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SUITABILITY OF BUILDING INFORMATION MODELING (BIM) IN CONSTRUCTION INDUSTRY: AN INNOVATIVE DIGITAL SOLUTION

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Abstract

The role of Building Information Modeling (BIM) technology is indispensable when it comes to conceptualizing, designing, planning and managing an infrastructure project. Construction companies as well as engineering and architectural companies around the world embarked on this endeavor to compete globally. However, not all companies involved in construction projects who are categorized as medium and small scale are aware of the benefits and importance of BIM software. This study aims at assessing the suitability, benefits, barriers and challenges of BIM technology which are described as gaps or findings from most literature reviewed in a worldwide perspective.

To attain this objective, the researcher consolidated and reviewed relevant literature and studies about BIM technology published internationally from 2021-2016. The study gathered the results on the findings and conclusions of each article. However, the literature reviewed shows that there were a lot of factors both from internal and external forces that prevented the suitability in the application and adoption of BIM software in the international construction industry.

Keywords: Suitability, Building Information Modeling, Construction Industry, Innovative, Digital Solution

Introduction

The concept of Building Information Modeling (BIM) was introduced by Professor Charles Eastman at the Georgia Tech School of Architecture in late 1970 (Mohd Noor, S. N. A., Junaidi, S. R., Ramly, M. K. A., 2018) but the term "Building Information Modeling (BIM)" only become popular in 2002 when Autodesk the developer of AutoCAD and Revit software released a white paper entitled "Building Information Modeling" which was supported by other software developers to assert their involvement in the field like Bentley System, Graphisoft, GMW Computers Ltd. among others. Although ArchiCAD was credited to have introduced a more mature BIM software in 1987, an earlier version of BIM software was credited to Sonata in 1986 (en.wikipedia.org).

Based on the United States National Institute of Building Sciences (NIBS) a BIM is a digital representation of physical and functional characteristics of a facility. It serves as a shared knowledge resource for information about the facility, forming a reliable basis for decisions during its lifecycle from inception onward. (Zima K.,Plebankiewicz E. & Wiczorek, D., 2020).

The improvement of BIM software and the advancement of technology worldwide have greatly affected the construction industry to accept technology changes. In a way that it modernized the methods, concept, design and analysis, project management system and processes. The construction industry is regarded as one of the biggest industries in the world, however, the said industry was far beyond expectation to be productive and efficient due to traditional primitive practices in construction methodologies and other internal and external factors affecting the application of BIM technology.

Hence, there is a need to allow digital innovation to come into play like BIM technology to help the Architect, Consultant and Engineer to design and build a structure using a high-end computer to simulate a model before, during and after the construction phase and in the maintenance phase of the building. With the increasing competitiveness in the construction industry, the strategic adoption of BIM is a key for a successful project. Most construction companies in developed countries like USA, Canada, Great Britain, Australia, New Zealand, Japan, Korea, Hongkong, Singapore, Malaysia, China and others are gearing towards the adoption of BIM technology as part of technological change for a new management concept and philosophy. Despite the effort to use advanced techniques, the efficiency and progress of the construction industry remained at a low rate.

The purpose of this study is to determine, assess and explore the underlying circumstances and factors that affect or prevent the suitability of BIM technology application in the international construction industry, taking into consideration user behavior and adoption, user behavior, impact, barriers and challenges.

Literature Review

1.Application and adoption of BIM

BIM technology was very well-known for more than two decades in the construction industry, which prompted its application, implementation and adoption especially by large architectural, engineering and construction firms involved in big and complex projects. However, its application and adoption were somewhat slow based on different literature/studies and research journals reviewed. The following studies were reviewed to determine the gaps or findings of existing related literature.

Umar, T. (2021) conducted a study on challenges of BIM implementation in the Gulf Cooperation Council (GCC) using a systematic literature review and a survey questionnaire. The study revealed that 69.79% reported that their companies are planning for BIM implementation in future projects. The gaps/findings noted were associated with four (4) main categories namely: Organization; Technical; Government and Legal and Environment. A similar study conducted by Muthusamy, K., & Chew, L. (2020) revealed that 71% of BIM users are inclined toward this technology among CIDB G7 contractors in Klang Valley, Malaysia. Using the Relative Importance Index, as a method of study. However, there are a lot of factors affecting the adoption of BIM such as: tax incentives, government support, cost, research collaboration, impact on business process, BIM standard, training, organizational leadership, organizational culture, time impact, data sharing protocol and interoperability. In Poland, a favorable acceptance of BIM in the market was noted, based on the research study of Zima, K., Plebankiewicz, E., & Wieczorek, D. (2020) using a SWOT analysis. However, it is quite difficult to forecast the wide implementation of BIM in Poland due to fast dynamic changes. Rodriguez, L.A. et.al (2019) of the Philippines also conducted a study on BIM adoption using a descriptive design method. The result showed that only 34% adopted BIM concept while 66% were BIM non-users which dictates that BIM is not yet widely accepted in the Philippine construction industry due to high cost of BIM related software, the lack of skilled BIM operators and contentment with the use of current software (CAD). In Indonesia a study was conducted by Hatmoko, J. U. D., Fundra, Y., & Wibowo, M. A. (2019), using qualitative and quantitative research methods about the adoption of BIM in the construction industry. The result showed that 60% of their respondents considered BIM is new to their companies while 40% said they have no idea about BIM, which connotes that BIM is unpopular to Indonesian construction industry. China was also subjected for review by Chen, Y., et.al (2019) using the technology-organization-environment (TOE) framework for BIM application. The result showed that there is a relative advantage of BIM coupled with management support for BIM adoption. It was also noted that engineering and consulting firms are more inclined to adopt BIM but not for construction firms. A study was made in Pakistan government hospital wherein the key stakeholders are convinced to take appropriate measures to use BIM for future projects as shown in the study of Ali, B., Zahoor, H., Mazher, K. M., & Maqsoom, A. (2018). In the United Kingdom, Ahmed, A. L., & Kassem, M. (2018), made a study for a Unified BIM adoption taxonomy: conceptual development, empirical validation and application. Using a systematic literature review, synthesization, confirmatory factor analysis and logistic regression of 177 samples, the result showed that the taxonomy's constructs have influence on the BIM awareness, interest and decision stage. Papadonikolaki, E. (2018) discussed the loosely coupled systems of innovation: aligning BIM adoption with implementation in Dutch construction. Using a qualitative method, the study showed that construction firms have strong external and internal BIM motivations and visions to adopt BIM but coordination among peers involved in the project to support BIM

implementation is missing. In the study of Milyutina, M. A. (2018) focuses on the introduction of Building Information Modeling (BIM) Technologies in Construction. Using 164 survey questionnaires from construction companies the results showed that BIM technology is widely implemented both in the construction industry and academia. It also captures the benefits of BIM such as systematic modeling process, interactive visualization and standard data exchange. In Nigeria, a study by Ogunmakinde, O. E., & Umeh, S. (2018) discussed the adoption of BIM in the Architecture Engineering and Construction (AEC) industry. Using a quantitative research method through a structured questionnaire, a sample size of 92 Nigerian professionals was collected and analysed. The result revealed the most common barriers of BIM adoption namely: lack of awareness, lack of trained professionals and cost of software. While the drivers of BIM adoption are: desire for innovation, capacity to ease design activities and improve design quality and ability to provide lifecycle value to clients. The study also noted that 58.1% medium level of awareness among those professionals but with less understanding of its techniques. In Sri Lanka, Ekanayake, S. P. (2017) made a research study regarding the suitability of building information modeling (BIM) for architecture, engineering & construction (AEC) industry. Using sample data collected from the AEC industry through a questionnaire posted on Google docs for three weeks. The result showed that the adoption of BIM in the AEC industry is well accepted in Sri Lanka. In the United Arab Emirates (UAE) Mehran, D. (2016) made a study which explored the Adoption of BIM in the Construction Industry for AEC Firms. The method of research used was an on-line survey questionnaire targeting eighty (80) AEC professionals but only 60 respondents returned the survey. The study showed that BIM in UAE is not yet mandatory for all construction projects and the government must develop BIM standards and protocols for their infrastructure projects. Lastly, Ginzburg, A., et.al. (2016) of Russia made a research on the implementation of BIM-technologies in the construction industry according to international experience. The Bew Richard model was used to make an assessment of the BIM implementation and the level of development. From the study it was noted that Graphisoft-Archicad, Autodesk-Revit, Nemetschek –Allplan and ASCON-Renga are the leaders of BIM software.

2. Influences, Drivers and Impacts of BIM

Digital technology has gained momentum every year and are universally hailed as drivers to increased productivity and efficiency but not yet accepted on a large scale like BIM technology. The following studies were reviewed to determine the gaps/limits of existing related literature.

In Germany, Berlak, J., Hafner, S., & Kuppelwieser, V. G. (2021) made a study about digitalization's impacts on productivity: a model-based approach and evaluation in the building construction industry. The study focuses on how digital technology has an impact on productivity using qualitative interviews based on Technology Acceptance Model (TAM) which identify the unknown influencing factors and a quantitative questionnaire to evaluate its suitability. In Lebanon, a study made by Shibani, A., Ghostin, M., Hassan, D., Saidani, M., & Agha, A. (2021), exploring the impact of implementing building information modelling to support sustainable development in the construction industry. The study showed that BIM in the Lebanese construction industry, is still the traditional fashion and the people lack skills and training. The barriers found were attributed due to economic, social and environmental issues of the said country. Lindblad, H., & Guerrero, J. R. (2020) studied and reviewed the client's role in promoting BIM implementation and innovation in construction. Using the interpretative case studies to explore two initiatives namely: "BIM implementation" and "Professional Client" to promote innovation policies in the industry. However, due to the limited scope of the study, only the client's perspective in the development of innovative policies was studied. In New Zealand,

Okakpu, A., GhaffarianHoseini, A., Tookey, J., Haar, J., & Ghaffarianhoseini, A. (2020) studied and explore the environmental influence on BIM adoption for refurbishment project using structural equation modelling. Using structural equation modelling and responses from 105 New Zealand construction professionals, they found out that there is a strong support for BIM adoption and the impact of sharing information, retrofit tools, client expectations and culture. The research study of Villena, F., García-Segura, T., & Pellicer, E. (2020, November) focuses on the drivers of innovation using BIM in Architecture, Engineering, and Construction firms. The study showed that there are positive effects of good strategic management using the different models of BIM, namely:3D model of the building, 4D for scheduling, 5D for costing/estimating and 6D for sustainability from construction to maintenance phase of the building. He, X., Xue, W., Xue, X., & Wang, L. (2020) studied and identified the impact factors of BIM cross-organizational collaborative innovation. The study showed that BIM technology involves cross organizational collaboration that involves technology adoption, absorption and diffusion and the influence of BIM technology with regards to standardization, legal issues, policies and applications. In a similar case, Liu, H., Skibniewski, M. J., Ju, Q., Li, J., & Jiang, H. (2020) made a study on BIM-enabled construction innovation through collaboration: a mixed-methods systematic review. Using a comprehensive theoretical framework and mixed methods to analyze the capability of BIM in construction projects. The result showed that BIM is being considered as a technical innovation while capability innovation remained unchanged due to differences and lack of collaboration among concerned entities. In China, Zhang, L., Chu, Z., & Song, H. (2020) studied the understanding and relationship between BIM application behavior and sustainable construction: A case study in China. Using a survey questionnaire from 353 BIM users and the structural equation model analysis, the result showed that BIM technology is user-friendly which is an influential factor in behavior attitude as well as making it sustainable if coupled with support from construction companies. Chan, D. W., Olawumi, T. O., & Ho, A. M. (2019) of Hongkong reviewed the critical success factors for building information modelling (BIM) implementation. Using a structured survey questionnaire and expert interviews the study found out that the most influential success factors for BIM implementation are: client's acceptance, good organization structure, knowledge and skill to use BIM and financial aid from the government to support the BIM system. Yuan, H., Yang, Y., & Xue, X. (2019) discussed promoting owners' BIM adoption behaviors to achieve sustainable project management. Using a structured questionnaire and adoption of Likert-type scale, the results indicated that BIM technical features and government BIM policies have positive effects on perceived usefulness while social and organizational support does not. Hence, the attitude of the BIM user plays a significant intermediary role among perceived usefulness, perceived ease of use and behavior intention. Also, Mahamadu, A. M. et.al, (2019), made a study about Building information modelling (BIM) capability and delivery success on construction projects. Using semi-structured interviews, multiple regression modelling, the result showed that BIM staff experience and use of proposed methodology before the start of the project were identified as the most influential factors for BIM delivery on good quality, timely schedule and cost. The administrative and strategic capacities are influential in collaboration, coordination and integration. Similarly, Santos, R., Costa, A. A., Silvestre, J. D., & Pyl, L. (2019) made a study which discussed informetric analysis and review of literature on the role of BIM in sustainable construction. Using informetric analysis of the literature covering a total of 317 journal articles were analyzed and found out that publications on the subject registered an exponential growth of 90% from 2008 and 2017 and also there is an increased use of BIM technology for the last 5 years. In Dutch country, Siebelink, S., Voordijk, J. T., & Adriaanse, A. (2018) discussed the developing and testing a tool to evaluate BIM maturity: Sectoral analysis in the construction industry. The method used is in-depth interviews from 53 Dutch firms that represent different disciplines from the construction industry. The result showed that there is a strong strategic

support for BIM among the companies evaluated, however, no formal stand as to the BIM related processes and responsibilities was affirmed. Hence, stimulation of BIM maturity growth is beyond reach due to culture, people, awareness, education and training. Lastly, Yaakob, M., Ali, W. N. A. W., & Radzuan, K. (2016, August), made a study identifying critical success factors (CSFs) of implementing building information modeling (BIM) in Malaysian construction industry. A series of interviews and literature review were conducted in order to identify the critical success factors of BIM implementation and to be validated during the workshop.

3. Benefits, Barriers and Challenges of BIM

The benefits, barriers and challenges of BIM have been seen in many Journals/Articles worldwide, especially in the Architectural, Engineering and Construction (AEC) industry. The use of BIM technology trimmed down project cost and time but increased the productivity and quality of work from the project management perspective towards achieving a "Smart City" The following studies were reviewed to determine the gaps/limits of existing related literature.

In Lebanon, Shibani, A., Ghostin, M., Hassan, D., Saidani, M., & Agha, A. (2021) explored the impact of implementing building information modelling to support sustainable development in the Lebanese Construction Industry. The study shows that BIM in the Lebanese construction industry, is still the traditional fashion methodology and the people lack skills and training. The barriers found are attributed to economic, social and environmental issues. While in the study of Gamil, Y., & Rahman, I. A. R. (2019) of Yemen, focus on the awareness and challenges of building information modelling (BIM) implementation in the Yemen construction industry. Using a questionnaire survey from 123 Yemen construction companies and analyzed using SPSS software, the results showed that the challenges are attributed to: financial constraint, lack of knowledge, lack of awareness of BIM benefits and no government support. Similarly, Ayinla, K. O., & Adamu, Z. (2018). conducted research on bridging the digital divide gap in BIM technology adoption. Using a mixed research method through on-line questionnaire survey from 240 respondents and semi-structured interview from nine experts, the result showed that organizations can be categorized into layers or levels in adopting BIM so that a conceptual model could be developed to identify the "Laggards", "Late Majority" and "Innovators" and customize adoption strategies. Ahmed, S. (2018) conducted a research on barriers to implementation of building information modeling (BIM) to the construction industry: a review. Using comprehensive literature review and data collection the result showed that there are five (5) most crucial barriers in the implementation of BIM namely: social and habitual resistance to change; traditional contracting; expensive training and software and lack of awareness about BIM. In Malaysia, Musa, S., Marshall-Ponting, A., Nifa, F. A. A., & Shahron, S. A. (2018) conducted a study about Building Information Modeling (BIM) in Malaysian construction industry: Benefits and future challenges. Using data collected from various sources such as journal articles, conference papers, books and internet, the result showed that BIM technology provides better information, communication and coordination as well as reduced financial expenses, improved visual picture of the project, safety and sustainability. While challenges in BIM implementation arise, covering the aspects of technology, culture, policy and process by stakeholders, organizations and the government. In the same year, Chin, L., et.al (2018), conducted research about the potential cost implications and benefits from building information modeling (BIM) in Malaysian construction industry. Using data collected from interview sessions and a framework analysis approach, the result showed an exemplified BIM implementation level in Malaysian construction industry in reference to actual practices and cost

benefits. Saieg, P., et.al., (2018) conducted a study about the interactions of building information modeling, lean and sustainability on the architectural, engineering and construction industry: a systematic review. Using a systematic literature review to understand how synergies of BIM technologies, methods and concepts have recently been explored by researchers. The result showed synergies appeared on the construction stage and in the conceptual design and decision making. In the United Kingdom, Alwan, Z., Jones, P., & Holgate, P. (2017) studied Strategic sustainable development in the UK construction industry, through the framework for strategic sustainable development, using Building Information Modelling. An actual case study was set-up from 15 individually designed dwellings in the North East of England using BIM as a platform aligned to the Modern Method of Construction. The result showed that it supports the integration framework for sustainable strategic development in construction procurement as means to implement bottom-up leadership in a value driven project. Finally, Matarneh, R., & Hamed, S. (2017) made a study about Barriers to the adoption of building information modeling in the Jordanian building industry. Using a structured on-line survey and literature review to identify the current level of BIM experience in the Jordan construction industry and define the perceived value, benefits and challenges. The result showed that only 5% of AEC organizations used BIM technology while 95% were non-users. Benefits were noted namely: eliminate clash detection; minimize conflicts and changes and reduced work schedules. Similarly, challenges encountered during the study namely: absence of government support; lack of awareness; lack of demand; resistance to change; and cost of BIM.

Conclusion and Recommendation

Based on the different literature reviews presented by international authors, the use of BIM technology is rapidly increasing around the world. Although the construction companies' experience the benefits, impacts, barriers and challenges of BIM technology the situation differs from developed to developing countries.

The construction industry is continuously re-engineering itself through the adoption and implementation of strategic government policies, technologies, and other associated processes. BIM and sustainability are salient concepts in the construction industry that must be reinforced and supported by its stakeholders to build a sustainable smart city. According to BIM product review data, a 32% Return of Investment (ROI) will be realized in 6 months or less (g2.com).

The relationship between BIM application behavior and sustainable construction in the construction industry has practical significance to bridge the gap in this field and reveal the current situation of BIM technology.

The government is encouraged to formulate policies, standards or measures to enforce the adoption and implementation of BIM technology for government infrastructure projects especially for large and complex designs. The educational institution or academe will also be of great help to introduce and include in the curriculum the needed BIM software application to the students to fill in the gap of the construction industry relative to BIM technology. Professional institutions and organizations must embark on rigid campaigns, workshops, seminars and conferences to formulate programs and training of AEC professionals and clients on the benefits of BIM to the industry, environment, clients, and the other stakeholders.

Conflict of Interest

The author declares no conflict of interest.

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