

Integrating Building Information Modelling (BIM) Tools and Techniques in AEC Organisations: Effect on Culture and Structure

¹Bello Mahmud Zailani, ¹Mu'awiya Abubakar, ²Yahaya Ibrahim Makarfi,

¹Kabir Bala and ¹Muhammad Sadiq Abdallah

¹Department of Building, Ahmadu Bello University, Nigeria

²Department of Quantity Surveying, Ahmadu Bello University, Nigeria

Email: bellomahmud34@gmail.com

Abstract:

Building Information Modeling (BIM), like all novel concepts, often changes organisational dynamics. Previous studies have lamented the need for the engagement of BIM actors and change in organisational culture and structure for an effective BIM implementation. However, the degree to which adopting BIM affects Nigerian firms' organisational structure and culture is yet to be ascertained. This study filled this gap in the literature through a quantitative research approach. A structured questionnaire was used to collect data from thirty-five (35) Architectural Engineering and Construction (AEC) firms using a snowballing sampling technique. Data collected was analysed using descriptive statistical methods. The study's findings show that BIM adoption has more effect on the organisational culture than the structure. This gives insight into the resilience of AEC firms in Nigeria at the advent of change in operational mode towards adapting to the modern dynamic and highly competitive market. Considering the apparent limitations of this study, it is recommended that longitudinal research studies should be conducted to gain deeper insight on BIM adoption and its effect on organisational dynamics for a clearer and vivid representation.

Keywords: AEC, BIM, Organisational Culture, Organisational Structure

1 Introduction

For centuries, the construction industry was plagued with traditional methods in managing information for project use. Professionals in the construction industry have had at their disposal only a sheet of paper, ink and a simple abacus for project designs and analysis (Yan & Damian, 2008). Professionals were limited to only information within their respective professional boundary. This traditional method of managing information has had a significant effect on the quality of projects as well as the time and cost performance of projects. As a result, the digitalisation of the built environment through various technological developments has been the recent trend worldwide. This is intended to improve information management in the industry as well as improve project performance. With the advances in technology, Yan and Damian (2008) observed that the design process in the global construction industry had experienced a vigorous and theatrical change. Evolving from the use of 2D paper-based drawings, the advancement in technology has led to the shift of design mediums to 2D Computer-Aided Design (CAD) and 3D digital models on the computer screen, which manifested into the modelling of building-related information (Company et al., 2009). East and Smith (2016) defined the basic premise of BIM as the systematic collaboration between project stakeholders at varying phases of the project life cycle, which enables efficient interaction of project information within the BIM process platform across all project participants.

AIA (2007) defines BIM as "a model-based technology linked with a database of project information." Building Information Modelling is viewed as the latest trend of object-oriented computer-aided design (OOCAD) systems (Azhar et al., 2012; Howard & Björk, 2008). Bryde et al. (2013) view BIM as a construction approach that supports the instant provision of reliable and integrated project design scope, schedule, and cost information. It allows all distinct components of Intelligent building object to coexist in a single 'project database' or 'virtual building space' that captures all relevant details about the building. This is much different from the traditional CAD systems with graphic objects in a two-dimensional CAD file, as objects in a BIM model are intelligible to computer programs as representations of real-world building components (Colombo et al., 2007). A building information model provides a single, logical and consistent source for all information associated with the building (Howell & Batcheler, 2015).

Despite the apparent potential of BIM in the construction industry, the effective adoption of BIM in AEC organisations has been seen to be plagued by challenges regarding the displacement of the well-established traditional working process (Hong et al., 2019; Succar & Kassem, 2015). Although most studies focus mainly on technical-related issues of BIM adoption, recent studies have adopted a socio-technical perspective on the digitalisation of business processes and BIM adoption in AEC organisations (Bosch-Sijtsema et al., 2017; Davies & Harty, 2013). Liao and Ai Lin Teo (2018) noted the significance of organisational change attributes in the vision and mission, management support and processes towards successful BIM adoption in organisations. Therefore, as BIM means technological change and change in management processes, the socio-technology informed concept of BIM management is applied (Ning Gu & London, 2010; Luo et al., 2016). The efficient integration of BIM in AEC organisations prompts the need to change almost all aspects of the business process, which requires a thorough understanding before the implementation and transformation (Eastman et al., 2011).

Based on the forgone, it is evident that the development and implementation of BIM in organisations is a change factor that improves organisations' culture and structure (Hartman and Fischer 2017; Kokkonen & Alin, 2016). Thus, adopting BIM manifests into changes. Change in the work process, change in staffing and project organisation and change in how a firm uses information (Zhou et al., 2012; Garwood et al., 2018). However, the extent to which adopting BIM affects AEC firms' organisational culture and structure in Nigeria is relatively not ascertained. This creates a gap in the Nigerian BIM adoption literature which this paper set out to address.

2 Literature Review

2.1 Organisational Culture

Across the literature in diverse contexts, there are numerous classifications of organisational culture which aid in understanding the complexity of the construct. Notably, Hofstede (2011) identified five cultural dimensions, namely; *Power Distance*, *Uncertainty Avoidance*, *Individualism and Collectivism*, *Masculinity versus Femininity*, and *Long versus Short-term Orientation*. These dimensions offer insight into varying factors of organisational culture. Collectively, the dimensions highlight the divergent traits that instigate diversity in individual and organisational dynamics. Schein (1985) developed a three-level cognitive model that defines organisational culture. The *artefacts* definition of culture focuses on the visible attributes of organisational behaviour that include but not limited to amenities, dress code, work

schedule. This differs from the view of culture as a *basic underlying assumption*, with elements that are not visible and mostly unstated such as the rule of thumb, unspoken rules and code of conduct that organisations often adopt. Whereas, from an *espoused value* perspective, culture includes the expression of the organisational vision and mission, and the functioning belief across the organisation.

Overall, organisational culture could be seen to relate to the unique way business organisations conduct business operations, which largely manifests into an overall success or failure of the business (Dartey-Baah, 2013). Culture is central in managing the current global workforce dynamics. According to (Willcoxson & Millett, 2000), cultures are history-based, evolving over time as organisations develop patterns of behaviour and belief that enable effective operations in dynamic business contexts. A change in business operation or circumstance often results in the development of new patterns of behaviour intertwined into existing beliefs and assumptions (Trice & Beyer, 1993).

Hofstede (1998) viewed culture as socially transmitted behaviour patterns, norms, beliefs and values of a given community or organisation that gives it a unique identity. However, Schein (1985) observed that culture is the most difficult organisational element to change, making it very difficult to understand the change fully. Regardless, businesses organisations in the modern global environment face the continuous need to be dynamic to maintain sustainable market relevance and competitive advantage. Certainly, organisational culture plays a significant role in achieving high levels of organisational effectiveness (Waterman & Peters, 1982).

2.2 Organisational Structure

The literature on organisational structure is almost unanimous on the notion that structuring and configuration in business organisations are often dynamic, with a flux relationship between underlying mechanisms (Mintzberg, 1980; Salaman, 1978). Organisational structuring involves the classification of organisational labour into a number of distinct tasks, coupled with a clear definition of how the conduct of the tasks will be coordinated to achieve the organisational objectives (Mintzberg, 1980). Across the breadth of this definition are also the various mechanisms that organisations use in the design of respective structures, which often are the fundamental elements of business organisations. These mechanisms include *job specialisation, behaviour formalisation, training and indoctrination, unit grouping, unit size, planning and control systems, and the liaison devices*. Mintzberg (1980) argued that organisations usually adopt a plausibly unchanging clustering of its elements as it strives for continuous synergy in its internal processes. However, as several internally and externally induced factors define the contemporary workplace, organisations must inevitably be driven to adopt changes in respective structures as they adapt to changing dynamics, evolving from one structure to another.

3 Research Methodology

This paper set out to assess the potential effect of BIM adoption on organisational structure and organisational culture in Architectural, Engineering and Construction firms in Nigeria. The aim of the study was achieved using a quantitative research approach. A structured questionnaire was designed, which was classified into three sections. Section 1 assessed the level of BIM adoption across AEC firms. Section 2 elicited data on the effect of adopting BIM tools and techniques on the existing organisational culture, while section 3 elicited data on the effect of

the adoption on the existing organisational structure. Due to the lack of a standardised database for AEC firms using BIM tools and techniques in Nigeria, a snowballing sampling technique was adopted for the study, which resulted in a total study population of 35 AEC firms. All 35 firms fully contributed to the study, with top executive officers of respective firms serving as independent respondents. Data collected were analysed using descriptive statistical techniques that include mean tables and graphical charts.

4 Findings and Discussion

4.1 BIM adoption and performance

Table 1 shows for how long the respective firms have been adopting BIM in their organisation. Considering the low level of awareness on the concept and benefits of BIM in the Nigerian construction industry, as noted by Babatunde, Ekundayo and Adekunle (2019). The majority of the firms, which represents 57.1%, reported adopting BIM for a period between 5-9 years. Firms with a period between 2-4 years represent 20% of the population. In comparison, 14.3% of the firms have been adopting BIM for 10 years or above. Only 8.6% of the studied population started adopting BIM recently within 1-2 years.

Table 1. Years of BIM Adoption

Years	Frequency	Percentage (%)
1-2 years	03	8.6
2-4 years	07	20.0
5-9 years	20	57.1
10years and above	05	14.3
Total	35	100

More so, a Likert scale of 1-5 (1 = Least influence and 5 = Most influence) was presented to the respondents to rate the influence of adopting BIM on delivery performance in their respective organisations. Table 2 shows a significant influence of BIM adoption on accuracy and precision of design and improvement in time and cost performance. The organisations also noted a relative improvement in response to queries. Since its emergence, AEC industry has highlighted BIM as a solution to the pattern of problems and issues of developed countries' construction industries (Gu & London, 2010). Love and Smith (2013) also found a positive influence of BIM on project delivery performance which is not farfetched from the findings of this study.

Table 2: Influence of BIM on Delivery Performance

Measures	Mean	Std. dev.
Accuracy and precision in design/analysis	4.3	0.488
Improvement in cost performance	4.3	0.568
Improvement in time performance	4.2	0.333
Quick response to queries	3.7	0.343

4.2 Effect of BIM on Organizational Culture and Structure

There are different theoretical views on changing or managing organisational culture, which suggest that the culture change process is complex (Pfister, 2009). Arnold et al. (2005) noted the fundamental function of organisational culture as providing a sense of meaning to organisational life by defining how business processes are executed. In this regard, nominal data was collected regarding the change in organisational culture due to BIM adoption in respective firms. A large percentage of the firms reported changing their steering document

and creating working templates with 69% and 66% respectively to accommodate BIM implementation. Whereas 57% of the firms noted no significant change in working hours, and only 51% reported ease in getting design/analysis approval. Figure 1 gives a graphical representation of the findings. This finding complements the view of Burgess and Harrison (1998) that organisations undertake conscious culture change only when it is necessary to do so. Cacciattolo (2015) observed that changing organisational culture similar to what is seen from these organisations is usually overwhelming as it often involves the establishment of new systems, rules and procedures to accommodate the changes in business processes.

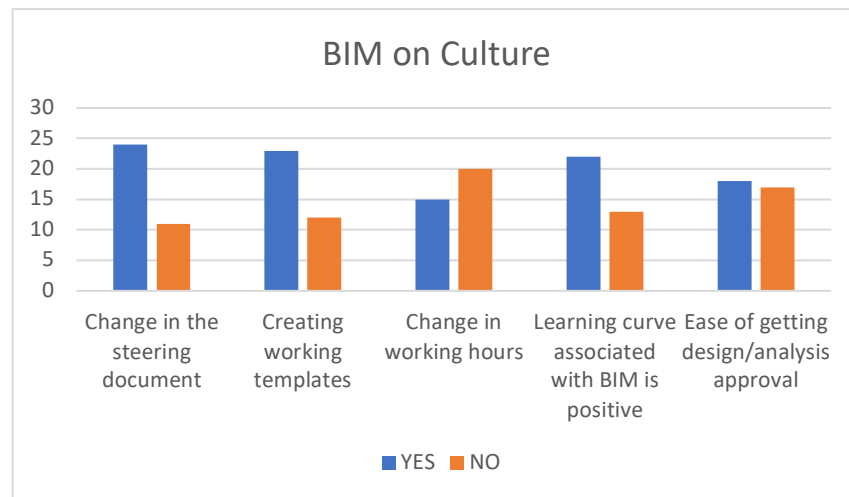


Figure 1: BIM on Culture

Despite the change in the cultural dimensions of the firms, there was no complementing change in the structure of respective organisations. Mintzberg (1980) viewed organisational structure as a set of methods for dividing the task in determining duties and coordinating them. Organisational structure is the framework of the relations between various units of an organisation (people and process) to achieve organisational goals (Lunenburg, 2012). Many firms (80%) reported not establishing an Information Technology (IT) department to manage IT infrastructure for BIM adoption. Furthermore, 63% reported not engaging BIM coordinators to handle the adoption process, while only 29% reported having labour turnover due to BIM adoption in their respective firms. However, only 57% had a change in the medium and channel of communication within and outside the firm, while 60% changed role description. Figure 2 presents the findings with regards to the effect of BIM on organisational structure in this study.

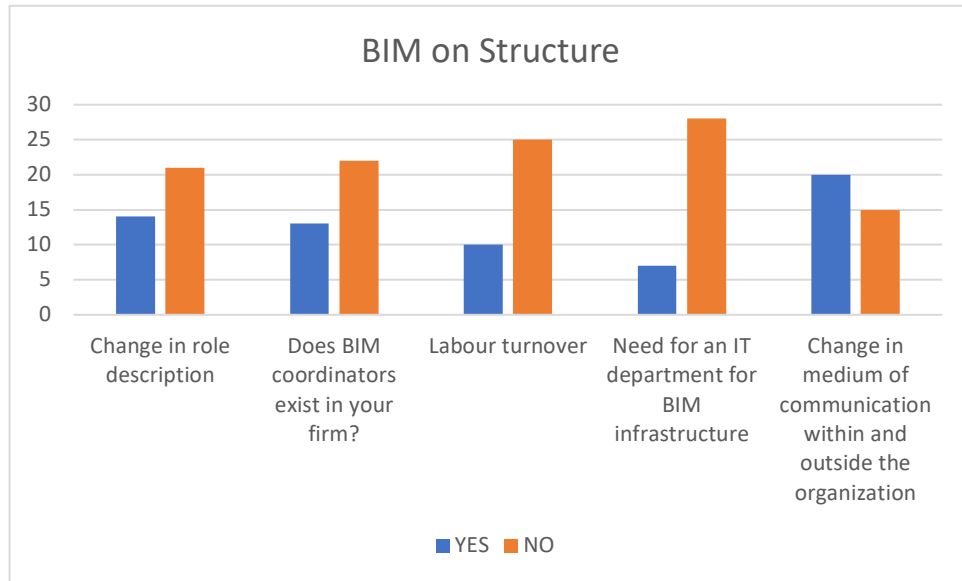


Figure 2: BIM on Structure

5 Discussion

Overall, this study's findings highlight the resilience of business organisations with a specific focus on AEC firms at the advent of changes in business processes. The dynamic nature of the modern construction business environment and the apparent need to adopt trending technologies for improved performance means AEC firms in Nigeria are pushed to evolve to adapt to changes in the global industry. Although the adoption of BIM tools and techniques is still slow in the country, as evident in the data earlier presented, with most of the firms integrating the technologies in their respective business operations over the last decade, there have been signs of improvement in the performance of the firms. There is evidence of improvement in design precision and accuracy, coupled with timely and costly delivery of projects, which undoubtedly sets the precedence for improved efficiency and effectiveness of the industry.

Relatedly, in dealing with the need to meet industry demands and adopting BIM tools and techniques, AEC firms in Nigeria often experience a change in the *operational mode* of business processes, which is a manifestation of change in organisational Behaviour. As BIM tools and techniques are designed to make AEC operations easier and more efficient, it becomes apparent that these tools and techniques will require a change in existing organisational norms to exploit the benefits that come with its integration fully. Although it is widely argued that organisational norms and principles is a manifestation of the underlying configurational mechanism across the organisation, it is seen that adopting BIM and a change in organisational culture does not necessarily result in a change in the organisational structure or configuration. However, it might be due to the level of BIM adoption across the study population, with most firms in their early years of adoption. It could be inferred that culture change is more rapid than a change in structure in AEC organisations as changing culture requires less bureaucratic processes.

6 Conclusion and Further Research

Although the adoption level of BIM in the Nigerian construction industry is relatively low compared to that of developed countries, a few firms have recognised the benefits attached to it and have started adopting the concept. This study assessed the effect of adopting the BIM concept and using BIM tools on organisational culture and structure in respective Nigerian firms. The study found a change in the organisational culture of most firms due to BIM adoption. However, there were no significant changes as it relates to the structure of the firms. As such, it could be concluded that BIM adoption has more effect on organisational culture than structure. However, it is imperative to note that change is gradual and takes time. Considering the period over which the firms have been adopting the concept, it can be deduced that the adoption phase is still ongoing, and therefore the effect might be minimal. Therefore, it is recommended that further longitudinal studies should be carried out to assess the level of BIM adoption and its effect on organisations for a clearer and vivid representation.

7 References

- AIA. (2007). *Integrated project delivery: A guide*.
- Arnold, J., Silvester, J., Cooper, C., & Robertson, I. (2005). *Work psychology: Understanding human behaviour in the workplace*. Prentice Hall.
- Azhar, S., Khalfan, M., & Maqsood, T. (2012). Building Information Modeling (BIM): Now and Beyond. *Construction Economics and Building*, 15–28.
- Babatunde, S., Ekundayo, D., & Adekunle, A. (2019). Analysis of BIM maturity level among AEC firms in developing countries: a case of Nigeria. *35th Annual ARCOM Conference. Association of Researchers in Construction Management, 2019.*, 225–234.
- Bosch-Sijtsema, P., Isaksson, A., Lennartsson, M., & Linderoth, H. C. J. (2017). Barriers and facilitators for BIM use among Swedish medium-sized contractors - “We wait until someone tells us to use it.” *Visualisation in Engineering*, 5(1).
- Bryde, D., Broquetas, M., & Volm, J. (2013). The project benefits of building information modelling (BIM). *International Journal of Project Management*, 31(7), 971–980.
- Burgess, J., & Harrison, C. M. (1998). Environmental communication and the cultural politics of environmental citizenship. In *Environment and Planning A* (Vol. 30).
- Colombo, G., Mosca, A., & Sartori, F. (2007). Towards the design of intelligent CAD systems: An ontological approach. *Advanced Engineering Informatics*, 21(2), 153–168.
- Company, P., Contero, M., Varley, P., Aleixos, N., & Naya, F. (2009). Computer-aided sketching as a tool to promote innovation in the new product development process. *Computers in Industry*, 60, 592–603.
- Cacciattolo, K. (2015). Understanding Organisational Cultures. *European Scientific Journal*, November 2014.
- Dartey-Baah, K. (2013). The Cultural Approach to the Management of the International Human Resource: An Analysis of Hofstede’s Cultural Dimensions. *International Journal of Business Administration*, 4(2), 39–45.
- Davies, R., & Harty, C. (2013). Implementing “Site BIM”: a case study of ICT innovation on a large hospital project. *Automation in Construction*, 30, 15–24.
- East, B., & Smith, D. (2016). The United States National Building Information Modeling Standard: The First Decade. *33rd CIB W78 Information Technology for Construction Conference*.
- Eastman, C., Eastman, C., Teicholz, P., Sacks, R., & Liston, K. (2011). *BIM handbook: A guide to building information modeling for owners, managers, designers, engineers and*

- contractors. Joh.
- Garwood, T., Hughes, B., O'Connor, D., & Calautit, J. (2018). A framework for producing gbXML building geometry from Point Clouds for accurate and efficient Building Energy Modelling. *Applied Energy*.
- Gu, N., & London, K. (2010). Understanding and facilitating BIM adoption in the AEC industry. *Automation in Construction*.
- Hofstede, G. (1998). Attitudes, values and organisational culture: Disentangling the concepts. *Organisation Studies*, 19(3), 477–492.
- Hofstede, G. (2011). Dimensionalising Cultures: The Hofstede Model in Context. *Online Readings in Psychology and Culture*, 2(1). <https://doi.org/10.9707/2307-0919.1014>
- Hong, Y., Hammad, A. W. A., Sepasgozar, S., & Akbarnezhad, A. (2019). BIM adoption model for small and medium construction organisations in Australia. *Engineering, Construction and Architectural Management*, 26(2), 154–183.
- Howard, R., & Björk, B.-C. (2008). Building Information Modelling-Experts'ViewsExperts'Views on Standardisation and Industry Deployment. *Advanced Engineering Informatics*, 22(2), 271–280.
- Howell, I., & Batcheler, B. (2015). Building information modeling two years later—huge potential, some success and several limitations. *The Laiserin Letter*, 22(4), 3521–3528.
- Kokkonen, A., & Alin, P. (2016). Practitioners deconstructing and reconstructing practices when responding to the implementation of BIM. *Construction Management and Economics*, 34(7–8), 578–591.
- Liao, L., & Ai Lin Teo, E. (2018). Organizational Change Perspective on People Management in BIM Implementation in Building Projects. *Journal of Management in Engineering*, 34(3).
- Lunenburg, F. C. (2012). Organisational Structure: Mintzberg's Framework. *International Journal of Scholarly, Academic, and Intellectual Diversity*, 14(1).
- Luo, L., He, Q., Xie, J., Yang, D., & Wu, G. (2016). Investigating the Relationship between Project Complexity and Success in Complex Construction Projects. *Journal of Management in Engineering*, xx(xx), 1–12.
- Mintzberg, H. (1980). Structure in 5's: A Synthesis of the Research on Organization Design. *Management Science*, 26(3), 322–341. <https://doi.org/10.1287/mnsc.26.3.322>
- Pfister, J. (2009). *Managing organisational culture for effective internal control: From practice to theory*. Springer Science & Business Media.
- Salaman, G. (1978). Towards a Sociology of Organisational Structure. *The Sociological Review*.
- Schein, V. (1985). Organisational realities: The politics of change. *Training and Development Journal* . <https://psycnet.apa.org/record/1985-16073-001>
- Succar, B., & Kassem, M. (2015). Macro-BIM adoption: Conceptual structures. *Automation in Construction*.
- Trice, H., & Beyer, J. (1993). *The cultures of work organisations*. <https://psycnet.apa.org/record/1992-98310-000>
- Waterman, R., & Peters, T. (1982). *In search of excellence: Lessons from America's best-run companies*. <https://pdfs.semanticscholar.org/ba37/1e835c429bb75352136d8638f1ed9dab969e.pdf>
- Willcoxson, L., & Millett, B. (2000). The management of organisational culture. *Australian Journal of Management & Organisational Behaviour*, 3(2), 91–99.
- Yan, H., & Damian, P. (2008). Benefits and barriers of building information modelling. *12th International Conference on Computing in Civil and Building Engineering & International Conference on Information Technology in Construction*, 16–18.

Zhou, L., Perera, S., Udejaja, C., & Paul, C. (2012). Readiness of BIM: a case study of a quantity surveying organisation. *First UK Academic Conference on BIM*.