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Capability improvement measures of the public sector for implementation of building information modeling in construction projects

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Abstract: This study examines the capability improvement measures of the public sector client for enhancing the implementation of building information modeling (BIM) in construction project delivery. The study adopted a quantitative descriptive analysis based on primary data obtained through a structured questionnaire. A total of 198 valid questionnaires obtained from construction professionals within public sector organizations in Lagos State, Nigeria, provided primary quantitative data for the assessment. Data collected were analyzed using descriptive and inferential statistics. The findings indicated the measures to enhance the capacity of the public sector for BIM implementation including the following: team-based structure and recruitment of adequate number of staff (with mean score [MS] = 3.66), government support and involvement (MS = 3.64), government policies, adoption of process open to innovation, and investment in equipment and technology (MS = 3.60) had been considerably entrenched. However, measures that resulted in improved efficiency were limited to the following: reward system for performance (MS = 3.81), government policies, and education and training of staff (MS = 3.74), government support and involvement (MS = 3.73), and clear job description (MS = 3.71). Most of the measures with high level of impact were not necessarily those that are frequently used. On this basis, the public sector needs to differ from the status quo by adopting improvement measures that are appropriate for enhancing its capabilities for BIM in project delivery. The findings indicate implications that could enable the public sector to adjust and make necessary policies in a bid to improve BIM implementation in project delivery.

Keywords: building information modeling, capability improvement, public sector, building projects, implementation

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1 Introduction

Poor delivery of public sector projects has been considered a major concern in Nigeria (Iwarere and Lawal 2011; Manu et al. 2019). This has been attributed primarily to the fragmentation of the construction industry, of which the public sector projects are not exempted (Eadie et al. 2014; Olorunkiya 2017; Olanrewaju et al. 2021). Therefore, Succar (2014), and Fitsilis and Chalatsis (2014) opined that integration is a highly recommended strategy for an organization to improve on performance. According to Ruya et al. (2018) and Olorunkiya (2017), integration can be achieved by building information modeling (BIM) implementation to improve on the current fragmentation and set right the lack of proper coordination in the construction industry (see Figure 1). BIM implementation is not yet well established in the public sector despite advances and the attendant project successes it has brought around the globe. The consequences of this apathy include time and cost overrun, project failure, and project abandonment, among others (Onungwa et al. 2017; Olanrewaju et al. 2021). Specifically, the public sector has been identified with unsatisfactory organizational capabilities with significant negative impact on achieving outcomes (Schmidtchen and Cotton 2014; Manu et al. 2019). Schmidtchen and Cotton (2014) and Arnaboldi et al. (2004) stressed that the public sector needs to develop and improve its organizational capabilities continuously, so as

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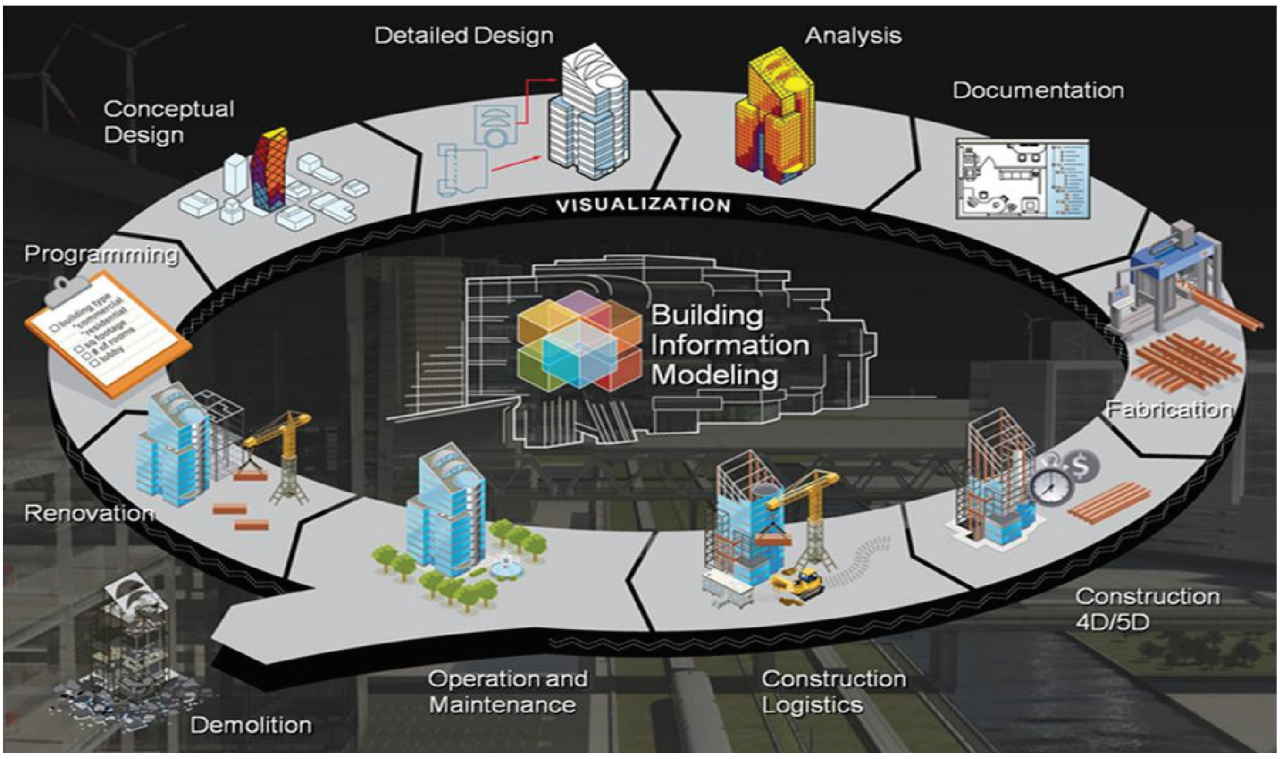

Fig. 1: Schematic representation of BIM interaction. Source: Hamma-Adama and Kouider (2018). BIM, building information modeling.

to efficiently complete projects and attain developmental objectives. The perceived absence of skilled personnel, poor data management, wild inflation of cost, poor budgeting, corruption, and inefficient infrastructure, which characterize the public sector, could be critical to the level of BIM implementation (Fatile and Adejuwon 2014; Fitsilis and Chalatsis 2014). These complex challenges, complemented with a high level fragmentation in the construction sector, have led to the call for improved project delivery and enhanced organizational performance of the public sector (Akande et al. 2018; Manu et al. 2019).

Implementation of BIM is justified for public sector projects for a number of reasons. First, public sector projects dominate Nigeria's construction sector (Alufohai 2012; Ruya et al. 2018), with the government being the major client (Hamma-Adama and Kouider 2018). Moreover, the public sector has been highly criticized for poor project planning, poor project performance, complex organizational environment, and the bureaucratic culture, among others (Kolo and Ibrahim 2010; Babatunde 2015; Manu et al. 2019). These undesirable qualities, which BIM could help to resolve, continue to be detrimental to public sector project delivery. Previous studies have identified major challenges militating against the implementation of BIM and include contractual issues, personnel inadequacies, lack of required infrastructure, shortage of information technology-literate personnel, and absence of a national implementation plan (Abubakar et al. 2013; Kori and Kiviniemi 2015; Bui et al. 2016; Onungwa et al. 2017). These challenges and the perceived low implementation of BIM by the public sector, coupled with its attendant problems, could be connected with the poor capabilities of the sector in adopting innovations (Babatunde 2015). Consequently, Manu et al. (2019) and Akinola and Wissink (2018) opined that there is a need to improve performance, enhance efficiency, and upgrade the capabilities of the public sector clients to ensure value for money in the industry. Hence, improving the capabilities of the public sector will better position and equip the sector to implement BIM in construction projects, thereby improving the project delivery process.

Previous studies such as those by Babatunde et al. (2016) and Ahmed (2011) have noted the inadequate capabilities of the public sector in project delivery, and this field has attracted a number of studies in recent times. The private sector has been said to have better capabilities in project execution than the public sector, in spite of the leading role of the latter in project finance (Fitsilis and Chalatsis 2014; Kori and Kiviniemi 2015). Furthermore, Olugboyega and Aina (2016), Tembo and Rwelamila

(2008), and Awwad (2013) have revealed that the major BIM users are private sector clients, contractors, and consultants, while the public sector seems to be not taking any steps to use it despite being a major player in the construction industry. As a result of this, many scholars have commented on the need for improvement in the capabilities of the public sector (Babatunde et al. 2016; Opawole et al. 2019).

Organizational capability is the ability of a firm to perform a coordinated task, utilizing organizational resources, for the purpose of achieving a particular end result (Inan and Bititci 2015). The aim of capability improvement measures is to enable an organization to retain and continuously improve its capabilities without further support from external sources (Baser and Morgan 2008; Guijt 2020). There are different capability milestones that organizations must achieve in order to implement BIM. These capabilities determine the level of BIM implementation in any organization (Succar 2010, 2014). These capabilities include standardized processes and acquisition of technological and software resources, training and education, policy stability, adequate power supply, good Internet facilities, efficient data management, new process and workflow implementation, coordination between BIM and computer-aided design (CAD) process flow, adequate work environment, and ability to mitigate risks (Succar 2014; Yusuf 2014; Kori and Kiviniemi 2015; Onungwa et al. 2017; Dakhil et al. 2019). Therefore, the public sector needs to improve its capability attributes continuously. The recent environment of the public sector has changed drastically. Goldsmith and Eggers (2004) have suggested that public officials must develop a new governance model that will suit the ever-increasing complexities in the society, especially those relating to dynamisms in innovations. According to Mazzucato and Kattel (2020), the public sector ought to be an entity that is ever learning to ensure that its knowledge is continuously enhanced and its processes are ever improving.

This study seeks to investigate the capability improvement measures of the public sector in order to provide information on the current measures in place and other necessary improvements relating to BIM implementation on construction projects. This will help to identify the requisite skill set – as well as the changes and adjustments that the public sector needs to embrace – for BIM implementation. This study is expected to provide implications that could enable the public sector to adjust and make necessary decisions and policies in a bid to improve BIM implementation in project delivery.

2 Global state of BIM implementation in the public sector

Dada (2013) and Iwarere and Lawal (2011) opined that the public sector is controlled by the government at the federal, state, or local levels, comprising several ministries, departments, and agencies in Nigeria. In the developed countries, the public sector sets the pace for BIM implementation. In the United States, for instance, the General Services Administration is a major public client that is leading BIM implementation (Wong et al. 2010). Moreover, the public sectors of countries such as the United Kingdom, Finland, Norway, Denmark, Hong Kong, Australia, and Singapore have also been implementing BIM (Wong et al. 2011). In the Brazilian context, Brito et al. (2021) asserted that to maximize the benefits of BIM use, clients, such as the public sector, can directly influence the enterprise viability by selecting the project delivery system that could lead to the search for alternative contractual requirements to traditional models. Within the European context, Šimenić (2021) concluded that the most critical factor for the successful implementation of BIM is national leadership and coordination by the public sector in order to maximize efficiency and avoid problems created by partial and inconsistent approaches. Jiang et al. (2021) noted that a government-driven approach was adopted in Singapore and the UK, where the government takes a leading role of mandating the use of BIM. In contrast, the US has adopted an industry-driven approach and the government is less involved in promoting BIM implementation. This reveals that the public sector plays a strategic role in BIM implementation in the construction industry.

In Nigeria, the public sector appears not to be doing enough about BIM implementation. BIM implementation is confronted by myriad challenges and there appears to be an absence of any plan for BIM implementation in the public sector (Olatunji et al. 2010; Abubakar et al. 2014). In the Malaysian context, according to Othman et al. (2021), BIM awareness and implementation is low, though the public sector organizations are leading the implementation. Although many countries around the world have implemented BIM tools and technologies, the vast majority is focused on the vertical construction sector or BIM is implemented through isolated initiatives. This is the case in countries, such as Armenia, Austria, Bosnia and Herzegovina, Bulgaria, Croatia, the Czech Republic, Georgia, Hungary, Italy, Lithuania, Poland, Romania, Slovakia, Slovenia, and Turkey (Šimenić 2021). On the

other hand, there are relatively few countries that have included BIM in public contracts and government legislation. The United States and the United Kingdom stand out as leaders in this regard, as they have incorporated this technology into several public sector bodies, promoting its implementation. Other countries with compulsory use of BIM by public authorities are Norway, Finland, Sweden, Singapore, Hong Kong, South Korea, and Australia (as shown in Figure 2). In some countries, governments recommend the use of BIM, acknowledge its benefits, make efforts to encourage its use, and play a leading role in implementing BIM. Significant among these are the Netherlands, Denmark, Belgium, Luxembourg, France, Germany, Italy, Malaysia, Spain, Switzerland, Ireland, Japan, China, Taiwan, New Zealand, and Canada (Šimenić 2021). Better implementation of BIM is apparent in developed countries, where there are several research activities on BIM implementation, e.g., the McGraw Hill BIM report (McGraw-Hill Construction 2014). The situation in developing countries is just the direct opposite of this. This is unfortunate despite the large scale of construction activities being undertaken, which are expected to take advantage of BIM in order to derive the enormous benefits of its implementation.

Several countries like the United Kingdom, the United States, and Australia (Lee et al. 2003; Wong, et al. 2009; HM Government 2012) have mandated the usage of BIM and have established strategies for BIM implementations in construction projects. In the European context, the adoption of the directive, officially called the European Union Public Procurement Directive (EUPPD), meant that all 28 European Union member states could encourage, designate, or mandate the use of BIM for publicly funded construction projects in the European Union by 2016. Italy and Spain (2019), the United Kingdom (2016), the Netherlands (2012), Denmark (2007), Finland (2007), and Norway (2007) already require mandatory use of BIM for publicly funded construction projects. Germany has done the same since the beginning of 2020. France plans to do so in 2022 (Šimenić 2021). These analyses show that Finland, Denmark, Norway, Sweden, and several other European countries are the BIM leaders in the world (Arayici et al. 2011; Šimenić 2021).

Although BIM is being implemented in Hong Kong, it is still in its early stages. Dubai was the first in the Middle East to make the usage of BIM compulsory for large-scale projects (Chan 2014). Awwad (2013) explained that the Middle East is grossly behind in BIM implementation and that the public sector has not taken steps toward its usage; except the United Arab Emirates and Qatar, there has not been any public authority insisting on the use of BIM (Gerges et al. 2017). In developing countries such as Nigeria, BIM implementation is not being encouraged and the implementation is rare and grossly inadequate (Onungwa et al. 2017). There are myriad challenges plaguing the implementation of BIM in Nigeria; BIM awareness level is only high at the design stage of a building life cycle, while it is extremely low at the construction and facility

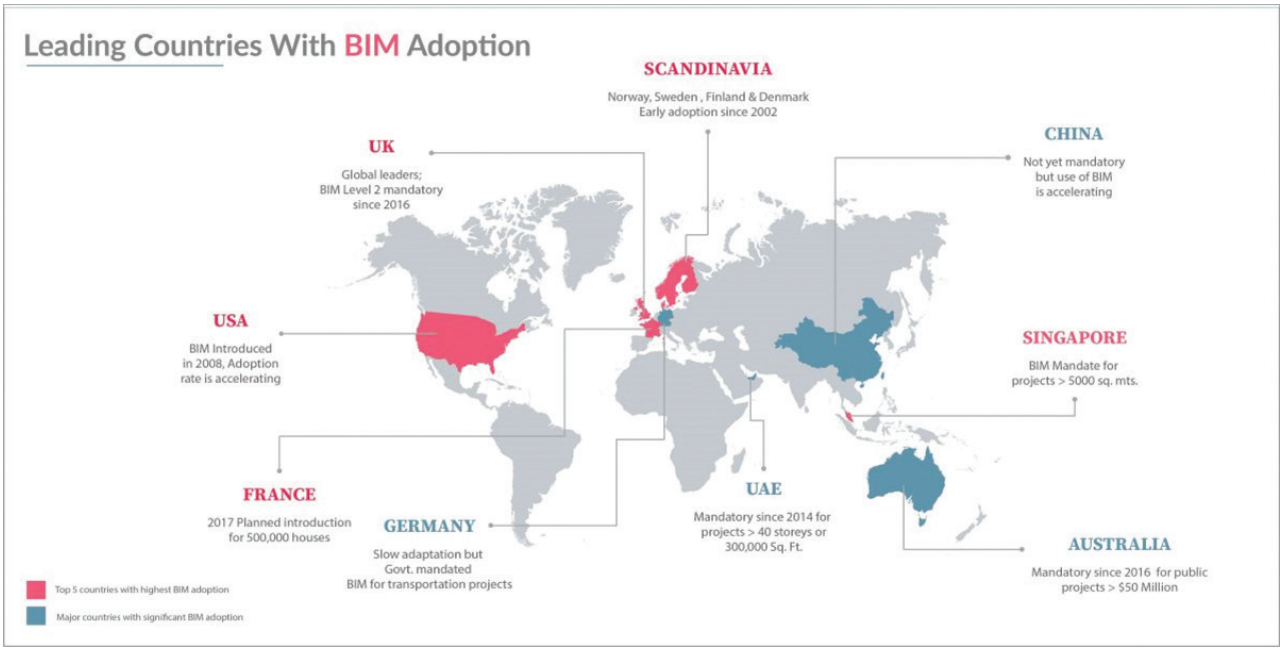

Fig. 2: Leading countries with BIM adoption. Source: United-BIM.com (2020). BIM, building information modeling.

management stages (Ruya et al. 2018; Olanrewaju et al. 2020, 2021). In fact, the Nigeria Construction Industry has no legislative roadmap for the use of technology, software, and other innovative tools (Hamma-Adama and Kouider 2018). Moreover, there is lack of government support and involvement in the implementation of BIM (Alufohai 2012). Only a small amount of research has been carried out on BIM implementation in Nigeria. Significant among these are the studies by Isa (2015), Usman (2015), Abubakar et al. (2013, 2014), and Abdullahi et al. (2011). The general consensus from these studies is that the public sector is not yet well equipped to implement BIM.

All over the globe, the public sector projects are plagued with higher unsolved complexity when compared with private sector projects (Weinstein and Jackques 2010). This conclusion is a perfect picture of the Nigerian public sector. Complex organizational environment, goal structure, and managerial values are some of the things that differentiate the public sector from the private sector. These factors reveal the difference in the capabilities of the private and public sectors. Private sector projects are managed with dynamism, simplicity, and commitment to obtaining value for money. However, the public sector tends to be conventional with slow response time, rigid unproductive processes, bottlenecks, and bureaucratic culture (Fatile and Adejuwon 2014). According to Management Organisation Unit (MOU) of Community Support Framework (2005), 22% of public sector clients are incapable of managing their projects and about 50% are not using modern methods. The public sector's inability to effectively deliver projects is not a local phenomenon; it is prevalent among developing countries (Kaul and Collins 1995; Arnaboldi et al. 2004). In the same context, Olugboyega and Aina (2016), Ogwueleka (2011), Tembo and Rwelamila (2008), and Awwad (2013) revealed that major BIM users are private sector clients, contractors, and consultants, while the public sector seems to be not taking any step to use it despite being a major player in the construction industry. Tembo and Rwelamila (2008) and Awwad (2013) further noted that the public sector has an overreliance on consultants in managing projects and merely get reports of the construction process.

Most empirical studies on BIM in developing countries such as Nigeria have centered on BIM benefits, BIM barriers, and BIM readiness (Abubakar et al. 2014; Chan et al. 2019; Olanrewaju et al. 2020). These studies examined the critical BIM attributes at the pre- and postadoption stages across the construction sector without specific emphasis on the public sector, which is the major client of complex project and the pioneer of leader of BIM implementation in most countries (Šimenić 2021). Meanwhile, there is also a growing interest in BIM implementation in the public infrastructure construction sector in the design, construction, and asset management fields (Ahuja et al. 2020). Ibrahim and Kagara (2014) observed that the use of BIM software technologies in Nigeria is limited to 3D visualizations, component details, and specifications, whereas it encompasses so much more. The highly limited knowledge of BIM in Nigeria has been attributed to lack of awareness and lack of equipped staff (Abubakar et al. 2013; Onungwa et al. 2017). Furthermore, the present adoption level of BIM in Nigeria is still at the individual organizational level, which represents BIM Stage 1, called "lonely BIM" (Hamma-Adama and Kouider 2018). In the current global landscape, wide implementation of BIM is still grossly lacking, especially in developing countries, despite many approaches such as frameworks and technology adoption proposed to support its implementation (Succar 2009; Arayici et al. 2011; Kekana et al. 2014; Masood et al. 2014). Therefore, there is a need to focus on the actual implementation of BIM, not just on its benefits.

3 Capability improvement measures of the public sector

An overview of sustainable capabilities aimed at enhancing the capabilities of the public sector identified measures, such as establishment of standard for good performance, clear job description and competitive payment scale to attract highly qualified personnel, good system of reporting, power to hire and fire workforce, and high degree of status, as the major factors (Grindle and Hilderbrand 1995; El-Taliawi and Van Der Wal (2019). According to Jones et al. (2004) and Palm (2020), observance of best practice principles involving development of standards, training of staff, and proper coordination are capability improvement measures that the public sector can adopt. Similarly, Gershon (2004) opined that making the best use of available resources, improvement of skill and knowledge of frontline professionals, significant rise in the overall levels of skills and capabilities, significant organizational changes, and redefining the knowledge and skill requirements are vital to improve the capabilities within the public sector. Government policies, support and involvement, strong commitment by stakeholders, training packages, and implementation of educational actions are other capability improvement measures identified by Alufohai (2012) and Fitsilis and Chalatsis (2014). Belay et al. (2021), Olugboyega and Aina (2016) identified information and communication technology (ICT)

literacy and staff cooperation, capacity building for BIM implementation, behavioral change among professionals, emphasis on research and development, knowledge management practice, commitment to BIM training, provision of standardized system of work, and information management as capability improvement measures for BIM implementation.

Brito et al. (2021) and Dim et al. (2015) posit that migrating from the conventional system to an integrated system of procurement is vital to BIM implementation at the organizational level. People are critical to implementing BIM. Hence, to ensure the successful implementation of BIM, the people in an organization must be trained on BIM. Education is a strategy to get this done by equipping the people with relevant skills and knowledge (Zahrizan et al. 2013; Lember et al. 2018). Education and training programs have been regarded as means to manage the culture of resistance to change among employees (Dewan et al. 2004). However, education and training solely might not overcome this problem because some personnel do not take training seriously. As stated by Winter (2003) and Olojede et al. (2020), outcomes and outputs of organizations depend on the action and behavior of employees. Hence, the quality of the human resources in an organization can enhance its capabilities. Sufficient retention of employees to capture their skills for organizational development and commitment, commitment to better regulation, adoption of transparent processes, performance analysis and peer review, accountability, and informed data for effective policy-making are identified as key capability improvement measures by (McDermott et al. 2013) and Andrew and Leon-Cazares (2015). In a review of human resource practices in the public sector in the United Kingdom, Gould-Williams (2003) identified teamwork, employment security, performance-based payment, selective hiring, training and development, information sharing, and egalitarianism as capability improvement measures. The findings of Andrew and Leon-Cazares (2015) and Olojede et al. (2020) suggest that low structural complexity or simplified organizational structure and personnel stability are also core capability improvement measures of public sector organizations.

Hase (2000) (cited in Ticha 2010) and Mazzucato and Kattel (2020) identified organizational capability improvement measures to include focus on learning, evaluation of performance, provision of resources for staff development, provision of opportunities for multiskilling, commitment of management to the enhancement of employees' competencies, valuing members of the organization and encouraging self-esteem, adequate reward system, team-based structure, presence of skilled leaders (rather than "managers"), management support for change, recognition, and commitment of all levels of staff to change. Tilley et al. (2015) conducted a review of literature on sustaining the public sector capabilities in developing countries and identified provision of strong leadership, engagement of adequate numbers of staff, selection of people with adequate skills, and provision of incentives as capability improvement measures. Gill and Delahaye (2004) and Kabrilyants et al. (2021) identified guided performance management, explicit direction through mission statement, job role alignment with strategic plan, and provision of informal organizational processes as means to improve organizational capabilities. Lember et al. (2018) and López-Cabarcos et al. (2015) identified capability improvement measures to include development of knowledge and technical expertise, provision of physical infrastructure, investment in equipment and technological capabilities, acquisition of software, and adoption of process open to innovations. Mazzucato and Kattel (2020) opined that governments should invest in building their muscle in critical areas, such as capacity to adapt and learn, capacity to align public services and citizen needs, capacity to govern resilient production systems, and capacity to govern data and digital platforms, in order to improve their capabilities. Zaini et al. (2020) identified BIM training, improved Internet facilities, better power supply infrastructure, government support/involvement, employment of competent personnel, and management support. Al-Ashmori et al. (2019) stated that skill development, training, education, adequate technology, and adoption of best practices from experts would enhance the capabilities of organizations to implement BIM.

Revelli and Tovmo (2007) and Ashworth et al. (2009) opined that performance classification can be adopted to drive capability improvements by encouraging healthy competition between organizations. In particular, acquisition of organizational knowledge, adequate human resources, and skills-dependent and interpersonal networks are not common and not easily imitated, and so, these offer a competitive advantage and improve capabilities (Barney 1991; Nahapiet and Ghoshal 1998). Stable workforce, selection, induction, and training of new recruits are also considered to enhance capability development in an organization though time and money are required (Griffith and Horn 2001; Ashforth et al. 2007). These issues may be especially important in the public sector, because effective organizational functioning depends on talent, training, motivation, and effort of various groups of professionals (Nigro et al. 2006). Verner (2014), in the context of public–private partnership (PPP)

projects, and Jooste and Levitt (2009), in an overview on the changing role of government and the public sector contracting (cited in Olojede 2018), identified training of public officials as a way to improve the capabilities of the public sector in discharging its duties. In the same vein, Yuan et al. (2008) opined that the long-term process in PPP project development requires adequate investment in research, learning, and training mechanism to continually increase the capabilities of the public sector to improve its performance by gaining new knowledge (cited in Olojede 2018). The adoption of standard project processes and their incorporation into working-routine by an organization can result in great advantages to the organization (Gareis and Huemann 2007). The way by which an organization deploys its human resource in the attainment of its objectives represents distinctive competencies and advantage, and as such, reveals the capabilities of an organization in achieving results (Helfat and Peteraf 2003). Combination of quality leadership, sound management practices, as well as adequate and strategic operational management, all constitute capability improvement measures (Andrew and Leon-Cazares 2015).

Manu et al. (2019) opined that short- and long-term capacity development plan(s), clear performance measurement, implementation of educational actions, knowledge management practice, and stakeholder support for change would improve the capabilities of the public sector. El-Taliawi and Van Der Wal (2019) stressed that with regard to enhancing the capabilities of the public sector, governments should realize that optimal or ideal systems or end states do not exist, but that systems need to be continuously upgraded. The capabilities of the public sector can be improved by decentralization, judicial independence, competitive service delivery, responsive feedback mechanisms, better management controls (or risk management tools and practices), more integrated and collaborative structures and arrangements, conventional practices, training and development, human capital enhancement, and government-aided intervention (Ammons 2019; Olojede et al. 2020). The summary

Tab. 1: Capability improvement measures of the public sector.

S. no.	Capability improvement measures	Author(s)
1	Retention of workers/personnel stability	Andrew and Leon-Cazares (2015)
2	Recruitment of highly skilled workers	Tilley et al. (2015); Zaini et al. (2020)
3	Education and training of staff	Dewan et al. (2004); Zahrizan et al. (2013); Palm (2020)
4	Clear job description	Grindle and Hilderbrand (1995); Gill and Delahaye (2004)
5	Adequate reward system for performance	Ticha (2010)
6	Greater autonomy to hire and fire	Grindle and Hilderbrand (1995)
7	Set standard for good performance	Grindle and Hilderbrand (1995); Gill and Delahaye (2004); Olugboyega and Aina (2016); Palm (2020)
8	Attractive salaries/pay scale	Grindle and Hilderbrand (1995); Jones et al. (2004)
9	Acquisition of software	López-Cabarcos et al. (2015); Lember et al. (2018)
10	Provision of physical infrastructure	López-Cabarcos et al. (2015); Lember et al. (2018)
11	Structured reporting system and relationship	Grindle and Hilderbrand (1995)
12	High degree of status for government employees	Grindle and Hilderbrand (1995)
13	Presence of skilled and strong leaders (not managers)	Ticha (2010); Tilley et al. (2015); Al-Ashmori et al. (2019)
14	Adequate number of staffs	Tilley et al. (2015); Zaini et al. (2020)
15	Information sharing/management	Olugboyega and Aina (2016); Hamma-Adama (2020)
16	Investment in equipment and technology	López-Cabarcos et al. (2015); Gould-Williams (2003)
17	Adoption of process open to innovations	López-Cabarcos et al. (2015); Al-Ashmori et al. (2019)
18	Skills-based and interpersonal networks	Barney (1991); Nahapiet and Ghoshal (1998)
19	ICT literacy of staff	Olugboyega and Aina (20160; Palm (2020)
20	Speedy project implementation	Gareis and Huemann (2007)
21	Improved financial results	Gareis and Huemann (2007)
22	Effective strategic and operational management practices	Andrew and Leon-Cazares (2015)
23	Commitment to BIM training	Olugboyega and Aina (2016); Al-Ashmori et al. (2019)

(*Continued*)

Tab. 1: Continued

S. no.	Capability improvement measures	Author(s)
24	Simplified organizational structure	Andrew and Leon-Cazares (2015); Olojede et al. (2020)
25	Performance-related pay	Gould-Williams (2003)
26	Team-based structure	Gould-Williams (2003); Ticha (2010)
27	Selective hiring	Gould-Williams (2003)
28	Performance evaluation	Ticha (2010)
29	Government policies	Alufohai (2012); Fitsilis and Chalatsis (2014)
30	Government support and involvement	Alufohai (2012); Fitsilis and Chalatsis (2014)
31	Research and development	Olugboyega and Aina (2016); Yuan et al. (2008)
32	Management/stakeholder support for change	Ticha (2010); Alufohai (2012); Fitsilis and Chalatsis (2014); Al-Ashmori et al. (2019)
33	Provision of incentives	Tilley et al. (2015)
34	Recognition and commitment of staff to change	Olugboyega and Aina (2016); Ticha (2010)
35	Valuing employee/encouraging self-esteem	Ticha (2010)
36	Elimination of internal conflicts	Gareis and Huemann (2007)
37	Commitment to learning	Chinowsky et al. (2007); Yuan et al. (2008); Ticha (2010); Mazzucato and Kattel (2020)
38	Provision of opportunities for multiskilling	Ticha (2010)
39	Provision resources for learning and development	Ticha (2010); Mazzucato and Kattel (2020)
40	Implementation of educational actions	Alufohai (2012); Fitsilis and Chalatsis (2014)
41	Knowledge management practice	Olugboyega and Aina (2016)

BIM, building information modeling; ICT, information and communication technology.

of capability improvement measures identified in some earlier studies is presented in Table 1.

4 Research methodology

The methodology adopted in this study is quantitative descriptive analysis, which was based on primary data. Pandey and Pandey (2021) explained the research design to be basically a statement of the objective of inquiry, strategies for collection of evidence, analysis of evidence, and recording of findings. Kowalczyk (2015) defines a descriptive research design as one that is aimed at systemically describing the characteristics of a population. The study used a quantitative approach in collecting and analyzing data. According to Askarzai and Unhelkar (2017), quantitative research usually entails gathering numeric data in a systematic format. The target population for this study consists of 1,634 construction professionals in Lagos State Public Service, Nigeria. Lagos State is located in the Southwestern part of Nigeria. Being a former Federal Capital and now the commercial nerve center 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 about 17 million in 2007 and a growth rate of 3.2%, which has an attendant pressure on its infrastructure. There are numerous construction projects in Lagos executed by both the private and public sectors to meet the housing, economic, and infrastructure requirements of the emerging megacity (Balogun et al. 2017). Among other stakeholders in public projects, the study focused on the constructional professionals (architects, quantity surveyors [QSs], builders, civil engineers, electrical engineers, and mechanical engineers) within the Lagos State public sector because they are the key professionals who are central to construction project execution and BIM implementation. According to the Disposition List of Lagos State Public Service (2019), the sampling frame comprises 154 architects, 85 QSs, 205 builders, 586 civil engineers, 283 electrical engineers, and 321 mechanical engineers in Lagos State Public Service. A 20% proportion was selected from each category of construction professionals. This makes a total of 327 construction professionals (as shown in Figure 3). Each respondent was chosen entirely by chance, not biased in a systematic manner, and each member of the population had the same chance of being included in the sample (Kumar 2018). For this

reason, randomization was used to achieve an unbiased sample. Hence, the portion selected from each professional classification is a true and accurate representation of the entire population (Silverman 2020).

A total of 327 copies of a structured questionnaire were administered to QSs, architects, electrical engineers, builders, civil engineers, and mechanical engineers, who worked in various ministries, departments, and agencies of Lagos State Public Service. The professionals were solely from the Lagos State Public Service in Nigeria, answering the questions only for the public sector in Nigeria. Research instruments are fact-finding strategies and tools used for data collection (Easterby-Smith et al. 2021). Data were collected using self-administered well-structured questionnaires, wherein certain information was listed for the respondents to complete (Easterby-Smith et al. 2021). Structured questionnaire has been considered an effective data collection method when measuring respondents' beliefs, attitudes, and opinions (Silverman 2020). The survey questionnaire was designed as a close-ended type. According to Kumar (2018), a close-ended questionnaire is easy to handle and relatively quick to analyze. The use of the questionnaire enabled freedom of opinion of individual respondents without fear of stigmatization since it ensures anonymity, confidentiality of responses, and identity protection of the respondents (Patten 2016). The questionnaire was developed based on the constructs of the literature review, and it was divided into two parts. Part 1 was designed to gather the respondents' profile. These items include the academic and professional qualifications, as well as years of working experience of the respondents in the construction industry generally. Part 2 of the questionnaire, which was related to the specific objective of the study, was further divided into two sections. Section 1 examined the frequency of usage of capability improvement measures for BIM implementation by the public sector. Section 2 examined the level of impact of the capability improvement measures for BIM implementation.

The respondents were informed about both the purpose of this study and their freedom to be anonymous. Data analysis was achieved through descriptive statistics such as the Kruskal–Wallis test, mean, frequency distribution, and percentage. Descriptive statistics are considered effective tools in understanding underlying details of a data set and putting them in a meaningful perspective (Castillo et al. 2010). Accordingly, 198 copies of valid questionnaires, which represent a response rate of 60.55%, were returned and used for the analysis. The total retrieved questionnaires made the breakdown of the study sample to be as follows: 17 QSs, 23 architects, 77 civil engineers, 32 builders, 30 electrical engineers, and 19 mechanical engineers (Figure 3). The response rate of 60.55% for a questionnaire survey is adjudged adequate by Naoum (2012), who recommended a rate not <30%–60%.

5 Data analysis and discussion of findings

5.1 Profile of the respondents

The profiles of the respondents analyzed include organization of the respondents, profession of the respondents,

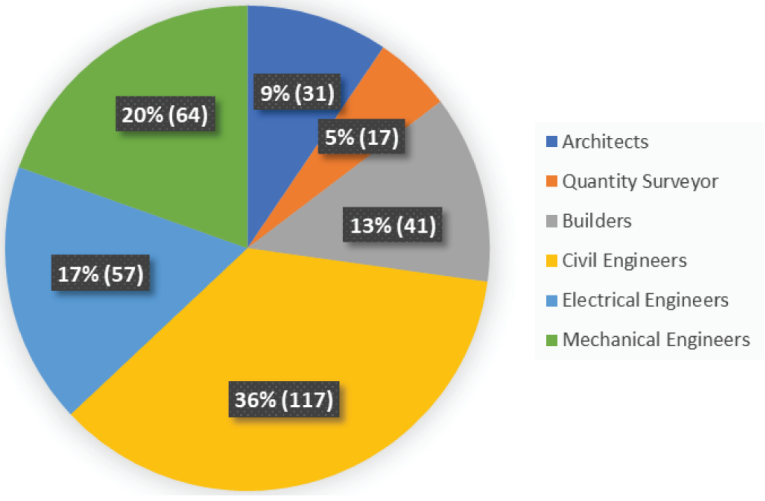

Fig. 3: Sample size for the study.

years of working experience, highest academic qualification, professional qualification, number of projects involved in since employment in which BIM was used, and number of projects involved in generally since employment. The results of the analysis are presented in Table 2. The distribution of the respondents was as follows: 8.1% were from the Ministry of Education, 22.7% were from the Ministry of Housing, 13.6% were from the Ministry of Environment and Physical Planning, 16.3% were from the Ministry of Transportation, 12.6% were from the Ministry of Waterfront Infrastructure, and 26.8% were from the Ministry of Works and Infrastructure. Moreover, the respondents had academic qualifications ranging from Higher National Diploma (HND) to Masters in their fields of interest. About 25.3% of the respondents had HND, 9.6% had postgraduate diploma (PGD), 32.8% had Bachelor of Science/Technology (B.Sc./B.Tech.), and 32.3% had Master's degree. The respondents had different professional affiliations, indicating their professional competence to practice in their various areas of discipline. This was supported by their membership in their respective discipline-related regulatory institutions. About 8.6% of the respondents belonged to the Nigerian Institute of Quantity Surveyors (NIQS), 16.2% belonged to the Nigerian Institute of Building, 12.1% belonged to the Nigerian Institute of Architects, and 62.1% belonged to The Nigerian Society of Engineers, while 1% of the respondents belonged to allied professional institutes. The percentage representation of the academic qualification and the level of competence of the respondents supported by their professional qualifications were deemed adequate for the provision of reliable information on the objectives of this study.

Moreover, QSs represented 8.6% of the respondents, 16.2% were builders, 15.2% were electrical engineers, 11.6% were architects, 9.6% were mechanical engineers, and 38.9% were civil engineers. These results showed that the respondents covered construction management professionals who could provide adequate information on the capability improvement measures of the public sector in the study area. The analysis of working experience of the respondents showed that 26.8% had 6–10 years, 28.8% had 11–15 years, 21.2% had 16–20 years, 8.6% had 21–25 years, and 5.6% had >25 years of working experience. Only 9.11% had <5 years' experience. The mean years of experience of the respondents and the mean of projects involved in generally are 18 years and 16 projects, respectively. This implied that the respondents had the fundamental knowledge of the public service system of operation and an adequate level of experience to provide reliable information on the objectives of this study. The respondents who had not been involved in projects where BIM was used represented 88.9%. About 11.1% were

Tab. 2: Background information of the respondents.

Profile of respondents	Frequency	(%)
Organization of respondents		
Ministry of Education	16	8.1
Ministry of Housing	45	22.7
Ministry of Environmental and Physical Planning	27	13.6
Ministry of Transportation	32	16.2
Ministry of Waterfront Infrastructure	25	12.6
Ministry of Works and Infrastructure	53	26.8
Total	**198**	**100**
Profession of respondents		
Quantity surveyor	17	8.6
Builder	32	16.2
Electrical engineer	30	15.2
Architect	23	11.6
Mechanical engineer	19	9.6
Civil engineer	77	38.9
Total	**198**	**100**
Respondent's highest academic qualification		
HND	50	25.3
PGD	19	9.6
B.Sc./B.Tech.	65	32.8
M.Sc.	64	32.3
Total	**198**	**100**
Professional qualification of respondents		
NIQS	17	8.6
NIOB	32	16.2
NIA	24	12.1
NSE	123	62.1
Others	2	1
Total	**198**	**100**
Years of experience of respondents		
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
More than 25	11	5.6
Total	**198**	**100%**
Number of projects since employment wherein BIM was used		
0	176	88.9
1–5	14	7.1
5–10	4	2
11–15	1	0.5
16–20	3	1.5
Total	**198**	**100**

(*Continued*)

Tab. 2: Continued

Profile of respondents	Frequency	(%)
Number of projects involved in generally since employment		
1–5	16	8.1
6–10	26	13.1
11–15	45	22.7
16–20	40	20.2
More than 20	71	35.9
Total	**198**	**100**

BIM, building information modeling; B.Sc./B.Tech., Bachelor of Science/Technology; HND, Higher National Diploma; NIA, Nigerian Institute of Architects; NIOB, Nigerian Institute of Builders; NSE, Nigerian Society of Engineers; NIQS, Nigerian Institute of Quantity Surveyors; PGD, postgraduate diploma.

involved in projects where BIM was used. This reveals the paucity of BIM usage in the public sector as opined by previous studies (Kori and Kiviniemi 2015; Olugboyega and Aina 2016).

5.2 Capability improvement measures used by the public sector for BIM implementation

To achieve this objective, capability improvement measures obtained from the review of literature were assessed based on the frequency of usage, using mean score (MS) and Kruskal–Wallis test. The result is as presented in Table 3. The result showed that team-based structure and adequate number of staff (MS = 3.66) ranked as the most frequently used measures. Other highly ranked capability improvement measures include government support and involvement (MS = 3.64), government policies, adoption of process open to innovation, investment in equipment and technology (MS = 3.60), ICT literacy of staff, information sharing/management, and simplified organizational structure (MS = 3.58), which ranked third, fourth, fifth, sixth, seventh, eighth, and ninth, respectively. The least-ranked capability improvement measures were greater autonomy to hire and fire (MS = 2.47), retention of workers/personnel stability (MS = 2.88), valuing employee/encouraging self-esteem (MS = 3.00), improvement of financial results (MS = 3.12), and effective strategic management practices (MS = 3.12). These ranked 41st, 40th, 39th, 38th, and 37th, respectively.

The high ranking of team-based structure could be due to the nature of construction project execution, which usually involves diverse professionals, stakeholders, and participants working together toward successful project delivery. This is especially the case within the public sector in Nigeria, which is the major client of complex projects in which there can be several stakeholders of interest on a particular project in compliance with government policy/directive and in observance of best practice as prescribed by the Nigerian Procurement Act. This result is in consonance with the assertions by Gould-Williams (2003) and Ticha (2010), who identified team-based structure as a core capability improvement measure since a team is usually equipped with diverse skills and competences that can be deployed to achieve the desired outcomes, which are usually multifaceted. The high ranking of adequate number of staff (MS = 3.66) is reflective of the fact that the government (the public sector) is the largest employer of labor and the client of the most complex projects in Nigeria (Dada 2013; Manu et al. 2019; Zaini et al. 2020). The complex projects executed by the public sector require a large number of personnel for management and administration. This agrees with the observations of Tilley et al. (2015) and Manu et al. (2019), who identified engagement of adequate number of staff as a means of improving the public sector capabilities in developing countries such as Nigeria. However, the public sector in Nigeria appears to lack adequate human capacity index, as noted by Olejede et al. (2020) and Mayedwa and Van Belle (2016). Hence, the large workforce in the Nigerian public sector has not translated to effectiveness and efficiency because it remains incapable of managing its projects, and its private sector counterparts with slim workforce perform better in project delivery (Management Organisation Unit (MOU) of Community Support Framework 2005; Fitsilis and Chalatsis 2014; Hamma-Adama 2020). Babatunde (2015) earlier showed that the private sector performs better in its project execution and its capability for PPP projects is higher than that of the public sector despite the latter being the major stakeholder in the Nigerian construction industry. Hence, it is obvious that the public sector needs not just adequate number of staff but adequate number of skilled and competent staff.

Other highly ranked capability improvement measures, such as government support and involvement (MS = 3.64) and government policies (MS = 3.60), could be explained by the fact that the public sector is owned and controlled by the government in Nigeria at the federal, state, and local levels, comprising ministries, departments, and agencies (Iwarere and Lawal 2011; Dada 2013). This finding agrees with those of Ruya et al. (2018) and Hamma-Adama and Kouider (2018), who noted that government policies, government support, and government intervention are crucial to aid the capabilities of the public sector for BIM implementation. The

Tab. 3: Frequency of usage of capability improvement measures of the public sector for BIM implementation in building projects

Capability improvement measures	Overall			QS		BLDR		EEG		ARC		MEG		CEG		K–W Sig.
	MS	SD	R	MS	R	MS	R	MS	R	MS	R	MS	R	MS	R	
Adequate number of staff	3.66	0.958	1	3.65	6	4.00	1	3.67	12	3.52	10	3.84	4	3.51	8	0.247
Team-based structure	3.66	0.968	2	3.59	10	3.63	13	3.83	3	3.57	9	3.74	5	3.62	1	0.866
Government support and involvement	3.64	0.911	3	3.47	20	3.59	14	3.47	23	3.48	12	3.63	10	3.47	12	0.982
Government policies	3.60	1.012	4	3.53	15	3.69	8	3.73	6	3.65	4	3.63	10	3.49	10	0.927
Adoption of process open to innovation	3.60	1.089	5	3.35	25	3.59	14	3.70	7	3.74	1	4.05	2	3.47	12	0.295
Investment in equipment and technology	3.60	1.094	6	3.65	6	3.72	4	3.70	7	3.65	4	3.89	3	3.4	21	0.585
ICT literacy of staff	3.58	0.930	7	3.53	15	3.69	8	3.53	19	3.48	12	4.11	1	3.47	12	0.182
Information sharing/management	3.58	1.062	8	3.71	5	3.81	2	3.47	23	3.74	1	3.58	14	3.45	17	0.548
Simplified organizational structure	3.58	1.081	9	3.53	15	3.66	11	3.83	3	3.17	37	3.68	6	3.55	4	0.313
Clear job description	3.56	0.968	10	3.53	15	3.59	14	3.67	12	3.61	8	3.47	20	3.52	6	0.991
Education and training of staff	3.55	0.882	11	3.53	15	3.50	22	3.53	19	3.48	12	3.68	6	3.56	2	0.955
Structured reporting system	3.55	1.035	12	3.88	2	3.78	3	3.47	23	3.65	4	3.21	35	3.47	16	0.370
Set standard for good performance	3.54	0.975	13	3.65	6	3.50	22	3.60	15	3.52	10	3.53	16	3.51	8	0.994
Presence of skilled and strong leaders	3.53	1.069	14	3.59	10	3.72	4	3.47	23	3.48	12	3.37	24	3.52	6	0.769
Performance-related pay	3.53	1.111	15	3.47	20	3.56	17	3.87	1	3.39	20	3.63	10	3.42	20	0.599
Recruitment of highly skilled workers	3.52	0.853	16	3.47	20	3.72	4	3.53	19	3.65	4	3.32	28	3.45	17	0.664
Commitment to BIM training	3.51	1.084	17	3.59	10	3.69	8	3.87	1	3.26	32	3.47	20	3.35	29	0.325
High degree of status for government employees	3.49	1.031	18	3.82	3	3.56	17	3.53	19	3.43	16	2.95	40	3.53	5	0.233
Provision of physical infrastructure	3.47	1.006	19	3.59	10	3.53	19	3.63	14	3.35	24	3.58	14	3.38	23	0.785
Reward system for performance	3.47	1.016	20	3.35	25	3.50	22	3.57	16	3.39	20	3.42	23	3.49	10	0.956
Skills-based and interpersonal networks	3.45	1.064	21	3.65	6	3.50	22	3.70	7	3.35	24	3.53	16	3.31	32	0.761
Research and development	3.45	1.069	22	3.94	1	3.38	31	3.47	23	3.43	16	3.47	22	3.38	23	0.544
Selective hiring	3.42	1.048	23	3.41	24	3.53	19	3.40	29	3.35	24	3.53	16	3.38	23	0.987
Attractive salaries/pay scale	3.39	1.050	24	3.35	25	3.34	33	3.47	23	3.17	37	3.68	6	3.39	22	0.701
Knowledge management practice	3.36	0.901	25	3.35	25	3.41	29	3.57	16	3.22	36	3.32	28	3.32	31	0.660
Management support for change	3.32	0.996	26	3.59	10	3.50	22	3.13	39	3.26	32	3.37	24	3.27	35	0.684
Provision of incentives	3.30	1.051	27	3.76	4	3.31	34	3.27	34	3.26	32	3.32	28	3.21	38	0.607
Commitment of staff to change	3.30	1.056	28	3.47	20	3.16	40	3.30	32	3.35	24	3.32	28	3.31	32	0.884
Implementation of educational actions	3.29	0.943	29	3.31	34	3.70	7	3.35	24	3.26	32	3.36	27	3.39	28	0.370
Acquisition of software	3.24	0.972	30	3.47	27	3.57	16	3.39	20	3.63	10	3.34	30	3.42	26	0.721

(*Continued*)

Tab. 3: Continued

Capability improvement measures	Overall			QS		BLDR		EEG		ARC		MEG		CEG		K–W
	MS	SD	R	MS	R	MS	R	MS	R	MS	R	MS	R	MS	R	Sig.
Acceleration of project implementation	3.24	0.978	31	3.47	27	3.30	32	3.39	20	3.53	16	3.36	27	3.38	29	0.954
Time and resources for learning	3.24	0.991	32	3.41	29	3.37	30	3.43	16	2.89	41	3.45	17	3.36	32	0.232
Commitment to learning	3.24	0.994	33	3.53	19	3.20	37	3.30	31	3.26	32	3.47	12	3.38	39	0.581
Elimination of internal conflicts	3.18	0.926	34	3.28	39	3.17	38	3.26	32	3.26	32	3.18	39	3.21	39	0.989
Performance evaluation	3.18	1.046	35	3.72	4	3.70	7	3.70	3	3.37	24	3.38	23	3.50	19	0.232
Opportunities for multiskilling	3.12	0.944	36	3.31	34	3.03	40	3.43	16	3.16	37	3.22	36	3.22	38	0.606
Effective strategic management practices	3.12	1.006	37	3.31	34	3.27	34	3.17	37	3.16	38	3.30	34	3.25	36	0.929
Improvement of financial results	3.12	1.010	38	3.31	34	3.27	34	3.35	24	3.21	35	3.22	36	3.25	37	0.927
Valuing employee/encouraging self-esteem	3.00	1.012	39	3.38	31	3.37	30	3.35	24	3.00	39	3.12	40	3.20	40	0.476
Retention of workers/personnel stability	2.88	0.908	40	3.66	11	3.77	5	3.65	4	3.68	6	3.56	2	3.57	10	0.053
Greater autonomy to hire and fire	2.47	1.065	41	3.09	41	3.03	40	3.17	37	3.37	24	3.05	41	3.05	41	0.128

ARC, architect; BIM, building information modeling; BLDR, builder; CEG, civil engineer; EEG, electrical engineer; ICT, information and communication technology; K–W, Kruskal–Wallis; MEG, mechanical engineer; MS, mean score; QS, quantity surveyor; R, rank; SD, standard deviation; Sig., significant factors with p-value ≤0.05.

public sector and government are interwoven and interconnected. The public sector is a reflection of the government in place. Aside from executing government plans and policies, the public sector is greatly influenced and shaped by the government. This concurred with the works of Fernandez and Rainey (2006), Alufohai (2012), Fitsilis and Chalatsis (2014), and Mazzucato and Kattel (2020), who opined that government policies and support affect the capabilities of the public sector in no small measure. The responses of government bodies and policy-makers to improving the capabilities of the public sector may involve diverse approaches. Attaining greater efficiencies across the public sector is very important to support the government's drive for continuous improvement in public service delivery (Siriwardena et al. 2006; Al-Ashmori et al. 2019; Manu et al. 2019).

Investment in equipment and technology also ranked high. This is perhaps as a result of the current global pandemic, which has compelled many organizations to acquire technologies and equipment required to conform to the new normal in the midst of the pandemic. ICT is a main enabler for improvement in the construction industry. The ICTs have become essential public sector artifacts for several governmental bodies (Nour et al. 2008; Lember et al. 2018), which empower the public sector to deliver its projects more effectively and efficiently. The low ranking of greater autonomy to hire and fire (MS = 2.47) could be justified by the mode of engagement within the Nigerian public sector, which is greatly influenced by political considerations and government policies. Within the public sector, superiors have little or no input in the recruitment process of their subordinates and cannot directly hire and fire them. Moreover, being a highly bureaucratic environment, the public sector is not open to market forces and gives no room for strategic maneuvers (Harvey et al. 2010; Kabrilyants et al. 2021), unlike in the private sector. The low ranking of retention of workers/personnel stability (MS = 2.88) is presumably as a result of the poor incentive and inadequate retention strategy of the public sector, as noted by Gberevbie (2009). This is highly disadvantageous to the Nigerian public sector, which needs to retain the best brains within its workforce and not lose them to its private sector counterparts.

The study further established that there is no statistically significant difference in the frequency of usage of the capability improvement measures required by the public sector for BIM implementation, as observed by various construction professionals within the organizations of Lagos Public Service studied. This implied that the construction professionals have the same perception about the frequency of usage of these capability improvement

measures. This is evident by their p-values, which were all >0.5 (Table 3). This is unsurprising because the public sector in Nigeria as an organization is being run strictly by laid-down procedures and policies of government operations. These procedures and policies cut across various departments, units, and agencies; hence, there is similarity in the opinion of the respondents.

6 Impact of capability improvement measures used by the public sector for BIM implementation

Data were collected to assess the level of impact of capability improvement measures put in place by the public sector for BIM implementation in building projects. The result is as shown in Table 4. The capability improvement measure with the highest level of impact on implementation of BIM is reward system for performance (MS = 3.81). Other highly ranked capability improvement measures include government policies and the education and training of staff (MS = 3.74), government support and involvement (MS = 3.73), and clear job description (MS = 3.71), which ranked second, third, fourth, and fifth, respectively. The least-ranked factors are elimination of internal conflicts (MS = 3.24), provision of opportunities for multiskilling (MS = 3.30), greater autonomy to hire and fire (MS = 3.31), provision of time and resources for learning and development (MS = 3.34), improvement of financial results, and knowledge management practice (MS = 3.36). These ranked 41st, 40th, 39th, 38th, 37th, and 36th, respectively.

The high ranking of reward system for performance (MS = 3.81) can be justified by the system of remuneration within the public sector, where wages, salaries, and promotions are not necessarily based on productivity and the contributions of employees to the achievement of organizational goals but on rigidly specified payment or remuneration scales defined by years of service and qualifications. This is highly significant in the Nigerian public sector because promotion, bonuses, and incentives are not based on performance but on policies and are usually applied across board, regardless of the varying levels of performance of employees. Hence, remuneration and incentives in the public sector are not productivity driven, as in the private sector. This may be demotivating to high-performing employees. The result agrees with the assertions by Ticha (2010) and Ammons (2019), who identified reward system for performance as a core capability improvement measure within the public sector. If the public sector adopts a reward system for performance, the productivity of the employees will improve and, consequently, the capabilities of the public sector too. The high ranking of education and training (MS = 3.74) as one of the highly effective capability improvement measures can be explained by the fact that the culture of continuous on-the-job training, education, and investment in employees' development is grossly lacking in the public sector, especially in Nigeria. The private sector is performing better in this regard. Many private organizations invest heavily in the training and development of their workforce in spite of the glaring risk of losing the employees trained with their resources to their competitors. The finding concurs with those of Dewan et al. (2004), Manu et al. (2019), and Olojede et al. (2020), who identified education and training as a key capability improvement measure and explained that education and training programs are the means to manage the culture of resistance to change among employees, which is prevalent in the public sector. Consequently, the public sector should embrace the culture of developing, training, and investing in jts employees in order to improve its capabilities. The key asset of the construction industry is people. Therefore, the public sector in Nigeria 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; Kabrilyants et al. 2021).

Other highly ranked factors, such as government policies (MS = 3.74) and government support and involvement (MS = 3.73), are reflective of the relationship between the government and other stakeholders of the public sector. The apex leadership of the public sector is the government. The public sector in Nigeria is a mirror of the government in place and is greatly influenced by it. The activities and operations of the public sector are regulated by government policies and political office holders. This finding concurred with those of Alufohai (2012), Fitsilis and Chalatsis (2014), and Ammons (2019). This is expected since the public sector is owned and controlled by the government at all levels (Iwarere and Lawal 2011; Dada 2013; Hamma-Adama 2020); hence, the activities and operations of the public sector will be largely dependent on the government in place. The better the government, the more effective and efficient the public sector would be. This is underscored by the experience of various countries (especially the developed ones) with good governance, which have a better and more-efficient public sector.

The findings of this study disagree with the observations of Grindle and Hilderbrand (1995) and Gareis and Huemann (2017) on those capability improvement measures of the public sector that are highly effective. In the context of foreign countries, Grindle and Hilderbrand

Tab 4. Level of Impact of Capability Improvement Measures of the Public Sector for BIM Implementation in Building projects

Capability improvement measures	OVERALL			QS		BLDR		EEG		ARC		MEG		CEG		K-W Sig.
	MS	SD	R	MS	R	MS	R	MS	R	MS	R	MS	R	MS	R	
Reward system for performance	3.81	0.951	1	3.71	3	3.75	12	3.87	11	3.70	2	4.26	1	3.77	1	0.351
Government policies	3.74	1.012	2	3.59	7	3.69	20	3.87	11	3.52	16	3.95	9	3.77	1	0.595
Education and training of staff	3.74	0.902	3	3.47	13	3.91	2	3.93	5	3.65	8	4.00	4	3.61	9	0.261
Government support and involvement	3.73	0.901	4	3.59	7	3.81	8	3.90	7	3.52	16	3.89	10	3.60	11	0.361
Clear job description	3.71	0.886	5	3.71	3	3.66	21	3.90	7	3.48	23	3.79	14	3.71	4	0.658
Provision of physical infrastructure	3.69	0.978	6	3.59	7	3.88	3	3.83	15	3.43	25	3.79	14	3.62	8	0.554
Adoption of process open to innovation	3.68	1.040	7	3.12	30	3.84	5	3.83	15	3.70	2	4.05	2	3.58	13	0.082
Structured reporting system	3.68	0.937	8	3.82	2	3.75	12	3.90	7	3.70	2	3.63	22	3.55	18	0.787
Investment in equipment and technology	3.68	1.041	9	3.18	27	3.84	5	3.80	20	3.65	8	4.00	4	3.60	11	0.253
Set standard for good performance	3.66	0.909	10	3.59	7	3.56	27	3.73	24	3.57	13	3.53	29	3.74	3	0.541
Presence of skilled and strong leaders	3.66	0.968	11	3.35	18	3.84	5	3.97	3	3.70	2	3.68	19	3.51	21	0.193
Commitment to BIM training	3.66	1.024	12	3.65	5	3.72	16	3.97	3	3.74	1	3.74	16	3.47	25	0.547
Team-based structure	3.65	1.000	13	3.47	13	3.59	24	3.93	5	3.48	23	4.00	4	3.57	15	0.234
ICT literacy of staff	3.65	1.036	14	3.41	15	3.81	8	3.70	27	3.30	36	3.89	10	3.65	6	0.225
Recruitment of highly skilled workers	3.64	0.900	15	3.41	15	3.44	37	3.83	15	3.61	11	3.63	22	3.71	4	0.291
High degree of status for government employees	3.63	0.973	16	3.59	7	3.75	12	4.00	1	3.43	25	3.37	32	3.56	17	0.201
Information sharing/management	3.63	1.053	17	3.06	34	3.66	21	3.83	15	3.43	25	3.89	10	3.65	6	0.117
Attractive salaries/ pay scale	3.62	1.029	18	3.12	30	3.88	3	3.73	24	3.65	8	3.63	22	3.57	15	0.232
Adequate number of staff	3.60	0.996	19	2.82	39	3.81	8	4.00	1	3.35	32	4.00	4	3.51	21	**0.000***
Performance evaluation	3.60	1.075	20	3.12	30	3.53	29	3.80	20	3.52	16	3.84	13	3.61	9	0.298
Performance-related pay	3.60	1.116	21	3.24	23	3.53	29	3.87	11	3.70	2	4.00	4	3.48	23	0.271
Simplified organizational structure	3.59	1.037	22	3.53	12	3.78	11	3.90	7	3.57	13	3.68	19	3.39	33	0.429
Research and development	3.57	1.043	23	3.88	1	3.75	12	3.80	20	3.43	25	3.74	16	3.34	39	0.252
Implementation of educational actions	3.55	1.030	24	3.18	27	3.53	29	3.83	15	3.52	16	3.32	33	3.58	13	0.262

Tab. 4: Continued

Capability improvement measures	OVERALL			QS		BLDR		EEG		ARC		MEG		CEG		K-W Sig.
	MS	SD	R	MS	R	MS	R	MS	R	MS	R	MS	R	MS	R	
Acquisition of software	3.53	1.041	25	3.24	23	4.06	1	3.67	28	3.52	16	3.63	22	3.29	40	**0.017***
Management support for change	3.51	0.928	26	3.65	5	3.59	24	3.57	30	3.26	37	3.63	22	3.45	26	0.747
Selective hiring	3.51	1.152	27	2.88	36	3.56	27	3.87	11	3.35	32	4.05	2	3.40	31	**0.034***
Commitment of staff to change	3.49	0.986	28	3.06	34	3.53	29	3.57	30	3.61	11	3.58	28	3.48	23	0.471
Provision of incentives	3.49	1.079	29	3.41	15	3.66	21	3.67	28	3.35	32	3.63	22	3.39	33	0.822
Acceleration of project implementation	3.48	1.065	30	3.35	18	3.53	29	3.47	34	3.52	16	3.26	34	3.55	18	0.845
Skills-based and interpersonal networks	3.48	1.098	31	3.35	18	3.59	24	3.77	23	3.26	37	3.68	19	3.38	35	0.527
Retention of workers/personnel stability	3.48	0.954	32	2.71	41	3.72	16	3.73	24	3.26	37	3.42	30	3.55	18	**0.016***
Effective strategic management practices	3.44	1.010	33	3.29	22	3.53	29	3.50	32	3.52	16	3.21	37	3.45	26	0.712
Commitment to learning	3.42	0.967	34	3.35	18	3.50	35	3.43	35	3.39	30	3.42	30	3.42	30	0.988
Valuing employee/encouraging self-esteem	3.41	0.998	35	2.88	36	3.72	16	3.50	32	3.70	2	3.11	41	3.36	36	**0.032***
Knowledge management practice	3.36	0.939	36	3.12	30	3.38	40	3.33	36	3.43	25	3.21	37	3.44	28	0.613
Improvement of inancial results	3.36	1.022	37	3.24	23	3.44	37	3.33	36	3.57	13	3.21	37	3.35	37	0.882
Time and resources for learning	3.34	1.018	38	3.18	27	3.31	41	3.27	40	3.39	30	3.21	37	3.43	29	0.767
Greater autonomy to hire and fire	3.31	1.122	39	2.82	39	3.41	39	3.23	41	2.96	41	3.74	16	3.40	31	**0.042***
Opportunities for multiskilling	3.30	0.960	40	3.24	23	3.31	41	3.30	39	3.22	40	3.26	34	3.34	38	0.969
Elimination of internal conflicts	3.24	0.929	41	2.88	36	3.50	35	3.33	36	3.35	32	3.26	34	3.13	41	0.227

ARC, architect; BIM, building information modeling; BLDR, builder; CEG, civil engineer; EEG, electrical engineer; ICT, information and communication technology; K–W, Kruskal–Wallis; MEG, mechanical engineer; MS, mean score; QS, quantity surveyor; R, rank; SD, standard deviation; Sig., significant factors with p-value ≤0.05.

(1995) and Gareis and Huemann (2017) identified greater autonomy to hire and fire, improvement of financial results, and elimination of internal conflicts as the top capability improvement measures of the public sector, but these factors were least ranked in this study. This could be as a result of the different conditions in the Nigerian construction industry due to size, contractual process, and arrangements, as well as politics. This may also be explained by the peculiar nature of the Nigerian public sector, wherein political influence and constraints are rife and strong. Furthermore, the power to hire and fire does not lie solely within the public sector but is influenced greatly by government policies (such as the Federal Character), nepotism, and favoritism by political office holders.

Comparing the results in Tables 3 and 4, the results show that most of the capability improvement measures with high frequency of usage are not those with a high level of impact. Only government support/involvement and government policies – as capability improvement measures – ranked with high frequency of usage and high level of impact. This suggests the need for the public sector in Nigeria to embrace appropriate capability improvement measures identified in this study with high impact in order to improve its organizational capabilities for BIM implementation in construction projects. The study further established that there is a statistically significant difference in the level of impact of the capability improvement measures of the public sector for BIM implementation, as observed by the respondents, with respect to only six capability improvement measures. These measures are as follows: acquisition of software (MS = 3.53, p-value = 0.017), selective hiring (MS = 3.51, p-value = 0.034), valuing employee/encouraging self-esteem (MS = 3.41, p-value = 0.032), greater autonomy to hire and fire (MS = 3.31, p-value = 0.042), adequate number of staff (MS = 3.60, p-value = 0.000), and retention of workers/personnel stability (MS = 3.48, p-value = 0.016). The p-values of the attributes were at a level of significance 0.05 (Table 4). This implies that the respondents had different perceptions about the level of impact of these capability improvement measures subject to the peculiarity of their individual professions and departments within the public sector organizations.

7 Conclusion

This study examined capability improvement measures of the public sector for BIM implementation. The findings indicated recommendations that could improve the capabilities of the public sector to implement BIM, thereby enhancing public project delivery. The conclusion is drawn that the capability improvement measures that were mostly considered within the public sector organizations to improve their capacity for BIM implementation are team-based structure and adequate number of staff, government support and involvement, government policies, adoption of process open to innovation, and investment in equipment and technology. Measures that produced significant impact were, however, reward system for performance, government policies, education and training of staff, government support and involvement, and clear job description. There were no significant differences in the perception of the groups of construction professionals on the extent of usage of the capability improvement measures. On the contrary, there exist significant differences in the perception of the groups of construction professionals on six of the measures that the public sector organizations have adopted to develop their capability to implement BIM. These are acquisition of software, selective hiring, valuing employee/encouraging self-esteem, greater autonomy to hire and fire, adequate number of staff, and retention of workers/personnel stability.

The results further showed that to improve the capabilities of the public sector for BIM implementation, there is a need for a focus on the workforce of the sector, which constitutes the key asset of the construction industry. Moreover, the public sector requires not just adequate number of staff but adequate number of competent, skilled, and trained personnel. The public sector could achieve this by attracting the best brain to public service through adequate remuneration and good working conditions. The personnel should be retained and their skills and capacities should also be developed to meet the ever-increasing demand of the construction industry. Moreover, the findings established that most of the capability improvement measures with high level of impact are not those that are frequently used within the public sector. Therefore, the study recommends that the public sector needs to review the status quo and imbibe changes by adopting appropriate capability improvement measures that will significantly enhance its capabilities for BIM implementation so as to improve public project delivery. This is very crucial because the public sector – as the major client in the construction industry in Nigeria – needs to set the pace for other participants.

The findings of this study could be generalized with caution to other States in Nigeria because of the wider variations in the economic status and the complex public sector organization setup of the study area. The study,

however, provided implications that could enable the public sector to adjust and make necessary decisions and policies in a bid to improve BIM implementation in construction project delivery. The findings of this study could also provide implications for improving the capabilities of the public sectors in other developing countries, especially those with similar economic and political characteristics as Nigeria.

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