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Proceedings of the International Conference on Computing in Civil and Building Engineering
W Tizani (Editor)

Identifying the consideration factors for successful BIM projects

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Abstract

The purpose of this paper is to identify consideration factors for successful building information modeling (BIM) projects. Such factors include critical success factors, criteria for determining BIM software, BIM function, and BIM pilot projects. Each of these was evaluated by using a survey of 61 international BIM experts. The survey was based on literature reviews and face-to-face interviews. This paper presents the results of the survey and identifies important consideration factors for BIM projects.

Keywords: BIM, critical success factors, BIM software, BIM function, BIM pilot project

1 Introduction

Several countries, including Finland, Denmark, and the United States request that contractors and architectural firms submit BIM or industry foundation classes (IFC) files in carrying out public construction projects (Seo and Kim 2009). Cases using BIM have increased exponentially and BIM has been adopted successfully in many cases. In order to increase efficiency, many construction companies have been interested in adopting BIM; however, they do not understand how to implement BIM into their projects efficiently, how to select from among the various BIM software applications available, or how to determine which projects would benefit the most from BIM.

Research into trends regarding BIM adoption has increased in recent years. However, since BIM technology is in the beginning stages, BIM projects depend more on the perspective of the BIM experts than they do on quantitative analysis. There have been no studies regarding consideration factors such as standards for selecting appropriate BIM software, criteria for selecting the most desirable BIM functions, and factors to be considered in determining the optimal BIM pilot projects. Since these consideration factors can affect the success of the BIM projects, they should be managed primarily and objectively. Therefore, the purpose of this paper is to identify the most relevant consideration factors. The survey performed in this paper was divided into four parts as follows: critical success factors in BIM adoption, factors for prioritizing BIM functions, factors that affect the selection of BIM software applications, and criteria for selecting BIM pilot projects. The questionnaire was based on previous studies and interviews with experts.

2 Outline of the survey

We developed an online questionnaire survey using Active Server Page (ASP).NET and extensible markup language (XML). The respondents were asked to rate each factor according to a 7-point Likert scale (1 = strongly unimportant and 7 = strongly important). We invited international 206 BIM experts to answer the questionnaire via e-mail. The criteria of choosing the invited BIM experts were as follows:

- Internationally well-known BIM consultants
- BIM managers or directors at architectural firms and construction companies with experience in internationally recognized BIM projects
- Government officers in charge of BIM
- Authors of major BIM books
- Researchers who published papers on BIM in international journals and conferences
- Members of BIM user groups or international BIM organizations such as buildingSMART

Out of 206 people queried, 61 (29.2%) responded. Based on their roles, the respondents are classified as follows: 22 were BIM managers/directors (36%), 23 were BIM researchers (38%), 10 were BIM consultants (16%), 2 were repetitive BIM software users (3%), and 4 others were not classifiable (7%).

Figure 2 shows the classification of respondents by geographic working area. Because the respondents could indicate more than one working area, the total number of the respondents (70) was more than the number of the respondents to the survey (61). Of the 70 respondents, 29 were working in North America (41%), 19 were in Europe (27%), 18 were in Asia (26%), 4 were in Oceania (6%), and 2 respondents did not answer the question. There were no respondents from South America or Africa.

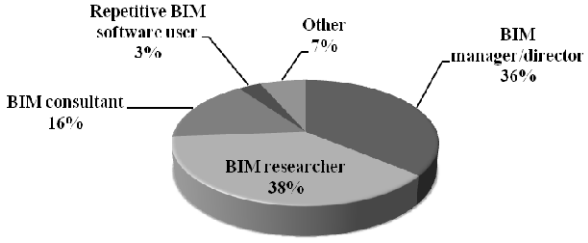

Figure 1, Classification of respondents by roles

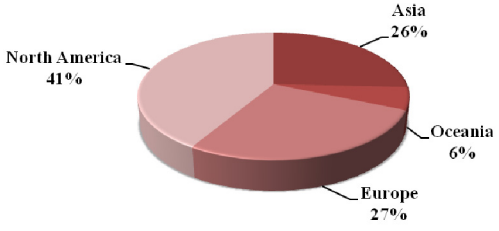

Figure 2, Classification of respondents by working areas

In the next section, the detailed results of the survey are presented.

3 Critical success factors in BIM adoption

To carry out BIM project successfully without confusing and unexpected trouble, many aspects should be effectively managed, such as outlining work procedures, collaborative planning, sharing information among the project participants, and avoidance of legal problems. However, because all of these cannot be managed simultaneously, we need to determine the most relevant factors and focus on their control.

Gilligan and Kunz (2007), Young et al. (2008), and Yan and Damian (2008) examined the benefits and barriers of BIM and the effects of adopting BIM by using the survey methodology. Won et al. (2009) compared the level of BIM adoption between the Korean construction industry and those of other countries. However, previous studies provided only basic data to confirm the current level of BIM implementation and the levels were only partly compared. Table 1 presents the survey results for the questions related to critical success factors for BIM implementation.

Table 1. Critical success factors in BIM adoption, as determined by survey

No	Factors	Avg.	SD
1	Willingness to share information between project participants	5.82	1.45
2	Master BIM model team/manager	5.80	1.37
3	Leadership of senior management	5.80	1.52
4	Organizational structure to support BIM	5.79	0.74
5	Effective collaboration between project participants	5.64	1.30
6	Continuous investment	5.62	1.52
7	BIM training programs	5.41	1.34
8	Information sharing protocols	5.38	1.52
9	Technical support for interoperability issues	5.20	1.50
10	Standardized work procedures for BIM	5.13	1.70
11	Clients' satisfaction with BIM projects	4.98	1.54
12	Clients' interest/request for BIM	4.77	1.44
13	Shared liability between project participants	4.69	1.23
14	Number of BIM software experts in a company	4.69	1.65
15	Collaboration (project) management tools	4.62	1.74
16	Metrics for quantitatively evaluating the effectiveness of BIM projects	4.62	1.59
17	Abundant BIM libraries	4.62	1.67
18	Number of subcontractors/partners who have experienced BIM projects	4.49	1.20
19	Incentive programs for using BIM	4.20	1.50
	Average	**5.12**	

The results of this questionnaire presented that information sharing (5.82), a master BIM model team/manager (5.80), and leadership of the senior management (5.80) should be the factors most controlled. Incentive program for using BIM (4.20) was of the lowest relative importance.

4 Criteria for selecting BIM software

Various types of commercial BIM software are used in the construction industry. According to the characteristics of each BIM project, such as size, shapes, methods for data exchange, primary BIM function, and implementation areas, BIM software might be chosen differently. However, there is no standard to select BIM software, and most BIM users depend on their own insight and market share of the software (i.e., they select the best-selling program). In order to identify which factors were important in selecting a BIM software application, we conducted a survey with international BIM experts, the results of which are shown in Table 2.

The 14 factors evaluated were based on the study of Khemlani (2007) and the opinions of the authors. The previous study presented important stand-alone criteria as follows: producing construction documents without the help of other CAD systems and smart objects such as the relationship to other objects and the availability of libraries.

The total average was 5.02 and the range among the factors was from 5.48 to 4.40. The most important factors in determining which BIM software would be best suited to the project were whether successful BIM cases using the relevant software were released (5.46) and how well the relevant software currently supported the function of interest (5.48). The less important factors were investment costs (4.67), the long-term strategy of vendors (4.65), and the quality of library content (4.40).

Table 2. Results of the questionnaire for selecting the optimal BIM software

No	Factors	Ave.	SD
1	How well a software application currently supports a function of interest	5.48	1.21
2	Are there known successful BIM cases for the software application?	5.46	1.32
3	How interoperable a software application is with other applications	5.35	1.63
4	Expected economic impact (return on investment)	5.25	1.44
5	The scalability of the software (how large of a building can a software handle?)	5.13	1.47
6	Are major subcontractors or business partners currently using the software?	5.10	1.49
7	Easiness to model and add new libraries	5.06	1.35
8	How well do current employees use the software application?	5.00	1.44
9	Is the use of the software application required by contract?	5.00	1.64
10	Learning curve to use the new BIM tool	4.94	1.42
11	Is the software application already in use in several departments?	4.81	1.37
12	Initial investment costs, including hardware, software, and training	4.67	1.38
13	The possibility of obtaining a targeted function in the near future in association with a software vendor's long-term strategy	4.65	1.47
14	How good content libraries are	4.40	1.43
	Average	**5.02**	

5 Factors for prioritizing BIM functions

The purpose of this section was to identify which factors are important in determining the adoption priority of BIM functions. BIM could be used in various areas, from simple clash check and quantity takeoff to database for building lifecycle management. However, all of the BIM functions cannot be used perfectly in current BIM technology. Therefore, people or organizations that want to implement BIM should consider the characteristics of the BIM projects and select the appropriate BIM function. To investigate the major criteria for prioritizing BIM functions, this paper compiled a questionnaire consisting of the 10 items shown in
Table 3. The author requested the respondents to give each factor a value from one to seven, with one being not important and seven being highly important.
Table 3 shows the results of the questionnaire, including the average and standard deviation of the responses to each item.

Table 3. Results of the questionnaire regarding the criteria for prioritizing BIM functions

No	Factors	Ave.	SD
1	Expected economic impact of adopting the BIM function	5.58	1.36
2	Is the function required by a company's business strategy?	5.54	1.15
3	Is the function required by a client or a specific project?	5.35	1.33
4	How well the current BIM technologies can support the area/function of interest	5.27	1.24
5	How well the current employees can use the BIM function	5.06	1.27
6	Can the function be adopted without conflict with a traditional work processes?	4.88	1.57
7	Learning curve (required time to adopt the function)	4.98	1.48
8	Can subcontracts support the function? (collaboration issue)	4.71	1.38
9	How soon the area/function of interest can be supported in association with a software vendor's long-term strategy	4.65	1.44
10	Initial investment costs, including hardware, software, and training	4.50	1.38
	Average	**5.05**	

The mean value of this questionnaire was 5.05 and the range was from 5.58 to 4.50. The most important factors in determining the BIM function to be used were the expected economic impact of using BIM (5.58) and matching the company's business strategy to the BIM selected (5.54). Initial investment costs (4.50) were the least important factor.

6 Criteria for determining BIM pilot projects

This section explained which factors were important for selecting BIM pilot projects. Many contractors and architectural firms in developed countries adopt BIM into their project and announce the effects by BIM implementation. Although other companies have interested in BIM technology, they have not yet adopted BIM for various reasons. These companies want to know how to adopt BIM without confusion. If they have a plan to adopt BIM, they wish to notify which project might be best to confirm the effects of BIM implementation.

We compiled a list of 13 factors to investigate the criteria for determining the optimal pilot project. The list was developed through discussions with two experts, each of whom had over 15 years experience, and the list was sent to international BIM experts. Table 4 shows the results of this questionnaire.

Table 4 Results of the questionnaire regarding BIM pilot projects

No	Factors	Ave.	SD
1	Project manager's interest and willingness in adopting BIM	6.13	1.10
2	Request from a client to use BIM	5.56	1.46
3	Complexity of a project (in terms of a building shape or building systems)	5.44	1.70
4	Field engineers' interest and willingness in adopting BIM	5.37	1.47
5	Subcontractors' interest and willingness in adopting BIM	4.77	1.77
6	Architectural firm's use of BIM	5.02	1.77
7	Availability of information on similar projects, which can be compared to the results of a selected pilot project	4.81	1.63
8	Subcontractors' capability to use the BIM tools	4.48	1.60
9	Use of a building (e.g., office, hospital, factory, residential, etc.)	4.54	1.73
10	Types of project delivery system (e.g., design-build, design-bid-build)	4.60	1.76
11	The physical size (floor area) of a project	4.15	1.73
12	The total construction cost of a project	4.15	1.79
13	Location of a site (e.g., overseas projects, domestic projects)	3.38	1.83
	Average	**4.80**	

The average of all criteria was 4.80, the highest score among the factors was 6.13 and the lowest was 3.38. The gap between the highest and the lowest was wider than in the other parts. The most important factors in determining the BIM pilot project were project manager's interest and willingness in adoption BIM (6.13) and whether the clients requested BIM (5.56). The location of the construction site (3.38) was the least important item.

7 Conclusion

The number of successful BIM cases has been increasing, however many construction companies did not understand how to use BIM and researches did not presented about these parts. Although some studies, like the BIM project execution planning guide (The Computer Integrated Construction Research Group 2009), have been released to implement BIM on a project successfully, such studies

proposed only a framework and did not propose how to determine which BIM software, BIM functions, and BIM pilot projects are the most appropriate. This paper conducted and analyzed a survey with 61 international BIM experts to indentify solutions to these questions. The survey consisted of four parts: critical success factors, BIM software, BIM functions, and BIM pilot project.

The most important critical success factors were information sharing, master BIM model team/manager, and leadership of the senior management. For selecting BIM software, the previous successes of BIM cases that used the relevant software and which supported the function of interest were the most important. The most important factors in determining the BIM functions were the expected economic impact of BIM implementation and matching the company's business strategy. In determining BIM pilot projects, we should consider criteria such as the project manager's willingness in adoption BIM and whether BIM was requested by the client.

A practical example in which these factors are used has not yet been provided. Therefore, we will apply these criteria into a project that will be compared with a project in which the criteria were not adopted.

Acknowledgements

This research was supported by a grant titled "06-Unified and Advanced Construction Technology Program-E01" from the Korean Institute of Construction and Transportation Technology Evaluation and Planning (KICTEP) and Yonsei University.

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