

Barriers Analysis to Effective Implementation of BIM in the Construction Industry

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Abstract

Building Information Modeling (BIM) as a new method presents a number of opportunities and challenges for the architectural, engineering and construction (AEC) industry. Obviously, there are many issues in the way of implementing BIM. Some of these issues have been largely eliminated over time and by the advancement of related technologies; however, various issues are emerging when dealing with the details of BIM implementation. Contract and legal barriers, cultural problems, management system, and economic and security issues are the most important challenges against implementing this technology. In order to bridge the gap between researchers and practitioners, this paper aims to summarize available information related to the implementation of BIM in the construction industry (about 47 papers) and its related barriers. This research focuses on the most repetitive challenges and barriers that have been more fundamental than the rest and other related issues have been ignored. Distribution of these barriers and challenges is different from region to region. Finally, challenges, which need to be addressed before we can fully benefit from BIM, are highlighted

Keywords –

Building Information Modeling (BIM); Challenges; Implementation barriers

1 Introduction

Building Information Modeling (BIM) as a new method presents a number of opportunities and challenges for the architectural, engineering and construction (AEC) industry. BIM is an evolution of the computer-aided design (CAD) system, which provides more intelligence and interoperable information and is named as project modeling, virtual building, virtual design, construction and finally nD modeling [1]. BIM is also unequivocally a tool of collaboration.

Collaboration in the design and construction decreases design mistakes and increases the productivity of the construction industry [2].

Contract and legal barriers, cultural problems, management system, and economic and security issues are the most important challenges toward implementing BIM. Understanding the challenges ahead in implementing BIM is the first step in finding a solution for them [3]. Therefore, this article attempts to present a statistical report of worldwide problems and obstacles that have been linked to the implementation of BIM by studying the articles published in the past decade, and then presents the most important challenges..

Obviously, there are many issues in the way of implementing BIM. Some of these issues have been largely eliminated over time and by the advancement of related technologies whereas various other issues are emerging when dealing with the details of implementing BIM. The focus of this research is on the most repetitive challenges and barriers that have been more fundamental than the rest, and other related issues have been ignored.

2 BIM History

The early concept of BIM dates back to the 1970s and 1980s when the computer-aided design (CAD) was introduced [4]. The creation of the ArchiCAD software in Hungary in 1982 is the real beginning of BIM, and Revit software in 2000 is considered a major turning point in the implementation of BIM [5]. Given that about two decades have passed since the advent of BIM, its implementation in the construction industry has been relatively slow in comparison to other industries, such as manufacturing and engineering industries [6]. However, in the last few years, there has been a lot of advancement in the technology and implementation of BIM, and the construction industry has realized that it can take advantage of using this technology. A brief history of BIM is given in Fig. 1.

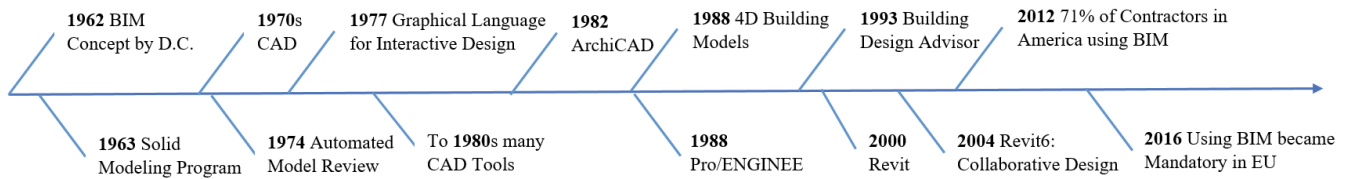


Figure 1. The History line of BIM

Many studies have been conducted to examine BIM implementation issues, which often emphasize the positive impacts of its implementation on the construction industry. Research has shown that major changes have taken place since the launch of BIM, and in recent years, the use of BIM has increased dramatically. In North America, the use of BIM by contractors has increased from about 28% in 2007 to more than 70% in 2012 [7]

Recent surveys also show that BIM implementation is accelerating in leading countries such as the United States and the United Kingdom, as well as in new adapter countries such as Brazil and Australia; more government and private owners want to recognize its benefits [1].

The EU made an important decision in 2014. Accordingly, 28 EU Member States may encourage, specify or mandate the use of BIM in public projects from 2016 onwards [8]. Until now, the United Kingdom, Denmark, Netherlands, Norway and Finland considered it necessary to use BIM in publicly funded projects. The first step in achieving the BIM utopia is to recognize the barriers and challenges of implementing it [1].

3 BIM Implementation Challenges

Despite the great benefits of BIM, there is still no clear strategy for its widespread use in the future. [9]. There exist vast variety of classifications in different studies with regard to barriers against implementing BIM .

After reviewing over 100 studies and selecting 47 final papers that were more related to this subject, five major problems in BIM implementation are divided by location listed in Fig. 2.

The USA with 19 papers and the UK with nine papers are the top countries working on issues related to BIM implementation. The map point of origins of the articles is shown in Fig. 3. Accordingly, 62% of the articles are from journals and 38% are collected from conference proceedings. Fig. 4 shows the distribution of the reviewed articles by year of publication.

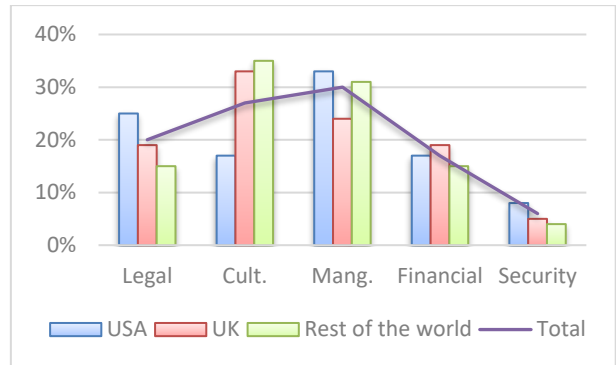


Figure 2. Distribution of BIM implementation Challenges



Figure 3. Map point: origins of reviewed articles

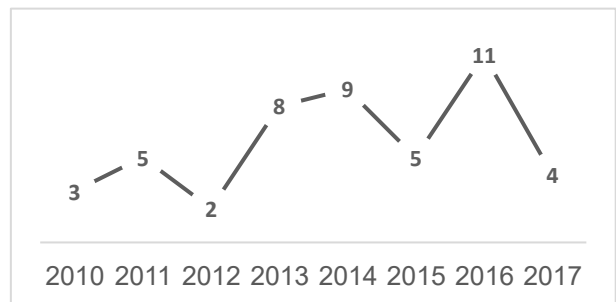


Figure 4. Distribution of reviewed articles by year of publication

Major issues according to the author's opinions and frequency of appearances on articles are management (30%), cultural (27%), legal (20%), financial (17%) and security issues (6%).

However, in the USA, arrange of barriers is slightly different from the world. Accordingly, issues related to management are first, but legal issues are more important than cultural and financial aspects of BIM implementation..

The UK is known as the leader of implementing BIM in the world. The most common problem in the UK is cultural-related issues, followed by the management, legal and financial problems.

If we ignore the papers from the USA and the UK, in the rest of the world, main barriers are related to cultural, management, financial, legal and security issues. Problems related to security appear only in a few articles; however, authors believe that this challenge is one of the major challenges in the future. The second point from this chart is that the order of problems is similar to that in the UK.

A short review of five more important issues is collected. Order of subjects is according to authors' opinions on the importance of subjects and different from the frequency of appearances on the articles.

Table 1. Literature on BIM implementation barriers

Challenges	Articles
Legal	[1],[10],[11],[12],[13],[14],[7],[15],[16],[17],[18],[19],[20],[21]
Cultural	[22],[23],[2],[24],[10],[11],[12],[13],[25],[8],[16],[26],[17],[27],[28],[29],[30]
Management	[31],[1],[32],[12],[33],[15],[34],[35],[36],[17],[37],[38],[39],[40],[41]
Financial	[22],[11],[12],[13],[42],[25],[38],[19],[43],[44],[41],[45],[20],[46]
Security	[22],[9],[7],[44],[18]

3.1 Legal and Contractual Issues

Despite the fact that BIM technical issues have been highly considered in recent years and considerable energy has been spent on these areas, “maturity of the legal body of BIM as well as its contractual configuration is more unsophisticated than its technical aspects. [18]” This weakness has a special effect on contractual terms and there is a challenge that limits the responsibilities of legal issues related to BIM implementation. Therefore, an appropriate substrate for implementing BIM in contract clauses of projects should be created or added.

3.1.1 Legal issues

In addition to technical barriers, resistance to changes in employment patterns and the need for education and training on the path toward implementing BIM in the industry, legal issues are the most neglected

challenges against BIM implementation. These legal problems are generally due to:

1. Liability issues: Legal liabilities are due to the multiple number of stakeholders contributing to the model and/or dependent on the precision and quality of the data in the model [1]. Moreover, fraction of sufficient legal structure for managing owners' comment in design, construction and installation is one of them [11].
2. The need for regulations: Executive regulations in this regard and their coordination at international level to create a common language, reduce conflicts and create a clear path to resolving the dispute are essential.
3. Intellectual property rights: Because BIM models can be easily extracted and copied, intellectual property rights are determinative in BIM implementation [18]. For example, a BIM protocol may need a higher price intellectual property licensing than that procured under traditional contracts [9] For intellectual property rights in contracts, these provisions are important: model ownership, copyrights, authorized and unauthorized uses of models and e-documents, and the level of exposure of the special trade information.

3.1.2 Contractual Issues

Poor contractual agreements in addition to failing to implement BIM may pose a significant risk to the success of the entire project. BIM contractual language must deal with two important risk categories, including:

1. BIM behavioural risks: Which may include collaboration issues, efficiency level of coordination, and collaborative information development..
2. Issues in BIM technological aspects: Arise in forms of information reliability, model accuracy, model management and maintenance, and model ownership.

BIM contractual provisions refer to levels of BIM maturity, which, in higher maturity level contract, should address more issues and more details on BIM implementation. This is because responsibilities, relationships, interactions, and technologies are different at each maturity level [18].

Thus, to avoid arguments concerning BIM responsibilities, limitations and liabilities, a new form of contract/amendment should be implemented. This would cover all the parties directly involved or any other party that may be affected by BIM working method. On the other hand, BIM protocols should be developed by taking into account legal issues, which could be used as an emendation to the main contract to

make it adequate for BIM [9].

A recent survey in the AEC industry revealed that approximately 40% of the professional BIM users are unaware of BIM standard forms of contract. This shows that many projects have incorporated custom manuscripts in their contracts [18].

In addition to the amendments, which are intended as a text to improve and correct the main agreement, an addendum is an informational or explanatory note of the requirements of the parties concerned, which has not been specified in the main contract document. Thus, BIM has entered into some of the contracts that have been produced in recent years in format of specific BIM addenda to contracts. Those addenda have the purpose of defining the scope of BIM for facilities designed and constructed for each owner. Owners such as the United States Army Corps of Engineers (USACE), Pennsylvania State University, and the United States Air Force Centre for Engineering and the Environment have developed their own BIM addenda, some of which are used with a whole package of other documents aiming to optimize and ensure the successful implementation of BIM. Those efforts subscribe to the goal of overcoming the challenges that have accompanied BIM use.

In addition to the owners mentioned above, two industry leaders, AIA and AGC, have developed BIM contracting standard forms to address BIM contracting requirements. These include Consensus DOCS 301: BIM Addendum: Building Information Modeling Protocol Exhibit [18].

3.2 Cultural Issues

In general, about 30% of the total number of articles studied in this project referred to cultural problems. Cultural problems are the background of other problems and by solving them, a great step can be taken to solve the problems of implementing BIM.

Cultural problems include many aspects and the most important ones are resistance to change, lack of cooperation between project stakeholders, and the absence of the real BIM-based sample.

3.2.1 Resistance to Change

Actually, only small fractions of companies are aware of BIM and are using this technology to benefit their own projects. While other companies do not have experience in this field and carry out their own projects traditionally as they are unwilling to use BIM technology. These companies believe that BIM is an underdeveloped technology with limited capabilities; they also feel that using BIM is very complicated and thus it is best to do their own projects using non-BIM tools.

The lack of knowledge and education is another

factor; engineers and companies are doubtful about learning BIMs concept and they believe that it is costly to train their employees in this regard.

In addition, the lack of knowledge and trained staff as well as inability to persuade other stakeholders to handle BIM implementation costs is among other issues that makes it difficult for individuals to carry out their projects using non-traditional methods.

3.2.2 Lack of Cooperation between Project Elements

In the success of BIM-based projects, there are many people involved; the collaboration and reflection of the project team can help ensure the success of the project, rather than discussing the goals that contribute to the success of the project. Lack of cooperation from any of the stakeholders can cause serious damage to the entire project. In general, BIM implementation in construction projects requires more collaborative and integrated delivery of the project.

3.2.3 Absence of a Real-World BIM-Based Sample

Another approach to persuading stakeholders to use BIM technology is the availability of run-time examples of projects implemented using BIM technology. If project stakeholders and companies visit a real sample of BIM-based project, they are more willing to do their projects using BIM technology.

By organizing several meeting sessions with activists in the AEC and introducing BIM technology and its benefits along with showing a real BIM-based sample, they can be familiar with BIM concept and its advantages. To this end, catalogues that briefly introduce BIM and its benefits are published and presented in the building industry exhibitions; moreover, experts are invited to these exhibitions to provide explanations and answers to questions. It is also possible to add a course to the university curriculum and invite BIM experts to train students in BIM area and related software. Companies and organizations can also arrange classes for their employees to become familiar with BIM technology. Moreover, BIM experts could be asked to prepare educational videos for teaching BIM software. Because BIM-based projects require teamwork, before the start of the project, it is necessary for one of the specialties to be selected as the head of the group and clearly describes the responsibilities and duties of all the team members. It is also necessary to control the work of all the members to guarantee a collaborative work.

3.3 Management

There is much debate on the benefits of implementing BIM. This improvement surely will make

the project managers more likely to be happy since BIM helps managers reduce their concerns in the following areas:

1. "Complexity of infrastructure development projects needs strong project management for (a) a multidisciplinary management system (s) to support decision making and (b) to motivate many practitioners involved in the design process" [47].
2. The role of information in the management of the design phase workflow [47].
3. Knowledge management for better risk management: One of the principles of risk management in the project is that all the team members must contribute to the risk database in different phases of the project. It is complicated to manage these databases with traditional methods [41].
4. Based on the main failures identified, and compared to international standards, cost management is one of the main categories, arising as the most recurrent issue [41].

In addition to the above, there are plenty of other things that cannot be considered here. With BIM, project management is better to be performed in these areas, and its quality becomes better through using less energy. However, to reach this point, the project manager should face the following challenge:

1. Need to upgrade the communication platform: Vital communication is more than ever before; it puts new risks on the project.
2. The complexity of team building in this new environment: The performance of virtual teams requires their own techniques, which usually require managers to master their skills. It should be recalled that in the last 40 years, the productivity of human resource in the construction industry has been less than productivity in the non-farm industry. Therefore, the use of experiences and other techniques of the basins (e.g., IT) is remarkable in this regard. The third party as BIM implementation manager can help in this category, since specific professions will have synergy with the project team members [26].
3. Challenges are caused by longer project engineering time, especially in EPC projects, where its nature is the integration of the stages of engineering and construction. Justifying the expectation of completing the model and engineering will be to some extent difficult.
4. Considering the production of the visual model: Stakeholders seem to be more willing to comment. Since prioritization is different from each stakeholder's point of view, their summing up in stakeholder management processes sometimes will

be more challenging.

However, due to the benefits and facilities BIM provides for project managers, it is justifiable to spend energy on overcoming the above problems. However, overcoming the above problems and other challenges mentioned in this article, especially EEFs, In practice, the implementation of BIM in projects has encountered obstacles. What is certain is that after the transition period has passed and BIM has been stabilized in future projects, one of the most beneficial stakeholders in this implementation will be project managers.

3.4 Financial Issues

Financial and investment issues are the determining factors in any project. These issues become more important during emerging BIM technology. As mentioned in the "cultural" section, the lack of a real and complete implementation of the model creates many doubts for investors and stakeholders. There are two main questions in this area, which will be answered in this section: 1- Is it reasonable to have a high initial investment to equip the company with BIM technology? 2- What is the rate of return on investment?

Implementing any new technology requires an initial investment. Most of the investment required to implement BIM is spent on purchasing software, hardware, personnel training, and recruiting specialized staff. The main challenge is to justify and explain these costs to project stakeholders. In 2012, equipping each workstation with BIM technology costed about 10,000 pounds. One point to note is whether this cost is estimated at project cost or considered as part of a larger process. These costs are only seen as purchases of software and personnel training, or as part of a business change process. The answer to these questions can greatly justify the initial investment [25].

The return on investment (ROI) is one of the main concerns of investors. Analysis of the ROI is one of the ways to evaluate the investment; $ROI = \text{earning}/\text{cost}$. According to the survey, 48% revealed average or higher ROI. In one study, BIM ROI was measured in 10 different projects, varying from 140% up to 39900%. An average of 1630% for all projects and 640% for projects without a value analysis phase were obtained. Although ROI values are very different and the way to calculate the savings is different for each project, it is shown that implementing BIM has a large impact on reducing costs. The actual BIM ROI can also be much larger than reported [19].

3.5 Security

Reputable organizations in the world predict that in 2019, cybercrime and information theft will cost \$ 2 trillion to the world economy. This figure has been

rising for years to come and will be up to \$ 6 trillion by 2021. The goals of a cyber-war are not limited to military complexes and installations and public and private financial and economic activities are also important goals.

The lack of proper civil law for cybercrime results in the ineffectiveness of international law in this area. Among the examples of these weaknesses, one can disrupt the electricity grid of Ukraine, hack the National Committee of the Democratic Party and the NSA, hack Taiwan and Philippines Government Networks, and attack on Russian banks, which is worth mentioning.

Cyber threats are not just about governments; individuals and companies are also threatened by these attacks. Since BIM is a shared knowledge centre for information about a facility creating an important basis for decisions during its product life cycle” [7]. Therefore, the feature of its being shared in the network context has led to security risks have been taken into account since the beginning of research on BIM implementation [44].

Now it can be even said that one of the main challenges facing the BIM adoption and implementation is the security challenge. Because parties' agreement on model access, software, security, information, archiving, transmitting, etc., is different, the safety of the model has always been and will be sensitive [9]. These security challenges arise from the following:

Intellectual property [9]- Since models can be easily transmitted, extracted, and reused (in whole or in parts) [18].

Cyber security of BIM tool outcomes As information sharing makes project data accessible to team members, cyber security is a concern due to the possibility of online unauthorized access and copyright infringement [9]. Data security is essential to avoid snooping, theft, virus and worms, and hacking [18]. One of the major challenges in BIM implementation at the AEC industry in the UK is security issues [22].

Clearly, solving this issue is beyond BIM control. As stated above, cyber security is a global challenge; however, it should be considered as one of the main challenges facing the implementation of BIM. Since there are fewer projects, all stakeholders do not have the same sensitivity to the information leakage. Therefore, solving the cyber security problem is crucial for the development of BIM implementation.

4 Discussion

In the previous section, we were acquainted with BIM implementation problems. This familiarization helps to better understand the subject and find the right path and think of the necessary arrangements for implementing BIM. The five categories of problems

identified in the section 3 are fundamental issues, today. However, familiarity with problems that have been solved over time or problems that will arise in the future will be needed to implement BIM.

4.1 Challenges Resolved over Time

It seems that problems related to the software issues were largely resolved. In the early papers (early 2010), widespread mention was made of technical problems, especially software problems; Problems such as the lack of single software, lack of coordination between the software used in different sectors, and lack of a single standard for software output. However, today, with the advances in software, the standard definition of the unit and the acceptable coordination between different softwares have been largely resolved.

4.2 Future Challenges

Problems that will emerge in the future on BIM implementation path will be mainly contractual and security issues. Both the issues have been discussed in detail in Section 3. However, in short, the successful implementation of BIM requires new contractual types. IPD contracts may be a way out of this turbulent path.

Making secure information in BIM also requires defining a new protocol security. Defining and limiting access to various levels of software and clouds is an interdisciplinary field that requires more research.

5 Conclusion

This article introduces BIM implementation issues. Five fundamental issues including managerial, cultural, financial, legal, and security issues were fully introduced in this paper. By knowing more about the issues of the day, better solutions could be found. In general, from the discussed issues, it can be concluded that many problems would be resolved over time by providing more real world examples. In addition, project stakeholders will invest on BIM with low risk. In addition, the support and guidance of governments as well as the mandatory use of BIM in specific projects will increase the speed of BIM implementation. Although software problems have been largely resolved, there is still a need for more secure software. The reason is that the construction industry compared to other industries is less advanced in the automation sector. However, the need to use modern tools like BIM is increasingly understood. The path to outdo other competitors in this competitive market is BIM implementation.

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