

Challenges with BIM Implementation: A Review of Literature

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BIM is an innovative concept for the majority of firms operating in the AEC industry. BIM offers a new paradigm to design, construct, operate, and maintain a facility. However, even with the most conscientious use, stakeholders can run into trouble during its implementation on a project or within an organization. At times, project stakeholders are unaware of the challenges that they can face with the implementation at the project level or an organizational level. Therefore, the study aimed to identify and compile barriers associated with the BIM implementation at the project and organizational level, as per the literature. The study used two staged content analysis methods. Thirty-six challenges with BIM implementation were identified, and the majority of the barriers could be associated with the organization/ adopting unit. The researchers also found that the most of the commonly identified challenges dealt with the training of employees, lack of national standards for BIM in the US, and interoperability of the software. The study provides design and construction companies that either possess low BIM maturity or are yet to adopt BIM the ability to prioritize challenges and respond to them appropriately while creating the BIM implementation plan. One of the future researchers can aim towards conducting a severity analysis for the identified factors with regard to the design and construction industry.

Keywords: Building Information Modeling (BIM) barriers, Challenges with BIM Adoption and Implementation, BIM adoption on Projects

Introduction and Background

Multiple stakeholders have defined Building Information Modelling (BIM) in different ways (AGC 2007; Azhar 2008), and most of the definitions define the functions and benefits offered by it to the adopting/implementing unit. Azhar (2011) defines BIM as "*A model that characterizes the geometry, spatial relationships, geographic information, quantities, and properties of building elements, cost estimates, material inventories, and project schedule*." Along with the use of BIM as a product that results in the creation of a three-dimensional data-rich model, use of BIM can also lead to *process improvements* that not only fosters collaboration and trust among project stakeholders, but also results in work processes that are lean, efficient, and accurate. This viewpoint is supported by the BIM definition established by Autodesk (2009) which defines BIM as *"An integrated process built on coordinated reliable information about a project from the design through construction and operations."* Finally, BIM adoption/implementation can result in the creation of a paradigm where the technological advancements of software used to create object-oriented data-rich models are integrated into business functions that can potentially lead to the creation of a Strategic Business Unit (SBU) for the organization. Given the levels at which BIM can be utilized (*project, organization, creation of a specialized business unit, and others*), the stakeholders that it can assist, and various functions and benefits offered to each stakeholder, it would be safe to state that the Architecture Engineering and Construction (AEC) industry is receptive to its adoption/implementation.

Various studies across the globe have identified that BIM adoption and implementation among major stakeholders (architects, contractors, owners, and engineers) across the globe have increased over the years (Ku and Taibet 2011; Langar and Pearce 2014, Luthra 2010; Ku and Taibet 2011; McGraw Hill 2009; McGraw Hill 2010). This continuous increase in adoption and implementation by the associated stakeholders can be attributed to a multitude of benefits realized by the stakeholders it serves. Given the multiple contexts within which the tools can be utilized, it is found that the tool also offers stakeholder specific benefits. For example, Ku and Taibet (2011) identified seventeen BIM functions that can be utilized by General Contractors whereas Langar and Pearce (2016) identified eighteen such BIM functions for Designers. Comparing the functions identified by the two studies, it is safe to state that half of BIM functions were mutually exclusive and can be associated with specific professionals, thus, indicating that BIM functions specifically caters to the need of adopting stakeholder specialization, at times project, and other attributes. In addition, BIM adopters can realize a multitude of benefits with its adoption. For example, BIM adoption and implementation at an organizational level can result in enhanced efficiency and reduction of errors and de-duplication of tasks because of the ability to foster greater collaboration between project stakeholders (Glick and Guggemos, 2009) and departments, to integrate building systems, resolve conflicts and software interoperability. Further, BIM adoption at the organizational level can result in a positive return on the investment mostly generated through savings reduced project costs (Azhar, 2011). At the project level, the use of software associated with BIM has the ability to enhance project sustainability, contribute towards project sustainability certification goals (Azhar et al. 2008; Siddiqui et al. 2009), improve visualization (Langar and Pearce 2014), reduce waste, detect clashes, prefabricate, systems coordination, widening the search for solutions, and integrated decision making (Campbell 2007; Staub and Khanzode 2007; Korkmaz et al. 2010).

Given the benefits, one might assume that BIM implementation should be a top priority for the firms, implemented on all/most projects, heavily supported by owners of all project types, and improve project efficiencies considerably. However, that is not the case. Multiple barriers still exist. For example, interoperability is identified as one of the major benefits associated with BIM implementation. Interoperability is defined as the ability of the software/computer system to exchange information from one platform to another without losing any information. Interoperability among software systems allows multiple project stakeholders to collaborate as project details and information is refined, updated, and evolved. This allows assistance for design problems and changes the workflow resulting in fewer errors (Azhar 2011), reduces task redundancy, enhances efficiency, and allows stakeholders to spend more time on analyzing the data than re-creating it. However, one of the biggest challenges to interoperability comes from the economy within which we operate. On the one hand, the presence of multiple software vendors promotes innovation, market competition, and lower software costs; at the same time, it also creates issues that might be tough to resolve, particularly regarding interoperability. Given the multitude of software companies existing in today's market, there is a greater possibility that a lot of the software is not compatible with each other unless the same organization made it. Also, there are instances where that data has been lost in the process of transfer (Tulenheimo 2015). The probability of stakeholders using different software is also high, given the project contextual, industry diversity, and stakeholder software preference. Further, there is a likelihood that project stakeholders are unfamiliar with its benefits or unaware of the protocols about the information transfer, thereby rendering software interoperability unusable (Migilinskasa et al. 2013). Also, time and money can be saved by incorporating BIM's parameters, efficient processes, and multi-functional tools but requires a substantial initial investment. These early investments include the time and cost of training and hiring employees to use BIM and the software associated with it, and the need for complementing software and better hardware (Tulenheim 2015). Apart from the list barriers, constant learning required on the part of employees can impact the organization productivity. The availability of such resources (time and money) might be implausible for smaller/newer firms, thereby resulting in organizations that might be passive to BIM adoption (Migilinskasa et al. 2013). In addition, with the use of BIM another potential concern among stakeholders, especially the general contractor, is the model editing authority when multiple stakeholders expect to participate in the creation and development of the model, thus creating a concern for legal, contractual, and responsible means, especially when multiple stakeholders are constantly developing/editing

the project model. In such a scenario, it is tough to ensure that there is no mistake(s) and in case there are, identify the responsible stakeholder. Further, management of the model during the project duration can be a concern. Apart from public projects, model ownership can also be an issue that needs to be addressed at the beginning of the project.

Thus, to synthesize, BIM is an innovative concept for the majority of firms operating in the AEC industry. BIM offers a new paradigm to design, construct, operate, and maintain a facility. However, even with the most conscientious use, stakeholders can run into trouble during its implementation on a project or within an organization. At times, project stakeholders are unaware of the challenges that they can face with the implementation at the project level or an organizational level. Therefore, the study aimed to identify and compile all challenges/barriers associated with the BIM implementation at the project and organizational level, as per the literature.

Methodology

The aim of the study was to offer a compiled repository of challenges associated with BIM implementation, as per literature. Therefore, for the study, the content analysis method was utilized. As per literature, content analysis is a flexible method that can be utilized towards analyzing text data and has been used for an extended period (Hsieh and Shannon 2005). For this study, a two-step process was associated with the content analysis method. In the first step, keywords were identified along with the search engine. For this study, the keywords utilized during the search were BIM barriers, challenges, implementation, and issues. With the help of keywords, the authors were able to identify an initial pool of approximately 50 publications. These publications were reviewed at a superficial level to determine if the study contributed towards the objectives of the study. If it did, the authors moved the study to the second stage, if the study did not meet the objective, it was deleted from the list. This process of elimination enabled authors to shortlist the initially identified publications for detailed review, and the final number of publications that were moved to the second stage was about fifteen.

In the second phase, the shortlisted fifteen publications were thoroughly reviewed and every time a challenge was identified, it was noted in an excel file and allocated a point. If an identified challenge was repeated, additional points were allocated. After the review of all shortlisted publications, a compiled list of challenges associated with BIM implementation on projects and within an organization was identified. In addition, the researchers were also able to identify the most cited challenge associated with BIM implementation, as per the literature. After compiling and identifying the importance of each challenge related to BIM implementation, the list of compiled challenges was subjected to a constrained pile sort. Constrained pile sort allowed researchers to sort identified challenges into certain categories. The three categories for the study were the applicability of the identified challenge to project, organization, or both. The researcher had one opportunity to map each challenge onto the category that could be associated with the most (*project specific, organization specific, or both*). After completing the pile sort, an analysis of the sort was conducted to identify the convergence of the sort. Therefore at the end of this phase, the authors were able to determine a comprehensive list of challenges impacting BIM implementation and then associate each challenge to earlier established categories.

Results

After the review of fifteen shortlisted publication, it was found that academicians authored approximately 60% of the reviewed and analyzed publications, whereas industry professionals authored the remaining 40%. Also, the literature reviews were used to identify the BIM challenges from across the globe. The studies analyzed BIM challenges in the countries of the US, Finland, Australia, England, United Kingdom, and Lithuania. Five percent of the studies had a global scope, and about 20% of the studies did not present barriers to a specific region.

In addition, the study presented 36 obstacles that impacted BIM implementation on projects and within an organization. Of those 36 obstacles, 44.4% (16 barriers) of the obstacles were associated with an organization, and 27.8% (10 barriers) were associated with a project, and 27.8% (10 barriers) of the obstacles were associated with both the organization and the project. Therefore, indicating that as per the literature, most of the barriers to BIM implementation were associated at an organizational level. Also, of the 36 barriers identified, the three most commonly identified barriers as per the literature were "*Time needed for hiring/training people to use BIM, Cost of hiring or training people to use BIM,* and *No official standard or process to evaluate the use of BIM*." All of the top three barriers were associated with the organization as per the applicability of the challenge. Lastly, the three least commonly identified barriers as per the literature were "*More time needed to send and receive back files between stakeholders, Fear of the unknowns of BIM will lead to failure, and Some believe BIM is not suitable for their projects.*" Two of the three least commonly identified barriers as per the literature were perception based. All of the least three barriers were equally distributed between the organization, project and both (Organization and Project) as per the applicability of the challenge.

Table 1

BIM Implementation Challenges and its association with Project, Organization, or both.

Challenges	**Importance**	**Challenge Applicability**		
	Based on repetition	*Organization*	*Project*	*Organization and Project*
Time needed for hiring/training people to use BIM	9	1		
Cost of hiring or training people to use BIM	8	1		
No official standard or process to evaluate the use of BIM	8	1		
Copyright protection for ownership of data	7		1	
Determining who owns data/ components used	7		1	
Reference to legal or contract issues	7		1	
Who is responsible for/ manages data entry	6		1	
Cost of hardware	6	1		
Compatibility issues between Software	6			1
Who is responsible for inaccuracies and errors	5			1
Software license and update cost	5	1		
Lack of businesses desire to change to BIM processes/ or against change	5	1		
Require competent quality hardware	4	1		
Who is responsible for maintaining and updating model	3		1	
Difficult to determine when and who made what error	3		1	
Complexity of BIM	3			1
Requires more time for high detail model for stakeholders	3		1	
Customers do not know how to use BIM models/ do not implement	3			1
No standard for Contractual BIM document	2			1

Who is allowed access and use of the BIM info/ product	2		1	
Insurance carriers have no policy to insure for aspects BIM	2		1	
Appropriate/efficiently trained staff	2	1		
Ability to use multiple software	2	1		
Information lost between different software	2			1
Small businesses lack the resources to implement BIM fully	2	1		
How will new tasks/ responsibilities affect rate of pay	1	1		
Will licensed professionals still stamp documents if there are multi-contributors?	1			1
Issues for collaborating with multiple Stakeholders	1	1		
A lot of projects available do not have other stakeholders using BIM	1	1		
Architects are fine with the traditional method/ what they have now is good enough	1	1		
Don't know of BIM, or don't know enough	1	1		
Lack of case study evidence of the financial benefit of BIM	1			1
BIM is a waste of time and resources	1			1
More time needed to send and receive back files between stakeholders	1		1	
Fear of the unknowns of BIM will lead to failure	1	1		
Some believe BIM is not suitable for their projects	1			1
Total		16	10	10
Percentage impacting specific area		**44.4%**	**27.8%**	**27.8%**

Conclusion and Discussion

The study aimed to identify barriers associated with BIM adoption, after a thorough review of the literature. After analyzing the various research publications, the study was able to determine 36 barriers that influence BIM implementation. Most of the challenges, including the ones most commonly established in the literature, were determined at the organization level. This indicates that companies have to overcome higher resistance regarding BIM implementation than projects. Most of the significant barriers dealt with the training of employees, lack of national standards for BIM in the US, management of data, and interoperability of the software. If these barriers are not tackled at the earliest by various public and private entities associated with the construction industry, there is a high probability that these obstacles could start impacting at the project levels and the overall BIM adoption within the industry. In addition, two of the three most commonly identified barriers "*Time needed for hiring/training people to use BIM, and Cost of hiring or training people to use BIM"* dealt with economic conditions of the company and its ability to invest in maintaining innovativeness and competitiveness. These two barriers can be crucial for small and medium sized design and construction companies.

The study provides design and construction companies that either possess low BIM maturity or are yet to adopt BIM the ability to identify and prioritize challenges. In doing so, the companies can then respond appropriately to each of the identified challenges while creating the BIM implementation plan. Also, this study emphasizes the need for software that is interoperable as one of the important aspects of continued BIM implementation within the industry. Future research also needs to be conducted to ascertain the severity of the identified challenges from the perspective of stakeholders such as design firms, construction firms, owners and others. This analysis is important as each of the identified challenges can be perceived differently by each stakeholder, regarding the severity. Therefore, a severity analysis of the identified challenges from stakeholder perspective is recommended, in the future. Researchers also believe that each of these barriers can be grouped into broader categories, such as interoperability, education, hiring, technology, legal issues, and others to identify groups that encompass maximum challenges. Furthermore, the researchers expect that in the course of time due to technological advancements some of the problems might be eliminated. Moreover, the need for a constant update of the challenges associated with BIM implementation at the project and organizational level is deemed essential.

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