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An Empirical Investigation on the Benefits and Leakages in the Use of Web-Based Technologies in the Construction Industry

[1]Afolabi, Adedeji; Fagbenle, Olabosipo; Mosaku, Timothy; Ojelabi , Rapheal and Omuh, Ignatius

Department of Building Technology, Covenant University, Ota, Ogun State, Nigeria.
Corresponding author
[1]Orcid: 0000-0002-9065-4766

Abstract

The internet and the World Wide Web (WWW) has the capacity to link the construction industry and its stakeholders to the desired smart and seamless future, although there are several leakages that have engendered the slow and low adoption in the construction process. Therefore, the study examined the benefits and leakages in the use of web-based technologies in the construction industry. The research selected registered construction professionals through a simple random sampling method from Lagos and Abuja (FCT). A total of 1,160 construction professionals participated in the study. A structured questionnaire was used as the principal instrument for obtaining primary data in form of responses from the construction professionals. Using a system block diagram, the study designed a web-based system using MySQL connected to the HTML web-interface through a PHP script processing the data back and forth. The study revealed that the use of web-based technologies in the construction industry can be engender efficient recording benefits, optimized production benefits and effective information processing. However, there are leakages such as usage risk leakages, culture leakages and tools leakages that may hinder the integration of web-based technologies in the construction processes. The study developed a framework for a web-based material planning and control system that can be used in the building materials' planning and control processes that ensures that building materials information are archived, stock levels are identified and material delay is minimized. The study recommended the use of web-based technologies in several of the construction processes by harnessing its benefits. Efforts should be made to increase ICT training and education amongst construction professionals to intensify the proficiency of stakeholders in the use of web-based technologies in the construction industry.

Keywords: Benefits, Construction Industry, Empirical, Leakages, Web-based Technologies

INTRODUCTION

The extreme demands of the business world, the social enthusiasm of the public and the needs of the construction industry led to the introduction of the internet and the World Wide Web (WWW) which has moved the world to a new phase of advancement [1]. For the last three decades, these two entities have become indispensable, changing the way activities are conducted. The internet and the World Wide Web (WWW) are rapidly changing environments driven by technological advancements and the perceived needs of organizations who are poised to gain competitive advantage and unprecedented opportunities by engendering a web presence. The political sphere, which one would have thought that the use of electronic systems could not be well integrated in a developing economy has witnessed a spontaneous shift. Studies in [2] and [3] have reported on the factors influencing users' acceptance and the use of technology in participatory democracy in developing nations of the world compared with more developed countries in order to predict its successful implementation. As at 2001, Joshim Aref, Ghaffor and Spafford projected that web based applications in the e-commerce market would exceed one trillion dollars ($1 trillion) over the next several years due to the large number of web applications being developed. This is not far-fetched, individuals and organizations such as Facebook (social media), Amazon (e-commerce), Google (search engine), Alibaba (e-commerce), Netflix (web portal), Microsoft and Apple (software and hardware) to mention a few, gross billions of dollars in income annually as a result of their activities via the internet and the World Wide Web (WWW). The unmatched prospects and benefits of the internet and the web translating to web based applications means they are here to stay and therefore, should be explored to solve every day issues such as planning, which is an important aspect of life.

According to [4], information and communication technology (ICT) tools are masterpiece in increasing organizational output. The introduction of information and communication technology (ICT) in the construction industry over 40 years ago has drastically transformed the traditional landscape of the industry to one with faster and more sophisticated processes. The rational for the use of ICT in the construction industry can be understood from the unique nature of the industry [1]. The industry is perceived as one the largest employer of labour, thereby making the industry information intensive in terms of paper works, processes and communication [5]. These requires close coordination which ICT offers. [6] added that the internet is a major driver increasing the use of ICT due to its ability to connect various project participants in diverse locations in order to readily exchange information. The close coordination is required due to the heavy exchange of data and information that takes place among the project participants on a daily basis [7]. However, [8] stated that the adoption of ICT by construction firms have been very slow. [9] noted that majority of construction process information is still heavily based on the traditional means of communication such as huge paper works and face to face meetings. As a result, [10] argued that the industry has suffered from difficult to access, out-of-date and incomplete information. Whereas, [11] stated that the construction industry needs to increase its efficiency of

information management by ensuring massive volumes of accurate information are exchanged at high speed and at relatively low cost. The poor oversight on the information generated and used in the construction industry has resulted in some cost, time and quality deprived issues been encountered in the industry [1].

With over 60% of construction professionals connected to the internet, most construction professionals' use of the internet is mainly for sending e-mails which is a far cry from the capacity and benefits which the internet and web based technologies can contribute to the construction industry [6]. The construction industry needs to tap into the many benefits that web-based technologies has to offer, although there are many leakages that are limiting the use of web-based technologies by construction professionals. The study therefore intends to examine the benefits and leakages in the use of web-based technologies in the construction industry. With this understanding, the study intends to proffer answers to the following research questions;

- What are the benefits and leakages in the use of web-based technologies in the construction industry?
- How can a web-based system be used in managing building materials' planning and control processes?

BENEFITS OF USING INFORMATION COMMUNICATION AND TECHNOLOGY (ICT) IN THE CONSTRUCTION PROCESS

According to [12], computers opened the door to an inventory system in material management helping to keep up-to-date records on the status of every inventory in stock. This brought a better understanding of production operation and new ways of managing production. [6] opined that ICT is a potent tool for accelerating socio-economic development and narrowing the gap between developing and developed countries. According to [13] information technologies can assist project and construction managers to standardize routine tasks so that available organizational resources are utilized both effectively and efficiently.

[14] explained that the advancement in information and communication technology (ICT) is working for the fast transformation of the whole world into a global village where goods and services can be made available with minimum restrictions and delays. However, the Nigerian building and construction industry has not largely participated in using ICT to solve its day to day needs [1]. According to [15], two-third of construction problems are blamed on inadequate communication and exchange of information and data. [16] argued that the use of ICT can heavily impact on the traditional processes, working methods, culture of professional organizations in construction. [17] identified effects of providing an inventory control system on organizational performance. The effects include reduction in wastes, reduction in production costs, increased product quality, timely deliveries, increased profitability, reduced stock levels, decreased production cycle times and system flexibility. [6] stated the benefits of using ICT in the construction industry as improving quality of work, make complex tasks easier to perform, save time, improve productivity, enhance public image, save cost and facilitate decision making.

[9] opined that the huge volume of information to be exchanged among project parties has increased the awareness of the value of ICT in the construction industry. [18] stated that the use of ICT has reduced the time for data processing/communicating information and engendered the effectiveness of decision making and coordination among project participants.

LEAKAGES IN THE USE OF INFORMATION COMMUNICATION AND TECHNOLOGY (ICT)

Leakages in this context mean attributes that makes it difficult to harness the benefits that ICT has to offer the construction industry. It is continually acknowledged that the construction industry has great potential for the uptake of ICT and e-business [19], but, it appears that some fundamental problems still exist. Some of these issues include: organizational factors (people and process); the enabling environment and supportive infrastructure, and the actual technology itself [20]. In the organizational factor, [20] opined that poor user acceptance can occur when transitioning from an existing system such as a paper based system to a new system such as a fully electronic environment. [21] explained that when organizations implement a new technology, commonly employees are not ready to adopt that technology and resist its introduction.

According to [6], the factors impeding the use of ICT in the construction industry include insufficient/erratic power supply, job sizes and fees not enough for ICT, high cost of hardware/software, fear of virus attacks, high rate of obsolescence of hardware/software, inadequate ICT content in construction education, scarcity of professional software, high cost of engaging computer staff, lack of management desire and appreciation of ICT, security, low return on investment, personnel abuse and fear of ICT making professionals redundant. Similarly, [22] identified the main barriers to ICT transformation in materials management as: when the industry believes hard copy is substantial, limited technical life cycle, dearth in innovative culture, lack of flexibility of new technologies, lack of reliability, difficulty to integrate in existing process, risk of technical malfunction, absence of trained staff, resistance from employees, time taken for training, lack of market information, uncertain economic situation, uncertain returns on investment, cost for training staff, high cost of specialist software and maintenance cost. [23] and [24] also believed that lack of user-friendly construction software packages is considered a major leakage to the development of ICT in the construction industry. Figure 1 showed a pictorial illustration of selected benefits and leakages from literature to the use of web-based technologies in the construction industry.

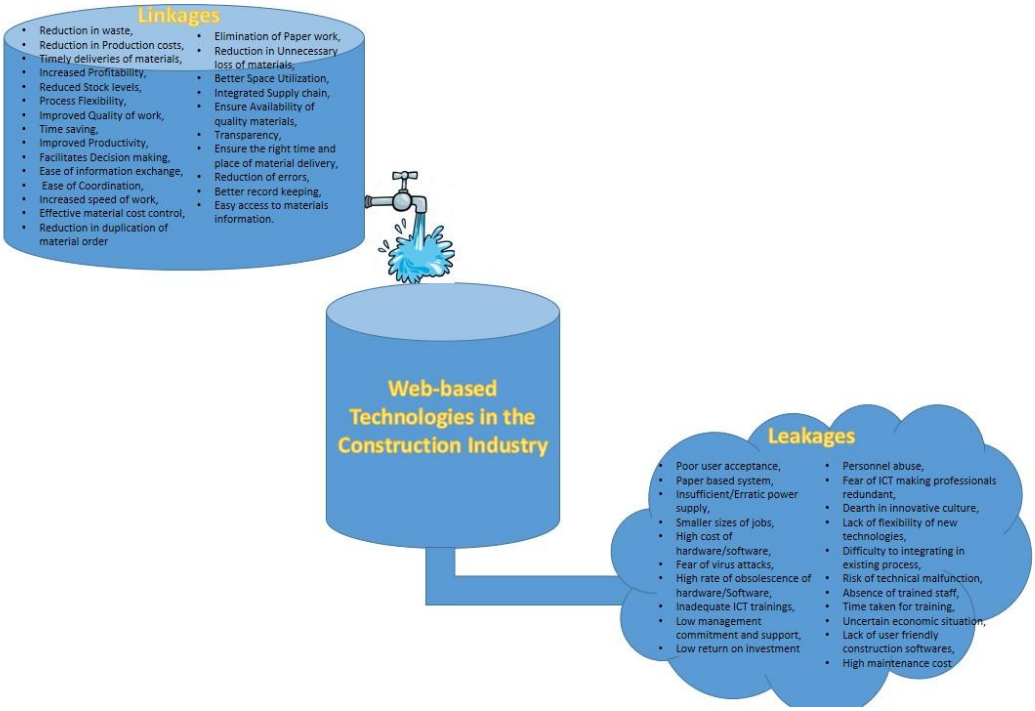

Figure 1. Benefits and Leakages to Web-based Technologies

Source: Author's Design

METHODOLOGY

This section presented the general outline or procedure for conducting the study. The study is quantitative in nature and therefore utilized a survey research design in order to achieve the outlined objectives. Specifically, a cross-sectional survey research design was used where samples were drawn from the population of study at one point in time. The study has chosen two study areas namely Abuja (FCT) and Lagos state. These two locations have been chosen due to their commercial and administrative importance to Nigeria. The population of the study were registered and unregistered construction professionals working on building construction sites in such a way that the study can get in depth information. The target population included architects, builders, engineers and quantity surveyors in the built environment. In order to estimate the sample size due to the inability to cover all the population in the study, a statistical approach using a simple random sampling method was selected ensuring that samples are drawn from the comprehensive list of registered construction professionals. The calculated sample size for this study consists of 317 fully registered architects, 281 fully registered Builders, 311 fully registered Quantity Surveying and 251 fully registered Structural Engineers in the built environment in Lagos and Abuja (FCT) making a total calculated sample size of 1,160 respondents. A structured questionnaire was used as the principal instrument for obtaining primary data in form of responses from the respondents. The questionnaire instrument comprised of three (3) sections which are Section A – demographics, Section B and C for measuring the benefits and leakages in the use of web-based technologies. In Section B and C, the level of agreement were analyzed using 5-point Likert scale with "Strongly Agree = 5", "Agree = 4", "Undecided = 3", "Disagree = 2" and "Strongly Disagree = 1". Statistical tools of frequency, percentage and Principal component factor analysis were used to analyse the data collected. A framework of a web-based system that can be used in planning and control of building materials on construction sites was developed. The IT system setup is such that, it can only be accessed via an online platform through web browsers on desktop systems. Adopting the framework of [25], where the database system is designed using MySQL connected to the HTML web-interface through a PHP script processing the data back and forth. The study showed the architectural design of the web application using a system block diagram to describe the processes of using a web-based system for planning and control of building materials on a construction site.

RESULT AND DISCUSSION

This section highlighted the result and discussion of the objectives set for this study. The analysis of the benefits and leakages in the use of web-based technologies in the construction industry are presented. The study developed a system block diagram of a web-based system to be used in managing building materials' planning and control processes.

Background Information

In the conduct of this research, construction professionals were selected to take part in the survey. Table 1 showed the background information of the respondents to the study. The table revealed the summary of their highest academic qualifications, professional background and industry

experience in the construction industry. From, Table 1, the highest academic qualification attained by the respondents revealed that B.Sc/B.Tech/B.Eng degree holders represented 37.7% (310), from the survey, M.Sc/M.Tech/MBA/MPM degree holders 37.5% (309), OND/HND degree holders had 15.6 (128), while Ph.D degree holders represented 9.2% (76) of the total population. An inquiry into the professional background of the respondents revealed that 29.5% (243) registered Builders, 24.9% (205) registered Quantity Surveyors, 23.2% (191) registered Structural Engineers and 22.4% (184) registered Architects participated in the study. The distribution of the construction industry experience of the respondents showed that 46.2% (380) 11-20 years' experience, 37.8% (311) had 1-10 years' experience, 11.2% (92) had 21-30 years' experience, 4.1% (34) had 31-40 years' experience, 0.7% (6) had 41-50 years' experience. The background information revealed that the construction professionals had adequate academic qualification to partake in the survey while the professional background of the respondents were equally distributed to elicit a good judgment for the study. Majority of the respondents had more than 10 years working experience in the construction industry which is a proficient experience to take part in the study.

Table 1. Summary Background Information

Background Information	Frequency	Percent	Cumulative Percent
Highest Academic Qualification			
B.Sc/B.Tech/B.Eng	310	37.7	37.7
MSc/MBA/MPM	309	37.5	75.2
OND/HND	128	15.6	90.8
Ph.D	76	9.2	100.0
Professional Background			
Builder	243	29.5	29.5
Quantity Surveyor	205	24.9	54.4
Structural Engineer	191	23.2	77.6
Architect	184	22.4	100.0
Industry Experience			
11-20 years	380	46.2	46.2
1-10 years	311	37.8	84.0
21-30 years	92	11.2	95.1
31-40 years	34	4.1	99.3
41-50 years	6	0.7	100.0

Benefits in the use of web-based technologies

The study sought to examine the level of agreement on the benefits of using web-based technologies in the Nigerian construction business. The study identified twenty-four (24) benefits that may arise from using web-based technologies in the construction industry. This section used the statistical tool principal component factor analysis to group these essential benefits. The Principal component factor extraction analysis with Varimax rotation was performed using SPSS 21. To assess the suitability of the data for factor analysis, the KMO measure of sampling adequacy and Bartlett's test of Sphericity were conducted. Table 2 showed that the KMO measure for sampling adequacy was 0.835, which is larger than 0.7, suggesting that the sample was acceptable for factor analysis. The Bartlett's test was 7935.001 and the associated significance level was p-value< 0.001, indicating that the population correlation matrix was not an identity matrix. Both of the tests showed that the obtained data supported the use of factor analysis. Table 3 lists the eigenvalues associated with each linear component before extraction, after extraction and after rotation. Principal components analysis revealed the presence of six components with eigenvalues exceeding 1, explaining 29.6%, 10.2%, 6.7%, 6%, 4.5% and 4.2% of the variance respectively.

Table 2. KMO and Bartlett's Test of Benefits in the use of web-based technologies

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.841
Bartlett's Test of Sphericity:		
	Approx. Chi-square	7935.001
	Degree of freedom	276
	Significant level	0.000

Table 3. Component transformation matrix of the Benefits in the use of web-based technologies

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings[a]
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	7.115	29.645	29.645	7.115	29.645	29.645	5.873
2	2.438	10.158	39.803	2.438	10.158	39.803	4.013
3	1.607	6.695	46.498	1.607	6.695	46.498	3.729
4	1.429	5.955	52.453				
5	1.081	4.504	56.957				
6	1.010	4.208	61.165				
7	.971	4.046	65.212				
8	.900	3.749	68.960				
9	.761	3.172	72.133				
10	.700	2.918	75.051				
11	.648	2.702	77.753				
12	.620	2.582	80.334				
13	.588	2.450	82.785				
14	.538	2.240	85.025				
15	.518	2.160	87.184				
16	.463	1.929	89.113				
17	.451	1.878	90.991				
18	.434	1.808	92.799				
19	.390	1.625	94.424				
20	.343	1.428	95.852				
21	.318	1.326	97.178				
22	.261	1.087	98.264				
23	.223	.929	99.193				
24	.194	.807	100.000				

Extraction Method: Principal Component Analysis.

a. When components are correlated, sums of squared loadings cannot be added to obtain a total variance.

These six factors explain a total of 61.2 percent of the variance. But, from Table 3 it is realized that too many factors are extracted, so it is important to also look at the Screeplot. With a change in the shape of the screeplot (elbow) as shown in Figure 2. Only components above this point are retained. An inspection of the screeplot revealed a clear break after the third component. Therefore, the extraction was re-computed with a fixed number of factors to extract at 3. The three-component solution explained a total of 46.5% of the variance, with factor 1 contributing 29.6%, factor 2 contributing 10.2% and factor 3

contributing 6.7%.

The three-factor solution with the respective loading scores is shown in Table 4. The factor loading of 0.50 was considered to be the cut-off point. From Table 4, there are three (3) main benefits (component) that reflect in the loading and have factor loadings above 0.50. The three (3) benefits have been titled Recording benefits, Production benefits and Information Processing benefits.

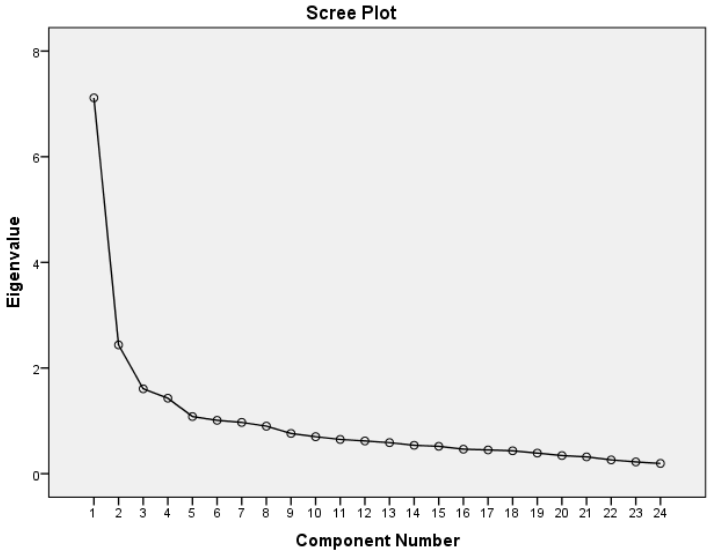

Figure 2 Sreeplot of Benefits in the use of web-based technologies

Table 4. Factor loading for Benefits in the use of web-based technologies (Rotated Component Matrix)

	Rotated Component Matrix	Component		
		1	2	3
Recording Benefits	Elimination of Paperwork	**0.608**	-	-
	Reduction in errors	0.590	-	-
	Better record keeping	0.587	-	-
	Reduction in duplication of material order	0.545	-	-
Production Benefits	Reduced Stock levels	-	**0.686**	-
	Better Space Utilization	-	0.655	-
	Reduction in Production costs	-	0.580	-
	Reduction in waste	-	0.531	-
Information Processing Benefits	Ease of information exchange	-	-	**0.740**
	Facilitates Decision making	-	-	0.737
	Process Flexibility	-	-	0.589
	Easy access to material information	-	-	0.560

Extraction Method: Principal Component Analysis.

a. 3 components extracted.

The first factor which had the largest variance of 29.6% was titled recording benefits based on the components such as elimination of paperwork, reduction in errors, better record keeping and reduction in duplication of material order. The paper method has been identified to be prone to many drawbacks which brings the justification of this study. The main challenge of the paper method is in recording and retrieving the data afterwards [1]. The study posits that there would be better record keeping thereby reducing the many errors and duplicity associated with the paper-based methods in the construction process. This is corroborated by [26], in that, storage of building materials goes hand in hand with store recording, while good record keeping can detect theft and pilfering early enough by showing how much building materials are in the store. The construction industry would greatly benefit from using systems that are able to provide up-to-date data and information on construction projects.

The production benefit was the second factor with a variance of 10.2% and comprised of reduced stock levels, better space utilization, reduction in production costs and reduction in waste. These benefits are as a result of using web-based technologies through the production process. By engaging web-based technologies tools, there would be limited need to over-stock building materials thereby leading to better space utilization on construction sites. Capital that would have been used to over-stock can be saved or used in other construction processes. With reduced stock from the efficient use of web-based technologies, there can be reduction in waste lying around on construction sites based on proper estimation and ability to keep track of building materials on construction sites. For example, [27] found out that e-Procurement; a web-based technology saves up to fifteen percent (15%) of total purchase cost. The web-based system lowers the internal requisitioning cost by automating the internal requisitioning process. In addition, companies reduce personnel costs and time inefficiencies with requisition approval and order processing. [27] noted that web-based e-Procurement systems automates the workflow of procurement/resource management processes, which reduces the cycle time of purchases, decreases stocking requirements, and lowers inventory management costs. [28] stated that the production stage of construction projects consume extra amount of construction materials due to high levels of material wastage during this stage. Previous studies from various countries have confirmed that waste represents relatively larger percentage [29]. The use of web-based technologies can help re-shape the cultural structure of construction sites thereby leading to efficient construction project delivery processes.

The third factor was titled the information processing benefits which was derived from the variables of ease of information exchange, facilitates decision making, process flexibility and easy access to material information. The third benefit emphasized that the construction process is heavily dependent on the acquisition, use and dissemination of information. The construction process makes use of vast amount of information and the way it is used determines the success or failure of the construction project. The information at this stage must easily be accessible when needed to all prominent project stakeholders, flexible to the complex processes of the construction industry and easily transferable in spite of the heavy data. The implication of understanding these benefits of using web-based technologies in the construction industry is that when construction data or information are recorded/stored using web-based system, the data can be easily processed for easy decision making which would positively affect the production process on construction projects. The construction industry is heavily dependent on exchange of data and information making it one of the most information-intensive sector [30]. Data, information and acquisition of knowledge are parameters that drive the construction industry. [21] opined that the way these parameters are captured, stored and reused can be fast-tracked through the use of ICT. [10] reported that the construction industry has for many years constantly suffered from difficult-to-access, obsolete and incomplete information. Whereas, [31] noted that efficient functioning of the sector requires that reliable and accurate information are provided, this can only be made possible by the use of computer based systems.

Leakages in the use of web-based technologies

The slow and the low use of web-based technologies in the Nigerian construction business spurred this study to evaluate some leakages even though there may be benefits in the use of web-based technologies. By identifying the leakages the study aims that it would be reduced or eliminated. The study identified eighteen (18) leakages that may arise in the use of web-based technologies in the Nigerian construction business. This section used the statistical tool principal component factor analysis to group these essential leakages. The Principal component factor extraction analysis with Varimax rotation was performed using SPSS 21. To assess the suitability of the data for factor analysis, the KMO measure of sampling adequacy and Bartlett's test of Sphericity were conducted. Table 5 showed that the KMO measure for sampling adequacy was 0.797, which is larger than 0.7, suggesting that the sample was acceptable for factor analysis. The Bartlett's test was 5818.281 and the associated significance level was p-value< 0.001, indicating that the population correlation matrix was not an identity matrix. Both of the tests showed that the obtained data supported the use of factor analysis. Table 6 lists the eigenvalues associated with each linear component before extraction, after extraction and after rotation. Principal components analysis revealed the presence of five components with eigenvalues exceeding 1, explaining 30.2%, 13.5%, 8.1%, 6.9% and 5.6% of the variance respectively.

Table 5. KMO and Bartlett's Test of Leakages in the use of web-based technologies

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.797
Bartlett's Test of Sphericity:		
	Approx. Chi-square	5818.281
	Degree of freedom	153
	Significant level	0.000

These five factors explain a total of 64.3 percent of the variance. But, from Table 6 it is realized that too many factors are extracted, so it is important to also look at the Screeplot. With a change in the shape of the screeplot (elbow) as shown in Figure 3. Only components above this point are retained. An inspection of the screeplot revealed a clear break after the third component.

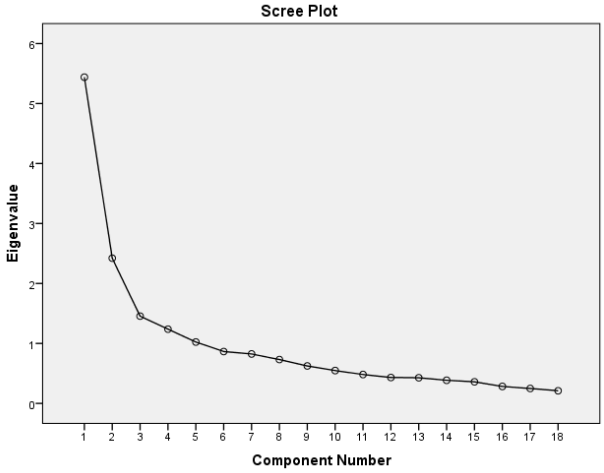

Figure 3. Sreeplot of Leakages in the use of web-based technologies

Table 6 Component transformation matrix of Leakages in the use of web-based technologies

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings[a]
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	5.439	30.219	30.219	5.439	30.219	30.219	4.676
2	2.421	13.453	43.671	2.421	13.453	43.671	2.951
3	1.455	8.084	51.755	1.455	8.084	51.755	3.023
4	1.238	6.879	58.634				
5	1.024	5.687	64.321				
6	.865	4.804	69.125				
7	.824	4.579	73.704				
8	.731	4.062	77.766				
9	.624	3.468	81.234				
10	.548	3.043	84.277				
11	.482	2.677	86.954				
12	.432	2.401	89.355				
13	.428	2.378	91.733				
14	.385	2.141	93.874				
15	.360	2.000	95.874				
16	.283	1.573	97.447				
17	.249	1.382	98.829				
18	.211	1.171	100.000				

Extraction Method: Principal Component Analysis.

a. When components are correlated, sums of squared loadings cannot be added to obtain a total variance.

Table 7. Factor loading for leakages in the use of web-based technologies (Rotated Component Matrix)

	Rotated Component Matrix	Component		
		1	2	3
Usage Risk Leakages	Risk of technical malfunction	**0.783**	-	-
	Fear of virus attacks	0.735	-	-
	High rate of obsolescence of hardware/Software	0.639	-	-
	Inadequate ICT trainings	0.572	-	-
Culture Leakages	Paper based system	-	**0.682**	-
	Fear of ICT making professionals redundant	-	0.679	-
	Poor user acceptance	-	0.677	-
	Low management commitment and support	-	0.560	-
	Difficulty to integrating in existing process	-	0.502	-
Tools Leakages	High cost of hardware/software	-	-	**0.733**
	Insufficient/Erratic power supply	-	-	0.723
	Absence of trained staff	-	-	0.657
	Low return on investment	-	-	0.651

Extraction Method: Principal Component Analysis.

a. 3 components extracted.

Therefore, the extraction was re-computed with a fixed number of factors to extract at 3. The three-component solution explained a total of 51.8% of the variance, with factor 1 contributing 30.2%, factor 2 contributing 13.5% and factor 3 contributing 8.1%. The three-factor solution with the respective loading scores is shown in Table 7

The factor loading of 0.50 was considered to be the cut-off point. From Table 7, there are three main leakages (component) that reflect in the loading and have factor loadings above 0.50. The three leakages have been titled Usage Risk leakages, Culture leakages and Tools leakages. The first factor which had the largest variance of 30.2% was titled usage risk leakages based on the components such as risk of technical malfunction, fear of virus attacks, high rate of obsolescence of hardware/Software and inadequate ICT trainings. This is supported by [32], in that, identified risk related to ICT usage is one of the critical success factors (CSFs) for integration of ICT in the construction business. [33] noted that security is a major concern when working on the internet such as using web-based technologies. [34] stated that "the World Wide Web leaks like a sieve. Data transmitted on it can be garbled, can reassemble wrongly at the other end, or can display only partially because of incompatible software". The risk of technical malfunction is one issue that all web-based systems should endeavor to overcome to ascertain the adoption and success of the system. Although, [35] assured that electronic exchange can be more secure than traditional paper and allows the possibility to provide added protection (e.g., the use of digital certificates, and incorporation of encryption into the process). Another leakage identified in this section is the inadequate ICT training which increases the risk in the usage of web-based systems. This is validated by [36], in that their study observed that the most significant obstacle in the implementation of project management tools is the lack of ICT knowledge in the use of the tools and techniques. In line with the [37], the non-provision of adequate ICT trainings for employees by their managers in construction firms during IT implementation results in the IT implementation not been sustained and finally abandoned. [38] substantiated further that when construction professionals find it difficult to use computer based applications for materials management they eventually fall back on the use of the paper based method which becomes a major barrier in the use of ICT.

The culture leakage was the second factor with a variance of 13.5% and comprised of paper based system, fear of ICT making professionals redundant, poor user acceptance, low management commitment and support and difficulty to integrating in existing process. [18] observed that the benefits of using ICT can be limited if the adoption and use is poorly diffused within the organization or within the culture of the individual user. This diffusion can be related to the user's acceptance of the innovative tool. In line with the study by [18], poor user acceptance can occur when transitioning from an existing system to a new system such as transitioning from a paper-based which is prone to so many associated drawbacks, to a fully electronic environment. [38, 39] agreed with this in that organizations tend to become accustomed to their own established procedures, and they find it difficult to give up and change. Resistance to change, lack of a widely accepted solution and lack of leadership, which are cultural issues, are highlighted as barriers by [40] in the USA. According to [33], these produce a slowdown in adoption of web-based

technologies and result in a failure to reap many of the perceived benefits. Therefore, [33] argued that a cultural change needs to take place prior to adoption of web-based technologies. In order to bring this about, champions need to be appointed with full senior management support. There is a perception within the construction sector that senior management tend to be lacking in awareness of the available and forthcoming technologies and of the potential benefits of these technologies for process improvement and competitive advantage [41]. [42] noted that this can greatly hamper the adoption of new technologies since most investment decisions are usually taken at the senior management level.

The third factor was titled the tools leakages which was derived from the variables of high cost of hardware/software, insufficient/Erratic power supply, absence of trained staff and low return on investment. According to [6], the top three constraints to the use of ICT in the Nigerian construction industry are inadequate/erratic power supply, high cost of computer hardware and software and lack of sufficient jobs. In the study by [42], the availability of hardware and software to carry out activities on a web-based system was adjudged marginal. This low level of availability of facilities was attributed to the high financial implications of setting them up in the Nigerian environment. In the South African setting, [43] identified critical issues in the use of a web-based system as the unreliable IT infrastructure, cultural issues, security issues and access to IT infrastructure. In Nigeria, another key issue reported by [42, 44] was irregular power supply. Although, the challenge of frequent power outage is not peculiar to a developing country like Nigeria alone, [6] observed that it is a major constraint to the use of ICT by construction professionals. The African Development Bank reported that the electricity in Nigeria is unreliable and therefore, companies are forced to procure and run their own power generating facilities leading to high production costs.

System Design and Implementation

According to [23], the development of a successful web application (website) involves many different kinds of design, including functional design, software architecture, business process or workflow design, user interface design, and database design. The purpose of the web-based material planning and control (WB-MPC) model is to have an interactive web-based interface which allows construction professionals to be able to estimate and store building material quantities, while planning and controlling the usage of building materials per time. The system is designed in a way that a shortfall in quantities of selected building materials can be brought to the notice of the construction professional by periodic short messaging systems (SMS) or email format. Figure 4 showed the system block diagram of the web-based material planning and control (WB-MPC) system; an IT system that can be used for managing these processes. The administrator or project manager for the construction site and the back end users can access the platform through a login page. The Director, Head office or any other official permitted through the people and permission can access critical information on the state of building materials to be used and onsite leading to transparency, openness and accountability. In addition, there is a messaging platform where back end users can use to make and send clarifications to the project manager on what was noticed about the ongoing project. The messaging platform also stores the previous messages that have been sent to the project manager about shortfalls in the building materials on site.

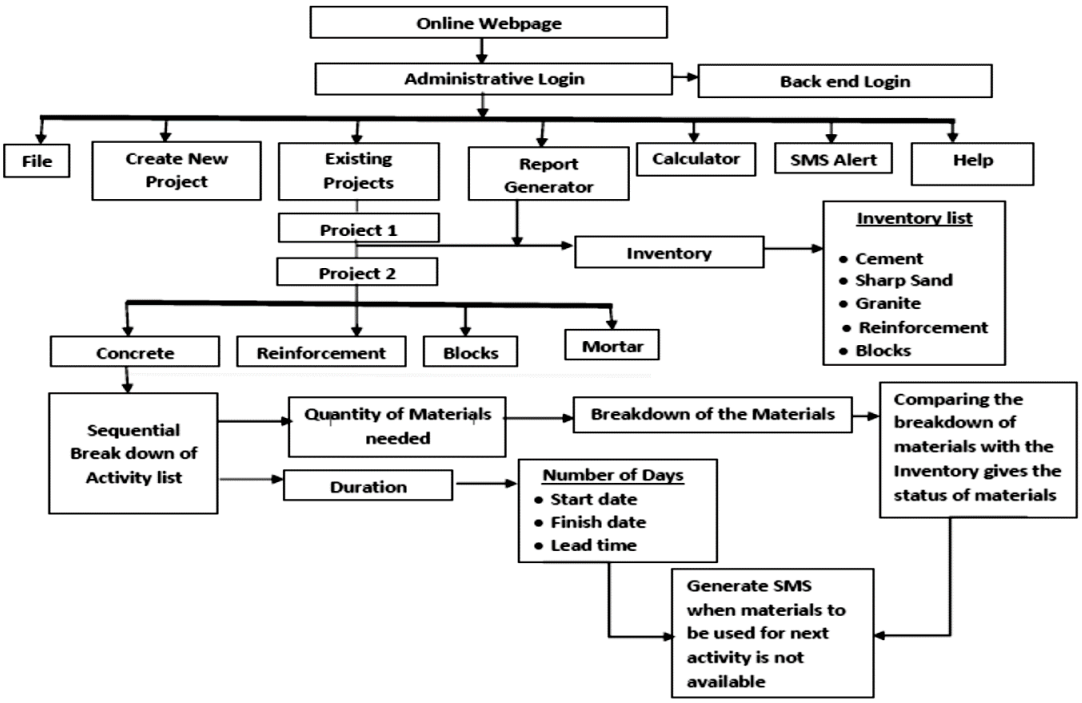

Figure 4. System Block Diagram of the WB-MPC

Source: Author's design

CONCLUSION AND RECOMMENDATION

The study examined the benefits and leakages in the use of web-based technologies in the construction industry. The study revealed that the use of web-based technologies in the construction process can engender the benefits of efficient recording, optimized production and effective information processing. These processes are further broken down into recording benefits - elimination of paperwork, reduction in errors, better record keeping and reduction in duplication of material order; the production benefits comprised of reduced stock levels, better space utilization, reduction in production costs and reduction in waste. The third benefit titled the information processing benefit was derived from the variables of ease of information exchange, facilitates decision making, process flexibility and easy access to material information. The study revealed that the leakages in the use of web-based technologies in the construction industry can be categorized as the usage risk, culture and tools leakages in that these leakages may hinder the integration of web-based technologies in the construction industry. The study developed a framework for a web-based material planning and control system that can be used in the construction process, this ensures that building materials' information are archived, stock levels are identified and material delay is minimized. It is expected that this study would be of great benefit to web-based technology developers and construction industry stakeholders. Maximum efforts should be made to understand the benefits and the leakages that would engender the wide-spread use and adoption of web-based technologies. Web-based technology developers should ensure that the leakages identified in the study are reduced to the barest minimum. The study recommended the use of web-based technologies in several of the construction processes by harnessing its benefits. Efforts should be made to increase ICT training and education amongst construction professionals to intensify the proficiency of stakeholders in the use of web-based technologies in the construction industry.

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