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Benefits and Barriers of Building Information Modelling

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Abstract: Building Information Modelling (BIM) as a powerful set of design management's tool has been highlighted by the Architecture, Engineering, and Construction (AEC) industry. BIM has significant advantages over the entire building lifecycle, particularly design but also construction and facility management. The full impact of BIM on the evolution of design tools in the AEC industry has recently become a topical research area. This paper opens with a literature review which outlines the historical evolution of design tools. The literature review describes the benefits of BIM claimed by its proponents as well as barriers to its implementation. Next, the paper describes questionnaire data from a survey of about 70 individuals from the AEC industry on BIM adoption, perceived benefits, and perceived barriers. The questionnaire is intended to determine professional opinions about BIM and whether companies adopt BIM tools or plan to adopt this technology. It is found that BIM adoption is much higher in the US than in the rest of the world. Still, the majority of companies were neither currently using BIM technology, nor did they have any plans to use BIM in the future. The paper concludes that improvements are still needed in the development of BIM technology. Secondly, the paper concludes that complete adoption of the technology by the AEC industry will take a few more years.

Key words: Building Information Modelling; questionnaire; barriers; benefits; future of BIM

Introduction

In the 21st century, every evolution in technology has been achieved with advances in computer science. The result of each evolution is to provide more information to attain objectives easily. This technical evolution is also reflected in the Architecture, Engineering, and Construction (AEC) Industry. In the past 10 years, design tools in the AEC industry have been improved from 2D modelling to 3D modelling. Today, some software companies such as Autodesk claim that they produce new design software based on the concept of Building Information Modelling (BIM).

This research aims to analyse the benefits and drawbacks of Building Information Modelling in the AEC industry based on the current adoption of design tools. In addition, to identify the barriers in the adoption of BIM and to encourage their use is also an important issue that needs to be analysed. Lastly, the future direction of BIM will be forecasted according to the results of case study and questionnaire data.

Methodology

This research begins with a historical review of literature on design tools, and then proceeds to collect questionnaire data specifically about BIM. Thirteen questions are set and delivered to related construction professionals in the UK, US and other countries. The purposes of this questionnaire are to survey the current situation of BIM and to clarify why some companies choose this technology while others do not. The discussion analyses the main relative merits of using BIM and attempts to forecast their future.

1 Literature review

The literature review includes four main sections:

original design; 2D CAD; current design methods and Building Information Modelling. These correspond to the various stages of AEC design technology.

1.1 Original design

Until the mid-nineteenth century, the general method of design did not change a lot. Engineers used simple tools (such as pen, paper and ruler) to describe their buildings. However, with advances in mathematics and building materials, the process of design changed and improved rapidly. [1-2]

1.2 Initial 2D CAD method

With the invention of the computer, 2D CAD as a new drawing tool was adopted completely in the AEC industry. [3] After the Second World War, American martial technology was applied in the civil field. SKETCHPAD was first developed by Ivan Sutherland. That was the root of CAD. At the beginning, the technology of CAD was not as popular as in modern times. However, with the popularisation of personal computers, the renowned software company Autodesk developed AutoCAD. Suddenly, all the architects in the world started to learn and use this type of software to design their project. [4]

1.3 Current design methods

The technology development form 2D CAD to 4D simulation greatly improved the design process. Internet technology and emerging media (such as videoconferencing) also strongly influence the development of design tools and literature in those fields was reviewed as part of this research. [5]

2D CAD developed into 3D modelling. This innovation changed the process of building design and the relationship between the structural engineer and the architectural designer. It did not only change the way building designs are visualized, but also signalled a paradigm shrift in design thinking from pure visualisation to simulation. [6]

1.4 Building Information Modelling

Beyond the 3D modelling, BIM is emerging as a new powerful technology. Firstly, it has all the functions of 3D CAD. Whereas 3D CAD modelling was merely collections of points, lines, 2D shapes and 3D volumes, in the BIM concept, such geometric entities can also have symbolic or abstract “meaning”, as well as quantitative or qualitative data.

In order to compare the differences between traditional CAD documents and Building Information Modelling, Leicht and Messner used these two methods to create the same project named Dickson School of Law Building in Penn State University in the USA. [7] It is easier to analyse the benefits of using BIM though this comparison.

To summaries, the literature review is based on the evolution of building design methods and technologies. In the past, the design technology was driven by developments in computer science. And the result of each innovation is that more information about the building design is modelled by the new tool or new method. BIM as a new design tool has been adopted by some construction companies. On the other hand, few companies claim that they already exploited the whole functionality of BIM.

2 Questionnaire

2.1 The objectives and the sample

There are two main objectives of this questionnaire. The first objective is to survey the ratio of AEC companies of using BIM in the UK, US and other countries. The second objective is to identify the benefits to the companies who are using this design technology. Furthermore, for the companies who have not used BIM, what are the barriers to adopt this technology can also be analysed through questionnaire.

The questionnaire was sent to AEC industry practitioners and academics. Two countries were focused on to analyse, USA and UK. The USA is arguably the leader in development of this technology. However, lots of companies in the UK have been researching this technology for a long time. Only a few companies are planning to use BIM. In addition, academics who conduct research in BIM were also invited to complete the questionnaire.

2.2 Questionnaire results

The questionnaire was sent in paper/electronic form to about 100 AEC academics and practitioners. Those were randomly chosen from personal contacts. The re-

sponse rate was about 70%. Several responses contained invalid answers and were therefore disregarded. Thus, 67 valid responses were gathered, 21 from the UK, 23 from the USA and 23 from other countries.

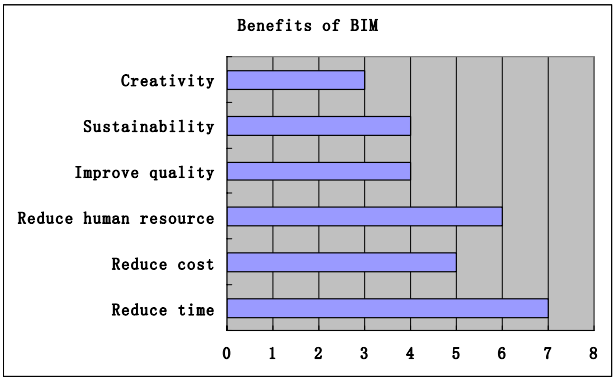

Fig. 1 Advantages of BIM

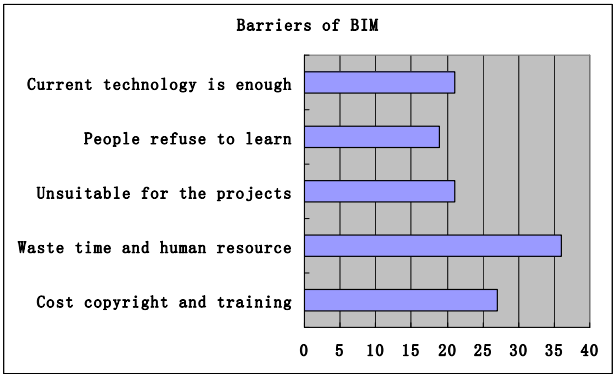

Fig. 2 Drawbacks of BIM

The results reflect that BIM as a new design tool has not been fully accepted yet. 24 respondents claimed that they knew nothing about BIM. 31 respondents said that they knew very little about BIM. The total number of people who report that they knew a fair amount about BIM was only 13. No-one in total was found to be an expert in this technology. The result from the USA which was thought to be the largest client of BIM also mirrors the same situation. Only 26% companies in the USA (14% companies in the UK and 5% companies in the other countries) report that they are using BIM to design, construct and operate their projects. This result also reflects that to reduce the construction time is the most significant benefit of using BIM. On the other hand, most of the companies who do not use BIM believe that BIM training would cost their companies too much time and human resource. This is the largest barrier to implementation of BIM. Figure 1 shows that BIM's reduction of construction time is the most important benefit. Figure 2 shows that the time and human resource cost of BIM training is the largest barrier to their adoption.

3 Discussion

This section discusses four parts of Building Information Modelling, (comparison analysis, benefits, barriers and the future of BIM), based on the results of questionnaire and the literature review.

3.1 Comparison between UK and US

This comparison analysis aims to identify the current situation of BIM in the UK and US. Thus, the reasons why more American companies choose BIM as their design tool can be determined.

According to the questionnaire results, American companies in AEC industry are using more BIM to design their projects than their British counterparts. (From the questionnaire results, 16% AEC companies from UK are using BIM to design their projects, and 33% AEC companies are using BIM in the USA.) Figure 3 shows awareness of BIM in the UK and US. The results of questionnaire also show that architects in the UK expect to learn how to operate BIM to design their projects. About 67% of companies in the UK want to adopt BIM within 3 years. However, compared with US companies, they do have different considerations about BIM and different views of BIM's benefits and barriers.

Figure 4 and figure 5 mirror the different opinions about the benefits and barriers of using BIM from the UK and US. For instance, British AEC practitioners hope BIM could help them to reduce the total cost of the projects. And, some British respondents believe that BIM is not suitable for their current projects. Regarding the future of BIM, both two countries' architects are of the same opinion that BIM will become more popular and useful in the foreseeable future. (52% respondents from UK and 78% respondents from US have a positive view of BIM's future.)

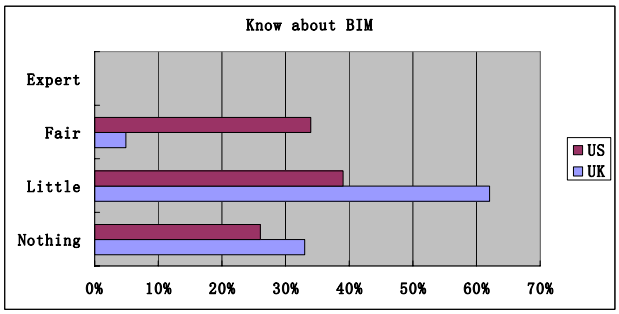

Fig. 3 Know about BIM in UK and US

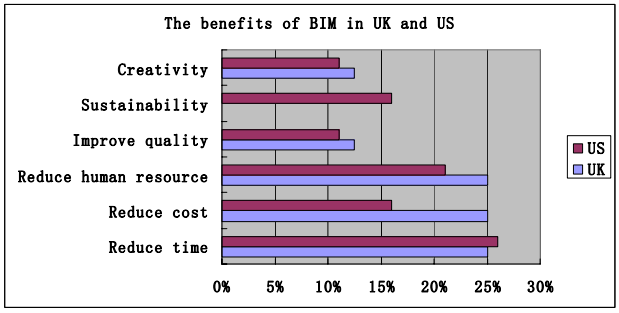

Fig. 4 Benefits of BIM in UK and US

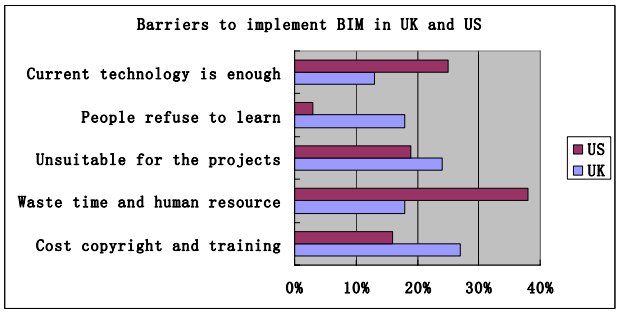

Fig. 5 Barriers to implement BIM in UK and US

3.2 The benefits of using BIM

3.2.1 BIM changes the process

BIM not only improves the technology itself, also changes the process of design and build. From the questionnaire results, all BIM users choose this option as the main benefit of using BIM. Walter claims that: "BIM enables better decisions; faster BIM reduces the abstraction and integrates the multiple disciplines, including design and documentation. And BIM integrates plans, sections, details, graphics, and data in ways not possible in 2D." [8] Based on his argument, the period which is spent on the design can be cut by about half at half the cost. Moreover, "half time at half cost" will not just save the money, it is also reducing the time to the market. Therefore, using BIM can save the cost of design and can benefit from earlier access to the construction market.

3.2.2. BIM benefits during the operation phase

In the operation phase, Building Information Modelling creates obtainable concurrent information on performance of the project; and the economic aspects of the project. BIM leaves a digital document trail resulting from transformations and developments during operation. An Autodesk publication claims that: "BIM accelerates the adaptation of standard building prototypes to site conditions for businesses, such as retail, that require the construction of similar buildings in many different locations." [9] From the questionnaire, most BIM users believe that BIM can reduce human resource during the entire operation phase.

3.3 The barriers to implement BIM

3.3.1 People barriers

This category poses the largest latent barriers to the application of BIM. According to the results of questionnaire, about 40% of respondents from USA and about 20% respondents from UK believe that their companies have to allocate lots of time and human resource to the training process. (Figure 5) Decisions made in organisations are mainly derived from a business perspective (make profit). The AEC industry is not glad to invest in BIM, because of the lack of case study evidence of the financial benefit of BIM. Investment in BIM by the AEC industry will be achieved when a good business case is made with case study evidence. [10] Moreover, social and habitual resistance to change, as lots of architects are satisfied with traditional methods to design their projects and are incredulous of the new functions and advantages of BIM.

3.4 The future of BIM

From results of questionnaire, only a few companies are currently using BIM to model their projects. However, the results also reflect that most of the respondents are confident that BIM will be more popular in the future. Lots of the design teams are planning to adopt BIM within 3 years and the rest are also interested in BIM. Figure 6 shows the respondents' views about the future of BIM.

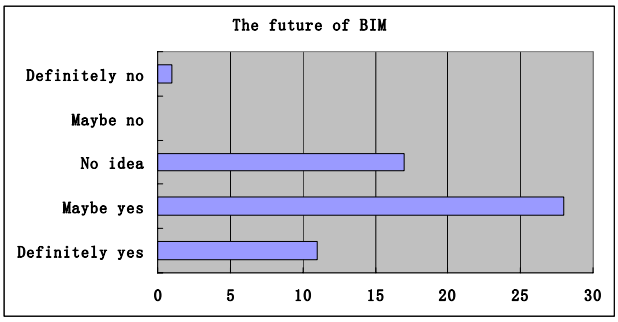

Fig. 6 Respondents' views about the future of BIM

For the future development of BIM, more detailed information needs to be offered by BIM. For instance, the designers could even know where the desks in the classroom are made and when they will be delivered.

4 Conclusions

This paper identified the benefits of using BIM and the barriers to its implementation. The literature review surveyed each historical evolution of design technology in the AEC industry. The second part analyses about BIM based on questionnaire data. Last section discusses the benefits and barriers of BIM. Also, the future of BIM is forecasted from the consequences of literature review and questionnaire.

In the discussion section, the benefits of using BIM and the barriers to implement BIM are discussed. BIM could improve the design phase. For example, the architects can use BIM to make any change at any time without any difficult process, hard harmonisation and manual checking work. BIM also shows its power in construction phase and operation phase, such as BIM could reduce the construction time and reduce the spending on operation and overhead cost. BIM also improves the process of construction, project documents and the relationship between clients and architects.

On the other hand, BIM has its flaws. People barriers are discussed. For instance, the results of questionnaire show that lots of people do not want to learn how to operate BIM, or they may think current design technology is enough for them to design the projects.

The prospect of BIM is optimistic by the architects. Al-though few companies are using BIM, most people are aware of them and show an interest in BIM. Some companies also claim that they will adopt BIM within 3 years. In the future, BIM will encompass more accurate data about the project. It will be easier to operate, will be able to manage and integrate all the project documents, and will be able to adapt to the rapidly changing built environment.

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