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Factors Affecting as Barrier for Adaptation of Building Information Modelling in Architecture Practice in Bangladesh

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Abstract

In practice worldwide, the concept and technology of Building Information Modeling (BIM) have been applied, and the great benefits of BIM applications are being increasingly discovered in architecture practice. Despite the global adoption of BIM, the application of BIM in Bangladesh lags far behind its capacity due to the presence of multiple obstacles. This paper aims at identifying, classifying, and prioritizing these barriers by conducting a correlational research approach. In this context, this paper will identify that the Stakeholders particularly the architectural firms remain unaware of the benefits of BIM which results in a lower adaptation. Besides, the paper established that BIM's awareness in the University syllabus will increase its adaptation in practice. It was quite expected from this study that this would help to understand the value of BIM and its implementation barriers in architecture practice, with the extent to find out future directions can be suggested to nourish the effective use of BIM.

Keywords: Architecture practice Bangladesh; Building Information Modelling; BIM adaption; Barrier of BIM.

I. Introduction

Due to the extreme advancement of computer science, many sectors have undergone drastic shifts since the very beginning of the 21st century. The increased use of information technology, which often affected improvements in their structure and workplace processes, maybe due to businesses improving efficiency (Chan, 2019). On the opposite, in terms of productivity, coherence, performance standards, and sustainability, the building construction industry, which is perceived to be one of the world's biggest sectors, is also dawdling. The National Research Council (NRC) points out that Building Information Modeling (BIM) is not only the main approach but also the most auspicious choice for enhancing the consistency, cost-effectiveness, efficiency, and sustainability of building projects.

From the Succar point of view, Building Information Modeling (BIM) is a "Computer-Aided Design (CAD) paradigm" that generates "a set of interacting policies, processes, and technologies that generate a methodology for managing the vital building design and project data in digital format throughout the life cycle of the building" (Succar, 2012). It is an intelligent computer-based 3D modeling program for architects, construction professionals, and engineers that provides insight and tools to more efficient in buildings and infrastructure concerning planning, designing, construction, and managing (Rakib, 2018)

BIM technology has a variety of direct and indirect benefits and makes the whole design and development process more streamlined and straightforward in many respects (Jung, W., and Lee, G., 2015). With the aid of BIM technologies, almost 40 percent of the unbudgeted expense is reduced and the time to project completion to the client without any significant disagreement is reduced by 7 percent and approximately 80 percent (S. Azhar, 2011) Moreover, this program can create, coordinate, document, manage/operate the specific facility of a building as well as it can also asset the life cycle of that particular building. (AGC, 2005) Many Governments have taken strategies to implantation of BIM in building construction resulting in the widespread adoption of BIM (Clevenger, C. M. *et al*., 2010) for instance in Singapore adaptation increases in the years 2009, 2012, 2014 were 20%, 32%and 65%, respectively (Qian, 2012). A similar overview can be found in Finland and Denmark about 93% and

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65% of design firms utilizing the BIM platform respectively. (Kiviniemi, M. *et al*., 2011) In a review of 2009, a similar adaption of BIM was seen in UK, USA, and Australian design firms (Wong, 2009).

From the opinions of Shakill (2018) and Hussain (2019), though having the tremendous benefits of BIM, the rate of implementation of BIM within the AEC industry has been at a slow tempo in developing countries. A good number of reasons leading to this dilemma are recognized, such as social and habitual aversion to reform, conventional procurement practices, preparation expenditures, costly learning curve, high software buying costs, higher authority, and complete support for decision-makers, and lack of knowledge of BIM, and so on.

Although there is a growing shift that can be seen in the outside world from traditional 2D CAD-based design to nD BIM-based design, the adoption of BIM in Bangladesh comparatively low. (Rakib, 2018). Yet, there is not sufficient study to find out the factors that act as barriers to BIM adaption in architectural practice, Bangladesh. But the adaptation of BIM can contribute to many aspects.

In Bangladesh, the construction industry has contributed 7.88 percent of GDP to the national economy. As the safety of the workplace has been very volatile in recent years, the most unsafe industry has been established (Ahmed, Islam, et al. 2018). Protection standards for jobs are a vital need, according to the Bangladesh National Building Code (BNBC, 2006) and the Bangladesh Labor Acts (BLA, 2006). It is possible to enhance the reliability and applicability of the safety track and mitigate safety-related issues using BIM technologies 2019. (Hossain, M. M., and Ahmed, S., 2019).

Communication between designer and contractor/subcontractor has been a challenge in the Bangladeshi construction industry (Rashid, 2014). BIM is the platform to share knowledge and communicate the separate necessities of all project participants (Succar, 2012). By implementing BIM, the question of lack of coordination between the designers and the subcontractor will easily be overcome (Rashid, 2014).

Another recurrent problem in Bangladesh is wrong estimation or budgeting. (Rashid, 2014) BIM can overcome this very easily by generating a pretty accurate estimation (Jung, W. and Lee, G., 2015)

It is always the case in Bangladesh that these contractors struggle to grasp broad CAD concept sheets. In this scenario, owing to the difficulty of estimating back to the manufacturer, the more frightening aspect is that the contractors tend to use their tacit information acquired by experience. BIM plays an important part here (Haque, 2014). Contractors should engage and have visual aids to inform them clearly what needs to be achieved and how it needs to be done. (Rashid, 2014) Besides, BIM implementation is projected to bring about a new way of working and thought in Bangladesh's construction industry (Shakil, 2018).

The purpose of the study was to examine the factors which acted as a barrier in BIM adaption in the architectural practice, Bangladesh as well as find out a way of successful BIM adaptation. It was quite expected from this study that this would help to understand the value of BIM and its implementation barriers in architecture practice, with the extent to find out future directions can be suggested to nourish the effective use of BIM.

II. Literature Review

To understand the depth of the problem, the literature review of this study was divided into two parts. The first part addressed the barrier of the BIM adaptation and the second part contained references and examples of successful BIM adaptation.

It was prominent from the literature analysis that the introduction of BIM in the construction industry was limited by many obstacles, such as lack of a national standard; high costs of the application; lack of qualified employees; organizational problems; and legal issues, etc. (Aibinu and Venkatesh, 2014; Smith and Tardif, 2009; Mohd and Michael, 2014). On the opposite, the effective introduction of BIM in many countries has demonstrated the essential functions and obligations of special agencies, actors in the sector, and private and educational institutions (Mohd and Michael, 2014). Moreover, it can be justified that strong involvement and cooperation

with the governments of the respective countries by industry players and higher institutions is also important for the success of the BIM transformation in the industry (Wong, *et al*. 2010).

III. Conceptual Framework

From the above literature review, it is quite prominent that adaptation of BIM has a close relation with different factors, such as government and non-government initiatives, knowledge, cost of implementation (Aibinu and Venkatesh, 2014; Mohd and Michael, 2013; Smith and Tardif, 2009). Lack of any of the above factors acts as a barrier (Smith and Tardif, 2009; Allen Consulting Group, 2010). But most of the studies overlooked the cultural factors which as a barrier in the AEC industry (Sawhney, 2015) On the other hand, from the opinion of Robert Eadie, Henry Odeyinka (2009), cultural factors, and organizational factors act as major role for the successful implementation of BIM and it may act as a prominent barrier for the BIM adaptation in adaptation Bangladesh (Shakill, 2018). But there is no strong evidence that cultural factors act as a major barrier to the adaptation of BIM in architecture practice, Bangladesh.

The current study investigated the barriers to the adaptation of BIM in Bangladesh based on a model where it addressed the perception of 6 factors (National standard, cost of application, skilled personnel, Organizational factors, legal factors, and cultural factors) among industry professionals (inserted annex) play a curtail role for successful BIM implementation in developing and developed countries. On the contrary, the lack of any above factors acts as a barrier for BIM adaptation.

III. A. Dependent Variable

This research followed the model where the adaptation of BIM was considered as a dependent variable because the adaptation of BIM had been greatly influenced by many factors such as government and non-government initiatives, cost of implementation, knowledge (Aibinu and Venkatesh, 2014; Mohd and Michael, 2013; Smith and Tardif, 2009) Lack of any of the above factors acts as a barrier (Smith and Tardif, 2009; Allen Consulting Group, 2010).

III. B. Independent Variable

The independent variable in this study was focused on 6 different factors (national norm, application expense, trained workers, organizational factors, legal factors, cultural factors) that played a major role in BIM adaptation. The absence of all of them would serve as an obstacle.

IV. Methodology

IV.A. Research Design

The purpose of the study was to find out the factors that act as a barrier in BIM adaptation in architecture practice, which implies a close relationship between BIM adaptation and 6 other factors in the Liu, S., *et al*. Model: national standard, cost of application, and initial cost, organizational factors, organizational factors, legal factors, cultural factors, where these factors can play a crucial role in BIM adaptation or lack of any of them can act as a Barrier. This study is concerned with the complex relationship between BIM adaptation variables and Liu, S., *et al*. model variables. The study topic Architecture practice, BIM adaptation, and all the Liu, S., *et al*. factors are real-world scenarios or naturally occurring patterns.

As a result, a correlational research approach was employed to examine relationships between BIM adaptation variables and the Liu, S., *et al*. model variables. Where the correlational research sought to clarify the pattern of relationship between two or more real-world variables (Groat, L. and Wang, D., 2004). Moreover, correlational research focuses on the measurement of specific variables (Groat, L., and Wang, D., 2004). Both the dependent and independent variables of the current study were measurable by using different scales.

The use of statistics to clarify the pattern of relationship another significant character of correlation research (Groat, L. and Wang, D., 2010) This study used statistics to establish concrete quantitative evidence to seek out the barrier of BIM adaptation.

Within the correlational research framework, two strategies were implied to carry out research one of them was Relationship studies, which

sought to describe the relationship between key variables (Groat, L. and Wang, D., 2010) like as the BIM adaptation (number of projects using/used BIM as a tool) and the cultural barrier (habitual factors). Further, it also gave the statistically significant predictive power of those relationships.

A casual comparative strategy was also introduced by selecting comparable groups (Groat, L. and Wang, D., 2004) mainly architects, BIM technicians, and academics familiar with BIM. This was done to isolate plausible relevant factors that could reveal a 'cause' for significant differences in the measured variables. Though there was no 'treatment' implied in the independent variable, the selection of comparable groups was suggested to find out a significant 'cause'.

IV.B. Collecting Data

Archival data is a great source of co-relation research (Groat, L. and Wang, D., 2004). There was a limited number of 'archival' data available regarding the use of BIM in Bangladesh and the concept of BIM in the Bangladeshi AEC industry (Rakib, 2018). Due to a lack of available archival data, the process was divided into two stages.

Semi-structured interviews with business experts participating in BIM ventures were performed in the first step. This was undertaken in the sense of the Bangladeshi building industry to gain a better understanding of the problems around the use of BIM. By using the IAB and IEB directory and personal connection, the list of industry professionals was compiled. A random sample process is accompanied by semi-structured interviews and questionnaires.

IV.C.1 Semi-Structured Interviews

Semi-structured interviews were conducted using a reasonably transparent system that facilitates two-way, concentrated, conversational dialogue (Yin, 1984). Semi-structured interviews continue with more general questions or subjects, unlike the questionnaire system, where specific questions are developed ahead of time (Wengraf, 2001). Semi-structured/in-depth interviews require a minimum sample size of between 5 and 25 (Kuzel, 1992 cited in Saunders, 2012; Crowe, S. *et al*., 2011). By using this reference, the information was collected by interviewing 6 industry professionals from 3 different organizations. 'Creswell data collection framework' is used to organize and collect the data.

Then the transcripts of the interviews were analyzed using NVivo. Figure 1 contains a flow chart that explains the steps involved in the analysis of the data using NVivo.

Figure 1: Flow chart of the steps involved in data analysis by NVivo.

IV.C.2 Questionnaire Survey

Centered on the outcomes of semi-structured interviews and the literature review and analysis of Liu, S. *et al*., in the second process (2015). A web-based questionnaire (inserted in the annex) survey was performed earlier in the model. The questionnaire consists of two parts: the first part relates to respondents' details (for example, workplace, years of experience using BIM, category of industry, etc.). The second part relates to the factors that have been an obstacle to Bangladesh's adoption of BIM. It was based on the following words: Liu, S., *et al*., model (2015) in which 6 variables have been established as a significant influence on adaptation to BIM.

Respondents had given a score to most of the research variable by the range from 1 to 5 (Likert scale) when 1 is "Strongly disagree" and 5 is "Strongly agree". The responses were measured on an interval scale. (Blalock Jr, H. M., 1960) The questionnaire was distributed and collected through internet sources such as Google Forms, Gmail, and personnel distribution and retrieval. A total of 50 Questionnaires were distributed among the architects, BIM Technicians, academics. It was not fairly a large respondent but it is quite a practical sample size applied for all virtual surveys. (Chapter 3: Designing the sample) A sample size of fewer than 30 respondents generally gives too little certainty to be practical.

IV.C.3 Analysis Methods (Questionnaire Survey

The data was evaluated by numerous statistical methods, leading to a very clear inference for the respective studies. To analyze the

results, the program SPSS 24 was used. Pie charts and tables were used to evaluate the first portion of the questionnaire. Although the percentages and frequencies of each bar item are simple to determine.

V. Results and Analysis

The research aimed to find out the factors that act as a barrier in BIM adaptation in architecture practice In Bangladesh. This lead to an examination of the relationship between BIM adaptation and Shijing Liu's variables among the professionals. About 60 questioners were sent to different organizations and industry professionals and 22 of them responded to the survey. Data found from those 20 respondees were collected and analyzed by using SPSS 24. The Questionnaires (inserted in annex) were designed in such a way that only those who were familiar with BIM only could respond to the questions which influencing the adaptation of BIM. From table 01 it can be seen that most of the respondents were architects (65%) then academia (20%) and the rest of them were engineers (15%). All of the 20 respondents were familiar with the concept of BIM and 30 % of them were experienced in BIM for more than 5 years and 30% 1-2 years and the rest 40 percent had experienced varying from 0-1 year (25%) and 2-5 (15%) years. (Table 01)

Table 1: Respondent's Grouping

Profession	Frequency	Percent	Cumulative Percent
Architect	13	65	65
Engineer	3	15	80
Academia	4	20	100.0
Total	**20**	**100.0**	

Table 2: Respondent's Experience

Age	Frequency	Percent	Cumulative Percent
0- 1 year	5	25.0	25.0
1- 2 years	6	30.0	55.0
2-5 years	3	15.0	70.0
> 5 years	6	30.0	100.0
Total	**20**	**100.0**	

The sample size should not be less than 30 if the analysis has a relational survey design (Gall, 1979). If causal-comparative or longitudinal experiments need more than 50 participants (Cohen *et al*., 2000, p. 93), the approach of this study was casual comparative in the correlational context and the sample size was less than 50. To perform the analysis, it was also important to verify the validity and reliability test.

V.A. Reliability Test

To check the reliability of the data obtained from the respondents, the alpha value of the Cronbach is determined. For all of the variables in BIM adoption, the collective alpha value is determined. The Cronbach alpha value of respondent data obtained is 0.752, which is inside the appropriate range of 0.3 to 0.8 (Ferketich, 1991). Cronbach's alpha should be at least 0.75 for the lesser sample size (sample size 19) (Conroy and Ronán, 2014)

V.B. Validity (Principal Components Analysis)

For the validity of the research KMO (Kaiser-Meyer-Olkin) test was conducted where the KMO sampling adequacy was 0.519 where the minimum acceptable range is 0.5-0.6 and 0.8-1 is the most desirable (Alex, 2009). It was acceptable and the significance is 0.004, which sustained the null hypothesis and no statistically significant differences in variables.

Table 3: KMO and Bartlett's Test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.519
Bartlett's Test of Sphericity	Approx. Chi-Square	107.773
	df	45
	Sig.	0.004

$p < 0.001$

To find out the barrier of BIM adaptation it was needed to examine the relationship between BIM adaptation and Liu, S. *et al*., factors (variables) by analyzing it in three ways:

1. Bivariate Analysis
2. Multivariate analysis of variance (MANOVA)
3. Descriptive Statistics

V.C Bivariate Analysis

From the bivariate analysis, it was quite prominent that 5 variables were individually significantly related to BIM adaptation in

Bangladesh. One from the national standard and legal factor and Cultural factors they are– National BIM policy, habitual issues, and complex licensing system. Further two from the organizational factors: lack of awareness of BIM benefit and adopting BIM in the university curriculum.

Table 4: Bivariate Analysis

Variable	Correlation (Pearson/ Spearman)
National Standard 1. National BIM policy program and Guidelines will increase the adaptation of BIM in Bangladesh 2. Higher authority and decision-maker may play an important role in the adaptation of BIM.	- 0.381** -0.263
Cost Of Application 1.BIM software demands initial high cost and its costly implantation process.	-0.024
Skilled Personnel 1.BIM demands highly professional skills and in-depth training to complete a project.	-0.319
Organizational Factors 1.Clients demand BIM oriented drawings or data in the design phase as well as the construction phase 2.Most of the architectural firms are not aware of the benefits of BIM. 3.Knowledge of BIM in the University syllabus will increase its adaptation in practice	0.155 **0.522**** **0.333****
Legal Factors 1.Most of the BIM software has a complex licensing system	-0.84**
Cultural Factors 1.Traditional 2D software (like AUTOCAD) is more preferable to the nD based 02.BIM software in Architectural firms. CAD drawings are more readable than BIM drawings	-0.416** -0.333

Note. Pearson correlation was used for continuous variables, and Spearman for categorical variables. Significant correlation values are bolded. ** p < .001 and * p < .05.

V.D Multivariate analysis of variance (MANOVA)

As the bivariate analysis showed the relationship between individual variables where the MANOVA showed a combined relationship (10 variables) in BIM adaptation. A one-way MANOVA was conducted to test the hypothesis that there are one or more mean differences in Liu, S. *et al*., factors, and BIM adaptation. A statistically MANOVA result was obtained, Pillai's Trace = 1.73, F (63, 70) = 1.38, p > 0.001. Which sustained the null hypothesis that one or more mean differences in Liu, S., *et al*. factors, and BIM adaptation. The multivariate effect size was 0.44 which implied that 44 percent of the variance is canonically derived. So from the MANOVA analysis, it suggested that the analysis done by bivariate analysis is statistically significant.

Table 5: Multivariate Tests

Projects Completed by using BIM Pillai's Trace	
Value	3.88
F	1.388
Hypothesis df	63
Sig	0.091
Partial Eta Squared	0.441

V.E Descriptive Statistics

The two factors which were statistically significant in bivariate analysis further analyzed Descriptive Statistics (Table 06) for deeper understanding, it can be seen that the Standard Deviation between two variable is remarkably low, which implied that most of the professionals (with different level of experience) were agree with the factor that, most of the architectural firms are not aware of the benefits of BIM as well as Knowledge of BIM in the University syllabus will increase its adaptation in practice. This means that the adaptation of BIM in Bangladesh can be increased by giving concern among these factors according to Liu, S. *et al*. model (2015).

Table 6: Descriptive Statistics

Parameter	Project using/ used BIM as a tool	Knowledge of BIM in the University syllabus will increase its adaptation in practice	Most of the architectural firms are not aware of the benefits of BIM
N	20	20	20
Min.	00	2.00	3.00
Max.	13.00	5.00	5.00
Mean	5.00	4.500	4.500
Std. Dev.	4.31643	0.88704	0.68825

VI. Discussions

There some key findings marked by conducting the research. All of them are equally important in BIM adaptation in Architecture practice, Bangladesh. Six factors from the Liu, S. *et al*. model curved the path of the research but there are some striking findings outlined that were negatively correlated with BIM adaptation. On the other hand, two findings were proved and created a statistically strong relation in BIM adaptation.

VI.A. Most architectural firms are not aware of the advantages of BIM.

Most Bangladeshi architecture firms are not aware of the advantages of BIM. The semi-structured interview also highlighted that most businesses had familiarity with two-dimensional (2D) drawing in the front-end activities of the project, such as expense accounting and quantity billing, in computer-aided take-off. Using 3D models, most of them have no experience with automatic quantity extraction. For simulation only, 3D computer-aided drawing (CAD) drawings are used. This will increase its adaptation by making the stakeholders (especially the architectural firms) more conscious of the advantages of BIM.

VI.B. Knowledge of BIM in the University syllabus will increase its adaptation in practice

The professional body of the building and architecture industry in Bangladesh will run a series of programs involving the introduction of BIM education and science, i.e. the BIM Knowledge Portal, along with the cooperation of various universities (BIM Library). Examples can be seen from Malaysia, where a few kinds of research and RandD on project integration implementing BIM with 3D modeling activities using the Revit Method are systematically carried out by the BIM Technology Centre at Universiti Teknologi Malaysia. (2011) (Wong, K.D., Francis, A.). The cooperation of these core players in the design and architecture industries will offer excellent BIM deployment and benefits to the architecture industry at any point of BIM adoption.

VII. Conclusions

In reality, the BIM theory and developments have been implemented globally, and the great advantages of BIM applications in the AEC industry are gradually being discovered. The implementation of BIM is relevant not only for economic issues but also for security issues, as previously mentioned, for the AEC industry. Interest has also been derived from the barriers to the implementation of BIM. And its adaptation from the research will increase understanding of the benefits of BIM, as well as acceptance of BIM in the university syllabus.

Besides, in this study, the small sample size raised the variability of the findings. The analysis methodology was a correlation in nature, and where the particular variables in question became measurable, it was acceptable. But it did not give the ‘holistic’ understanding of the naturally occurring patterns. So, the effects may not be sufficient or may be generalized to other sectors. It was necessary to explore the relations between answers to questions and further study was also needed to verify the real obstacles from the point of view of stakeholders.

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