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BUILDING INFORMATION MODELLING: A TOOL FOR DIFFUSION OF INFORMATION IN NIGERIA

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Building information modelling (BIM) technology has now reached maturity level in several countries around the world. The construction industry internationally is realising potential benefits of using collaborative process in construction, and the increasing return on investment; and the potential benefits of integrating the industry is not fully realized in Nigeria. A quantitative approach was adopted to x-ray the Nigerian construction industry; a structured questionnaire was used across the AEC to evaluate BIM awareness and adoption in Nigeria through the line of enquiry known as the 'diffusion of innovations'. The result revealed that 59.5% are aware of BIM technology; 22.8% are aware and currently using BIM and the remaining 17.7% neither aware nor using BIM; consequently, the industry was evaluated just within the *Late Majority* in terms of awareness and just entered the *Early Majority* in terms of BIM technology adoption. The country's adoption pattern was compared with three other countries where BIM is at advance stage; consequently, Nigeria is at least five years behind US, UK and South Africa. The industry is likely to take the UK pattern to adopting the BIM.

Keywords: adoption, BIM, collaboration, diffusion of innovations, integration

INTRODUCTION

Engineering businesses are recognising that the effective and integrated management of design information is a vital component to achieving engineering and business goals. This project is an opportunity to contribute to setting the agenda of research and industrial practice in this key area: Building Information Modelling (BIM). BIM has a development approach to design and construction (Memon, *et al* 2014); NBS, 2016 defined BIM as a way of working and also the means by which everyone can appreciate a building via the use of a digital model which draws on an array of data assembled collaboratively, throughout the stages of procuring a building and its lifecycle. BIM is the most significant information technology development and a paradigm shift in Architecture, Engineering and Construction (AEC), therefore gaining recognition as a powerful tool to deliver benefits across the construction industry and Facility Management (Hammad, Rishi & Yahaya, 2012). Moreover, BIM is a tool or system of visualisation and documentation/communication (Sabol, 2008; Hammad, Rishi & Yahaya, 2012).

BIM potentiality as a system is not limited to the effective management of primary data, but also offers effective and detailed monitoring, and facility performance analysis that can support innovative and more cost effective management of complex facilities (Matchell & Schevers, 2006). It can be realized that many *countries are increasingly using BIM for innovative approaches to construction relationships, which is likely to give them a competitive advantage in an increasingly globalised economy* (Froise and Shakantu, 2014).

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The primary data of this research were gathered through questionnaire survey and aimed at Nigerian contractors and consultants (architects, engineers and quantity surveyors); the approach to the research was quantitative in nature. The results were analysed and compared with surveys conducted independently in other countries that studied BIM adoption rates. The adoption rates were examined in terms of the line of enquiry known as the 'diffusion of innovations' to produce status in Nigeria.

LITERATURE REVIEW

Building Information Modelling

Considering BIM as a complete 3 dimensional digital depiction of a building system or subsystem, and a sophisticated technology comprising both accurate building model and incorporated information (in database) of the building components, requires recognition beyond a 3D of it being sample representation of a building or its components (NBS, 2012; Memon *et al*, 2014; NBS, 2015). BIM remains the most potential development in the world of construction industry (Chan, 2014).

BIM has gone beyond being just a drawing and documentation tool. It is not solely about software, but represents a more collaborative method of working (NBS, 2015). This process is also transforming the way cities are designed, and life cycle performance of buildings and systems (Beaven, 2012). The benefits of using BIM during the building design stage have been well-publicized and are fuelling its adoption rate among architects worldwide - transforming their drawing-based processes to model-based processes. Even though as adopted at design and construction stages in countries like United States (US), UK, Finland, Germany and Norway; BIM effective usage still remained unaware especially as a platform for facility management which along inclined to the entire facility life cycle. Beaven (2012) stated that,

"The benefits of using information from a building model for facilities management are likewise compelling - fuelling the discussion surrounding building lifecycle management and nudging facilities management towards model-based processes".

BIM is the latest software technology being introduced throughout the built environment and related manufacturing industry. Manufacturing industry has long realised the benefits of use of BIM, i.e. automobile industry recorded significant success from its adoption (Egan, 1998). However, the construction industry is generally known to be resistive to changes; and most constructors are not ready for new innovations, preferred to sticking to the traditional way of doing things (Latham, 1996; Walasek & Barszcz, 2017).

Abubakar and Ibrahim (2014) found that education and training, software availability and enabling environment are the most important factors that will aid the adoption of BIM technology in Nigeria; while social and habitual resistance to change, legal and contractual constraints as well as high cost of training were found to be the main barriers to BIM adoption in Nigeria. Moreover, adoption rates in Nigeria lag behind considering other nations where BIM implementation evolve. The industry professionals need more awareness to these trends in order to stay competitive in this changing environment.

BIM adoption in other countries

In spite of progressive adoption of BIM in US, UK and some developed nations, the construction industry is known to be a very conventional/bound by tradition and rigidity group to bring on board (Walasek and Barszcz, 2017). There is however, significant development in the Hong Kong construction industry and, considering the support by the Chinese Government on BIM adoption and implementation, there is still considerably low or slow adoption of BIM in the industry (Chan, 2014). Moreover, Chan (2014) study discovered that about 33% of the study responders believed a lack of training to be a significant reason for insufficient use of BIM; while two-third (67%) felt that use of BIM is not necessary; 2D is sufficient to meet their need. This shows a clear lack of understanding (awareness) of BIM. Similarly, in addressing individual perceptions to this great tool in the UK, some perceived BIM as an unrequited addition to the existing work process (Haward, Restrepo & Chang, 2017); this is more of remnants to the high initial cost (Walasek and Barszcz, 2017). Thus, design cost/fee will most likely increase in order to reward BIM usage. Success in terms of positive return on investment (ROI) also encourages the use of BIM.

In the UK and US, much research has been carried out on BIM, especially regarding potential benefits as well as streamlining the stages of its full adoption in their construction industries. However, the 2015 NBS National BIM Report lamented the limited expertise and resource that can research and educate the industry in this innovative field (i.e. BIM). Moreover, more countries are building up to BIM adoption (i.e. Ireland, Germany, Finland, Denmark, Norway, France, Canada, Malaysia and China); where nearly 60% of western European countries are frequent users of BIM and 74% of them perceived positive return on their overall investment on its adoption (McGraw & Hill, 2010).

South Africa is considered more developed than most African countries, including Nigeria. Their level of BIM adoption is higher than any other country in the African continent as a whole (Froise & Shakantu, 2014). However, South Africa has also encountered setbacks to its implementation, with contractual issues (i.e. procurement route) being one of the major barriers to BIM implementation (Froise & Shakantu, 2014; Kekana, Aigbavboa & Thwala, 2014).

The diffusion of innovations

Rogers (1983) discusses what he has called the 'diffusion of innovations' and demonstrates in what way an innovation takes some time to feast, even if it is demonstrably better.

Africa are amongst the contributory factors that slow the BIM adoption process. Considering low infiltration level of BIM technology in developing countries, the technology diffusion level need to be established by the help of diffusion of innovation model.

Rogers (2003) described the cumulative diffusion of innovation in an S-curve model, and any adopter falls under one of the following categories: Innovators, early adopters, early majority, late majority and laggards. The graphs below fully described the categories of adopters.

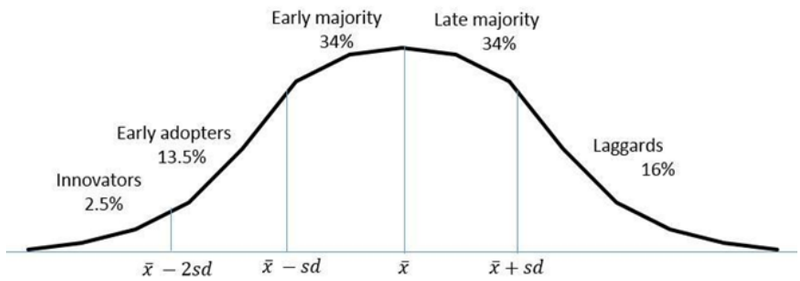

Figure 1: Innovation diffusion categories (Rogers, 1983)

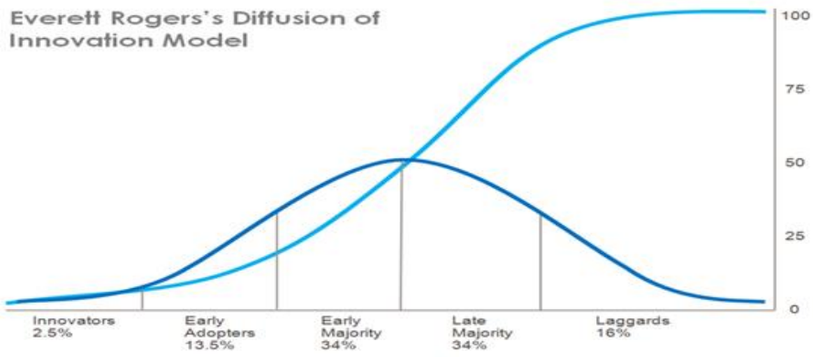

Figure 2: The diffusion of innovation (Rogers, 2003)

Going by the diffusion of innovation model, Jung and Lee's (2015) survey revealed that the main BIM users worldwide were in third phase (early majority), but those in the Middle East, Africa and South America were found to be in second phase (early adopters).

Africa recorded low and slow awareness and adoption of BIM with about 16% in the second phase (Jung & Lee, 2015). However, South Africa can be considered to be in the fore front of this collaborative innovation with a status of "early majority" i.e. third phase (Froise & Shakantu, 2014), but this status was recorded in what can be referred to as a 'lonely BIM' or 'small BIM' (mostly at organisational level); hence, the collaboration is quite limited. Thus, the country also has major barriers to the BIM adoption, these include: procurement

process, lack of awareness by the government, lack of awareness by the industry itself, and confidentiality of information.

Cox and Alm (2008) discuss the idea of inventive destruction (this involve innovation phasing out traditional way of working) and observe that the sustenance of producers depends on their capability to streamline production by introducing newer and better tools that increase productivity. Companies that do not deliver client requirements at competitive prices will eventually lose clients and die.

RESEARCH METHODOLOGY

The purpose of the survey was to determine the level to which CAD technologies and integrated construction process are currently being used by the construction industry in Nigeria. These results were then compared to the status and uptake of these technologies in some of examined countries in the literature review (US, UK and South Africa).

Precedents

In order to gather comparable results, the questions were aimed at gathering similar information to that available from other countries. The NBS survey has done extended research on BIM report in the UK and surveys by Froise & Shakantu, 2014 in South Africa. Figure 1 below described adoption rate of three different regions:

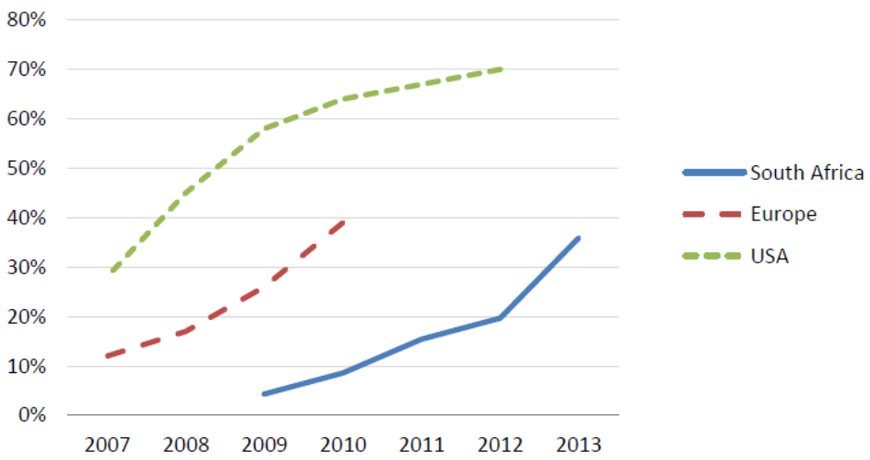

Figure 1: BIM adoption (Froise & Shakantu, 2014*)*

Two modern precedent studies are relevant to this research so as to match the Nigerian situation with those of other countries. Firstly, is a survey piloted by the NBS in the UK in 2011, then in 2012 …2017 which analysed sequential BIM use and perceptions of professionals in the industry. Secondly, is a Froise & Shakantu survey that compares the Europe, USA and South Africa markets and looks at BIM awareness, usage and perceptions levels, and take-up among architects and contractors, this was conducted in 2014.

The United Kingdom (UK), the United States (US) and South Africa are selected as sample countries to test BIM awareness and adoption. This selection is a reflection of two main principles or measures (Kassem, Succar and Dawood 2013): (a) the resemblance between the two developed nations (UK and US) in their construction markets in terms of applicable technologies and terminology; and also the two developing nations (South Africa and Nigeria), (b) the availability of reasonably wide BIM adoption surveys (BEIIC, 2010 in Australia, NBS survey from 2011 to 2017 in the U.K. and McGraw-Hill Construction, 2013 in the U.S.)

Survey questionnaire

The type of questions used were generally closed-ended and multiple choice, although there was also an opportunity to answer an open-ended question especially where further information may be required or the respondent may want to provide different or additional information.

The following section shows the result of a survey that examined different aspects of the use of BIM in Nigeria. The questionnaires were sent to contractors and consultants mostly from general building category in Nigeria predominantly from the following zones: North-west,

North-central and South-west in descending order of quantity followed by very few from North-east and South-east; due difficulty in gaining contact information for the North-east and South-east, therefore the result may not reflect the true picture of the industry in those regions.

The surveys were set up in a word document format (as an attachment) as well as *'google doc.'* (as a link) and sent via established personnel emails, the questionnaire could be accessed over the internet on PCs and Android phones. A total of 133 mails were sent, out of which a total of 80 responses were received (some by email and some by completing the online version); this represents approximately 60.2% response rate, hence this vindicated both the 55% for paper-based response rate and 47% for online response rate according to Ballantyne (2005). The responses received from contractors were 5 which represents 6.3% of the responses, architects returned 30 (37.5%), quantity surveyors returned 6 (7.5%), engineers returned 36 (45%) and Clients returned 3 (3.8%).

ANALYSIS AND DISCUSSION

Survey findings

The survey results were analysed and the findings are presented below. An initial observation was the substantial difference in the response rates for the surveys, where same method of notification and delivery was used. The difference may potentially credited to the awareness levels of the five different groups, where architects were substantially more aware than other professionals of the BIM concept considering architects as a single entity, however engineers recorded higher numbers, but this is associated with number of disciplines involved in the engineering (civil, electrical and mechanical) profession. The chart below (*figure 2.*) presented the response distribution.

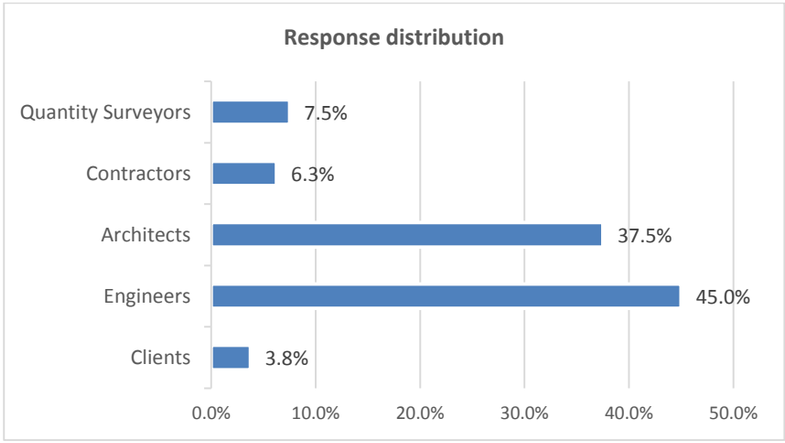

Figure 2: Response distribution

Awareness of BIM

It can be noticed that there is a significant dissimilarity amongst architects and engineers, and the rest (especially, the contractors) when it comes to BIM awareness. 34.8% of those aware are architects and 51.5% of those aware are civil, electrical and mechanical engineers, while only 6.1% is the contribution of the contractors in terms of BIM awareness. Below (figure 2) is a chart presenting BIM awareness.

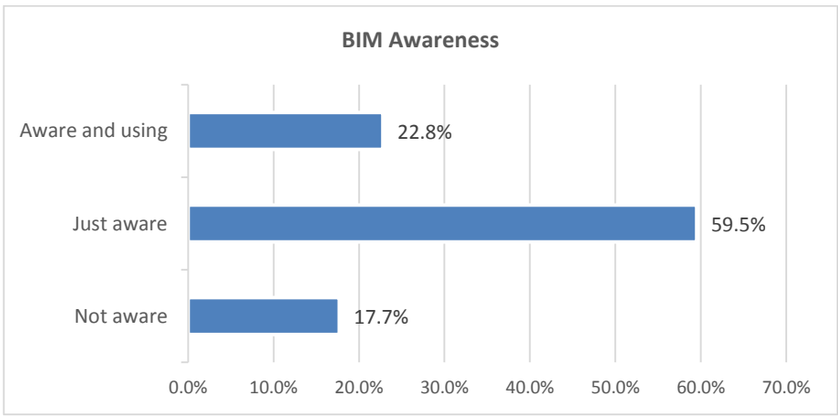

Figure 3: BIM awareness

Generally, refer to the above (figure 3), the awareness level is in the late majority (59.5% + 22.8% = 82.3%); but the adoption is just in early majority (22.8%).

Use of BIM

Most architects (61.9%) are aware of BIM, but only 26.9% use some form of BIM. Other than the clients, all the professions are at least aware of BIM to reasonably 50% but the adoption has a lot of disparities; the awareness to adoption are 57.5% to 27.5%; 60% to 20%; 66% to 0% for engineers, contractors and quantity surveyors consecutively. Figure 4 below is presenting the awareness and adoption percentages independently.

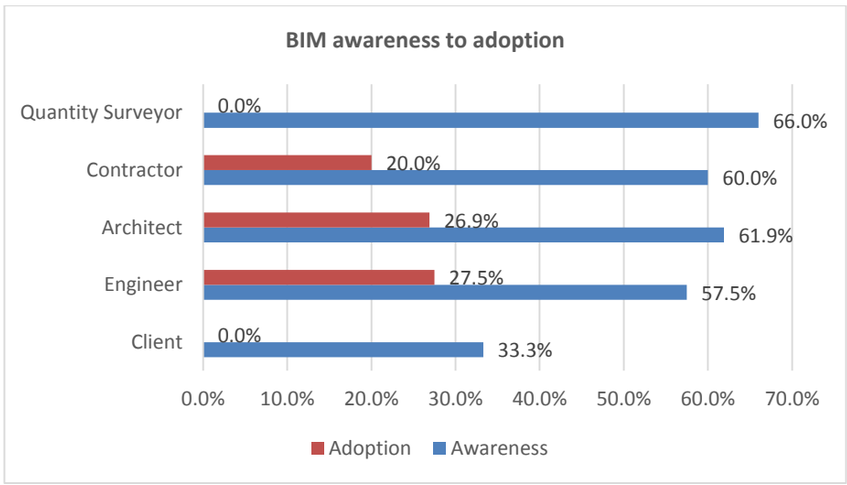

Figure 4: BIM awareness and adoption

The results were compared with surveys conducted in other countries. The most recent is the National BIM survey, conducted for 2017 (NBS, 2017) which reveals 97% BIM awareness (nearly universal) and 62% adoption; therefore, the gap is too wide to be compared, therefore the nearer survey findings is the 2012 NBS report where 79% BIM awareness was recorded and 31% adoption.

Considering 2012 survey in the UK, 2012 survey by McGraw-Hill was also considered, where McGraw-Hill (2012) found that BIM adoption recorded up to 71% in the USA, which demonstrates how fast BIM is being adopted especially considering 49% adoption in the year 2009.

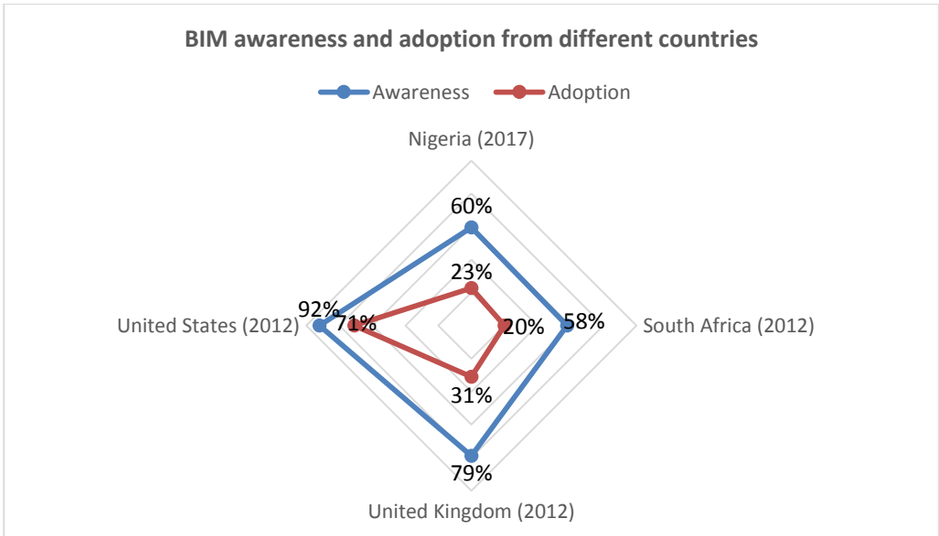

Figure 5: BIM awareness and adoption variations

Thus, the last country is South Africa, the findings by Froise and Shakantu (2014) reveals that 58% were considered to be familiar with BIM with an average of 20% adoption. With the above findings, the chart below (figure 6) presented combination of the surveys' results.

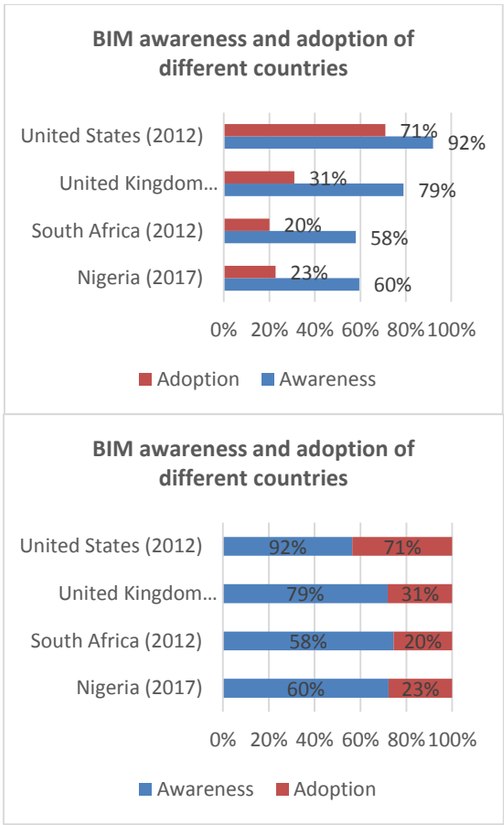

Figure 6: BIM awareness and adoption from different countries

Refer to Rogers (1983) that adoption of innovation generates self-pressure towards the rate at which the innovation diffuses. The adoption rate is expected to progress (faster) since it is still below 50%, although it will keep on slowing down before the adoption reaches 50% (where the adoption curve flattens), at the same time the awareness level becomes extensive through the adopting group.

As of 2012, Nigeria is five years behind United States plus 50% of adoption (71%, US-2012 against 22.8%, Nigeria-2017). While UK BIM adoption in 2012 was 31% which is 8.2% more than its adoption today (2017) in Nigeria (31%, UK-2012 against 22.8%, Nigeria-2017); hence Nigeria is more than five years behind UK. For a developing country closer to Nigeria (South Africa), Nigeria is approximately five years behind South Africa in BIM adoption (20%, South Africa-2012 against 22.8%, Nigeria-2017).

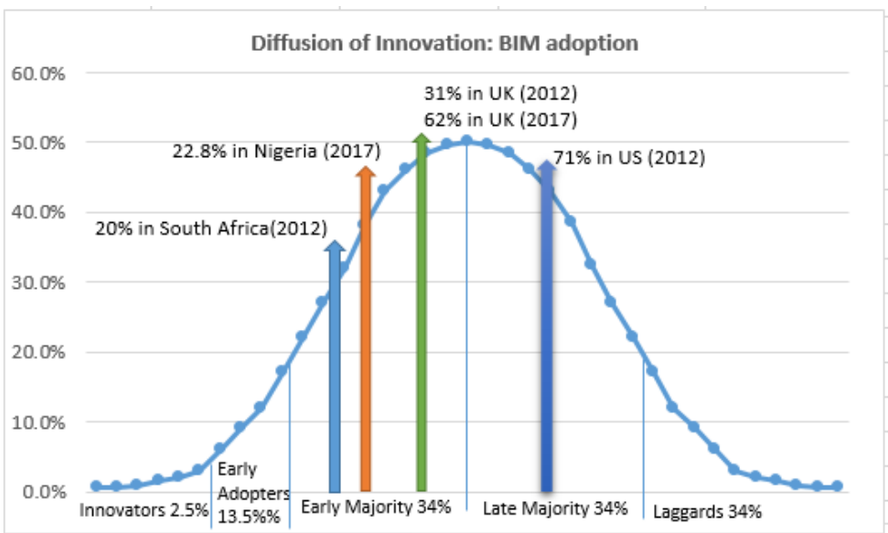

Figure 7: Innovation adoption curve: Summary of BIM adoption

CONCLUSION

The investigation reveals that there is reasonable awareness on BIM technology, although many are aware of the tools without knowing it as BIM, and without knowing it as a process; therefore the awareness of BIM as a process is lacking.

It can be seen that BIM adoption in Nigerian construction industry is lagging behind all the three countries (US, UK and South Africa) by at least five years. Moreover, the adoption to awareness pattern of Nigerian construction industry is more like that of the UK and South Africa, but followed nearly like the UK's pattern of 31:79 in 2012 while Nigerian pattern of 23:60 in 2017 (approximate adoption to awareness ration of 2:5).

Finally, Nigerian construction industry has just entered the *Early Majority* in adopting BIM technology and just entered the *Late Majority* in its awareness. The industry is expected to follow the UK trend, but the adoption process need to be streamlined to achieving the adoption rate of 6% (average) achieved by the UK construction industry yearly. All these came up due to a streamlined process to achieving BIM mandate in the UK, and also the UK's major clients are progressively insisting on a BIM platform for their new facilities, while the government is driving the process by creating a conducive atmosphere to the BIM utilization and requiring that new public buildings are produced in a collaborative environment using BIM.

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