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## Research Article

## A Survey of Digital Technologies Used in the Procurement of Building Projects: Empirical Evidence from Nigeria

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## Abstract

**Background and Objective:** In spite of the important roles digital technologies play in the procurement of construction projects, there is a limited understanding of the extent of their adoption in Nigeria. The aim of this study was to investigate the different categories of digital technologies used by stakeholders in the design, tendering and construction stages of building projects and factors that influenced the decision to adopt them in the Nigerian building industry. **Materials and Methods:** The data were sourced via a questionnaire survey of 213 professional consultants, client organisations and contractors in the Nigerian building industry. Descriptive statistics and relative importance index (RII) were used to analyse the data. **Results:** The findings show that 61.5% of the participants were architects and quantity surveyors and most of them used software packages at project design stage and communication technologies at the tendering and construction stages. However, besides email, only very few used web/cloud-based systems, applications and services at the tendering and construction stages of building projects delivery. The top four most influential factors in the decision to adopt digital technologies in the procurement of building projects were the benefits of these technologies in eliminating geographic barriers (RII = 0.861), enhancing efficiency (RII = 0.855), promoting good inventory management and record keeping (RII = 0.813) and effective communication amongst project team members (RII = 0.812). **Conclusion:** Stakeholders in the Nigerian building industry use more of project data creation and communication technologies than intelligent systems; and thus, significant barriers exist in the adoption of intelligent systems in the procurement of building projects in the study area.

**Key words:** Digital technologies, building projects, procurement, questionnaire survey, Nigeria

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**Data Availability:** All relevant data are within the paper and its supporting information files.

## INTRODUCTION

The building industry is faced with challenges resulting from inefficient communication, collaboration and poor coordination of activities and low productivity. In the midst of these challenges, the society expects this industry to play a prominent role in the provision of buildings for residential, work and recreational activities and at the same time contribute to achieving the sustainability agenda<sup>1</sup>. These expectations have compelled stakeholders in the building industry to seek ways of achieving efficiency and effectiveness in building procurement process and minimising the adverse impacts of building construction activities on the environment<sup>2</sup>. To align with current demands, one of the significant changes that have taken place in the building sub-sector, which is part of the construction industry, is the transition from the use of manual tools and processes to the adoption of digital technologies at the design, tendering and construction phases of buildings and infrastructure projects<sup>1,3</sup>.

Digital technologies are primarily information and communication technologies (ICTs) that engender effective production, storage, handling and display of different kinds of information and data and interactions between individuals and electronic systems using digital computer language<sup>4</sup>. Whereas Whyte and Lobo<sup>5</sup> and Ibrahim<sup>6</sup> viewed digital technologies as digital objects, Ibem and Laryea<sup>7</sup> explained that digital technologies encompass stand-alone and integrated tools, applications and software packages used in creating, processing, storing, displaying data and exchanging information. Based on this understanding, digital technologies as used in this study refer to the different kinds of non-manual tools, information systems, applications and services used to support the execution of activities related to the design, tendering and construction of building projects.

According to previous authors<sup>7,8</sup> digital technologies occur in five main different categories. The first category includes software packages used in architectural and engineering designs, cost estimation and word processing. The second category includes technologies and tools for capturing project data digitally. Third is hard infrastructure and communication technologies for processing, storing and displaying data and information. There are also repositories and databases, for the display of structured data related to building materials, equipment and machineries. The last category of digital technologies represents intelligent systems or 3CI technologies that facilitate communication, collaboration, coordination and integration of information, people, processes and activities involved in project delivery.

The existing studies<sup>9-11</sup> have examined the importance of digital technologies in achieving effective collaboration and

integration of construction procurement activities. In addition, Usman and Said<sup>12</sup> have identified the role of ICTs in construction site management, while Zhou *et al.*<sup>13</sup> have demonstrated how digital technologies can promote construction safety. In the Nigerian construction sector, the studies by Oladapo<sup>14,15</sup> revealed that the use of software packages like MS Word, MS PowerPoint, AUTOCAD, WinQS and MS Project and Internet service like email was very high, while the use of e-Business aspect of the Internet was low. The author noted that the changing trends in technology and client/customer have had significant influence on the adoption of digital technologies by construction firms in Nigeria. In another study, Ibironke *et al.*<sup>16</sup> also found the use of software packages like Masterbill (MB3+), QS Elite, Win QS (Estimating and QS Software), Snape (vector) and Catopro amongst quantity surveying firms in Lagos. The authors however noted the high initial cost of acquisition, the lack of infrastructure to support their use and security concerns were the key factors militating against the critical mass uptake of these software packages by most quantity surveying firms in the study area. In a survey of the extent of adoption of e-Tendering, Oyediran and Akintola<sup>17</sup> found that among architects, contractors, engineers and quantity surveyors in Abuja and southwest Nigeria, the most predominant digital technologies used at the tendering phase of construction projects were hardware (e.g., computers systems) and Internet services (e.g., e-mails), while the most frequently used software packages were ArchiCAD, AutoCAD and MasteBill and WinQs. That study however, revealed that there was relatively low usage of digital technologies in making and receiving payments for construction related activities in this country.

It is evident from the foregoing that although several research efforts have been made at investigating the adoption of digital technologies in construction in Nigeria, the existing studies only capture the views of professional consultants and contractors and excluded the perspectives of clients who are the main procurers of building projects. In addition, none of the published works examined the factors that influenced the decision by stakeholders in the Nigerian building industry to adopt digital technologies in the procurement of building projects. In view of this gap in research, the current study investigated the adoption of digital technologies in the procurement of building projects in Nigeria.

The two key objectives were (1) To identify and categorize the different digital technologies used in the procurement of building projects and (2) To examine the factors that influenced stakeholders' decision to use the identified digital technologies in the procurement of building projects in the study area.

## **MATERIALS AND METHODS**

**Research design:** The data used in this study were drawn from a larger research project designed to investigate the use of e-Procurement in the Nigerian construction industry. Evidence in the literature reveals that previous studies<sup>14-18</sup> related to this subject used the survey strategy with the administration of questionnaire as the principal data collection method. Based on this and the merits of cost effectiveness and greater coverage in a short time associated with survey research as explained by Bird<sup>19</sup>, this study relied on a questionnaire survey of building industry stakeholders in Nigeria in generating data for this study.

The questionnaire used in the collection of data for this research was designed by the authors based on findings from the review of literature. It had three sections. The first section helped in the collection of data on the roles of the respondents and their organizations in the Nigerian building industry. The second section was used to collect data on the different types of digital technologies used at the design, tendering and construction phases of building projects, while the last section was used to gather data on the factors the respondents considered important in their decision to adopt the digital technologies identified in the second section of the questionnaire. In collecting data on the frequency of use of the different digital technologies in the procurement of building projects, the participants were asked to indicate the frequency of use of each technology, tool or application identified based on 3-Likert-type scale using 1 = 'Never used', 2 = 'Sometimes' and 3 = 'Always'. In addition, the respondents were also requested to rate 29 carefully selected factors in the order of their importance in influencing the decision of their organizations to adopt digital technologies in the procurement of building projects using 5-Likert like scale of 1 = "Not Important", 2 = "Least Important", 3 = "Undecided" 4 = "Important" 5 = "Most Important".

**Data collection:** The main survey was preceded by a pilot survey in Lagos in April 2015 with the target population being architecture and quantity surveying firms and client organizations. Responses obtained from 30 participants in the pilot survey were useful in making necessary adjustments on some of the questions in the questionnaire. The main research was conducted between June and November, 2015 in Nigeria. It involved a survey of architecture, building construction and quantity surveying firms and client organizations in the country. In view of the geographic size of Nigeria, there was a

need to sample all categories of firms across the country to enhance the validity of findings of this study. Consequently, the researchers took advantage of annual meetings of stakeholders in the building industry to collect data for this research. The data from architecture firms were collected during the Architects' Colloquium held in June, 2015 in Abuja, while the data from building construction firms were collected at the Annual Builders' National Conference and Meeting, at the University of Ibadan, Ibadan in August, 2015. Similarly, the Annual QS Research Conference held in November, 2015 at the Federal University of Technology, Akure, provided the avenue for the collection of data from Quantity Surveyors. In each case, respondents were randomly selected for questionnaire administration, which was done by hand. In addition, data were extracted from client organizations, including government agencies and multinational oil and gas, telecommunication, building construction companies and banks in three major cities of Lagos, Abuja and Port Harcourt. One key step taken to ensure that only one respondent from each organization was included in the survey, the participants were requested to write the names and locations of their organizations at the end of the questionnaire. Although the authors and six trained Research Assistants distributed 500 questionnaires, 213 valid questionnaires representing around 43% of the total questionnaire administered were retrieved.

**Data analysis:** In the data analysis, the reliability of the scale used to measure the respondents' perception of the importance of 29 factors in the decision to adopt digital technologies was examined using Cronbach reliability test. The result returned Cronbach's Alpha value of 0.773, which is greater than 0.6 recommended by Pallant<sup>20</sup>. Thereafter descriptive statistics and relative importance index (RII) were used to analyse the responses obtained via the questionnaire and this was done using the Statistical Package of the Social Sciences (SPSS) Version 20. Specifically, descriptive statistics were used to compute the proportions and percentages of the seven variables used in describing the professional roles of the respondents and the profiles of their organizations as well as their responses on extent of use of digital technologies. The influence of each of the 29 factors on the decision to adopt digital technologies was examined. Ranking of the factors was done based on their relative importance index. The relative importance index (RII) for each factor investigated was computed using the equation:

$$RII = \frac{\sum W}{A \times N}; (0 \leq RII \leq 1) \quad (1)$$

$$\sum W = \text{Sum of weights } (W_1 + W_2 + W_3 + \dots + W_{29}) \quad (2)$$

W = Weighting given to each of the 29 factors by all the respondents in the survey  
 A = Highest possible score, which is 5 in the current study  
 N = Total number of respondents in the survey

**RESULTS**

**Profile of respondents and their organizations:** Table 1 shows profiles of the respondents in the survey and their organizations.

From the result in Table 1 it is evident that the highest number of participants in the survey were architects (35.2%), followed by quantity surveyors (26.3%) and builders (22.1%). The result also shows that 35.2% of the respondents were employees of government organizations, while around 33.8% worked in consulting firms. It is also evident in Table 1 that a around 44.1% of the respondents' organizations had staff strength of below 20 employees, 59.2% of them are more than 10 years old and 39.4% of the organisations have only one office in Nigeria. This result suggests that most of the organisations have staff strength of more than 20 employees, more than 10 years old and have more than one office in Nigeria.

**Categories of digital technologies used:** Table 2 shows the result of the different software packages used at the design stage of building projects. The result shows that in the design of building projects, the most commonly used software package was AUTOCAD, followed by ArchiCAD, Revit and SketchUp, respectively, while software packages like RealCADD, CGS Revit Tools, SolidWorks, Draftsight, Vectorworks and VariCAD are not commonly used by the respondents.

Table 2 also reveals that the most commonly used software packages in project cost estimation were non-CAD based estimation software packages, including Masterbill (MB3+), QS Elite and Win QS, followed by CAD-based quantities, take-off software applications and BIM-based construction materials and quantity takeoff software, respectively.

Table 3 is a display of the result on the digital technologies used at the tendering stage of building projects in the study area. The result (Table 3) reveals that a higher

Table 1: Profile of the respondents and their organizations

Attributes	N = 213	Percentage
<b>Role/duty/profession</b>		
Architect	75	35.2
Builder	47	22.1
Engineer	6	2.8
Contractor	3	1.4
Construction/project manager	20	9.4
Quantity surveyor	56	26.3
Procurement/supply chain manager	1	0.5
Others	5	1.4
<b>Type of organization</b>		
Consulting firms	72	33.8
Contractors	45	21.1
Client organization	11	5.2
Government ministry/parastatals	75	35.2
Academic Institutions	10	4.7
<b>Sector of Procurement Experience</b>		
Public sector only	36	16.9
Private sector only	52	24.4
Both public and private	125	58.7
<b>Staff strength (persons)</b>		
Below 20	94	44.1
20-50	45	21.1
51-100	14	6.6
More than 100	56	26.3
No Response	4	1.9
<b>Age of organization</b>		
Below 5 years	31	14.6
6-10 years	52	24.4
More than 10 years	126	59.2
No Response	4	1.9
<b>Number of offices in Nigeria</b>		
One	84	39.4
Two	52	24.4
Three	17	8.0
More than three	42	19.7
No Response	18	8.5

N: Number of respondents. Source: Authors' Field Survey (2015)

percentage of the respondents in the survey used e-mail to exchange project briefs and specifications such as call for tender offers. It is also evident in Table 3 that whereas in the submission of expression of interests, design proposals or tender offers, the most commonly used digital technology was the e-mail, followed by Internet-based systems/software applications, Compact (CD)/digital video disc (DVD) and project portals, respectively, while the use of electronic data interchange (EDI) and cloud-based systems and applications such as SharePoint and dropbox was very minimal. In addition, the result also reveals that the most common digital technologies used in the evaluation and selection of expression of interests, design proposals and tender offers was internet-based tendering software applications and Voice over Internet Protocol (VOIP) technologies like Skype, Google Talk, Windows Live Messenger and others.

Table 2: Digital technologies for project design and cost estimation

Procurement task	Software package	Frequency of use	N = 213	Percentage
Design of project	Revit	Never used	101	47.5
		Sometimes	53	24.9
		Always	59	27.7
	ArchiCAD	Never used	100	47.0
		Sometimes	53	24.9
		Always	60	28.2
	Sketch Up	Never used	105	54.0
		Sometimes	54	25.4
		Always	44	20.7
	AUTOCAD	Never used	30	14.1
		Sometimes	40	18.8
		Always	143	67.1
	VariCAD	Never used	175	82.2
		Sometimes	25	11.7
		Always	13	6.1
	DraftSight	Never used	178	83.6
		Sometimes	26	12.2
		Always	9	4.2
	Vectorworks	Never used	179	84.1
		Sometimes	26	12.2
		Always	8	3.8
Solid Works	Never used	180	85.0	
	Sometimes	24	11.3	
	Always	9	4.2	
CGS Revit Tools	Never used	171	80.3	
	Sometimes	31	14.6	
	Always	11	5.2	
RealCADD	Never used	183	86.0	
	Sometimes	25	11.7	
	Always	5	2.3	
Project cost estimation	BIM-based construction materials, quantity takeoff software	Never Used	141	66.2
		Sometimes	55	25.8
		Always	17	8.0
	CAD-based quantities, take-off software applications	Never used	121	56.8
		Sometimes	53	24.9
		Always	39	18.3
	Other quantity and cost estimation software (e.g., Masterbill (MB3+), QS Elite or Win QS)	Never used	130	61.0
		Sometimes	13	6.1
		Always	70	32.9
	E-catalogues	Never used	85	39.9
		Sometimes	110	51.7
		Always	18	8.5

Source: Authors' Field Survey (2015)

Table 4 is the result showing the different digital technologies used at the construction stage of building projects as identified by the participants in the survey. It is also evident in Table 4 that the most popular way of communication amongst project team members was via e-mail, followed by the use of mobile communication Apps, Web 2.0 technology and Voice over Internet Protocol (VOIP) technologies, respectively. For work scheduling, Microsoft Project was identified as the most commonly used software package, followed by BIM and project management software applications, respectively. Furthermore, Table 4 also reveals that in purchasing building materials and/or hiring equipment, very few people used e-Market place and Voice

over Internet Protocol (VOIP) technologies, while tracking the movement of materials from suppliers to construction sites was via wireless communication networks.

**Factors influencing the decision to adopt digital technologies:** Table 5 is a presentation of the result on the factors that influenced the organizations' decision to use digital technologies in the procurement of building projects in the study area. The result in Table 5 shows that the factors in the decreasing order of importance in their influence of the decision to adopt the identified digital technologies in the procurement of building projects in Nigeria were the benefits of eliminating geographic barriers with RII of 0.861, benefits of

Table 3: Digital technologies for tendering

Procurement task	Digital technologies	Frequency of use	N = 213	Percentage	
Exchange of project briefs and specifications	E-mail technology	Never used	45	21.1	
		Sometimes	74	34.7	
		Always	94	44.1	
	Clients website	Never used	78	36.6	
		Sometimes	72	33.8	
		Always	63	29.6	
	Submission of expression of interest, proposals or tender offers	E-mail technology	Never used	64	30.0
			Sometimes	56	26.3
			Always	93	43.7
Project Portal		Never used	137	64.3	
		Sometimes	58	27.2	
		Always	18	8.5	
Cloud-based systems and applications (e.g Microsoft SharePoint, Dropbox)		Never used	155	72.8	
		Sometimes	40	18.8	
		Always	18	8.5	
Internet-based systems/software applications		Never used	102	48.9	
		Sometimes	61	28.6	
		Always	50	23.5	
Compact (CD)/digital video disc (DVD)		Never used	101	52.1	
		Sometimes	59	27.7	
		Always	43	20.2	
Electronic data interchange (EDI)	Never used	148	70.5		
	Sometimes	45	21.1		
	Always	20	9.4		
Evaluation and selection of expression of interests, proposals and tender offers	Electronic reverse auctioning	Never used	213	100.0	
		Sometimes	0	0.0	
		Always	0	0.0	
	Voice over internet protocol (VOIP)	Never used	169	79.3	
		Sometimes	30	14.1	
		Always	14	6.6	
	Internet-based tendering software (e.g., DecisionMax Software).	Never used	163	76.5	
		Sometimes	15	7.0	
		Always	35	16.4	

Source: Authors' Field Survey (2015)

Table 4: Digital technologies for construction stage

Procurement tasks	Application	Frequency of use	N = 213	Percentage
Communication with project team members	E-mail technology	Never used	5	2.4
		Sometimes	71	33.3
		Always	137	64.3
	Web 2.0 technology (e.g.) social media platforms	Never used	50	23.5
		Sometimes	55	25.8
		Always	108	50.7
	Voice over Internet Protocol (VOIP)	Never used	114	53.5
		Sometimes	68	31.9
		Always	31	14.6
Web-based Communication Apps	Never used	43	20.2	
	Sometimes	50	23.5	
	Always	120	56.3	
Work scheduling	Project management software application	Never used	140	65.8
		Sometimes	42	19.7
		Always	31	14.6
	Microsoft project	Never used	86	40.4
		Sometimes	44	20.7
		Always	83	39.0
	Building information modelling (BIM)	Never used	131	61.5
		Sometimes	60	28.2
		Always	22	10.3
Searching for building materials and equipment	E-market place	Never used	118	55.4
		Sometimes	59	27.7
		Always	36	16.9

Table 4: Continue

Procurement tasks	Application	Frequency of use	N = 213	Percentage	
Purchasing and hiring of building materials equipments	Geographic information system (GIS)	Never used	118	55.40	
		Sometimes	57	26.80	
		Always	38	17.80	
	Company/suppliers website	Never used	40	18.80	
		Sometimes	63	29.60	
		Always	110	51.60	
	E-Market place	Never used	137	54.30	
		Sometimes	51	23.90	
		Always	25	11.70	
	Voice over internet protocol (VOIP)	Never used	169	79.30	
		Sometimes	30	14.10	
		Always	14	6.60	
	Web-based project management systems (WPMS)	Never used	180	84.50	
		Sometimes	8	3.80	
		Always	25	11.74	
Tracking of the movement of materials from Suppliers to sites	Wireless networks e.g., cellular modems, phones	Never used	38	17.84	
		Sometimes	70	32.86	
		Always	105	49.30	
	Radio frequency identification (RFID)	Never used	173	81.20	
		Sometimes	32	15.00	
		Always	8	3.80	
	Barcode Technology	Never used	181	84.90	
		Sometimes	27	12.70	
		Always	5	2.40	
	Geographic positioning systems (GPS)	Never used	151	71.00	
		Sometimes	51	23.90	
		Always	11	5.20	
	Monitoring the progress of work on Construction sites	Cloud-based BIM	Never used	149	70.00
			Sometimes	43	20.20
			Always	21	9.90
Web-enabled project management system		Never used	139	65.30	
		Sometimes	50	23.50	
		Always	24	11.30	
Web-enabled digital cameras		Never used	147	69.00	
		Sometimes	47	22.10	
		Always	19	8.90	
3D scanner or LADAR Technology		Never used	165	77.40	
		Sometimes	38	17.80	
		Always	10	4.70	
Web-enabled multimedia technology		Never used	146	67.60	
		Sometimes	48	22.50	
		Always	19	8.90	

Source: Authors' Field Survey (2015)

enhance efficiency in project delivery with RII of 0.855, the benefits of good inventory management and record keeping with RII of 0.813 and benefit of effective communication amongst project team members with RII of 0.812. Others were the need to align with the global trends in digital technologies adoption in construction (RII = 0.801), the benefits of improved efficiency in collaborative work among project team members (RI = 0.794), advantage of less time spent on building procurement process (RII = 0.781), availability of IT manpower in the organisations (RII = 0.778), the involvement of less paper work (RII = 0.775) and others.

## DISCUSSION

On the profiles of participants of the research, the result of this study shows that unlike the previous studies<sup>14-17</sup> that presented only the views of professional consultants on the use of ICTs in construction in Nigeria, all key stakeholders in the Nigerian building industry, including client organisations participated in the current study. Therefore, findings of this study can be generalised in the context of the Nigerian building industry.

Table 5: Factors influencing the use of digital technologies in procurement of building projects

Factors influencing the decision to adopt digital technologies	RII	Rank
The benefit of eliminating geographic barriers	0.861	1
The benefit of enhanced level of efficiency in job delivery	0.855	2
The benefit of good inventory management and record keeping	0.813	3
The benefit of effective communication between project team members	0.812	4
The need to align with global trends in the use of digital technologies in construction	0.801	5
The benefits of improved efficiency in collaboration amongst project team members	0.794	6
The advantage of reduction in time spent on building procurement process	0.781	7
The availability of IT manpower in my organization	0.778	8
Involvement of less paper work	0.775	9
The benefit of easier coordination of procurement activities	0.775	9
The benefit of reduction in errors associated with manual methods	0.773	10
The extent to which digital technologies are easy to use	0.757	11
Less labour intensive feature of digital technologies	0.752	12
The cost of acquiring and operating the digital technologies	0.749	13
Compatibility of digital technologies with our existing procurement process	0.748	14
Financial base of my organization	0.745	15
The benefit of competitiveness inherent in the use of digital technologies	0.743	16
The availability of digital technologies in Nigeria	0.733	17
The increase in profit margin associated with the use of digital technologies	0.727	18
The perceived benefits associated with reduction in the procurement cost	0.726	19
The benefit of visibility of our business in the local and global markets	0.726	19
The level of business activities in the Nigerian building industry	0.722	20
The size of my organization	0.719	21
The decision by our clients/service providers digital technologies	0.715	22
The scope of operational activities of my organization	0.697	23
The number of existing users of digital technologies amongst my business partners	0.678	24
The geographical spread of the business activities of my organization	0.673	25
Result of the initial attempt to digital technologies in my organization	0.641	26
What early users said about digital technologies	0.632	27

Source: Authors' Field Survey (2015)

Regarding the categories of digital technologies used in the procurement of building projects by the respondents, the result reveals that there is a predominant use of software packages. Specifically, the study found that among architects and engineers the most commonly software package used in the design of building projects was AutoCAD, followed by Revit and ArchiCAD, respectively. On the other hand, the most common software packages for estimating building project cost include Masterbill (MB3+), QS Elite and Win QS. These results appear to be in line with those of previous studies<sup>14,17</sup> which revealed that the most used software package for designing projects among construction industry professionals in the Nigeria was AUTOCAD and that by Ibironke *et al.*<sup>16</sup> showing that Masterbill (MB3+), QS Elite and Win QS, were the most commonly used software packages for estimating the cost of construction projects in this country. The second category of digital technologies used by the respondents was communication and interactive technologies and tools such as e-mail, wireless networks (e.g., cellular modems, phones), web-based communication apps, Voice Over Internet Protocol (VOIP) technology, Web 2.0 technology and electronic data interchange (EDI). The results presented in Table 3 and 4 show that in addition to the use of e-mail for communication, it was also used to exchange project briefs and specifications and in the submission of expression of interests, proposals or tender

offers. Notably, this result is also consistent with the finding by Oladapo<sup>15</sup> indicating that one of the most commonly used Internet services in the Nigerian construction industry was e-mail. It is also provides support to the findings of previous studies<sup>3,17,18</sup> indicating that e-mail is the most common digital technologies used for tendering in construction.

In addition, the result also indicates that another category of digital technologies used as identified by the respondents was the repositories, including e-Catalogues and e-Market place. It was however observed that in spite of the strategic importance of this category of digital technologies in the estimation of building project cost, search for and purchasing of building materials and equipment as indicated in the literature<sup>7</sup>, a majority of the respondents in the survey were not using them for these purposes. This result corroborates that of the previous study by Oladapo<sup>15</sup> indicating that the use of e-Business aspect of the Internet was low in the Nigerian construction industry. The last category of digital technologies used by the respondents was the "intelligent systems" that facilitate communication, collaboration, coordination and integration. This category of digital technologies comprises cloud-based systems and applications (e.g., BIM Microsoft SharePoint, Dropbox), Internet-based systems and software applications like project management and tendering software packages. This category of digital technologies has found



relevance in supporting the execution of construction procurement activities like project specifications, tendering and monitoring of the progress of construction work remotely. The result of this study however reveals that most of the participants in the survey were not using this category of digital technologies in the procurement of building projects. The result is contrary to the finding Ibrahim<sup>6</sup> indicating a critical mass uptake of this category of digital technologies in the procurement of major building and infrastructure projects across the world. This result implies that there are significant barriers to the adoption of the category digital technologies referred to as intelligent systems that have multiple function capabilities in the Nigerian building industry.

On the factors that influenced the decision of stakeholders in the Nigerian building industry to adopt digital technologies in the procurement of building projects, the result of this study is also in line with that of a previous study<sup>21</sup> confirming that effort expectancy is one of the most influential factors in the adoption of digital technologies in construction business. This is in view of the fact that the first four factors identified in Table 5 are related to the benefits associated with the use of these technologies in construction procurement activities. Further examination of the result reveals that the first factor deals with the perceived benefit of digital technologies in eliminating geographic barriers for participants in building procurement activities. The result appears to be in line with those of previous authors<sup>2,5,6</sup>, who have alluded that one of the principal reasons for adopting of digital technologies in construction procurement was that they promote real time communication, collaboration, coordination and integration of tasks among project participants irrespective of their geographic locations.

The second most influential factor identified in the survey is the benefit of digital technologies in enhancing the level of efficiency in project delivery. Kim *et al.*<sup>22</sup> and Boland *et al.*<sup>23</sup> have also shown how the use of digital technologies can improve efficiency in the various aspects construction procurement activities. Onyegiri *et al.*<sup>24</sup> and Hosseini *et al.*<sup>25</sup> have also alluded that digital technologies were increasingly being used in the construction sector principally for the purpose of achieving efficiency and effectiveness in the entire procurement lifecycle of projects leading to increase in productivity and value for money. From the foregoing, it can be inferred that one of the main reasons for adopting digital technologies is the desire to curb the level of inefficiency and low productivity associated with the use of manual methods and processes in the procurement of building projects in the Nigerian building industry.

The benefit of good inventory management and record keeping is the next most influential factor in the decision to adopt digital technologies in the procurement of building projects identified in the survey. Nawari<sup>26</sup> was of the view that in construction supply chain management, the manual method of capturing, producing, processing and storing project data was no longer effective due to the large volume of data involved and thus Peansupap and Walker<sup>27</sup> opined that one of the ways for ensuring good inventory management and record keeping was to deploy digital technologies in construction procurement process and this helps in making information easily accessible by all parties at the shortest possible time. Therefore, the emergence of benefit of digital technologies in ensuring good inventory management and record keeping as the third most influential factor in the decision to adopt digital technologies in the survey did not come as a surprise. From these results, it is clear that the current research has further confirmed that in line with global trends, the relative advantage of digital technologies over the manual tools and processes is the principal factor influencing their adoption in the procurement of building projects in Nigeria.

## CONCLUSION

This study attempted to identify the different categories of digital technologies and factors influencing the decision to adopt them by stakeholders in the Nigerian building industry. It revealed a greater use of stand-alone than integrative/intelligent digital technologies. The study also found that the benefits of digital technologies to eliminate geographical barriers, improve efficiency and promote good inventory management were the three most influential factors in the decision to use them in the procurement of building projects in study area.

## SIGNIFICANCE STATEMENTS

This study provides a fresh insight into the different categories of digital technologies used and the factors that influenced the decision to use them in the Nigerian building industry. The findings are beneficial to researchers by uncovering areas for further research, especially, on how to improve the uptake and maximise the benefits of intelligent systems in the procurement of building projects in Nigeria. For educators, the study has identified areas of focus in the training of students on the categories of digital technologies currently used in the industry. It also informs manufacturers and vendors of the market opportunities for digital technologies in Nigeria.

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