

Appraisal of the critical success factors for building information modelling (BIM) adoption by clients in northeast universities in Nigeria

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Abstract:

Adoption and implementation of Building Information Modelling (BIM) in the Nigerian construction industry by clients will increase building performance, give automatic cost estimates and corrections during the design stage. It will also help in discovering design errors and omissions before construction begin. This study aims to assess the critical success factors (CSFs) of BIM with a view of enhancing the its adoption by clients in construction and making recommendations for implementation. Descriptive survey was employed involving quantitative methods using questionnaire survey strategy in collecting the data in six selected federal universities in northeast Nigeria. However, the survey was conducted among only 52 sectional heads of construction related professionals and staff of the works and physical planning unit. Data collected were analysed using descriptive analysis. Findings revealed that the level of awareness of BIM authorizing tools by clients is as high as 64% which is adequate for implementation. The major CSFs for BIM implementation are mandating BIM for all projects with a mean value of 4.93. Also, a mean value of 4.80, 4.69 and 4.62 were obtained in providing incentives for training and software, readiness of other project stakeholders to adopt BIM, and support leadership of the organization respectively. Based on these findings, the study recommended that BIM promotion agencies should be established by the federal government also be established and funded by universities. The study found that there is a high level of underutilisation of BIM tools by clients in their projects. In conclusion, the underutilisation is attributed to lack of leadership, direction and enforcement. BIM implementation strategy and policy in universities should be developed to improve the utilisation of BIM tools. The CSFs for BIM implementation by clients are mandating BIM for all projects and subsidizing cost of BIM.

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1. Introduction

Nowadays, many public and private organizations are experiencing conflicts, complexities, uncertainties and ambiguities with traditional practices in implementing construction projects, the use of ICT in construction projects helps to manage projects in productive and effective ways Sebastian [1]. Building Information Modelling (BIM) has emerged as an innovative way to manage construction project planning [2]. It is a new emerging approach to design and construction which facilitated by a digital representation of the building process [3]. With BIM technology, an accurate virtual model of a building known as BIM is digitally constructed and used to support the design, procurement, fabrication and physical site construction activities required to realize the structure. The model is also used for the maintenance and facility management of the building after completion [4].

Furthermore, in the past 10 years, much discussion has centred on the potential for BIM to change industry work practices, especially the ways that architects, engineers, contractors, and owners share information, models, and data [5]. BIM is a modelling technology and associated set of processes to produce, communicate and analyse building models [6]. BIM has been defined by Lee, *et al.* [7] as the process of generating and managing building data during its life cycle. Typically, it uses three-dimensional, real-time, dynamic building modelling software to increase productivity in building design and construction. The ability to work collaboratively and share information is key to efficient practices as reported in Building Smart [8].

Furthermore Green [9] pointed out that it is becoming pretty clear that BIM will be more than just a process to design and construct buildings because it is already playing a bigger role in the development of operational strategies for the improved management of buildings and structures. With

improved procedures often come improved quality, decreased time, and most importantly decreased costs. Time is money when dealing with construction, and with BIM being able to further improve on current practices, this technology will indeed become an essential asset within the industry. BIM allows real-time communication based on the multidimensional models that have been introduced before and permits some additional analysis such as quantity take offs or clash detection [10].

BIM is a data-rich, object-oriented, intelligent and parametric digital representation of the facility, from which views and data appropriate to various users' needs can be extracted and analysed to generate information that can be used to make decisions and to improve the process of delivering the facility [11]. Nowadays BIM is being used in "preconstruction, design visualization, constructability reviews, design coordination, planning of trades and systems, 4D construction scheduling and sequencing, 5D quantity survey estimating, prefabrication and modularisation, and as-built modelling for facilities operations and maintenance as reported in Campbell [12].

The Nigerian construction industry has come under severe criticism over its poor performance and lacking the capacity to deliver due to inefficiency and poor service delivery among other problems [13]. Current construction is characterized with increasing uncertainties, resulting in more unpredictable delays. The industry has faced so many criticisms across the globe for its inefficiency and lack of productivity, which have been attributed to its fragmented nature of project delivery [14]. Therefore, many construction industries in Nigeria have issues on adopting BIM and implementation by the clients on the project delivery within a period of time, cost saving which has become a source of worry to many concerned stakeholders, in order to practice in line with the global best practices and achieve the implementation needed by the clients. Adoption of BIM by the clients would bring about the most needed success in the construction processes and operational procedures in the Nigerian construction industry. It was in this respect that the current paper seeks to assess the critical success factors (CSFs) of BIM, with a view to enhance adoption of BIM by the clients in construction projects and making recommendations for implementations. To achieve this overall aim, the study sets out the following objectives: (i) to assess the level of awareness with BIM tools by clients (ii) to determine the CSFs for BIM adoption by clients and make recommendations for implementations.

1.1 Clients

All construction projects must begin with a client. The Chartered Institute of Building CIOB [15] defined client as the party who has instigated the project, will have thought about why the facility should be built, will have organized the funding and be convinced that it is a worthwhile investment. It further stated that the construction client has a significant role in the sustainable development of the construction industry. The construction client as a purchaser of the construction sectors products and services, steers the process from concept to implementation, and there by creates the condition for the use and technical management

of buildings or structures. Therefore, a major motivation to BIM adoption in the construction industry is client request as reported by Bergdahl, et al. [16] who stated that;

- a. The client is responsible to develop and drive a construction project from concept to commissioning, ensuring that the needs of the company, the customers, the industry and the community are met. This is called "client driven process: The construction client, through its choice of partners, determines the type of skills and expertise that will be involved in the process, shaping skills development in this sector. He governs the procurement of services or products which aim to encourage competition and further development of processes and products
- b. Secondly, acting according to the building lifecycle demands, the construction client is responsible for the holistic approach that governs the creation of every building or structure. This holistic approach creates the appropriate conditions for project participants to design, construct and operate the building or facility

1.2 Construction industry

Construction industry plays a major role in economic development in the less industrialized nations. it is a key player in the socio-economic progress of several countries internationally [17]. The construction industry is known as an important contributor to nation's economies all over the world. It is regarded as a leading driver of the economy because almost all other sectors partly depend on the industry's products and services to carry out their operations [18]. Also, the Nigeria construction industry is a broad variety of loosely incorporated organizations that jointly erect, adjust and restore a large range of different buildings and public engineering projects. The building industry is also defined as financial activities that centre on the construction of physical projects, such as buildings and road and rail network, despite of the construction being land or maritime based [19].

2. Methodology

The study adopted descriptive approach in nature where quantitative data were collected in order to achieve the aim of the study. A semi-structured questionnaire was used for data collection in the quantitative phase of the study. The targeted populations in the quantitative were construction related professionals and staffs of the works and physical planning unit who are sectional heads of construction related departments or units working in northeast universities Nigeria. Six (6) federal universities comprising of Federal University Kashere (FUK), Abubakar Tafawa Balewa University (ATBU), Modibbo Adama University (MAU, Yola), University of Maiduguri (Unimaid), Federal University Gashu'a (FUG) and Federal University Wukari (FUW) were selected.

It was gathered that there are nine (9) construction related units or departments in each of the universities namely; director of works and maintenance, director of physical planning, head of procurement, head of architecture, head of building, head of quantity surveyor, head of civil engineering, head of mechanical engineering

and head of electrical. This gives us a total population of 54 construction related professionals.

The samples of respondents were selected using the non-probability purposive sampling technique. The questionnaire sought for the respondent's opinions on CSFs on BIM adoption by the clients as well as to assess the level of awareness with BIM tools by clients. All the 54 questionnaires distributed to the respondents 52 was returned and used for analysis in this study. The quantitative data was analysed using descriptive statistics including frequency, percentages, means and standard deviation with the aid of SPSS software.

The Table 1 below shown breakdown of questionnaires administered to the respondents and the numbers properly filled and returned.

Table 1: Breakdown of Questionnaires Administered

Distribution of Questionnaires	Percentage
No. distributed	54
No. properly filled and returned	52
Percentage response	96%

Source: Field survey (2021)

3. Results and discussion

Demographic characteristic of respondents and the first section shows the profession of the respondents (Table 2). The result shows that 24% of respondents are Architects and Civil engineers, 17% are builders and electrical engineers, 13% are quantity surveyors, while 12% are mechanical engineers. The result indicated that majority of the respondents are professionals in construction field, which is considered for the study building information modelling BIM. However, the second phase shows years of experienced of the respondents which revealed that majority of the respondents (75%) had at least ten years of working experiences, while 25% of the respondents had at least 20-30 years of working experience. The respondents were quite knowledgeable and experienced in the built environment to the CSFs for IBM adoption by clients in north east universities in Nigeria respectively. The last phase shows gender differences of the respondents; the results revealed that 90% were male, while female represented 10% of the sampled population. The summary of the respondents' demographic information is presented in Table 2.

3.1 Unit/ Section of Respondents

Table 3 below shown the units/ sections of the respondents. 24% of the respondents work directly in Civil/structural engineers units, 16% work directly in Electrical engineers' units, while those working in Architectural, Mechanical and Building units accounted for 12% each. Those working under procurement units accounted for 7% of the population. Those working in Quantity Surveying Units, Maintenance units and project planning units each accounted for 6% of the respondents.

3.2 CSFs for BIM Adoption

Table 4 shows the views of respondents on CSFs for BIM adoption by clients. The result indicates that mandating BIM for all public projects with a mean value of 4.93 was

ranked first followed by incentive for training/ education ranked second (4.80) and then readiness of other project participants which was ranked third (4.69). Funding was ranked fourth (4.62), collaborating with vendors was ranked fourth (4.62).

Table 2: Demographic data of the Respondents

Items	Observations	Frequency	Percentage
Profession	Architects	9	17
	Builders	9	17
	Civil Engineers	12	24
	Electrical Engineers	9	17
	Quantity Surveyors	7	13
	Mechanical Engineers	6	12
		52	100
Years of Experience	0-10	-	-
	10-20	39	75
	20-30	13	25
	Above 30	-	-
		52	100
Gender	Male	47	90
	Female	5	10
Total		52	100

Table 3: Units/ Section of Respondents

Department	Frequency	Percentage
Architecture	6	12
Civil/ Structural Engineering	12	24
Building	6	12
Electrical Engineering	9	16
Mechanical Engineering	6	12
Quantity Surveying	3	6
Procurement Unit	4	7
Works and Maintenance	3	6
Project planning Unit	3	6
Total	52	100

Similarly, organizational culture was ranked sixth (4.46) and standardized implementation framework was ranked seventh (4.38). Also, BIM enabled procurement system was ranked eighth (4.31), ability of other stakeholders to use BIM was ranked ninth (4.23), legal aspects of BIM implementation was ranked tenth (3.24). Returns on investment and industry culture were ranked eleventh and twelfth with mean values of 3.24 and 3.22 respectively.

These results suggest that mandating BIM for all public projects is the most significant critical success factor for BIM implementation by clients. Mandating BIM adoption is a strategy that has helped in driving BIM technology in Britain. It is an important variable in technology implementation.

3.3 Level of BIM Awareness

Table 5 shows the level of awareness with BIM tools by respondents. The Table is divided into five sections. Each section contains for BIM authorizing tools applicable to the various professionals according to their units in their organizations. The first section contains BIM authorizing

tools used in architectural design and modelling. However, (100%) of Architects are familiar with Revit Architecture, Google SketchUp and ArchiCAD, while 70% of the Architects are familiar with Bentley Architecture.

Table 4: CSFs for BIM implementation by Clients

Critical Success Factor	Mean	SD	Rank
Mandating BIM for all projects	4.93	0.287	1 st
Incentive for training and software	4.80	0.760	2 nd
Readiness of stakeholders to use BIM	4.69	0.480	3 rd
Leadership	4.62	0.506	4 th
Funding	4.52	0.877	5 th
Organizational culture	4.46	0.448	6 th
Implementation Framework	4.38	0.552	7 th
BIM enabled procurement system	4.31	0.751	8 th
Business process reengineering	4.23	0.832	9 th
Return on investment	4.00	0.816	10 th
Standardization of products and processes	3.24	1.003	11 th
Legal Aspect	3.22	1.377	12 th
Grand Mean Total	4.28	0.72	8th

(1= strongly- disagree, 2= disagree, 3= neutral, 4= agree, 5= strongly agree)

From average, 93% of Architects are familiar with Architectural BIM authorizing tools. The second section contains BIM authorizing tools used in structural design and modelling. All the structural engineers (100%) are familiar with Revit structures, 75% are familiar with Bentley structural modeler, while 70% are familiar with Tekla structures and Fastrack respectively. On the average, 79% of structural engineers are familiar with BIM tools, while 21% of civil engineers are not familiar with BIM authorizing tools used by Builders.

The third section contains BIM authorizing tools used in services design and modelling; services engineers were the respondents to this section. On the average, 80% of services engineers are aware of BIM tools with Revit MEP being the most popular (80% awareness rate) followed by Fine MEP and Bentley Hevacomp (60% awareness rate of each) and 4MSA fine HAC being the least popular (20%). The fourth section contains BIM authorizing tools used in quantity take-offs and estimating. This section was filled by Quantity Surveyors. The most familiar BIM tools known by Quantity Surveyors are eTakeoff and cubit in which all the Quantity Surveyors are aware of it (100%). PriMUS IFC and Vico office take off manager had familiarity of 43% and 14% respectively.

Therefore, 64% Quantity Surveyors on the average are familiar with BIM tools. The fifth section contains BIM authorizing tools used in building production and project monitoring; this section was filled by Builders. All the Builders (100%) are familiar with Trimble connect and Autodesk BIM 360. While 50% of Builders are familiar with Builder trend and Procore is the only unknown tool. On the average, 50% of Builders are familiar with BIM tools, while another 50% are not familiar with BIM authorizing tools used by Builders. The finding shows that Architects have the highest awareness rate (93%), followed by Structural engineers (79%), Quantity Surveyors (65%), Builders (63%) services engineers 60% respectively. Therefore, from Table

5, it can be concluded that there is a high level of awareness with BIM authorizing tools among clients with 64% awareness and only 36% are unaware.

Table 5: Level of Awareness with BIM Authoring Tools among Respondents

BIM Tools	Aware	%	Not Aware	%
Audodesk Revit Architecture	9	100	-	-
Graphisoft ArchiCAD	9	100	-	-
Bentley Architecture	6	70	3	30
Google SketchUp	9	100	-	-
Average		93%		7%
Autodesk Revit Structures	12	100	-	-
Bentley structural modeler	9	75	3	
25Tekla structures	6	70	3	30
Fastrack	3	70	9	30
Average		79%		21%
Autodesk Revit MEP	12	80	3	20
Fine MEP	9	60	6	40
Bentley Hevacomp	9	60	6	40
4MSA fine HAC	6	40	9	60
Average		60%		40%
PriMus IFC	3	43	4	57
Vico office Takeoff Manager	1	14	6	86
eTakeoff	7	100	-	-
Cubit	7	100	-	-
Average		64%		36%
Trimble connect	6	100	-	-
Autodesk BIM 360	6	100	-	-
Buildertrend	3	50	-	50
Procore	-	-	3	100
Average		63%		37%

Source: Field Survey (2018)

3.4 Barriers to BIM Implementation

Table 6 shows responses on barriers to BIM implementation.

Table 6: Barriers to BIM implementation by Clients

Barriers to BIM Implementation	Mean	SD	Rank
Lack of government lead/direction	4.92	0.277	1 st
Cost of BIM development	4.85	0.376	2 nd
Procurement policy	4.77	0.599	3 rd
Difficulty measuring impact of BIM	4.31	0.752	4 th
Lack of top management support	4.31	0.751	5 th
Resistance to change	4.23	1.092	6 th
Lack of BIM experts	3.78	1.014	7 th
Low level of awareness	3.77	1.013	8 th
Lack of standard implementation process	3.62	1.557	9 th
Poor project collaboration	3.54	1.506	10 th
Legal and security risk	3.50	1.305	11 th
Lack of industry standard	3.47	1.406	12 th

(1= strongly- disagree, 2= disagree, 3= neutral, 4= agree, 5= strongly agree)

Source: Field Survey, (2018)

From the results in Table 6, lack of government lead/direction was ranked first having a mean value of (4.92), cost of BIM development ranked second (4.85), procurement policy ranked third (4.77) while difficulty in measuring impact of BIM ranked fourth (4.31). However, lack of top management support had a mean score of (4.31) was ranked fifth while resistance to change was ranked sixth with a mean value of (4.23). Lack of BIM experts was ranked seventh (3.78). Low level of awareness was ranked eighth with a mean score of (3.77). Lack of standard implementation process and poor project collaboration were ranked ninth and tenth with mean scores of (3.62) and (3.54) respectively. Security risk was ranked eleventh with a mean score of (3.50) and lack of industry standard was ranked twelfth with a mean score of (3.47).

In summary, the study observed that the level of awareness with BIM authorising tools by the respondents is high up to 64% leading to need of its consideration for implementation in these organisations. While lack of government lead/direction is the most challenging barrier to BIM implementation in universities or by clients. This indicates that government has pivotal role to play in promoting BIM adoption. On the other hand, the findings of this study support previous works of Umar *et al.*, [18] who identified without supports from the government, Nigerian Construction Industry will be ineffective and remain as uncompetitive compared to others

However, the major CSFs for BIM implementation are mandating BIM for all projects, incentive for training and software, readiness of other project stakeholders to adopt BIM, as well as support from top leadership of the organization. This also in line with the statement make by Umar *et al.*, [18] who advocate that the most important factor for adoption is government's roles and supports such as developing incentives for enhancing professional involvement in BIM-enabled projects and support in the form of complementary training should be provided to inexperienced project teams.

4. Conclusions

Findings from this study reveal that there is an adequate level of familiarity and awareness with BIM authorizing tools among clients. The study also deduced that there is a high level of underutilization of BIM tools by clients in their projects. It also established that there is a high level of underutilization of BIM tools, which is attributed to a lack of government leadership and direction, the cost of BIM development, procurement policies, and difficulty measuring the impact of BIM in projects. The CSFs for BIM implementation by clients are mandating BIM for all projects, subsidizing the cost of BIM development, the readiness of other project stakeholders to adopt BIM, and strong commitment from the leadership of the organization.

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