BUILDING INFORMATION MODELLING: BENEFITS AND CHALLENGES FOR WIDESPREAD ADOPTION IN THE NIGERIAN BUILT INDUSTRY

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ABSTRACT
Building Information Modelling (BIM) is a process involving the generation and management of digital representations of physical and functional characteristics of structures for the consumption of professionals in the building industry. This is due to its capabilities and potentials mostly in collaborative endeavours. Architecture, Engineering, and Construction (AEC) professionals are now able to collaborate more effectively even remotely thus ensuring a more streamlined design process and greater savings of construction costs through clash detection and predictable synergies. This study highlights the benefits of BIM adoption within the AEC industry while analysing the challenges encountered in its implementation. Various relevant literature were analysed with a bearing to better understanding of BIM usefulness in a more streamlined design process from design and construction management through to facility management. A few forefront local Architectural practices were observed with the aim of understanding the challenges inherent in the adoption of BIM in local practice. Findings show increased levels of apathy, unwillingness to adopt technological innovations like BIM with increased age of principals of firms. Other important challenges include costs, technological, standardization challenges and the dearth of other professionals willing to collaborate on such platforms. The most important challenges identified as barriers for BIM adoption are the absence of technical expertise on BIM tools deployment, reluctance to change, high investment cost in staff training, dearth of awareness of BIM technology and software/hardware upgrade issues.

KEYWORDS: Building Information Modelling, Adoption, Nigeria, Built, Industry, Challenges.

INTRODUCTION
Building Information Modelling (BIM) is an intelligent three dimensional model-based process that gives Architecture, Engineering and Construction (AEC) professionals the insight and tools to plan, design, construct, and manage buildings and infrastructure more efficiently. Azhar, et al (2012) described BIM as an improved process and tool, which contains a set of virtual aspects, concepts and systems of a facility within one environment. Also, Arayici and Coates (2012) viewed BIM in most simple terms as the utilization of a database infrastructure to encapsulate built facilities with specific viewpoints of stakeholders. BIM technology supports Architects throughout the design process and helps them gain more insight earlier in the building design process to optimize designs for clients' requirements (Autodesk 2018). The construction industry is undergoing a radical change as project owners are demanding for more at lower cost and better risk management; thus increasing the use of new technologies in project implementations, (Ogwueleka and Ikediashi, 2017). This paper aims to highlight the benefits of BIM and challenges facing its adoption in the Nigerian built industry with a view to encourage its widespread adoption by design and construction professionals in the Nigerian built industry.

According to the US National Building Information Model Standard Project Committee, BIM is a digital representation of physical and functional characteristics of a facility. As such it helps as a shared knowledge resource for information about a facility

creating a reliable basis for decisions during its life-cycle from inception onward. A basic premise of BIM is collaboration by different stakeholders at different phases of the life cycle of a facility to insert, extract, update or modify information in the BIM to support and reflect the roles of that stakeholder such as the Architect, the Civil Engineer, the mechanical Engineer, the Electrical Engineer etc. It is a shared digital representation founded on open standards for interoperability. Mohammed and Ahmad (2017) asserted that Construction companies are constantly faced with the need to innovatively integrate the construction process and address project development challenges. A novel approach towards this is the amalgamation of BIM in the building design and development cycles.

Methodology

A qualitative assessment of scholarly views was carried out through critical review of literature bearing on the paper's goal. The feedback from Nigerian Architectural firms observed locally formed the primary source of data for the work while already published works on BIM served as a source of secondary data for the study.

Review of BIM Applications

While Building design is mostly dependent upon two-dimensional technical drawings (plans, elevations, sections, etc.) and three-dimensional virtual realism, Building information Modelling extends this beyond 3D, supplementing the three primary spatial dimensions (width, height and depth) with time as the fourth dimension (4D) and cost as the fifth (5D). BIM does more than cover geometry, it covers spatial relationships, light analysis, geographic information, quantities and properties of building components (for example, manufacturers' details etc).

Lindblad (2013) offers a wide list of benefits associated with the use of BIM to include; efficiency of handling project or building related information, increased productivity, streamlined construction processes, cost reductions, improved product quality, improved building sustainability, customer / client communications, improved time management, more convenient data exchange, faster analysis, less data input and transfer errors, enablement of collaborations, and improved building performance.

However, this review analyses BIM competencies under the following headings:

- Multidisciplinary cooperation
- Clash detection
- Energy efficiency
- 3D visualization
- 4D constructability
- 5D cost estimating
- Facility operations

Multi-Disciplinary Co-Operation

A common misconception is that BIM is only a software and nothing more. It is a process that allows all project stakeholders to collaborate effectively and deliver projects successfully. BIM permits a virtual information sharing environment where all members of the design team (Architects, landscape Architects, surveyors, Civil, Structural and building services Engineers, etc.) can collaborate on a particular or several projects from different workstations in real time, i.e, simultaneously. The information thus generated could be transmitted to the main contractor, subcontractors and the client through digital format when necessary. This sort of virtual communication allows each professional to incorporate discipline-specific data to the single shared model thus encouragingsharing and collaboration which are essential throughout the AEC industry. Diverse professionals collaborating on large scale projects such as residential layouts, markets etc can depend

upon the ex-situ or cloud functionality capabilities of BIM to guarantee a more refined process and timely work delivery. The figure below depicts clearly how a typical BIM work team functions. It shows in a cyclic cloud arrangement how every member of a building project team can access and contribute to the project at hand with the use of BIM project management facilities.



Fig 1 : Typical BIM work team. Source: Zigurat Global Institute Of Technology

Additionally, information related to all stages of a project's lifecycle from design, scheduling, construction management to commissioning, building occupancy and deconstruction are readily made available through servers or the cloud. Thus, one can be afforded the ability to monitor one's project from anywhere. This, in no small way helps to improve communication and coordination between teams while saving immensely on decision making time. Reviews and mark up designs can be done at any time by any certified member of the team. And with a comprehensive history of a project's development, cases of file losses or compromise are eliminated. The result is a fine-tuned environment for optimal coordination and collaboration.

Clash Detection

Through collaborative coordination of discipline-specific data, task collisions are spotted early in the design process. This has proven to be a major advantage of working with BIM as a cost effective tool. It affords great reduction in expenses during construction. An array of disciplines merge together to work on different aspects of a construction project. With the Architects' model as a starting point, a Structural Engineer, Environmental Engineer, Mechanical and Electrical Engineer and a host of others will each produce their own models. All outputs while having unique graphic languages must be in the same format. Each 'model' consists of a variety of model files, documents and organised data files containing geometric and non-geometric information of the intended project. The conglomeration of all these is what is referred to as a digital model.

At pre-determined junctions and intermissions, the different models are juxtaposed to check for undesirable clashes between any of the design elements from any of the building team stakeholders. Thus, with data from a horde of models coming together to form a

master model, it is very simple to recognize, categorize and eliminate unwanted intersections.

Energy Efficiency

With BIM as an integral aspect of design, it means that sustainability can be integrated into the design process. With traditional design and construction processes, one would carry out environmental analysis only after the design was complete and built. This would make issues that may arise eventually, both costly and problematic to correct. By comparison, BIM affords users the opportunity to conduct early-stage environmental analysis, amongst other possibilities. Aspects like building orientation, energy use and daylight can be explored in a virtual environment that imitates the real-life scenario, thus saving hugely on time, and resources.

With BIM, building sustainability in all its ramifications becomes a significant component of the design process. Fundamental elements such as energy efficiency, material efficiency, waste management, water management, proper siting and landscape, lifecycle analysis, building commissioning, and much more are taken care of from the beginning. Furthermore, issues discovered in analysis no longer sets the design process back because one can make quick and easily distributable changes (changes that can reflect automatically on every place where that entity of information is) to virtual models instead of re-designing. There's also the opportunity to create a paper-free AEC working environment with this cloud-computing and collaborative process.

3D Visualization

BIM empowers one to assemble every part of a project into one complete design, together with detailed floor plans and 3D models. Simulations afforded by BIM can also enable users to visualize their projects in real-world circumstances. This enables users to visualize their projects at different times of the day, and even view its overall energy performance. Observations can then be compared to expectations and due corrections or adjustments made even before the project is implemented with the help of virtual and augmented reality.

4D - Constructability

BIM permits the fourth dimension of time factor to be added to the 3D model of a proposed building. Building components like walls, materials, M/E components are identified and drawn as object-oriented elements. Building construction data like resources needed, time schedule, costs are linked to their corresponding elements using Industry Foundation Class (IFC) modules already defined in the software. 4D models are models that link the 3D description of a product to be erected with the plan and time-based schedule to build it in order to portray the simulation of the construction of a project.

5D - Cost Estimating

Conventional estimating techniques which rely on two-dimensional drawing measurements have proven over time to be inefficient, filled with uncertainty, and errors. Once quantities are generated from the model with qualities relating to the manufacturer's specifications, cost estimates can be gotten from the models, thus equipping the model with a fifth dimension of cost.

5-Dimensional estimates are BIM extrapolated values to construction cost estimation of material quantities that are routinely generated from the data within the model. 5D Estimation improves budgeting, provides cost-loaded schedules, and affords users meaningful opportunity to make accurate comparisons from displays of multiple interactive predictions. When the design is changed, cost adjustments are calculated in real time using

predefined (by user) cost values for each building element included in the model. This enables general contractors to help the owner improve design with value-engineering decisions.
Parametric definition of objects is the backbone of any BIM software; that is, the objects are defined as parameters in relation to other objects, thus if the value of a related object is modified, dependent ones will be automatically updated. Each model element or space has intrinsic characteristics that allow users to order them automatically as needed, providing cost estimates as well as material tracking and organization.

Facility Management

Equipment inventory and facility maintenance are the foundation of facility operations. The key challenge in developing a maintenance program is imputing the product and asset information required for precautionary and preventive maintenance. The information on building equipment stored in BIM models can eradicate months of effort to accurately populate maintenance systems.

BIM has the potential to provide accurate, timely, and relevant information not just during design and construction for a single building, but also throughout the lifecycle of an entire portfolio of facilities. Lifecycle BIM is the practice of generating, maintaining and employing building information to manage operations and maintenance of facilities throughout their operational lifecycles. It is fast becoming common to see building design professionals embedding data on replacement costs and life expectancy in BIM models, thereby helping an owner understand benefits of investing in materials and systems and their cost nature over the life of the building. For example, utilizing polished wooden floor finishes is more expensive than tiles initially, but is likely to result in reduced overall lifecycle costs since it is more durable. Lifecycle data is also very valuable for predicting ongoing capital improvement costs.

Challenges to Global Adoption of BIM

Lindblad (2013) mentioned an extensive list of barriers for BIM adoption including slow technology development, limited compatibility and interoperability, difficulties of capturing fragmented AEC industries in BIM, difficulties to apply BIM across the entire design process and building life cycle, limited libraries of standard objects, high demands on computing hardware, the emergence of new professional roles and relationships in the context of BIM. Others are the lack of international standards, difficulties of using BIM models for unintended purposes, lack of interest in the part of professionals working with well-established non-BIM procedures, time and cost required for training, limited confidence in data security, as well as challenges of agreeing on model ownership, project responsibilities, access rights, intellectual property rights, contractual responsibilities for inaccuracies, and payment arrangements. This study discusses BIM adoption challenges under the following sub-headings:

- Lack of skilled personnel
- Lack of interest on the part of professionals working with well-established non-BIM procedures
- Age related barriers
- Limited libraries of standard objects
- Limited compatibility
- Difficulties of capturing fragmented AEC industries in BIM

Lack of Skilled Personnel

In a survey carried out for the state of Kuwait, the participants were asked to evaluate “Lack of BIM Training” as a perceived barrier of BIM. About 42% of the respondents strongly

agree that it is a perceived BIM barrier. In addition, about 48% of the respondents just agree that it is a barrier. About 8% of the respondents were neutral in their opinion, and only 2% disagreed that it is a barrier of BIM. No respondents disagreed strongly to this barrier. Hence, it is concluded that lack of BIM training is a significant barrier of BIM implementation (Noor et al 2017).

Lack of Interest on The Part of Professionals Working with Well-Established Non-BIM Procedures

Most construction processes rely on 2D drawings to cope with demands for high-speed design and construction demanded by clients. This is a major factor in the inability or reluctance of traditional practices in implementing BIM procedures in their workflows. Despite the glaring benefits of new technological innovations, many established (older) firms are very reluctant in venturing into them because of the view that they're often complicated in learning and application. This phobia of moving into uncharted territories often keep many of them away from adapting to changing times and the benefits accruing from it.

Age Related Barriers

It is a well known fact that the vast majority of well-established firms or organizations in the AEC industry are owned and managed by people in their late 40s and above. This same category or class of practitioners are found to have increased levels of apathy, and various degrees of phobia towards anything that contains "high-tech"or the internet. This becomes a cause for concern since it is often difficult for an organization to adopt a contemporary working mode, even if staffed with youths when leadership does not show enough enthusiasm.

Gilly and Zeithaml,(1985) showed in their study of adoption of several key consumer-related technologies by the elderly, that adoption patterns for the elderly differed significantly from those of younger ages. While the gap was not considerable with regards to adoption patterns for technology that has to do with financial services or lifestyle applications, it was very glaring for work related technological innovations. This trend bears down heavily on the acceptance and use of BIM by employees and owners of practices who are around 45 years and above. The solution to this is simply designing BIM systems that are not complex in nature with easy learning and application curves. Omotayo (2015), concluded that it would be favourable to design applications that meet the needs and wants of the elderly people, in addition to ensuring the applications are easy to use by this group of people.

This is in line with previous studies which have indicated that older people are more likely to use technologies that are useful to them and are easy to understand and navigate through (McCloskey, 2006; Panand Jordan-Marsh, 2010; Conci, Pianesi and Zancanaro,2009; Su et al., 2013).

Limited Libraries of Standard Objects

Smith (2014), opined that design might be limited only to BIM software library components because of its limited contents. As they require geometric data and programming rules to guide their conduct, producing library components is time consuming; partly justifying this issue, most BIM software comes equipped with a standard library (Eastman et al., 2011) creating a library by oneself is at first time consuming, but eventually pays off by growing productivity in future projects. It is recommended that minor home-builders initially invest in creating a standard library within their software that satisfies their peculiar designs or style when adopting BIM for the first instance and onwards (Sears, 2015).

Limited Compatibility

As with every laudable innovation in the modern world, competition follows suit, often leaving in its wake confusion and chaos in modes of operation and standards. Since every provider of BIM software has their own specific functions and file formats, there is yet no standard or common platform and compatibility issues abound when projects are transferred between each other (Andreas 2012). This can be easily observed when moving data from BIM infused Autocad or Revit Architecture to Archicad- both BIM software applications.

Difficulties of Capturing Fragmented AEC Industries in BIM

Analysis of several survey data confirms that, besides some advanced high profile projects, design and construction processes are highly linear in nature and characterized by a separation of professions. This is the situation with professionals employed in large design organizations, where different professionals work in close physical proximity to each other (Christiane2017). Majority of surveyed AEC professionals describe their profession's normal workflow as mostly direct, with little temporal overlaps of Architecture and Engineering processes.

CONCLUSION AND RECOMMENDATIONS

Possessing the right cognizance of BIM capabilities and its breakthroughs within the AEC industry is necessary in order to encourage BIM adoption and gain better insights into BIM implementation procedures. Challenges to BIM adoption were highlighted in an effort to better understand the processes towards BIM implementation. Studies have shown that BIM adoption is low in the construction Industry of most emerging markets like Nigeria.

Identifying challenges/benefits and approaches to overcoming them in this study will assist in its acceptance and adoption in the local scenario. BIM is at the heart of the AEC industry and is indeed an invaluable tool to AEC professionals.

This paper recommends that there should be a wholistic government intervention in the move toward use of BIM for the Architecture, Engineering and construction industry of Nigeria. This should be imbibed in the educational curriculum of courses of study within the built environment such as Architecture, Estate management, Civil Engineering, Building, Surveying, Mechanical / Electrical Engineering, etc.

Furthermore, the development control authorities should inculcate BIM technology in the assessment of building design for approval purposes. There should be a law that authorizes the planning bodies to request and obtain the BIM models from the different professionals who worked on the design of a proposed development and such models should be subjected to various tests by industry experts to check for any inconsistencies which can be corrected early enough before the construction. Failure to do this may lead to fatal building collapses and serious malfunctions.

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