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Barriers of Implementing BIM in Construction Industry from the Designers' Perspective: A Hong Kong Experience

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Abstract. In view of the strategic plan of the Hong Kong Government to implement BIM in all public housing projects starting from 2014, there is a need to review the current use of BIM in Hong Kong. However, there is no thorough study conducted in Hong Kong to provide empirical data for further study. Although the study is conducted in Hong Kong, the results contribute practical insights to the subject in other countries. The main purpose of this paper is to examine the application of BIM among the design firms in Hong Kong and to identify their needs and barriers in the BIM adoption process. From such, suitable directions can be suggested for the government, professional bodies and BIM vendors to foster the local use of BIM. A questionnaire survey was designed to collect primary data regarding the implementation and barriers of BIM usage from design firms in Hong Kong. Respondents were asked to provide opinions on the extent of BIM implementation, their barriers encountered during implementation and the required support from government / professional institutions. Fifty-two responses were received in the survey. Results indicated that BIM application among designers was limited. Several barriers to BIM adoption were identified, including lack of qualified in-house staff, lack of training/education, lack of standards and lack of client demand. The government should collaborate with the industry, professional bodies and education institutes to establish clear standards and guidance on the use of BIM and to provide more tailored training to practitioners and future students.

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1. Introduction

In the 21st century, evolution in computer science has changed the work process of almost every industry. Wireless communication, mobile monitoring and electronic documentation systems become integral components of contemporary business models. In the worldwide construction industry, one of the most significant developments is the BIM (Building Information Modelling) technology. BIM is an information technology enabled approach that involves applying and maintaining an integral digital representation of all building information for different phases of the complex construction project lifecycle (Chen & Qu, 2011) in the form of a data repository (Gu & London, 2010). BIM manages both graphical perspectives and building information, allowing the computer-aided generation of drawings and reports, design evaluation, project scheduling and resources organisation from facility design to operation.

1.1. Advantages of BIM

Over the last decade, many case studies on the application and advantages of BIM have been done. Many researchers suggest that BIM provides a platform which facilitates the creation and sharing of information relevant for design, construction and maintenance of buildings over their entire lifecycle (Popov, Juocevicius, Migilinskas, Ustinovichius, & Mikalauskas, 2010). BIM is capable of supporting collaboration between various stakeholders by acting as an information backbone (Grilo & Jardim-Goncalves, 2010). The completeness of the information enables better lifecycle management (Popov et al., 2010),(Gecevska, Chiabert, Anisic, Lombardi, & Cus, 2010) and sustainable building design (Azhar, Carlton, Olsen, & Ahmad, 2011). With the integrated information model, visualisation of construction process and design details is easier which facilitates analysis of alternative solutions (Popov et al., 2010) and identification of potential conflicts (Grilo & Jardim-Goncalves, 2010),(Roh, Aziz, & Peña-Mora, 2011). It is also believed that BIM can effectively improve cost estimating and tendering (Elbeltagi & Dawood, 2011),(Ma, Wei, Wu, & Zhe, 2011), site planning (Grilo & Jardim-Goncalves, 2010),(Babič, Podbreznik, & Rebolj, 2010),(Sacks, Radosavljevic, & Barak, 2010) and safety management (Zhou, Whyte, & Sacks, 2011).

1.2. Usage of BIM in Hong Kong

Although there is a growing shift from 2D CAD design to nD BIM, the adoption of BIM in the construction industry in Hong Kong is considerably low. Survey results published in 2005 (Tse, Wong, & Wong, 2005) indicated a low uptake of BIM in the architectural firms in Hong Kong. Many of the respondents indicated refusal to use BIM after trial. The main reason was the fact that clients and other project team members did not require BIM to be used. One-thirds of the respondents agreed that lack of training was a reason for not using BIM. Two-thirds of the respondents thought that 2D CAD systems could fulfill the design needs satisfactorily and the need for BIM was not noticeable.

2. Purpose of this study

Today, different BIM softwares have been streamlined with add-on modules, user-friendly interfaces and improved interoperability. The advantages of BIM are well recognized by governments around the globe. The U.K. Government announced to require 3D BIM on its projects by 2016. “BIM will be future IT solution in China: The Chinese Government is strongly supporting BIM” (HM Government, 2012). The Government of Hong Kong Special Administrative Region also intends to use BIM in all new public housing projects from design stage starting from 2014 (Fung, 2011).

In the U.K. and U.S., many BIM surveys have been done by researchers and institutions. However, surveys on BIM usage in Hong Kong are very limited. A thorough review of the current use of BIM in Hong Kong is strongly demanded. Since architects and civil engineers are leaders in establishing BIM in the project lifecycle, it is important to understand their usage pattern and difficulties in order to formulate appropriate steps to achieve the government strategic plan. The purpose of this study is to examine the application of BIM in the design firms in Hong Kong and to identify their needs and barriers in the BIM adoption process. From such, future directions can be suggested for the government, professional bodies and BIM vendors to foster the local use of BIM.

3. Data Collection

To meet the objectives of this study, primary data has to be collected from the design firms in Hong Kong. Among the various data collection techniques, questionnaire survey was chosen as it is the most popular and economical method. Based on the existing literature on BIM surveys conducted in other countries (NBS, 2012),(Building Cost Information Service, Royal Institution of Chartered Surveyors, 2011),(Kunz & Gilligan, 2007), a questionnaire was developed to collect the usage pattern and opinions from the design firms in Hong Kong.

The questionnaire was divided into three main sections. The first section was to collect some basic information about the respondents and their organisations. The second section was to survey the extent of BIM implementation. Closed-end questions were set to ask the respondents on: their BIM softwares installed, the extent of BIM application in past and current projects and reasons for their companies to adopt BIM. The third section was to collect BIM users' opinions about usage, barriers and support required. Firstly, those respondents who know about BIM were requested to rate twenty-nine statements about BIM on a five-point scale, ranging from 5 (representing "strongly agree") to 1 (representing "strongly disagree"). The statements can be broadly divided into two groups: positive views and negative views on BIM usage. Then, they were asked to evaluate the significance of twelve barriers to BIM adoption on a five-point scale ranging from very significant ("5") to very insignificant ("1"). Respondents were also invited to give comments on any barriers to BIM which were not included in the list. Lastly, they were asked comment on whether supportive actions from government / professional bodies were required to improve BIM adoption.

Since there is no published list of design firms available in Hong Kong, various sources including personal contacts and professional bodies' websites were sought to compile the sample. The questionnaire was posted to the directors of 137 architectural and engineering design firms in Hong Kong during Dec 2012 to Jan 2013.

4. Results and Analysis

4.1. Respondents' profile

Fifty-two valid responses were received, representing a response rate of 38%. It is considered satisfactory with reference to the minimum threshold of 30% as recommended in literature (Fellows & Liu, 2003). Among the respondents, 40% were engineers, 56% were architects and 4% were landscape architects. 50% of the respondents worked in very large design firms with more 250 employees. Only around 4% came from small design firms with less than 10 employees.

4.2. Test for internal consistency

Internal consistency analysis was applied to the questions in section three, including the positive issues, negative issues and barriers related to the use of BIM. The alpha coefficient of the three groups of questions is above or close to 0.7, indicating that the items in the group presented relatively high internal consistency.

4.3. Extent of BIM usage

As shown in Fig. 1, ten respondents indicated that no BIM software was installed in their companies, which means 83% of the respondents have at least one type of BIM software procured. Regarding those design firms which had not installed any BIM softwares, all of them were small local firms employing less than 50 staff. Autodesk Revit was the most popular BIM software irrespective to the size of firm, with around 90% users. Although ArchiCAD is an open system, only one respondent had ArchiCAD in his/her company. Microstation was the second most popular BIM software with around 17% users.

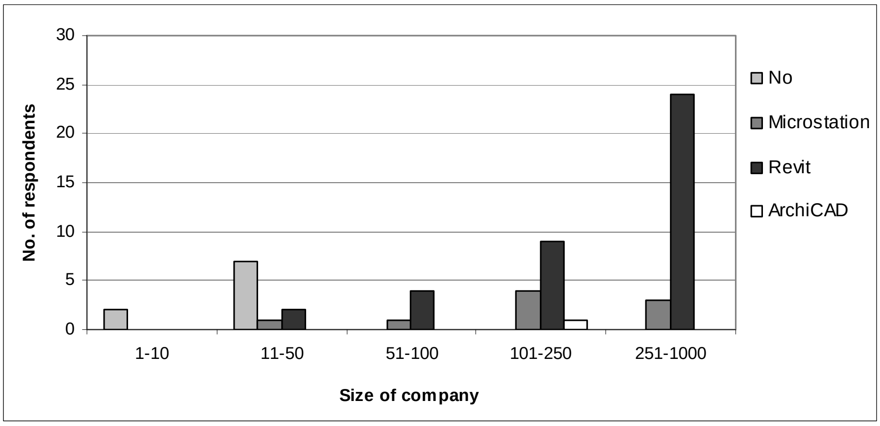

Fig. 1: BIM softwares used by designer firms

Although the majority of the respondents had used BIM in their past projects, the frequency of use was in fact very limited. Among the forty-two respondents who had used BIM in their projects, 76% had less than 10% of their current projects using BIM. There was one single design firm which had more than 70% of its current projects using BIM. This company was subsequently verified and identified as an architectural practice specialized in BIM.

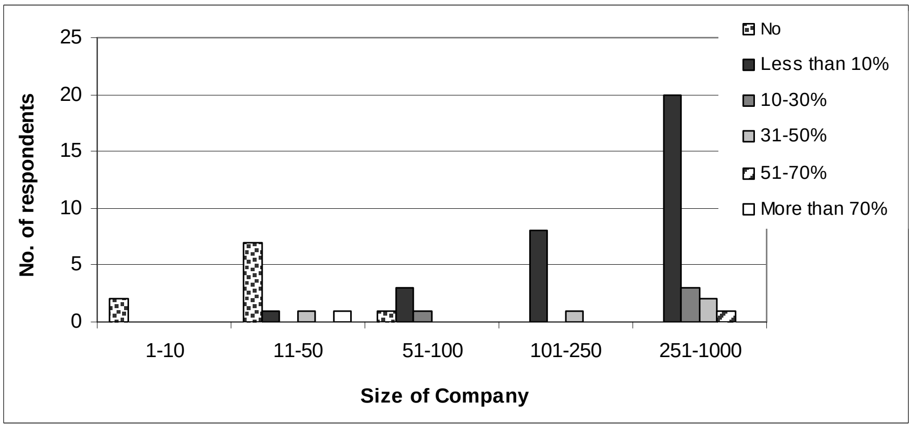

Fig. 2: Frequency of BIM use

Table 1 shows the percentages of respondents citing different frequencies of BIM uses for different tasks by their firms. The table is sorted on the sums of the ‘Very often’ and ‘Often’ BIM % columns, but if these are equal, the ‘Sometimes’ column figure determined the relative ranking. In the questionnaire survey, only those respondents whose organisations had used BIM in their projects were invited to answer these questions. There were forty-two respondents responding to this section.

Table 1. Frequencies of BIM activities

	BIM activity	Very often	Often	Sometimes	Rarely	Never
1	Interaction with non-professionals	2%	29%	33%	24%	12%
2	Design analysis	7%	19%	48%	17%	10%
3	Drawing production	7%	19%	40%	19%	14%
4	Site layout planning	0%	10%	17%	48%	26%
5	Tendering	0%	2%	38%	38%	21%
6	Project scheduling (programming)	0%	2%	10%	57%	31%
7	Cost estimating	0%	0%	17%	36%	48%

The sums of the 'Very often' and 'Often' percentages indicate that less than 31% of the firms made frequent use of BIM in project activities. If considered the rare application of BIM in current projects as identified in the earlier part, the actual frequencies of BIM activities undertaken by the firms are even lower. According to the results in Table 1, BIM was mostly used for interaction with other non-professionals, followed by design analysis and drawing production.

Table 2 tabulates the reasons for BIM adoption in the respondents' companies. Client's requirement is the major reason for the implementation of BIM, with two-thirds of the respondents choosing this factor. Around 40% respondents thought that their companies adopted BIM for improvement.

Table 2. Reasons for adopting BIM in the company

Rank	Reasons for adopting BIM	No. of respondents
1	Client's requirement	28
2	For improvement	17
3	Competitors are using it	9
4	Other project parties are using it	7

4.4. Opinions on BIM

At the beginning of this section, the respondents were asked to what extent they were familiar with BIM. Although 80% of the firms had projects using BIM, only 29% of the respondents were familiar or very familiar with BIM. 25% of the respondents had no idea about BIM. Those who had no idea about BIM were working in smaller design firms where BIM had never been used in their projects.

The respondents who knew about BIM were requested to give opinions on the subsequent parts. First, they were asked to rate twenty-nine statements about BIM on a five-point scale ranging from 5 (representing "strongly agree") to 1 (representing "strongly disagree"). The statements can be broadly divided into two groups: positive views and negative views on BIM usage. Table 1 and Table 2 show the responses. The results were ranked by the weighted average scores in descending order.

Table 3. Designers' opinions on BIM (positive issues)

Rank	Statement	Weighted average score
1	I welcome adoption of BIM in my organisation.	4.03
2	BIM checks the potential conflicts during pre-construction stage.	4
3	Adopting BIM enable users to create a model visualizing the real construction process.	3.9
4	BIM increases consistency and accuracy of information used during the whole project.	3.87
5	BIM benefits for better data reuse.	3.82
6	BIM enhances communication among project members.	3.74
7	BIM enhances collaboration among project members.	3.74
8	BIM checks design non-conformities during pre-construction stage.	3.69
9	BIM checks the constructability during pre-construction stage.	3.69
10	BIM is an information centre for the project.	3.62
11	Adopting BIM encourages users to give feedback more frequently than before.	3.36
12	BIM helps tendering.	3.26
13	BIM has a high degree of customisation to meet your requirement.	3.13
14	BIM helps procurement.	3.03
15	BIM reduces the time spent on project documentation and communication.	2.97
16	BIM lowers the project cost.	2.92
17	BIM improves construction safety.	2.87
18	BIM will reduce the amount of staff/workers in your organisation in the long run.	2.72

From Table 3, respondents in general welcomed the adoption of BIM in their organisations. Most of the benefits / advantages of BIM were agreed by the respondents with weighted average score higher than 3.0 However, there was a substantially large extent of disagreement with four statements, including: "*BIM reduces the time spent on* *project documentation and communication*", "*BIM lowers the project cost", "BIM improves construction safety*" and "*BIM will reduce the amount of staff/workers in the organisation in the long run*". Although these four benefits are suggested by some literature, local designers do not show much support. The average weighted score of these four statements were below 3.0.

Designers' view on the negative issues related to the use of BIM exhibited higher consistency. In Table 4, all of the negative statements scored higher than 3.0 on average. Among the eleven statements, "BIM standard and specification is not unified" was mostly agreed. Other five statements scored above 3.82, including "*It does not help if your counter-parties are not using the BIM*", "*BIM files have compatibility / interoperability problem when transferring to other software*", "*BIM software is costly*", "*Initial set up of BIM is difficult*" and "*The model in BIM needs to be manually updated frequently*". It means that the designers highly agree with these negative issues.

Table 4. Designers' opinions on BIM (negative issues)

Rank	Statement	Weighted average score
1	The current standard and specification in BIM is not unified in the construction industry.	4.05
2	It does not help if your counter-parties are not using the BIM.	3.95
3	BIM files have compatibility / interoperability problem when transferring to other software.	3.9
4	BIM software is costly.	3.87
5	Initial set up of BIM is difficult.	3.82
6	The model in BIM needs to be manually updated frequently.	3.82
7	Adopting BIM will propagate the error if a mistake is produced.	3.49
8	BIM is not yet mature for adoption in the local construction industry.	3.44
9	BIM is too complex and should be made easier to use.	3.36
10	BIM creates redundant work transforming project data between different parties.	3.26
11	Responsibilities of parties will be unclear after adopting BIM.	3.1

Barriers to take up BIM are always an area of interest to BIM vendors and government. Table 5 lists out the weighted average score of responses received. Recall that respondents had rated these on a five-point scale, ranging from "very significant" to "very insignificant". If the weighted average score is above 3.0, it means that the barrier is considered as significant. From Table 4, all barriers in the questionnaire scored higher than 3.0, indicating their strong negative influence to the adoption of BIM. Lack of qualified in-house staff, lack of training / education and lack of standards were the most significant barriers to BIM adoption; all exhibited an average score above 4.0. Lack of client demand and lack of government's lead were the next two critical barriers opined by the designers.

Table 5. Designers' opinions on BIM barriers

Rank	Statement	Weighted average score
1	Lack of qualified in-house staff to carry out the BIM related works.	4.18
2	Lack of training/education.	4.08
3	Lack of standards.	4.03
4	Lack of client demand.	3.92
5	Lack of government's lead/direction.	3.92
6	Lack of incentive to have subcontractors and suppliers (lower part of the supply chain) to adopt BIM.	3.87
7	High cost.	3.77
8	Uncertainties over interoperability of BIM software with other software.	3.77
9	Lack of IT infrastructure.	3.69
10	Uncertainties over ownership of data and responsibilities.	3.54
11	Lack of new and/or amended forms of construction contracts.	3.18
12	Current professional indemnity and insurance terms.	3.08

The respondents were asked if there should be any support from the government or professional institutes. At least 60% of respondents commented that further action was required to improve the uptake of BIM, including *provide guidance on the use of BIM, define levels of BIM working, provide training, develop data exchange standards and develop new form of contract*.

Table 6. Required support on BIM

	Required	Not Required
Providing guidance on use of BIM	33	6
Defining levels of BIM working for reference in professional services agreements	32	7
Providing training	31	8
Developing data exchange standards	31	8

5. Discussion

5.1. Slow Uptake of BIM by Designers

The results reflect that although BIM has been discussed over the last decade, it has not been implemented satisfactorily among the designers in Hong Kong. While having more than 80% of the designers installed BIM in their companies, most of them had used BIM in less than 10% of their current projects. In the U.S., there were 74-77% of firms using BIM significantly during design (Kunz & Gilligan, 2007). If compared the current findings with the survey results obtained in 2004 in Hong Kong (Tse et al., 2005), there was an increase in the installation of BIM across the design firms (from around 50% to 83%) but the extent of application in projects was never improved. The percentage of firms which applied BIM in more than 50% of their projects was 37% in 2004, although the authors highlighted that the real application might be lower than the stated figures as some respondents might be using 2D features of BIM only. In the current study, only 5% of firms applied BIM in more than 50% of their current projects. The findings in this study evidence considerably low application of BIM among the design firms over the last decade in Hong Kong.

5.2. Does Cultural Barrier Exist?

National culture, management style, customs, etc. can affect the way of doing business. Previous studies suggested that these national differences have varying impact on different areas of information technology implementation such as technology transfer (Shore & Venkatachalam, 1996), information management (Lai, 2001) and technology adoption (Png, Tan, & Wee, 2001). The business models and processes underlying BIM reflect European and U.S. industry practices. Therefore, there may a higher chance of resistance to operate BIM in Asian places like Hong Kong according to the past theories. Since the application of BIM has been limited as discussed earlier, it is important to check whether there is any cultural barrier exist which impedes BIM adoption in Hong Kong.

From the results in section two, we can see that the majority of the respondents welcomed BIM. No additional barriers to BIM were suggested by the respondents. This implies that cultural resistance is not a significant problem to BIM adoption in Hong Kong.

5.3. Government to Raise the Need for BIM

From many survey results, the largest impediment to BIM adoption is the lack of client demand (Building Cost Information Service, Royal Institution of Chartered Surveyors, 2011), (Kunz & Gilligan, 2007). Similar finding is observed in this study and the lack of client demand ranked as the fourth significant barrier. It is understood that if BIM is required for project design, professional fees will be substantially increased as the time and effort spent by the designers will be more. It is difficult to change the mindset of private clients within a short period of time by expecting them to pay more for the professional fees. Being the largest client in the construction industry, the government should take the lead to increase the demand for BIM implementation in her projects. As indicated in the findings of this study, most of the designers have installed BIM already. Two-thirds of the respondents applied BIM in their projects due to client demand. There is no doubt that the use of BIM by the designers is client-driven. In recent years, some local clients including the government request the contractors to use BIM in the construction stage. Contractors have to recruit BIM experts to reproduce the design information, transform the 2D designs into 3D BIM files. The whole process is costly and time-consuming. Government departments should encourage the use of BIM starting from design stage, even if the design is prepared by in-house designers. When the benefits of BIM are widely recognized by different professionals, private clients will demand BIM in their project design and construction.

5.4. BIM Education and Training

Although the majority of the designers welcome BIM, there were designers who do not know much about BIM. As commented by the respondents, *lack of qualified in-house staff* and *lack of BIM education/training* were the most critical barriers to BIM adoption. Almost 80% of the respondents wanted to have training provided by the government / professional bodies.

It is true that there is a wide range of BIM short courses offering in the market. However, without clear BIM guidelines established by the government, the quality of these BIM courses varies considerably. Even for the sub-degree and undergraduate degree programmes offered by the local universities, requiring BIM training in their curricula is neither standardised nor mandatory. This situation explains why the respondents demand more "proper" education and training for BIM.

Most of the practicing designers are educated and trained in the conventional 2D CAD environment. To accelerate the uptake of BIM in design firms, BIM training for practitioners and future designers is indispensible (Building Cost Information Service, Royal Institution of Chartered Surveyors, 2011), (Kunz & Gilligan, 2007). Professional bodies should work with education institutions to review the curriculum for architectural studies so as to adopt BIM as their major pedagogical platform. Curricula should aim at developing students with both the drafting skills and collaborative skills in the BIM environment. Furthermore, professional bodies should collaborate with BIM vendors to support continuing professional development programs for practicing designers, enabling them to equip with the latest BIM skills. Last but not the least, to design appropriate training for practitioners and students, the leading role of the government must not be ignored. From this study, respondents identified a need for clear BIM directions and standards from the government. The government should invite the industry to establish BIM standards in no time.

5.5. BIM as a Platform – From Communication to Collaboration

As indicated in Table 1, BIM was most heavily used for interaction with non-professionals like clients, potential buyers, pressure groups, etc. The power of 3D visualisation enables better understanding of the complex details of construction. From the findings in Table 3, designers agreed that BIM could act as an information centre to improve communication and collaboration between project parties. However, designers also showed disagreement with the ability to reduce time on project documentation and communication by using BIM. Such conflicting view is probably due to the interoperability problem when transferring BIM files to other softwares (as indicated by the strong agreement with the compatibility / interoperability problem in Table 4).

To exploit the advantages of BIM, we should not use it for communication purpose only. BIM should be extended to serve as a platform for multi-disciplinary collaboration.

However, the interoperability problem has to be tackled first. This requires more collaborative researches to be done by building professionals and BIM vendors.

Besides, the use of BIM in other project management functions like project scheduling and cost estimating is not yet mature. More extensive investigation on the use of BIM among other project parties like contractors and consultant quantity surveyors is necessary to devise appropriate plans for boosting BIM application in a broader arena.

6. Conclusion

Realizing the importance and potential benefits of BIM, an empirical study has been reported in this paper to highlight the implementation issues of BIM in Hong Kong. This study aimed at examining the current usage of BIM among the design firms in Hong Kong and to identify any barriers or necessary actions to foster the use of BIM. This empirical study is based on the data collected from design firms in Hong Kong by using a questionnaire survey.

Fifty-two replies were received in the survey. From the descriptive statistics of survey results, limited application of BIM was observed among the respondents although the level of BIM installation was much improved when compared with previous years. Autodesk Revit was the most popular BIM software used by the Hong Kong designers. For those who applied BIM in their projects, the technology was mainly used for interaction with non-professionals, design analysis and drawing production. Most of the respondents welcomed the use of BIM and agreed with the benefits of using it. Several problems / barriers to BIM adoption were identified, including lack of qualified in-house staff, lack of training/education, lack of standards and lack of client demand. Support from government / professional bodies was requested by the respondents to improve the uptake of BIM, including provide guidance on the use of BIM, define levels of BIM working, provide training, develop data exchange standards and develop new form of contract. To foster BIM adoption in Hong Kong, the government should take an active role to demand the use of BIM from design stage in her projects. In addition, the government should collaborate with the industry, professional bodies and education institutes to establish clear standards and guidance on the use of BIM and to provide more tailored training to future students and practitioners. Although the study is conducted in Hong Kong, the results should contribute practical insights to those countries like China where the use of BIM is not yet mature.

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