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# Critical Success Factors of the Intention-To-Use Building Information Modelling (BIM) in the Nigerian Construction Industry

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## *Abstract*

*The use of technology in the Nigerian construction industry has continued to draw the interest of researchers particularly in the area of BIM. This study aims to assess the critical success factors of the intention to use BIM. The study adopted a quantitative research approach which include the use of a questionnaire. The population of the study include construction professionals registered with Federal Inland Revenue Service (FIRS) which is 4,195. The Kothari sample size formula was applied to calculate the sample size of the study (352 professionals). The questionnaire was then served to the professionals in the population randomly and a total of 156 questionnaires representing a 44% response rate were retrieved. The data collected was analyzed using a mean item score. The study revealed the top five critical success factors to include; Training and learning ($MS = 4.12$; $SD = 0.96$; $p < 0.05$), Functionality ($MS = 4.11$; $SD = 1.08$; $p < 0.05$), 3D visualization, data sharing and bim platform access ($MS = 4.11$; $SD = 0.80$; $p < 0.05$), Ease of use and adoption ($MS = 4.11$; $SD = 0.77$; $p < 0.05$), and Standardization (product and process) ($MS = 4.06$; $SD = 0.80$; $p < 0.05$). This study would serve as a theoretical foundation for future studies and as well assist construction industry stakeholders to develop appropriate policies to improve BIM adoption in Nigeria.*

***Keywords:*** *Building Information Modelling, Adoption, Built Environment Professionals, Critical Success Factors*

# Introduction

Over the last decades, the construction industry has undergone several transformations including increasing interest in information technology with the view to improve construction productivity and cost management. The information technology applied in the construction industry includes 3D printing (Pessoa, Guimarães, Lucas & Simões, 2021), big data analytics (Aghimien, Ikuabe, Aigbavboa, Oke & Shirinda, 2021), building information modelling (BIM) (Olanrewaju, Babarinde, Chileshe & Sandanayake, 2021), digital twin (Opoku, Perera, Osei-Kyei & Rashidi, 2021), blockchain (Scott, Broyd, & Ma, 2021) among others. BIM is one of the most researched emerging technologies in the construction industry with diverse applications.

The idea of BIM can be traced to the 1970s when the building description system with simulation capabilities was introduced (Eastman, 1975). The Royal Institution of Chartered Surveyors [RICS] (2014) stated that there is no standard definition for BIM due to its evolving nature. The existing definitions commonly refer to BIM as a "product", "process", "technology", "innovation" or "strategy". BIM encompasses the use of technology through the utilization of information technology in the design, use, interaction, and information exchange between the different entities required in construction project design and construction.

The slow adoption of emerging technologies (Okpala, Nnaji, Awolusi & Akanmu, 2021) can be attributed to the construction industry. Hence, the application of emerging technologies in a meaningful way solves some of the issues in the construction industry (Akdag and Maqsood, 2019). Given the slow adoption of BIM in the construction industry, this study seeks to examine the critical success factors of the intention to use BIM in the Nigerian construction industry.

## Critical Success Factors of Intention-to-use BIM

The adoption of building information modelling has opened a vista of prospects to help in efficiently driving construction projects (Darwish *et al.*, 2020). It was also opined that the successful implementation of BIM in construction projects would require a detailed analysis of the influencing success factors. The need to critically analyze the critical success factors in BIM project implementation in construction projects is a major requisite based on the need to ensure the successful completion of projects without being crippled by challenges.

Various researchers have majorly focused on the identification of the various barriers to BIM implementation, Darwish *et al*. (2020), provided justifications on the need to critically examine the success factors as earlier carried out in Ozorhon *et al*. (2016); Ahmed (2017); Hamada (2017); and Elhendawi (2018). Amuda-Yusuf (2018) explored the critical success factors affecting BIM implementation collating 28 critical success factors from previous researches. Phang, Chen & Tiong (2020) identified critical success factors influencing BIM adoption in the Precast Concrete Industry. Zezhou *et al*. (2021) also investigated the critical factors of professionals' BIM adoption. Darwish *et al*. (2020) identified critical success factors for BIM for construction projects in the UAE. Furthermore, Yaakob *et al*. (2016) categorized the success factors identified from past literature based on similarities in details, they identified the categories wherein these factors can be classified as shown in Table 1.

**Table 1: Critical Success Factors of Intention-to-use BIM**

| S/N | Critical Success Factors |
|---|---|
| **CSF1** | Interoperability and collaboration |
| **CSF2** | Consumer and client requirement |
| **CSF3** | Appropriate hardware and software |
| **CSF4** | Integration and communication platforms |
| **CSF5** | Culture and structure |
| **CSF6** | Training and Learning |
| **CSF7** | Communication of BIM objectives/strategy |
| **CSF8** | Top Management support |
| **CSF9** | Awareness and experience level |
| **CSF10** | Organizational and staff BIM competencies |
| **CSF11** | Policy |
| **CSF12** | Business process reengineering and coordination |
| **CSF13** | Standardization (Product and Process) |

| | |
|---|---|
| **CSF14** | Ease of Use and Adoption |
| **CSF15** | Project Information Coordination |
| **CSF16** | BIM adoption strategies |
| **CSF17** | Functionality |
| **CSF18** | Management Support |
| **CSF19** | 3D Visualization , Data Sharing and BIM Platform Access |
| **CSF20** | Client requirement and ownership |
| **CSF21** | Commitment |
| **CSF22** | Stakeholders Involvement and Information Sharing |
| **CSF23** | Regulatory agencies participation |
| **CSF24** | Government's roles, support and legislation |
| **CSF25** | Cost of Development |
| **CSF26** | Return on Investment |
| **CSF27** | Company' Economic Capabilities |
| **CSF28** | Availability of financial resources |

**Research Methodology**

A quantitative research approach was adopted for this study. Furthermore, the review of relevant literature resulted in the formulation of a structured questionnaire based on a 5-point Likert-scale measurement. Collins (2010) maintains that Likert scales are effective to elicit participants' opinions on various statements.

Questionnaires were administered to the relevant built environment professionals based in Abuja. The population of the study include construction professionals registered with Federal Inland Revenue Service (FIRS) which is 4,195. Therefore the sample size is 352 professionals based on the Kothari sample size formula. 352 questionnaires were distributed, 156 were completed and returned, and this resulted in a response rate of 44%.

IBM SPSS version 23 and Microsoft Excel were used for data analysis. The study adopted descriptive (Mean Item Score). Mean Item Score (**MIS**) was used to rank the critical success factors of the intention-to-use BIM. It is represented mathematically below;

$$Mean\ Score\ (MS) = \frac{\sum(f \times s)}{N}, (1 \leq MS \leq 5) \qquad (4)$$

Where: s = Score given to each variable by the respondents and ranging from 1 to 5 where "1" means "strongly disagree" and "5" means "strongly agree". f = Frequency of responses to each rating (1 - 5), for each factor N = Total number of responses concerning that variable.

## Results and Discussion

### *Characteristics of Respondents*

Table 2 shows the demographic characteristics of respondents. As regards educational qualification, 46.15% have a bachelor degree, 8.97% have a Higher National Diploma (HND), 7.05% have a postgraduate diploma, 37.18% have a master degree, while 0.68% have a Doctorate qualification. The revealed that the respondents are adequately educated to provide meaningful information for this research.

As regards the professional background of the respondents, 41.67% were Architect having a majority, followed by Quantity Surveyor with 32.05%, Engineers with 16%, Estate Surveyor with 5.77% while Builder having minority with 4.49%. The major professions in the Nigerian construction industry are well represented.

For the age group, 44.87% of the respondents were between 21 and 30 years old, 32.05% were between 31 and 40 years old, 10.90% were between 41 and 50 years old and 12.18% were 50 years and above. This shows that almost all age groups are well represented.

In the case of years of experience, 2.56% of the respondents have 10-15 years of working experience, 21.15% have 15-20 years working experience, 54.49% had 5–10 years, 1.92% had less than 5 years working experience while 19.87% have working experience of 20 years and above. This connotes that the respondents are well experienced to provide valuable information for this research.

**Table 2: Demographics Characteristics of Respondents**

| Variables | | Frequency | Percentage (%) |
|---|---|---|---|
| | Higher National Diploma | 14 | 8.97 |
| Highest Academic Qualification | Bachelor Degree | 72 | 46.15 |
| | Post Graduate Diploma | 11 | 7.05 |
| | Master Degree | 58 | 37.18 |

| | | | |
|---|---|---|---|
| | Doctorate Degree | 1 | 0.64 |
| | **Total** | **156** | **100.00** |
| Profession | Architect | 65 | 41.67 |
| | Builder | 7 | 4.49 |
| | Engineer | 25 | 16.03 |
| | Estate Surveyor | 9 | 5.77 |
| | Quantity Surveyor | 50 | 32.05 |
| | **Total** | **156** | **100.00** |
| Age Group | 21-30 | 70 | 44.87 |
| | 31-40 | 50 | 32.05 |
| | 41-50 | 17 | 10.90 |
| | 50 above | 19 | 12.18 |
| | **Total** | **156** | **100.00** |
| Years of Experience | 10-15 years | 4 | 2.56 |
| | 15-20 years | 33 | 21.15 |
| | 20 years above | 31 | 19.87 |
| | 5-10 years | 85 | 54.49 |
| | Less than 5 years | 3 | 1.92 |
| | **Total** | **156** | **100.00** |

***Critical Success Factors of Intention-to-use BIM***

Table 3 above shows the ranking of the twenty-eight intention-to-use BIM among construction professional implementation according to the mean scores in descending order. The table also shows that the majority of the hypothesized barriers are perceived as statistically significant ($p < 0.05$) by the respondents using the one-sample t-test value of 3.5. The mean score of the barrier ranges between 3.19 and 4.12. These BIM implementation barriers ranged from "Training and Learning" (mean = 4.12; *SD* = 0.96; *t* (155) = 8.09; *p* = 0.00 < 0.05) which is the highest ranked to"Communication of BIM objectives/strategy" (mean = 3.19; *SD* = 0.89; *t* (155) = -4.33; *p* = 0.00) which is the least ranked. To get the most significant BIM implementation barriers based on the mean score, a threshold of 3.50 was set. This same threshold approach was used in Olanrewaju *et al*. (2020a) to assess the significant variables. As a result, twenty-one (21) BIM implementation barriers were above 3.50 and considered significant. These implementation barriers include:

“Training and Learning” (mean = 4.12; *SD* = 0.96; *t* (155) =8.09; *p* = 0.00), “Functionality” (mean = 4.11; *SD* = 1.08; *t* (155) = 7.07; *p* = 0.00), “3D visualization,Data sharing and BIM platform access”(mean = 4.11; *SD* = 0.80; *t* (155) = 9.51; *p* = 0.00). “Ease of use and Adoption” (mean = 4.10; *SD* = 0.77; *t* (155) = 9.69; *p* = 0.00), “Standardization(product and process)” (mean = 4.06; *SD* = 0.80; *t* (155) = 8.74; *p* = 0.00), “Commitment” (mean = 4.03; *SD* = 0.84; *t* (155) = 7.80; *p* = 0.00). “Availability of financial resources” (mean = 4.01; *SD* = 1.01; *t* (155) = 6.28; *p* = 0.00), “3D visualization,Data sharing and BIM platform access”(mean = 4.11; *SD* = 0.80; *t* (155) = 9.51; *p* = 0.00). “Company Economic Capabilities” (mean = 3.97; *SD* = 0.73; *t* (155) = 9.69; *p* = 0.00), “Standardization (product and process)” (mean = 4.06; *SD* = 0.80; *t* (155) = 8.15; *p* = 0.00), “Business process re-engineering and coordination” (mean = 3.96; *SD* = 0.85; *t* (155) = 6.79; *p* = 0.00), “Awareness and experience level” (mean = 3.93; *SD* = 0.84; *t* (155) = 6.42; *p* = 0.00). “BIM adoption strategies” (mean = 3.92; *SD* = 1.16; *t* (155) = 4.47; *p* = 0.00), “Culture and structure” (mean = 3.91; *SD* = 0.77; *t* (155) = 6.62; *p* = 0.00), “Policy” (mean = 3.90; *SD* = 0.96; *t* (155) = 5.18; *p* = 0.00).“Top management support” (mean = 3.89; *SD* =1.20; *t* (155) = 4.07; *p* = 0.00), “Client requirement and ownership ”(mean = 3.77; *SD* =1.26; *t* (155) = 2.67; *p* = 0.01), “Regulatory agencies participation”(mean = 3.67; *SD* = 1.80; *t* (155) = 6.42; *p* = 0.00). “Return on investment” (mean = 3.63; *SD* =1.02; *t* (155) = 1.65; *p* = 0.10), “Management support” (mean = 3.62; *SD* = 1.04; *t* (155) = 1.46; *p* = 0.15), “Cost development” (mean = 3.60; *SD* = 0.98; *t* (155) = 1.23; *p* = 0.22), “Integration and communication platforms” (mean = 3.57; *SD* = 1.04; *t* (155) = 0.85; *p* = 0.40), “Interoperability and collaboration”(mean = 3.52; *SD* = 1.16; *t* (155) = 0.21; *p* = 0.84). The approach revealed a total of eighteen (18) significant critical success factors to BIM implementation. Liu, Lu, Nath, Wang, Tiong, & Peh (2021) explored the critical success factors to BIM in the Singapore context and found that the critical success factors to BIM adoption in the construction industry include; “BIM applications”, “Organization’s financial considerations”, “Workflow transformation strategies”, “Policies, capabilities, and support”, “Teams” and “BIM functionalities”. The findings from Liu *et al*. (2021) is in line with this current study because there is an agreement regarding financial factors, BIM applications and usage including policies to support its implementation. Similarly, Phang, Chen & Tiong (2020) developed a new model for identifying the critical success factors to BIM adoption based on precast concrete manufacturers' perspectives. The top three critical success factors include government policies and support on BIM adoption, usage of BIM to maintain competitive advantage, and commitment from top management.

**Table 3: Ranking of the Critical Success Factors of Intention-to-use BIM**

| S/N | Critical Success Factors | MS | *SD* | t-value (μ = 3.5) | *df* | Sig. (2-tailed) | R |
|---|---|---|---|---|---|---|---|
| **CSF6** | Training and learning | 4.12 | 0.96 | 8.09 | 155 | 0.00* | 1 |
| **CSF17** | Functionality | 4.11 | 1.08 | 7.07 | 155 | 0.00* | 2 |
| **CSF19** | 3D visualization, data sharing and bim platform access | 4.11 | 0.80 | 9.51 | 155 | 0.00* | 3 |
| **CSF14** | Ease of use and adoption | 4.10 | 0.77 | 9.69 | 155 | 0.00* | 4 |
| **CSF13** | Standardization (product and process) | 4.06 | 0.80 | 8.74 | 155 | 0.00* | 5 |
| **CSF21** | Commitment | 4.03 | 0.84 | 7.80 | 155 | 0.00* | 6 |
| **CSF28** | Availability of financial resources | 4.01 | 1.01 | 6.28 | 155 | 0.00* | 7 |
| **CSF27** | Company economic capabilities | 3.97 | 0.73 | 8.15 | 155 | 0.00* | 8 |
| **CSF12** | Business process reengineering and coordination | 3.96 | 0.85 | 6.79 | 155 | 0.00* | 9 |
| **CSF9** | Awareness and experience level | 3.93 | 0.84 | 6.42 | 155 | 0.00* | 10 |
| **CSF16** | BIM adoption strategies | 3.92 | 1.16 | 4.47 | 155 | 0.00* | 11 |
| **CSF5** | Culture and structure | 3.91 | 0.77 | 6.62 | 155 | 0.00* | 12 |
| **CSF11** | Policy | 3.90 | 0.96 | 5.18 | 155 | 0.00* | 13 |
| **CSF8** | Top management support | 3.89 | 1.20 | 4.07 | 155 | 0.00* | 14 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **CSF20** | Client requirement and ownership | 3.77 | 1.26 | 2.67 | 155 | 0.01* | 15 |
| **CSF23** | Regulatory agencies participation | 3.67 | 1.15 | 1.80 | 155 | 0.07 | 16 |
| **CSF26** | Return on investment | 3.63 | 1.02 | 1.65 | 155 | 0.10 | 17 |
| **CSF18** | Management support | 3.62 | 1.04 | 1.46 | 155 | 0.15 | 18 |
| **CSF25** | Cost of development | 3.60 | 0.98 | 1.23 | 155 | 0.22 | 19 |
| **CSF4** | Integration and communication platforms | 3.57 | 1.04 | 0.85 | 155 | 0.40 | 20 |
| **CSF1** | Interoperability and collaboration | 3.52 | 1.16 | 0.21 | 155 | 0.84 | 21 |
| **CSF15** | Project information coordination | 3.49 | 1.23 | -0.13 | 155 | 0.90 | 22 |
| **CSF3** | Appropriate hardware and software | 3.48 | 1.09 | -0.22 | 155 | 0.83 | 23 |
| **CSF2** | Consumer and client requirement | 3.43 | 1.22 | -0.72 | 155 | 0.47 | 24 |
| **CSF24** | Government's roles, support and legislation | 3.34 | 1.16 | -1.72 | 155 | 0.09 | 25 |
| **CSF10** | Organizational and staff BIM competencies | 3.33 | 1.09 | -1.98 | 155 | 0.05* | 26 |
| **CSF22** | Stakeholders involvement and information sharing | 3.23 | 1.30 | -2.58 | 155 | 0.01* | 27 |
| **CSF7** | Communication of BIM objectives/strategy | 3.19 | 0.89 | -4.33 | 155 | 0.00* | 28 |

Note: ***SD* = Standard Deviation; R = Rank; Sig. = Level of significance; MS = Mean score of the Critical Success Factors of Intention-to-use BIM among Construction Professionals where 5 = strongly agree; 4 = agree; 3 = neutral; 2 = disagree; 1 = strongly disagree. The higher the mean score the more severe the barrier; df = degrees of freedom, *Significant at the 95 per cent level ($p < 0.05$)**

## Conclusion and Recommendations

The study revealed the essential critical success factors of the intention-to-use BIM to include; Training and learning, Functionality, 3D Visualization, data sharing and BIM platform access, Ease of use and adoption, Standardization (product and process), Commitment, Availability of financial resources, Company' economic capabilities, Business process reengineering and coordination, and Awareness and experience level. Proper consideration of these factors would enhance BIM uptake in the construction industry. One of the fundamental problems of BIM in Nigeria is the lack of standards and policies which has influenced its adoption despite the level of awareness. However, this study recommends the following:

i. Stakeholders should be educated on the potentials of BIM;
ii. Stakeholders should be open to implementing BIM;
iii. Government should introduce policies that will support BIM implementation.

## REFERENCES


Akdag, S. G., & Maqsood, U. (2020). A roadmap for BIM adoption and implementation in developing countries: the Pakistan case. *ArchNet-IJAR: International Journal of Architectural Research*, *14*(1), 112-132.

Aghimien, D. O., Ikuabe, M., Aigbavboa, C., Oke, A., & Shirinda, W. (2021). Unravelling the Factors Influencing Construction Organisations' Intention to Adopt Big Data Analytics in South Africa. *Construction Economics and Building*, *21*(3).

Ahmed, N. (2017). Critical Success Factors plays a vital role in ERP Implementation in Developing Countries: An Exploratory Study in Pakistan. *International Journal of Advanced Computer Science and Applications. 8(10).* DOI:10.14569/IJACSA.2017.081004

Amuda-Yusuf, G. (2018). Critical success factors for building information modelling implementation. *Construction Economics and Building*, *18*(3), 55-73.

Collins, H. (2010). *Creative Research: The Theory and Practice of Research for the Creative Industries*, Lausanne: AVA Publishing SA.

Darwish, A.M., Tantawy, M. M. and Elbeltagi, E. (2020). Critical Success Factors for BIM implementation in Construction projects. *Saudi Journal of Civil Engineering* Nov.2020; 4(9): 180-191. DOI: 10.36348/sjce.2020.v04i09.006.

Eastman, C. (1975). The use of computers instead of drawings in building design. *AIA Journal*, *63*(3), 46-50.

Elhendawi, A. I. N. (2018). Methodology for BIM implementation in KSA in AEC industry. (Master of Science MSc in Construction Project Management), Edinburgh Napier University, UK

Hamada, H. M., Haron, A., Zakiria, Z & Humada, A. M. (2017). Factor Affecting of BIM Technique in the Construction Firms in Iraq. MATEC Web Conf., 103, 03003

Liu, Z., Lu, Y., Nath, T., Wang, Q., Tiong, R.L.K. and Peh, L.L.C. (2021). Critical success factors for BIM adoption during construction phase: a Singapore case study", *Engineering, Construction and Architectural Management*, Vol. ahead-of-print No. ahead-of-print. https://doi.org/10.1108/ECAM-12-2020-1072.

Okpala, I., Nnaji, C., Awolusi, I., & Akanmu, A. (2021). Developing a Success Model for Assessing the Impact of Wearable Sensing Devices in the Construction Industry. *Journal of Construction Engineering and Management*, *147*(7), 04021060.

Olanrewaju, O. I., Babarinde, S. A., Chileshe, N., & Sandanayake, M. (2021). Drivers for implementation of building information modeling (BIM) within the Nigerian construction industry. *Journal of Financial Management of Property and Construction*, 26(3), pp. 366-386.

Opoku, D. G. J., Perera, S., Osei-Kyei, R., & Rashidi, M. (2021). Digital twin application in the construction industry: A literature review. *Journal of Building Engineering*, Volume 40, August 2021, 102726.

Ozorhon, B. and Karahan, U. (2016). Critical success factors of building information modeling implementation. Journal of Management in Engineering, 33(3), 04016054.

Pessoa, S., Guimarães, A. S., Lucas, S. S., & Simões, N. (2021). 3D printing in the construction industry-A systematic review of the thermal performance in buildings. *Renewable and Sustainable Energy Reviews*, Volume 141, May 2021, 110794.

Phang, T., Chen, C. and Tiong, R.L.K. (2020). New Model for identifying critical success factors influencing BIM adoption from Precast concrete manufacturer's view. *Journal of Construction Engineering Management* 2020 146(4):040020014.

RICS. (2014). *International BIM Implementation Guide* (First ed.). Parliament Square, London.

Scott, D. J., Broyd, T., & Ma, L. (2021). Exploratory literature review of blockchain in the construction industry. *Automation in Construction*, *132*, 103914.

Yaakob, M., Wan, W. N. A., & Radzuan, K. (2016). Critical success factors to implementing building information modeling in Malaysia construction industry. *International Review of Management and Marketing*, *6*(8S).

Zezhou, W., Mingyang, J., Heng, L., Xiaochun, L. and Xiaoying, L. (2021). Investigating the critical factors of professionals' BIM Adoption behavior based on the theory of planned behavior. *International Journal of Environmental Research and Public Health*, 18(6), 3022.