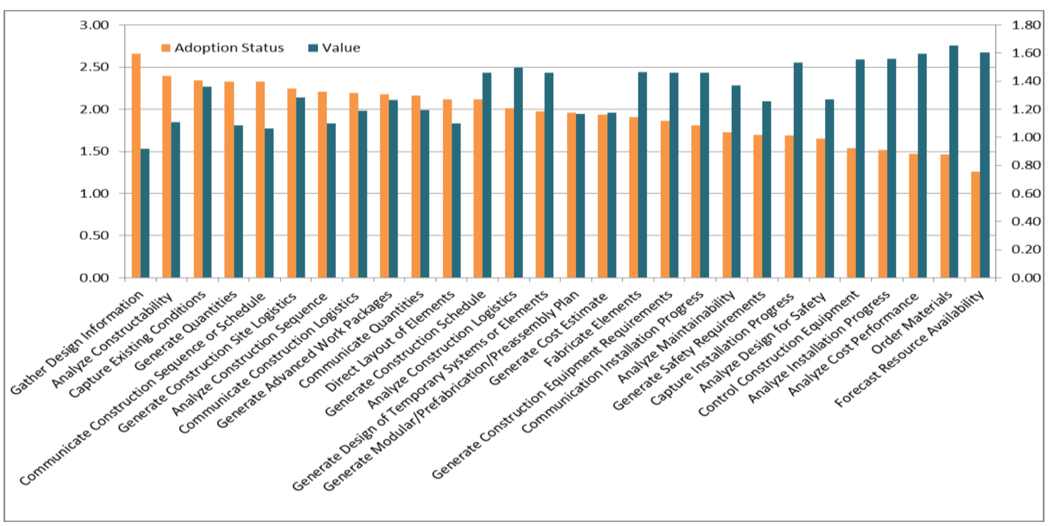

Figure 4. Bar chart of the Adoption Status and the perceived value of the model uses.

4.3 Perceived Difficulty

The difficulty for implementing the list of model uses were ranked from zero, indicating 'Difficult' up to two, suggesting the model use is easily applied on projects. The list of uses, as shown in Figure 5, are ordered from the easiest at the top, to the most difficult at the bottom.

Figure 5. Bar chart of the perceived Difficulty to implement model uses.

4 DISCUSSION

The responses from industry suggest that, while there is difficulty in adopting an array of the identified model uses for construction, all of the identified uses have been observed to some extent. This suggests, first, that the list of model uses is a valid and representative capture of the modeling uses that can be performed to support construction. Further, the open-ended responses were reviewed to identify potentially new model uses. All of the responses were coded and confirmed to fall as either more specific instance of the model uses were already identified, or to address a specific method of implementing the identified model use.

To further explore the survey responses, a summary of the 'highest' rated model uses in each of the categories were extracted and summarized in Table 1. First, the most common, and the most 'future' of the model uses were identified to understand the relative adoption. It should not be surprising that *Gather Design Information* serves as the most common construction use, as it serves as a precursor to nearly every other model use that could be employed in construction. It also further reinforces the previous research that suggests the challenges in the handover of models, with the creation or transfer of the design model serving as a distinct BIM Use of its own in the construction process. On the other hand, the most 'Future' uses all relate to models that require integration of specific construction resources linked in some way to automate elements of construction resource allocation.

In addition, the most difficult and the most 'Future' also have strong alignment, suggesting that the BIM uses that are the most challenging to implement are those least frequently used, or even pursued. The most valuable model use, overall, was identified to be analysis of constructability.

Table 1. Summary of respondent ratings for the top three model uses in each.

Most Common	Most 'Future'	Most Valuable	Most Difficult
Gather Design Information	Analyze Cost Performance	Analyze Constructability	Analyze Cost Performance
Analyze Constructability	Order Materials	Gather Design Information	Forecast Resource Availability
Capture Existing Conditions	Forecast Resource Availability	Capture Existing Conditions	Control Construction Equipment

5 CONCLUSIONS

This research sought to validate the identified list of BIM uses for Construction as well as investigate the relative adoption of the uses along with their perceived value and difficulty. The results indicated that the model uses identified in the Taxonomy were a comprehensive list, based upon the responses of over 500 industry members. In addition, this research confirmed the perception of model handover challenges, with gathering of design information considered to be one of the most common steps in the construction modeling process. The most valuable model use cited was analyzing constructability of designs.

While this research did collect responses from a broad cross-section of the industry, the familiarity of each respondent with the full list is not clear, indicating that some of the ratings, such as perceived difficulty to implement, may not have been based upon experience. Furthermore, some of the roles indicated, such as architect, imply that the value of each model use was likely influenced by the respondents' roles within the design and construction process. Future research offers opportunities in refining the model use definitions in other project phases, as well as clearer definitions and options related to the methods of implementing modeling.

Acknowledgments

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