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EVALUATION OF THE ORGANISATIONAL CAPABILITY OF THE PUBLIC SECTOR FOR THE IMPLEMENTATION OF BUILDING INFORMATION MODELLING ON CONSTRUCTION PROJECTS

RESEARCH ARTICLE[1]

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ABSTRACT

Organisations are required to possess certain capabilities in order to implement Building Information Modelling (BIM), one of the emerging technologies for overcoming the problem of fragmentation in the construction industry. This study examines the organisational capability attributes required for the implementation of BIM in construction projects, with a view to enhancing the performance of public sector projects. The study adopted a quantitative descriptive analysis based on primary data obtained from public sector organisations in Lagos State, Southwestern Nigeria. One hundred and ninety-eight (198) valid questionnaires, obtained from construction professionals within the organisations, provided quantitative data for the assessment. Data collected were analysed, using both descriptive and inferential statistics. The findings indicate that public sector organisations possess the capability attributes for BIM implementation in building projects at different levels of availability (LAv) and adequacy (LAq), with adequate power supply rated

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at (LAv = 76.00%; LAq = 75.80%); speedy internet connection (LAv = 70.20%; LAq = 69.80%); change from traditional workflow (LAv = 69.80%; LAq = 64.60%); adequate work environment for workers (LAv = 69.60%; LAq = 64.40%); standardised process (LAv = 66.00%; LAq = 63.40%); sufficient number of workers (LAv = 65.60%) and data-sharing skills (LAv = 65.00%); standardised process (LAq = 63.40%), and collaborative team culture (LAq = 63.00%). The study established that the organisational capability attributes with high availability rating also have high adequacy rating. The research concludes that the general organisational capability attributes of the public sector for BIM on construction projects are not yet sufficiently developed and thus suggests the need to strengthen specific capability attributes that are required to implement BIM.

ABSTRAK

Daar word van organisasies vereis om sekere vermoëns te besit om Bou-inligtingmodellering (BIM), een van die opkomende tegnologieë om die probleem van fragmentasie in die konstruksiebedryf te oorkom, te implementeer. Hierdie studie ondersoek die organisatoriese vermoë-eienskappe wat benodig word vir die implementering van BIM in konstruksieprojekte, met die oog daarop om die prestasie van openbare sektorprojekte te verbeter. Die studie het 'n kwantitatiewe beskrywende analise aangeneem wat gebaseer is op primêre data wat verkry is van openbare sektor-organisasies in Lagos-staat, Suidwes-Nigerië. Honderd agt-en-negentig (198) geldige vraelyste, verkry van konstruksieprofessionele persone binne die organisasies, het kwantitatiewe data vir die assessering verskaf. Data wat ingesamel is, is ontleed deur beide beskrywende en afleidingsstatistieke te gebruik. Die bevindinge dui daarop dat organisasies in die openbare sektor beskik oor die vermoë-eienskappe vir BIM-implementering in bouprojekte op verskillende vlakke van beskikbaarheid (LAv) en toereikendheid (LAq), met voldoende kragtoevoer wat gegradeer is teen (LAv = 76.00%; LAq = 75.80%); vinnige internetverbinding (LAv = 70.20%; LAq = 69.80%); verandering vanaf tradisionele werkvloei (LAv = 69.80%; LAq = 64.60%); voldoende werksomgewing vir werkers (LAv = 69.60%; LAq = 64.40%); gestandaardiseerde proses (LAv = 66.00%; LAq = 63.40%); voldoende aantal werkers (LAv = 65.60%) en vaardighede om data te deel (LAv = 65.00%); gestandaardiseerde proses (LAq = 63.40%), en samewerkende spankultuur (LAq = 63.00%). Die studie het vasgestel dat die organisasievermoë-eienskappe met 'n hoë beskikbaarheidsgradering ook 'n hoë toereikendheidgradering het. Die navorsing kom tot die gevolgtrekking dat die algemene organisatoriese vermoë-eienskappe van die openbare sektor vir BIM op konstruksieprojekte nog nie voldoende ontwikkel is nie en dui dus op die behoefte om spesifieke vermoë-eienskappe wat nodig is om BIM te implementeer, te versterk.

Sleutelwoorde: Bou-inligtingmodellering, BIM-implementering, bouprojekte, openbare sector, organisatoriese vermoë-kenmerke

1. INTRODUCTION

Tsang, Jardine and Kolodny (1999: 712) as well as Chuks (2022) define capability as the ability to carry out a specific function, that is getting things done in relation to quality, responsiveness and rate within a range of performance levels. In services rendering, this depends not only on technology, but human capabilities are similarly important (Straub, 2010: 1190; Koay & Muthuveloo, 2021: 188). Kangas *et al.* (1999: 35) and Moingeon *et al.* (1998: 299) define organisational capability as the strategic usage and deployment of competencies. The term 'competency' is the ability or capacity of an organisation to use its resources, in order to achieve specific organisational outcomes (Amit & Schoemaker, 1993: 35; Chuks, 2022). Organisational capability involves diverse concepts such as people, systems, processes, structures, and culture that determine the ability of organisations to deliver results (Schmidtchen & Cotton, 2014: 2; Koay & Muthuveloo, 2021: 170). It combines these concepts that contribute to continuous improvement in the performance of organisations (Schmidtchen & Cotton, 2014: 2: Koay & Muthuveloo, 2021: 170). Building Information Modelling (BIM) implementation by the public sector requires new processes, new technologies, and new behaviour and will inevitably cause organisational changes (Juan *et al.*, 2015: 359; Hardin & McCool, 2014: 45). Such changes will force much improvement of the organisational capabilities to deliver projects (Arayici *et al.*, 2009). These capabilities include personnel's adequacies in education, training, skills development, infrastructure, internet facilities, adequate power supply, government's support, and IT-literate personnel, among others (Abbasnejad *et al.*, 2021b: 987; Elhendawi, Smith & Elbeltagi*,* 2019: 11; Onungwa, Uduma-Olugu & Igwe, 2017: 27; Bui, Merschbrock & Munkvold, 2016; Kori & Kiviniemi, 2015; Alufohai, 2012).

Dim, Ezeabasili and Okoro (2015: 001) assert that, in the Nigerian construction industry (NCI), building projects are procured through the traditional system by public and private clients. This traditional system is known for shortcomings such as rework, ineffective sharing of information, lack of proper co-ordination, lack of interoperability and collaboration, as well as adversarial relationship among participants in the project-delivery process, giving rise to the poor performance of projects (Abbasnejad *et al.*, 2021a: 413; Dim *et al.*, 2015: 1; Idoro & Patunola-Ajayi, 2009: 28). Several attempts have been made in terms of initiatives, innovations, and tools such as new contractual arrangements, integrated projected delivery, modelling, and technological innovations, to achieve better performance of construction projects (Isikdag & Underwood, 2010: 550; Olatunji, Sher & Gu, 2010: 68). BIM is one of such processes leading healthy disruptions in construction project delivery across the globe, ensuring collaboration among construction participants, bringing about the expected changes, and leading to successful project delivery (Abbasnejad *et al*., 2021a: 413; Eadie *et al.*, 2013: 348). BIM is moving the construction industry from the current fragmented and paper-based processes to an integrated workflow, where tasks are condensed into a collaborative and more coordinated process using computation capabilities, internet communication, and data processing into information (Eastman *et al.*, 2011; Saka, Chan & Siu, 2020: 1). This is done to manage the built environment within a realistic and verifiable decision by manipulating reality-based models (Abdullahi *et al.*, 2011). Hence, the implementation of BIM by public sector clients becomes imperative, owing to its ability to substantially reduce the problems associated with public project delivery.

In spite of success reports on BIM and its potential to confront challenges of the public sector, Olugboyega and Aina (2016: 22) conclude that, in Nigeria, governments at all levels are not requesting BIM to be used in their projects. This could be partly due to lack of organisational capabilities by the public sector client for its implementation (Babatunde, 2015). This is unexpected because BIM has adequate potential to reduce disputes, address time and cost overrun, improve efficiency, and handle corruption (Alufohai, 2012; Saka *et al.*, 2020: 2). Saleh and Alshawi (2005: 58) suggest that, in order to make effective decisions towards attaining the required capabilities, organisations need to evaluate their current capabilities before implementing ICT systems.

In this study, assessment of the organisational capability attributes of the public sector for BIM implementation is, therefore, justified for a number of reasons. The necessity of BIM usage by all stakeholders in the construction industry to curb the problems inherent in the traditional method of project delivery is well established in literature. The public sector as the major stakeholder is expected to set the pace for other participants in the industry. The public sector is the major client of complex projects in Nigeria. Hence, there is n doubt as to the financial ability of the public sector to implement BIM. Moreover, BIM has been used by public sectors in countries such as the United Kingdom, the United States of America, and so on, and its benefits have been well established (Van Wyk, Kajimo-Shakantu & Opawole, 2021). This study has, therefore, become imperative to understand the preparedness of the public sector organisation for the implementation of BIM in the Nigerian construction industry.

2. LITERATURE REVIEW

2.1 Building Information Modelling

BIM has several definitions, due to its ever-changing nature (Aranda-Mena *et al.*, 2009: 426). One of these is that BIM is a product, a technology, a strategy, or an innovation. Regardless of its definition, the significant objective of BIM is to provide a complete replication of a structure in a computerised climate, with the sole objective of giving a community stage to overseeing building data all through its life cycle (Aouad *et al.*, 2014; Ibrahim, Hashim & Jamal, 2019: 2). This definition tends to the shortcomings of the past CAD advances. Hassan and Yolles (2009: 53) state that BIM is seven-dimensional. A BIM model begins with a parametrically advanced 3D that has both mathematical and non-mathematical data. The 3D model is a highly rich three-dimensional model (X, Y and Z) made up of intelligent/smart parametric objects extending to scheduling and sequencing (4D), cost estimating (5D), sustainable design, also termed green design (6D), and facility management (7D). However, as more data is added to the parametric articles in a 3D BIM model, the model becomes more extravagant and more vigorous, highlighting other dimensions (nD). Specialists arrange BIM as 3D, 4D, 5D, 6D, 7D and nD (Aouad, Wu & Lee 2006: 152).

2.2 BIM implementation stages

BIM stages are the multiple stages that demarcate capability milestones. BIM functionality, according to Succar (2010: 6), is the ability to perform a mission, produce a service, or create a product. BIM capability stages (or BIM stages) are described as the major milestones that teams and organisations must achieve as they implement BIM. BIM stages define a fixed starting point (the state prior to BIM implementation), three fixed BIM stages, and a variable ending point that allows for unanticipated future technological advances. Pre-BIM refers to the state of the industry prior to BIM implementation, while integrated project delivery (IPD) refers to a method or end objective for implementing BIM (Succar, 2010: 7). Technology, process, and policy components are all part of the BIM stages (Succar, 2010: 9; Koseoglu, Keskin & Ozorhon, 2019). Pre-BIM, BIM stage 1 (object-based modelling), BIM stage 2 (model-based collaboration), BIM stage 3 (network-based integration), and IPD are the stages to go through (Succar, 2014: 8).

The minimum requirements for BIM stages are specified. For instance, an organisation must have deployed an object-based modelling software tool to be considered at BIM capability stage 1 (Figure 1). An organisation must also be part of a multidisciplinary model-based collaborative project for BIM capability stage 2. An entity should utilise an organisation-based arrangement such as a model worker to share object-based models with any two different orders to be at BIM stage 3 (Succar, 2010: 7; Koseoglu *et al*., 2019). The pre-BIM status addresses incoherent venture conveyance, where antagonistic connections describe the development business. Much reliance is put on 2D documentation to portray a 3D reality. In addition, the focus is not on community-oriented practices between partners, and work process is straight and non-concurrent (Succar 2009: 11; Saka *et al.*, 2020: 3). Under pre-BIM conditions, industry experiences low interest in innovation and absence of interoperability (Succar, 2010: 8).

The volume and intricacy of changes needed to accomplish every one of the three BIM stages are groundbreaking and surprisingly revolutionary (Henderson & Clark, 1990: 22; Taylor & Levitt, 2005; Ibrahim *et al.*, 2019: 3). Notwithstanding, steady or transformative advances populate the entry from pre-BIM to BIM Stage 1, through every one of the three phases and towards IPD. Recognising these BIM Steps (Figure 1) is instrumental in empowering organisations and people to build their BIM capability and maturity in a methodical way (Succar, 2009: 12; Koseoglu *et al*., 2019).

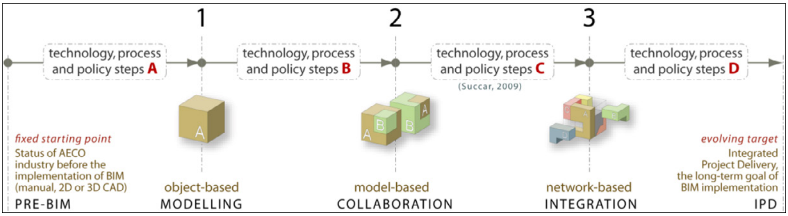

Figure 1: Steps leading to/separating BIM stages
Source: Succar, 2009: 12

2.3 Organisational capability attributes required for BIM implementation

Succar (2010: 10) and Dakhil, Underwood and Alshawi (2019: 83) refer to these attributes as BIM competency set, which represents the ability of a BIM player to achieve a BIM requirement. The potential of the BIM concept and its capacity to integrate different participants in the sector will be dependent on the adoption of standardised processes alongside the acquisition of technological equipment able to handle the necessary software, in addition to training and education needed to handle and analyse the information provided correctly. Consequently, this gives rise to the BIM paradigm defined by the triad of policies, processes and technology (Kori & Kiviniemi, 2015; Yusuf, 2014: 22; Succar, 2009: 11). Koseoglu *et al.* (2019), Haron (2013: 49) and Olatunji, Sher and Gu (2010: 68) identified people, process, and technology as the three vital areas of BIM investment for it to be successfully implemented. However, Zahrizan *et al.* (2013: 391) opine that people, technology, and policy are three paramount factors in BIM implementation. Similarly, Bew and Underwood (2010) consider them to be the main variables that must be put in place for BIM to be delivered. Although people and process are vital to change and improvement, technology is the enabler that sustains both elements.

In the implementation of e-commerce, for example, Ruikar, Anumba and Carrillo (2006: 105) introduced a management element to justify the role of management in coordinating and managing the implementation. Hence, to implement new technologies successfully, management's awareness, vision, and mission to implement new technologies are needed, in order to plan and drive policies (Abbasnejad *et al*., 2021b: 989). This was supported by Smith and Tardif (2009) and Eastman *et al*. (2011). As Abbasnejad *et al*. (2021b: 976) and Smith and Tardif (2009) further explain, the ability to motivate people, leadership, and management buy-in are critical factors to be considered, in order to implement BIM within an organisation. In addition, to implement BIM, Haron (2013: 43) and Saka *et al*. (2020: 17) note the need for software evaluation strategy, use of design and build type of project delivery and compatibility, as well as interoperability of BIM software. Hence, some researchers identify technology, process, and policy as the key factors in BIM implementation. Others highlight technology, process, and people, while some include management. After thorough examination, it was found that these classifications are essentially the same, depending on the context and content of each category. Hence, the classification of technology, process, and policy will be adopted as it basically encapsulates the factors of management and people in BIM implementation.

Succar (2010: 15) and Saka *et al*. (2020: 17) posit that for BIM stage 2, which involves model-based collaboration, database-sharing skills, and collaborative processes are essential to achieve it. Davenport (1993: 11, cited in Bew & Underwood [2010]) define process as an organised and measured array of activities aimed at producing specified outputs. In relation to BIM, Yusuf (2014: 24) explains that processes are the means whereby BIM uses are achieved, and process redesign is vital for BIM implementation. In this regard, in an attempt to implement BIM, a clear definition with a consideration of the entire life cycle and monitoring of BIM processes that the organisation will need to deliver its projects are extremely vital. The difference between failure and success of a BIM implementation plan can be having the right process (Abbasnejad *et al*., 2021b: 990). In addition, there will be a need to alter the conventional workflow practice, in order to provide coordination between BIM and CAD process flow (Succar, 2010: 6). Therefore, the initial compulsory attempt to achieve BIM compliance will be to clearly state the due processes as the yardstick for all activities of the model (Yusuf, 2014: 24).

Innovations are important in achieving accuracy, gaining a competitive edge, and attaining greater outcomes and outputs (Bew & Underwood, 2010). Usage of the right technology will be required to aid the already developed BIM processes, as it is a significant part of BIM implementation. BIM requires reasonable innovations to be carried out successfully and ought to be assessed by firms to comprehend the advantages and boundaries of each (Yusuf, 2014: 24; Saka *et al*., 2020: 17). An adequate plan to adopt international guidelines must be in place, in order to manage change effectively when a beneficial technology is identified. The BIM modeller needs to specify, define, and manage suitable hardware, version and structure, certified software (BIM authoring tools), interoperable data formats, storage processes, user workstation, and good internet connections, among others. It is important to match organisational capabilities with the required technology and BIM authoring tools (Yusuf, 2014: 25). According to Succar (2010: 6) and Adam *et al*. (2022: 825), the availability of BIM tools assists in the change from drafting-based to object-based workflow. BIM implementation requires adequate infrastructure, skilled and trained workers, sufficient awareness of BIM technology, and knowledge of BIM tools (Abubakar *et al*.,2013; Onungwa *et al.,* 2017: 26;

Elhendawi *et al.*, 2019: 10). Ruya, Chitumu and Kaduma (2018: 4) and Abbasnejad *et al*. (2021b: 976) opine that, in order to implement BIM, there should be awareness among stakeholders, standards to guide implementation, investment in education, BIM technology, information technology, adequate power supply, training programmes, and government intervention. Arayici *et al*. (2009) and Dakhil *et al.* (2019: 91) opine that the following are essential for BIM implementation: continuous staff training on the new process; continuous BIM education; new workflow/work process; new software and technology; new process and workflow implementation; new process establishment; adequate work environment, and the ability to mitigate risks.

People are the key asset of the construction industry. Therefore, the public sector must employ enough diligent people, retain them, and develop their skills and capacities to meet the ever-increasing demand of the industry (HM Government, 2013; Elhendawi *et al.*, 2019: 10). To successfully implement BIM, the public sector must engage the right workforce with the necessary skills and develop a collaborative work culture (Gu & London, 2010: 992; Adam *et al*., 2022: 826). For this reason, new roles such as BIM modeller and BIM administrator have emerged to provide coordination so as to ensure team integration and collaboration efforts in BIM implementation (Gu & London, 2010: 990, Dakhil *et al.*, 2019: 90; Adam *et al*., 2022: 829). The core objective of the BIM administrator is to guide the team in implementing BIM. The BIM administrator must work to ensure that the people, process, and technology work harmoniously (Yusuf, 2014: 37). According to Succar (2010: 12), alliance-based and risk-sharing contractual arrangements are essential to network-based integration (BIM Stage 3). Laakso and Kiviniemi (2012: 145) and Elhendawi *et al.* (2019: 10) suggest that BIM implementation requires contract amendment, process change, standardised process, technology adoption, and formal training to develop skill and knowledge. Table 1 summarises these organisational capability attributes.

Table 1: Organisational capability attributes required for BIM implementation

S/No.	*Organisational capability attributes required for BIM implementation*	*Author(s)*
1	Adequate power supply	Ruya, Chitumu and Kaduma (2018)
2	Process redesign	Succar (2010); Yusuf (2014); Abbasnejad *et al*. (2021a)
3	Collaborative team culture	Gu and London (2010); Saka *et al*. (2020)
4	Management awareness	Ruikar *et al*. (2006); Elhendawi *et al.* (2019)
5	The ability to motivate people	Smith and Tardif (2009)
6	Effective risk-management skill	Arayici *et al.* (2009)
7	Speedy internet connection	Yusuf (2014)

S/No.	*Organisational capability attributes required for BIM implementation*	*Author(s)*
8	Collaborative process	Succar (2010); Abbasnejad *et al*. (2021a)
9	Management's vision and missions for BIM implementation	Ruikar *et al.* (2006); Smith and Tardif (2009); Abbasnejad *et al*. (2021b)
10	Plan to adopt international guidelines	Yusuf (2014); Abbasnejad *et al*. (2021b)
11	Coordination between BIM and CAD process flow	Succar (2010); Yusuf (2014)
12	The use of design and build type of project delivery	Haron (2013)
13	Contract amendment	Laakso and Kiviniemi (2012); Elhendawi *et al.* (2019)
14	Defined responsibilities for the BIM administrator	Gu and London (2010); Dakhil *et al.* (2019)
15	Defined responsibilities for the BIM modeller	Gu and London (2010)
16	Formal training to develop skill and knowledge	HM Government (2013); Laakso and Kiviniemi (2012); Abbasnejad *et al*. (2021b)
17	Continuous BIM education and awareness	Arayici *et al.* (2009); Abubakar *et al*. (2013); Abbasnejad *et al*. (2021a)
18	Continuous on-the-job training	Arayici *et al.* (2009); Elhendawi *et al.* (2019)
19	Sufficient number of workers	HM Government (2013)
20	Adequate work environment for workers	Arayici *et al.* (2009); Dakhil *et al.* (2019)
21	Change from traditional work process	Yusuf (2014); Dakhil *et al.* (2019)
22	Adequate ICT infrastructure	Yusuf (2014); Olatunji *et al.* (2010)
23	Adequate technical support for BIM implementation	Succar (2010); Yusuf (2014)
24	Software evaluation strategy	Haron (2013); Dakhil *et al.* (2019)
25	Compatibility and interoperability of BIM software	Haron (2013); Saka *et al*. (2020)
26	Standardised process	Kori and Kiviniemi (2015)
27	Data-sharing skills	Succar (2010); Dakhil *et al*. (2019)

3. RESEARCH METHODOLOGY

3.1 Research design

The study evaluates the organisational capability attributes of the public sector for BIM implementation on construction projects in Nigeria. The methodology adopted in this study is quantitative descriptive analysis based on primary data collected through self-administered questionnaires. Singh (2006: 7) explains that research design is basically a statement of the objective of inquiry, strategies for collection of evidence, analysis of evidence, and recording of findings. The study employs a quantitative approach in collecting and analysing suitable data. In the questionnaire, the 27 organisational capability attributes identified through the literature review are presented to the respondents for evaluation with respect to their levels of availability and levels of adequacy.

3.2 Population, sample, and response rate

The target population for this study consists of 1,634 construction professionals in Lagos State Public Service, obtained from the disposition list of Lagos State Public Service. Lagos is located in the Southwestern part of Nigeria. Being a former federal capital and now the commercial nerve centre of the country, Lagos hosts many of the reputable construction companies operating in Nigeria. Lagos is listed as one of the 25 megacities of the world with an estimated population of roughly 17 million in 2007 and a growth rate of 3.2%, which has an attendant pressure on its infrastructure. The numerous construction projects in Lagos are executed by both the private and the public sectors to meet the housing as well as the economic and infrastructure requirements of the emerging megacity (Ameh & Osegbo, 2011: 60). The sampling frame comprises one hundred and fifty-four (154) architects, eighty-five (85) quantity surveyors, two hundred and five (205) builders, five hundred and eighty-six (586) civil engineers, two hundred and eighty-three (283) electrical engineers, and three hundred and twenty-one (321) mechanical engineers in Lagos State Public Service. A 20% sample was selected from each category of the professionals. This makes a total of 327 respondents. Each respondent was chosen entirely by chance, not biased in a systematic manner. Each member of the population had the same chance of being included in the sample (Singleton *et al.*, 1988; Kothari & Gary, 2004). For this reason, randomisation is employed to achieve an unbiased sample. Hence, the portions selected from each professional classification represent the entire population (Pilot & Hungler 1999: 25).

A total of 327 copies of the structured questionnaire were administered. Research instruments are fact-finding strategies and tools used for data-collection (Gajewska & Ropel, 2011: 11). One hundred and ninety-eight (198) copies, which represent a response rate of 60.55%, were the valid copies returned and used for the analysis. The total retrieved questionnaires made the breakdown of the study sample to be 17 quantity surveyors, 23 architects, 77 civil engineers, 32 builders, 30 electrical engineers, and 19 mechanical engineers. The response rate of 60.55% is adjudged adequate for a questionnaire survey by Moser and Kalton (1971: 35), who recommend not lower than 30-40%.

Table 2: Sample size for the study

Respondents	*Sampling frame*	*Sample size*
Architects	154	31
Quantity surveyor	85	17
Builders	205	41
Civil engineers	586	117
Electrical engineers	283	57
Mechanical engineers	321	64
Total	1634	327

Source: Disposition List of Lagos State Public Service, 2019

3.3 Data collection

Data were collected using self-administered well-structured questionnaires where specific information was listed for the respondents to complete (Bell & Bryman, 2007: 15). A structured questionnaire has been considered an effective data-collection method when measuring respondents' beliefs, attitudes, and opinions (Van Laerhoven, Van der Zaag-Loonen & Derkx, 2004: 833). The survey questionnaire was designed as a closed-ended type. According to Kothari (2004), closed-ended questionnaires can be easily completed and are relatively quick to analyse. The use of a questionnaire enabled freedom of opinion of individual respondents without fear of stigmatisation, since it ensures anonymity, confidentiality of responses, and protects the identity of respondents (Godfred, 1996, cited in Gajewska & Ropel, 2011: 11). The questionnaire was developed based on the constructs of the literature review and was administered between July and August 2021. The respondents were key professionals that are central to the execution of construction projects and BIM implementation within the public sector.

The questionnaire is divided into three parts. Part one, on the respondents' profiles, obtains information about their academic and professional qualifications, occupation, organisation type, and years of work experience. Part two, on the construct 'availability', is a set of 27 Likert-scale measurement items. Respondents were required to indicate the level of availability of organisational capability attributes from the scale measurements, in order to examine their level of availability for BIM implementation in the public sector (see Table 4). Part three, on the construct 'adequacy', is a set of 27 Likert-scale measurement items. Respondents were required to indicate the level of adequacy of organisational capability attributes from the scale measurements, in order to examine their level of adequacy for BIM implementation in the public sector (see Table 5). Respondents were informed about the purpose of this study and their freedom to be anonymous.

3.4 Method of analysis and interpretation of the findings

Both descriptive and inferential statistics are used for the analysis. These were achieved using the Statistical Package for Social Sciences (SPSS) version 20 (Pallant, 2013: 134). The respondents' background information was analysed, using descriptive statistics, while the specific concepts were analysed, using frequency distribution, percentage, mean, and the Kruskal-Wallis test. Descriptive statistics are considered effective tools in understanding the underlying details of a data set and putting them in a meaningful perspective (Castillo *et al.*, 2010: 168). The 27 organisational capability attributes identified for BIM implementation were rated on a five-point Likert scale. According to Leedy and Ormrod (2015: 185), Likert-type or frequency scales use fixed choice response formats and are designed to measure opinions. For levels of availability, 1 = Never available; 2 = Rarely available; 3 = Sometimes available; 4 = Often available, and 5 = Always available. For level of adequacy, 1 = Very inadequate; 2 = Not adequate; 3 = Averagely adequate; 4 = Adequate, and 5 = Highly adequate. The 5-point scales in each case were converted in the analysis such that 1 = 10%, 2 = 40%, 3 = 60%, 4 = 80% and 5 = 100%. The Kruskal-Wallis test was used to test whether there is any significant difference in the ranking of the attributes by the different categories of respondents (architects, quantity surveyors, civil engineers, electrical engineers, mechanical engineers, and builders) at a 5% significance level. The normality test indicated that the data used in this study significantly deviated from a normal distribution as Shapiro-Wilk Test (SPW) values in all cases were < 0.05. Hence, the Kruskal-Wallis test is considered appropriate for testing the differences in the opinions expressed by the group of respondents.

3.5 Limitations

The study was conducted in Lagos State, the commercial nerve centre and the most populous city in Nigeria. The study focuses on BIM implementation on building construction projects by the public sector. The findings mainly reflect the organisational capability attributes of the public sector for BIM implementation in the study environment and may not be generalised, because it could only be applied to the public sector in states or regions with a similar economic, political, and social context.

4. FINDINGS

4.1 Profile of the respondents

The profiles of the respondents analysed include organisation, profession, years of working experience, highest academic qualifications, and professional qualifications of the respondents. Other variables analysed were the number of projects in which the respondents were involved, where BIM was used, and the number of projects involved in general since employment. The results of the analysis in Table 3 show that half of the participants (49.5%) worked for the Ministry of Housing (22.7%) and the Ministry of Works and Infrastructure (26.8%). Overall, half of the respondents (65.1%) had either a Bachelor of Science/Bachelor of Technology, B.Sc/B.Tech) (32.8%), or a M.Sc. degree (32.8%), and 64.2% had over 10 years' work experience in their organisation. Except for civil engineers (38.9%), respondents were almost equally distributed in their occupations, with quantity surveyors (8.6%), architects (9.6%), mechanical engineers (9.6%), electrical engineers (11.6%), and builders (15.2%). This implies that most of the respondents have adequate tertiary qualifications and experience in the public service system of operation to provide information that could help in making useful deductions on organisational capability attributes of the public sector for BIM implementation.

The respondents had different professional affiliations, indicating their competence to practise in their various areas of disciplines. This was supported by their membership in their respective discipline regulatory institutions. Over half of the respondents were affiliated with The Nigerian Society of Engineers (62.1%), and the remainder of them were almost equally affiliated with the Nigerian Institute of Quantity Surveyors (NIQS) (8.6%), the Nigerian Institute of Building (NIOB) (16.2%), and the Nigerian Institute of Architects (NIA) (12.1%).

The vast majority of the respondents (78.8%) were involved in over 11 public sector projects, in general, but the vast majority of them (88.9%) had not been involved in projects where BIM was used. This reveals the paucity of BIM usage in the public sector. In general, the background information of the respondents gives credence to the validity of information gathered.

Table 3: Background information of the respondents

Demographic	*Category*	*Frequency (n=198)*	*(%)*
Organisation	Ministry of Works and Infrastructure	53	26.8
	Ministry of Housing	45	22.7
	Ministry of Transportation	32	16.2
	Ministry of Environmental and Physical Planning	27	13.6
	Ministry of Waterfront Infrastructure	25	12.6
	Ministry of Education	16	8.1

Profession	Civil engineer	77	38.9
	Builder	32	16.2
	Electrical engineer	30	15.2
	Architect	23	11.6
	Mechanical engineer	19	9.6
	Quantity surveyor	17	8.6
Education	Higher National Diploma (HND)	50	25.3
	Postgraduate Diploma (PGD)	19	9.6
	Bachelor of Science/Bachelor of Technology (B.Sc./B.Tech)	65	32.8
	M.Sc.	64	32.3
Professional registration	NIQS	17	8.6
	NIOB	32	16.2
	NIA	24	12.1
	NSE	123	62.1
	Other	2	1
Experience (years)	1-5	18	9.1
	6-10	53	26.8
	11-15	57	28.8
	16-20	42	21.2
	21-25	17	8.6
	Over 25	11	5.6
Number of BIM projects since employment	0	176	88.9
	1-5	14	7.1
	5-10	4	2
	11-15	1	0.5
	16-20	3	1.5
Number of general projects since employment	1-5	16	8.1
	6-10	26	13.1
	11-15	45	22.7
	16-20	40	20.2
	Over 20	71	35.9

4.2 Availability of organisational capability attributes of the public sector for BIM implementation

Data were collected to assess the organisational capability attributes of the public sector for BIM implementation in building projects. In order to achieve this sub-objective, the organisational capability attributes of the public sector were examined based on levels of availability. The result is presented in Table 4. Adequate power supply was the organisational capability attribute with the highest rating in terms of level of availability (LAv = 76.00%). This is followed by speedy internet connection (LAv = 70.20%), change from traditional workflow (LAv = 69.80%), adequate work environment for workers

(LAv = 69.60%), standardised process (LAv = 66.00%), sufficient number of workers (LAv = 65.60%), data-sharing skills (LAv = 65.00%), and continuous on the job training (LAv = 64.80%). The low rated organisational capability attributes with respect to availability were clearly defined roles for the BIM modeller (LAv = 41.40%), clearly defined roles for the BIM administrator (LAv = 41.80%), compatibility and interoperability of BIM (LAv = 42.20%), the use of design and build type of project delivery (LAv = 42.8%), and coordination between BIM and CAD process flow (LAv = 44.60%). These were followed by attributes such as software evaluation strategy (LAv = 45.00%), contract amendment (LAv = 49.20%), management's vision and missions for BIM implementation (LAv = 49.20%), and documented plan to adopt international guidelines and standards (LAv = 49.40%).

The high rating of adequate power supply (LAv = 76.00%) and of speedy internet connection (LAv = 70.20%) is presumably the result of alternative sources of power supply being used by the public sector in Lagos State. These alternative sources of power supply could include generator, solar energy, and inverter, among others. Most of the public offices depend on generators and are still paper based (Abubakar *et al*., 2014; Sawhney, 2014; Abbasnejad *et al*., 2021b: 974). The dependence on generator for power supply increases the running cost of offices and affects the judicious use of the limited available resources. The current paper-based and traditional system of operation within public offices is prone to errors and omissions, and also wastes time and money. This is in consonance with Ayodele and Alabi (2011: 143) and Saka *et al*. (2020: 2) who opined that the current system often leads to cost overruns, delays, and conflicts among the project team which are not favourable for BIM implementation.

The high rating of sufficient number of workers (LAv = 65.60%) and adequate work environment for workers (LAv = 69.60%) may result from the fact that the public sector remains the major employer of labour in Nigeria. The large workforce in the public sector has not translated to effectiveness and efficiency because they remain incapable of managing their projects and their private sector counterpart with slim workforce performs better in project delivery (Fitsilis & Chalatsis, 2014: 131; Olufemi *et al*., 2020: 846). Olufemi, Afegbua & Etim (2020: 849) and Babatunde (2015) earlier revealed that the private sector performs better in their project execution and their capability for PPP projects is higher than the public sector, despite being the major stakeholder in the Nigerian construction industry. The high ranking of adequate work environment for workers is expected since Lagos is the commercial nerve centre of Nigeria and an emerging megacity. Therefore, several projects are being executed to meet the need of the emerging megacity (Ameh & Osegbo, 2011: 60). In addition, the current global pandemic occasioned by COVID-19 has forced several organisations, including the public sector, to make certain capability attributes available, in order to align with the new normal in the discharge of their operation.

The low rating of several core capability attributes such as clearly defined roles for the BIM modeller (LAv = 41.40%); clearly defined roles for the BIM administrator (LAv = 41.80%); software evaluation strategy (LAv = 45.00%), and coordination between BIM and CAD process flow (LAv = 44.60%), among others, shows that the public sector lacks the necessary personnel to develop these capability attributes. The reason for this is that the sufficient number of workers is ranked high, but the necessary expertise required for BIM implementation is ranked low. This indicates that the public sector lacks the necessary expertise and know-how required for BIM implementation, although they have a sufficient number of workers. This agrees with previous research by Opawole *et al.* (2019), Tembo and Rwelamila (2008: 8), and Awwad (2013) which identified the public sector as having an over-reliance on outsourced consultants in managing projects and merely obtaining the reports of the construction process. It is also a reflection of the apathy of the public sector toward BIM and other related templates and software usage. It further underscores the fact that the public sector has no clear policy on the usage of computer software and other technological developments in its operations (Hamma-Adama & Kouider, 2018: 1118; Ihemeje & Afegbua, 2020: 60). This is not surprising because the usage of BIM technologies in Nigeria appears to be limited to 3D visualisation and the knowledge of BIM is low (Onungwa *et al.*, 2017: 27). The low rating of capability attributes such as the use of design and build type of project delivery (LAv = 42.80%), contract amendment (LAv = 49.20%), and documented plan to adapt international guidelines (LAv = 49.40%) portrays that the public sector in Nigeria is still entrenched in the traditional method of project delivery. Many professionals within Nigeria's public sector are not conversant with new development in the global construction landscape (Onungwa *et al*., 2017: 27; Ihemeje & Afegbua, 2020: 60).

These results reveal the absence of several basic organisational attributes for BIM implementation in the study area. Roughly 50% of these organisational attributes were rated below 60.00%. This agrees with Onungwa *et al*. (2017: 27) and Abubakar *et al*. (2014) who opine that public offices lack capability attributes to implement BIM. This confirm the absence of the required facilities for BIM implementation in the study area. Hence, to implement BIM, these organisational capability attributes must be made available and effectively deployed in public sector organisations.

Table 4: Availability of organisational capability attributes of the public sector for BIM implementation

Organisational capability attributes	*OVERALL*			*QS*		*BLDR*		*EEG*		*ARC*		*MEG*		*CEG*		*KW Sig.*
	LAv (%)	*SD*	*R*	*LAv (%)*	*R*	*LAv (%)*	*R*	*LAv (%)*	*R*	*LAv (%)*	*R*	*LAv (%)*	*R*	*LAv (%)*	*R*	
Adequate power supply	76.00	0.780	1	74.20	1	74.40	1	78.60	1	74.80	1	83.20	1	74.60	1	0.277
Speedy internet connection	70.20	0.911	2	67.00	5	71.20	2	67.40	4	71.40	2	75.80	2	69.60	4	0.567
Change from traditional work process	69.80	0.696	3	70.60	3	70.60	3	69.40	2	69.60	4	64.20	4	71.00	2	0.344
Adequate work environment for workers	69.60	0.703	4	71.80	2	70.00	4	69.40	2	71.40	2	63.20	7	70.20	3	0.339
Standardised process	66.00	0.847	5	65.80	6	68.80	5	62.60	7	66.00	6	64.20	4	66.40	6	0.933
Sufficient number of workers	65.60	0.794	6	69.40	4	66.80	7	63.40	6	62.60	8	63.20	7	66.80	5	0.719
Data-sharing skills	65.00	0.916	7	63.60	9	62.60	10	64.00	5	63.40	7	73.60	3	65.20	7	0.381
Continuous on-the-job training	64.80	0.856	8	64.80	8	68.80	5	62.00	9	67.80	5	61.00	9	64.40	9	0.580
Collaborative process	62.40	0.910	9	61.20	12	66.20	8	59.40	13	57.40	14	60.00	13	64.40	9	0.364
Adequate ICT infrastructure	62.40	0.935	10	63.60	9	59.40	15	60.00	10	60.80	10	61.00	9	65.00	8	0.603
Formal training to develop skill and knowledge	62.00	0.905	11	65.80	6	64.40	9	57.40	17	60.80	10	54.80	18	63.80	11	0.181
Ability to motivate people	61.40	0.898	12	60.00	14	60.00	14	60.00	10	61.80	9	61.00	9	62.80	13	0.989
Collaborative team culture	61.20	0.899	13	61.20	12	61.80	12	60.60	8	56.60	15	59.00	15	63.20	12	0.827
Continuous BIM education and awareness	60.80	0.966	14	60.00	14	62.60	10	60.00	10	60.00	13	61.00	9	60.80	15	0.996
Effective management skill	59.80	0.942	15	58.80	18	60.60	13	58.00	16	55.60	17	57.80	17	62.40	14	0.673
Management awareness of BIM	59.20	0.883	16	60.00	14	58.80	16	59.40	13	60.80	10	64.20	4	57.40	17	0.838
Adequate technical support for BIM implementation	58.80	0.993	17	60.00	14	57.60	16	59.40	13	56.60	15	60.00	13	59.40	16	0.985
Process redesign	56.20	0.967	18	57.60	20	53.80	18	56.00	18	55.60	17	59.00	15	56.60	18	0.929

Organisational capability attributes	*OVERALL*			*QS*		*BLDR*		*EEG*		*ARC*		*MEG*		*CEG*		*KW Sig.*
	LAv (%)	*SD*	*R*	*LAv (%)*	*R*	*LAv (%)*	*R*	*LAv (%)*	*R*	*LAv (%)*	*R*	*LAv (%)*	*R*	*LAv (%)*	*R*	
Plan to adopt international guidelines	49.40	1.074	19	58.80	18	53.80	18	44.00	20	49.60	21	44.20	20	48.80	21	0.282
Contract amendment	49.20	1.216	21	62.40	11	50.00	20	40.00	22	52.20	19	39.00	21	51.20	20	0.022*
Management's vision and missions for BIM	49.20	1.107	20	50.60	26	45.60	21	52.00	19	46.00	23	45.20	19	51.40	19	0.747
Software evaluation strategy	45.00	0.969	22	54.20	23	45.60	21	42.60	21	43.40	27	39.00	21	45.40	22	0.332
Coordination between BIM and CAD process flow	44.60	1.146	23	51.80	25	43.80	25	41.40	23	50.40	20	39.00	21	44.20	23	0.468
The use of design and build type of project delivery	42.80	1.191	24	55.20	22	39.40	27	39.40	24	45.20	24	33.60	25	44.20	23	0.089
Compatibility and interoperability of BIM	42.20	1.036	25	50.60	26	42.60	23	38.60	27	44.40	25	37.80	24	42.00	26	0.646
Clearly defined roles for the BIM administrator	41.80	1.218	26	54.20	23	42.60	23	37.40	25	44.40	25	31.60	36	42.40	25	0.065
Clearly defined roles for the BIM modeller	41.40	1.167	27	56.40	21	41.20	26	37.40	25	47.80	22	29.40	27	40.60	27	0.008*

LAv = Level of availability; SD = Standard deviation; R= Rank; QS = Quantity surveyor; BLDR= Builder; EEG= Electrical engineer; ARC= Architect; MEG= Mechanical engineer; CEG= Civil engineer; KW= Kruskal Wallis; *Sig. p-value ≤0.05

The study established that there is no statistically significant difference in the opinions of the group of respondents regarding the availability of the organisational capability attributes of the public sector for BIM implementation, except in two, namely contract amendment (LAv = 49.20%, p-value = 0.022) and clearly defined role for the BIM modeller (LAv = 41.40%, p-value = 0.008). The p-values of the attributes were ≤ 0.05 level of significance (Table 4). This implies that the construction professionals have different perceptions about the availability of these two organisational capability attributes (contract amendment and clearly defined role for the BIM modeller) in the study area. The respondents' consensus on the availability of most of the organisational capability attributes might be a reflection of bias to protect and portray their organisations in good light. In addition, the different level of engagement and interaction of the respondents with these organisational capability attributes, based on their various professional roles and responsibilities, might have influenced their opinions.

4.3 Adequacy of organisational capability attributes of the public sector for BIM implementation

Data were collected to assess the organisational capability attributes of the public sector for BIM implementation in building projects. In order to achieve this sub-objective, the organisational capability attributes of the public sector were examined, based on levels of adequacy. The result is presented in Table 5. Adequate power supply was the organisational capability attribute with the highest rating in terms of level of adequacy (LAq = 75.80%). This is followed by speedy internet connection (LAq = 69.80%); change from traditional work flow (LAq = 64.60%); adequate work environment for workers (LAq = 64.40%); data-sharing skills (LAq = 63.60%); standardised process (LAq = 63.40%); collaborative team culture (LAq = 63.00%); the ability to motivate people (LAq = 62.60%); collaborative process (LAq = 62.20%), and effective risk-management skills (LAq = 62.00%), which ranked 2nd, 3rd, 4th, 5th, 6th, 7th, 8th, 9th and 10th, respectively. The least rated capability attributes were the clearly defined roles for the BIM modeller (LAq = 38.20%); the clearly defined roles for the BIM administrator (LAq = 39.00%); the use of design and build type of project delivery to implement BIM (LAq = 40.40%); coordination between BIM and CAD process flow (LAq = 40.60%); compatibility and interoperability of BIM software (LAq = 42.40%); contract amendment (LAq = 43.40%); plan to adopt international standards (LAq = 43.60%), and software evaluation strategy (LAq = 43.60). These ranked 27th, 26th, 25th, 24th, 23rd, 22nd, 21st, and 20th, respectively.

The high rating of adequate power supply (LAq = 75.80%) could result from dependence on generator and other alternative sources of power supply. This agrees with Abubakar *et al.* (2014), Manu *et al.* (2019), as well as with Ihemeje and Afegbua (2020: 63), who noted that public offices in Nigeria depend more on generators for power supply. Although previous research (Afolabi *et al*. 2019; Onungwa *et al*., 2017: 26; Abubakar *et al*., 2014) noted that the use of ICT in public offices is low, speedy internet connection was rated high (LAq = 69.80%). This could have improved as a result of the current global pandemic (COVID-19), which has forced several organisations (public sector inclusive) to embrace the use of ICT in their operations. Most of the public offices operations are paper-based, with minimal usage of software, technology, and innovations that require high-speed internet connection to download and upload large files such as BIM (Sawhney, 2014; Zhao *et al*., 2016: 156; Afolabi *et al*., 2019). The high rating of collaborative team culture (LAq = 63.00%) and collaborative process (LAq = 62.20%) reflect the nature of the construction project execution, which entails interaction and cooperation with different professionals. This is especially the case in the public sector, where there can be diverse stakeholders on a particular project. Evidently, in such work environment, collaboration is very important for project execution and day-to-day operations. In addition, the current COVID-19 pandemic has forced several organisations, including the public sector, to improve on their capability attributes, in order to manage the disruptions in business operations and workflow.

The low rating of many core capability attributes, which are software related, such as clearly defined roles for the BIM modeller (LAq = 38.20%); clearly defined roles for the BIM administrator (LAq = 39.00%); the use of design and build type of project delivery to implement BIM (LAq = 40.4%); coordination between BIM and CAD process flow (LAq = 40.60%); compatibility and interoperability of BIM software (LAq = 42.4%); contract amendment (LAq = 43.40%), and software evaluation strategy (LAq = 43.60%) indicates that the public sector is lagging in the usage of software and modern techniques. The public sector still appears entrenched in the traditional practice, where lines and symbols on paper have been used to prepare working drawings, construction plans, bills of quantities, and engineering drawings. These results agree with previous research (Muhammed & Isah, 2012: 660; Kasimu & Usman, 2013: 126; Olorunkiya, 2017).

In Nigeria, where public projects dominate the construction sector (Alufohai, 2012; Hamma-Adama & Kouider, 2018: 1117), the implementation of modern methods and techniques is non-negotiable to enhance the performance of public projects. This is crucial to confront fragmentation and the uncoordinated way in which projects are being executed have been identified as the main causes of poor project performance. Unfortunately, compatibility and interoperability of BIM software, which is crucial for the public sector to implement BIM and eradicate the disjointed practices in project delivery, were rated very low in adequacy. Overall, the results show the poor state of organisational capability attributes of the public sector for BIM implementation. It is noteworthy that over 50% of these capability attributes have a level of adequacy below 60.00%. A good number of the capability attributes possessed by the public sector appear grossly inadequate although available. Hence, BIM may not be implemented soonest. This finding agrees with Afolabi *et al*. (2019), Iwarere and Lawal (2011: 23), Arnaboldi, Azzone and Savoldelli (2004: 218), and MOUCSF (2015), who identify the public sector as presently not capable of managing projects using modern methods. This is especially the situation in Nigeria, where there is no legislative roadmap for the use of technology, software, and innovative tools. This is unfortunate, despite the large-scale construction activities being undertaken by the public sector which is expected to take advantage of BIM, in order to enjoy its enormous advantage.

Table 5: Adequacy of organisational capability attributes of the public sector for BIM implementation

Organisational capability attributes	*OVERALL*			*QS*		*BLDR*		*EEG*		*ARC*		*MEG*		*CEG*		*KW Sig.*
	LAq (%)	*SD*	*R*	*LAq (%)*	*R*	*LAq (%)*	*R*	*LAq (%)*	*R*	*LAq (5)*	*R*	*LAq (%)*	*R*	*LAq (%)*	*R*	
Adequate power supply	75.80	0.816	1	69.40	1	77.60	1	77.40	1	74.80	1	83.20	1	74.20	1	0.253
Speedy internet connection	69.80	0.991	2	65.80	3	65.00	4	72.60	2	70.40	2	75.80	2	70.20	2	0.369
Change from traditional work process	64.60	0.841	3	65.80	3	65.60	2	62.00	9	64.40	8	62.20	5	65.80	3	0.910
Adequate work environment for workers	64.40	0.848	4	64.80	5	65.60	2	62.00	9	65.20	3	61.00	10	65.20	4	0.881
Data-sharing skills	63.60	0.942	5	63.60	6	59.40	12	62.60	8	65.20	3	68.40	3	63.80	7	0.817
Standardised process	63.40	0.905	6	67.00	2	63.20	5	63.40	6	65.20	3	57.80	12	63.40	9	0.703
Collaborative team culture	63.00	0.792	7	63.60	6	60.00	10	64.60	4	58.20	13	62.20	5	65.20	4	0.442
The ability to motivate people	62.60	0.824	8	57.60	13	61.80	6	64.60	4	65.20	3	62.20	5	62.40	11	0.782
Collaborative process	62.20	0.881	9	57.60	13	61.20	8	63.40	6	61.80	10	63.20	4	62.80	10	0.947
Effective risk-management skills	62.00	0.893	10	58.80	11	61.80	6	61.40	11	61.80	10	57.80	12	63.80	7	0.745
Sufficient number of workers	61.40	0.864	11	63.60	6	60.60	9	61.40	11	59.20	12	62.20	5	61.80	12	0.971
Continuous on-the-job training	61.40	0.870	12	56.40	17	59.40	12	58.00	15	65.20	3	59.00	11	64.20	6	0.245
Management awareness of BIM	60.20	0.934	13	50.60	25	57.60	15	65.40	3	64.40	8	62.20	5	59.80	13	0.097
Continuous BIM education and training	58.40	0.880	14	56.40	17	60.00	10	59.40	13	56.60	16	52.60	17	59.80	13	0.574
Adequate ICT infrastructure to support BIM	57.80	0.911	15	61.20	9	57.60	15	56.00	16	57.40	14	57.80	12	58.00	17	0.924
Process redesign	57.80	1.004	16	58.80	11	59.40	12	53.40	18	57.40	14	54.80	16	59.80	13	0.709

Organisational capability attributes	*OVERALL*			*QS*		*BLDR*		*EEG*		*ARC*		*MEG*		*CEG*		*KW Sig.*
	LAq (%)	*SD*	*R*	*LAq (%)*	*R*	*LAq (%)*	*R*	*LAq (%)*	*R*	*LAq (5)*	*R*	*LAq (%)*	*R*	*LAq (%)*	*R*	
Formal training to develop skills and knowledge	57.40	0.897	17	57.60	13	57.60	15	59.40	13	55.60	17	47.40	19	59.40	16	0.176
Adequate technical support for BIM	56.00	0.961	18	61.20	9	56.80	18	54.00	17	51.40	18	56.80	15	56.40	18	0.683
Management's vision and missions for BIM	51.00	1.111	19	55.20	19	48.80	19	49.40	19	47.00	19	48.40	18	53.20	19	0.705
Software evaluation strategy	43.60	1.039	20	54.20	21	43.20	20	43.40	20	37.40	26	41.00	20	43.80	22	0.318
Plan to adopt international guidelines	43.60	1.229	21	57.60	13	42.60	21	38.00	25	43.40	20	32.60	22	46.00	20	0.037*
Contract amendment	43.40	1.162	22	55.20	19	40.00	23	42.60	21	40.80	21	32.60	22	46.00	20	0.059
Compatibility and interoperability of BIM	42.40	1.074	23	49.40	26	40.60	22	42.00	22	40.80	21	36.80	21	43.60	23	0.696
Coordination between BIM and CAD	40.60	1.186	24	51.80	24	35.60	24	39.40	24	39.20	24	32.60	22	42.80	24	0.105
The use of design and build contract	40.40	1.162	25	54.20	21	35.60	24	42.00	22	40.00	23	29.40	25	41.60	25	0.025*
Clearly defined roles for the BIM administrator	39.00	1.130	26	54.20	21	35.00	26	38.00	25	36.60	27	26.40	26	41.60	25	0.003*
Clearly defined roles for the BIM modeler	38.20	1.081	27	49.40	26	36.20	27	37.40	27	38.20	25	25.20	27	41.60	27	0.019*

LAq = Level of adequacy; SD = Standard deviation; R= Rank; QS = Quantity surveyor; BLDR= Builder; EEG= Electrical engineer; ARC= Architect; MEG= Mechanical engineer; CEG= Civil engineer; KW= Kruskal Wallis; *Sig. p-value ≤0.05

It is noteworthy that capability attributes with a high level of availability (adequate power supply, speedy internet connection, change from traditional workflow, and adequate work environment for workers) also have a high level of adequacy. Similarly, attributes with a low level of availability (clearly defined roles for the BIM modeller, clearly defined roles for the BIM administrator, the use of design and build type of project delivery to implement BIM, compatibility and interoperability of BIM implementation, and coordination between BIM and CAD process flow) also have a low level of adequacy. This finding reveals the need for the public sector to improve on the critical attributes and make the same adequate, in order to implement BIM in the execution of building projects. These findings agree with Ihemeje and Afegbua (2020: 63), Olufemi *et al.* (2020: 846), Mayedwa and Van Belle (2016: 50), who posited that the public sector lacks adequate capability attributes to successfully execute its projects.

The study established that there is no statistically significant difference in the opinions expressed on the adequacy of the organisational capability attributes of the public sector for BIM implementation, except in four as observed by the respondents, namely plan to adopt international guidelines (LAq = 43.60%, *p*-value = 0.037); the use of design and build type of contract (LAq = 40.40%, *p*-value = 0.025); clearly defined role for the BIM administrator (LAq = 39.00%, *p*-value = 0.003), and clearly defined role for the BIM modeller (LAq = 38.20%, *p*-value = 0.019). The *p*-values of the attributes were ≤ 0.05 level of significance (Table 5). This implies that the construction professionals have a similar perception about the adequacy of these organisational capability attributes, except in four, namely plan to adopt international guidelines; the use of design and build type of contract; clearly defined role for the BIM administrator, and clearly defined role for the BIM modeller in the study area. The differences in the respondents' opinions on these four (4) organisational capability attributes are as expected, because all these capability attributes ranked low and are more or less peculiar to BIM implementation. It will be most unlikely for them to be adequate in an organisation that is not implementing BIM.

5. CONCLUSION

This study examined the organisational capability attributes of the public sector for the implementation of BIM and indicated the implications for enhancing the performance of public sector projects. Findings revealed that the capability attributes for BIM implementation with high rating are those that are not peculiar to BIM implementation, but are used for general and day-to-day operations in any typical organisation. Most of the attributes with low ratings are those that are specifically for BIM implementation. This suggests that the competence and capability of the public sector must be further developed, not only to capture capability attributes that are deployed in the general operational activities of the organisations, but also to include the specific requirements for BIM implementation. The findings of the study also showed that organisational capability attributes with high level of availability also had a high level of adequacy and those with low availability rating have a low adequacy rating. It can be further deduced from the results that roughly 50% of the organisational capability attributes have an availability rating below 60%, while over 50% of the organisational capability attributes have an adequacy rating below 60%. This shows that the organisational capability attributes of the public sector for BIM implementation are not yet satisfactorily developed. Hence, the public sector organisations in the study area need to aggressively pursue improvement measures to enhance the successful implementation of BIM on construction projects.

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