ISSN 2278-3091
Volume 14, No.1, January - February 2025
International Journal of Advanced Trends in Computer Science and Engineering
Available Online at http://www.warse.org/IJATCSE/static/pdf/file/ijatcse041412025.pdf
https://doi.org/10.30534/ijatcse/2025/041412025

Existing Approaches in Overcoming Barriers to Adoption of Internet of Things (IoTs) in Nigeria Construction Industry

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Received Date: December 24, 2024 Accepted Date: January 29, 2025 Published Date: February 06, 2025

ABSTRACT
In various areas, such as agriculture, health, education, manufacturing, and logistics, IoT technology is quickly gaining traction due to the rapid rate of innovation, which has resulted in enhanced communications and higher productivity. However, the construction sector, which is a significant consumer of manufactured goods, has yet to experience such disruptive shifts, resulting in continued project failure. This study is set out to identify and assess the existing approaches in overcoming the barriers to IoT adoption. A descriptive survey research design was used which utilized a structured questionnaire to obtain a primary data from a sample of size 100. A descriptive statistic of simple percentages, means, standard deviation, ranks and tables, and the students' T-test were adopted to draw valid conclusions. The findings reveal that, interoperability between information systems, technology awareness, crafting balanced policy and building coalitions, promoting standards and technology advancement, enabling infrastructure availability and access, encouraging markets, interoperability interfaces and compatibility among technology systemsand lastly, organizational climate and culture (OCC), would significantly abate the barriers posed to IoT adoption in the construction industry. The study therefore recommends that, these identified factors alongside the already existing approaches, should be implemented and practiced to enable the industry undergo notable changes.

Key words: Internet of Things (IoT), IoT technology, Smart Devices, Construction Industry.

1. INTRODUCTION

In several areas, such as agriculture, health, education, manufacturing, and logistics, the rate of innovation has been tremendous, thanks to enhanced communication and higher productivity. However, the construction sector, which is a significant consumer of manufactured goods, has yet to experience such disruptive shifts, resulting in continued project failure. The sector is inherently fragmented, with little to no coordination between partners and insufficient information transfer from project to project [1]. At the business, project, or site level, this technology offers a lot of promise to improve organisational performance.

The construction industry's dispersion of information and high rate of mobile content access provide an excellent setting for process optimization through the deployment of the Internet of Things paradigm (IoT). Smart devices are things that are connected in the Internet of Things, and they play a critical role in the application of digital solutions throughout the building process. The Internet of Things (IoT) was characterised by [2] as a model in which computing and networking capabilities are inserted into every type of potential device. These skills are used to enquire about the object's status and, if possible, to modify its state.

This makes use of the Internet of Things' computer capabilities to enquire about the object's status and, if possible, modify its state. The Internet of Things (IoT) is a term that describes a world in which all of the devices and equipment that are used are connected to a system. This may be used to work together to do complicated tasks that demand a high degree of understanding. IoTgadgets have embedded sensors, CPUs, actuators, and handsets for this intelligence and connectivity. The Internet of Things is not a single technology; rather, it is a collection of technologies that operate together in a cycle [3].

Technology is rapidly permeating the world, and corporations are focusing their efforts on it as a source of long-term sustainability, security, and economic progress [4]. Some of the technology's uses in Kenya include improving home/business security, energy management, weather forecasting, disaster monitoring, wildlife poaching prevention, and smart utility metering [5]. Following the success of IoT integration in other industries, particularly manufacturing, the construction industry may learn how to build value around this cutting-edge technology.

The construction industry has seen significant changes across the world. The trend toward integrated project delivery, enabled by virtual design and construction and aided by the usage of

Building Information Modelling (BIM), is gaining popularity, for example [6]. Still, considerable work has to be done in terms of using new tools and approaches to supplement project execution, which is now primarily reliant on traditional management practises. By borrowing the realised advantages from the manufacturing business, this research aimed to show the open potential given by IoT in the building industry. In a word, IoT allows for current building technologies such as offshore construction, lean construction, and smart assembly to be implemented [7].

The use of new technology in the digital realm will greatly increase production while also reducing delays. Furthermore, building quality will be considerably improved, safety will be addressed, and better working conditions and environmental compatibility will be fostered. Project managers may utilise IoT to take advantage of Real-TimeData (RTD), analyse it, and then convey meaningful information about the data to relevant stakeholders much more quickly. Overall, construction enterprises will profit from the use of digital solutions in coping with new complications, particularly in this era of globalisation, which has increased the value and interchange of information [1].

Smart devices, which vary from simple sensor nodes to household appliances and smartphones, are regarded things capable of communication and computation. They are typically the items present in the Internet of Things (IoT) network [8][9]. They are the central gadgets in the IoT paradigm's integration in today's sectors, and they play a critical role in the deployment of digital solutions in the construction industry.

Because of a lack of knowledge and understanding of the value and benefits of IoT among Nigerian construction professionals, the idea of IoT has not been generally adopted in the Nigerian construction sector [10]. This presents a significant obstacle to the construction industry's adoption of the Internet of Things. [11] examined the barriers to IoT technology in Smart cities in order to improve urban sustainability. The study report concentrated on overviews of the idea, characteristics, and problems of IoT as a component of the Smart city concept.

[12] investigated the architecture for an IoT-based shop floor material management system for panelized homebuilding and discovered that IoT can gather dynamic data in real-time and synthesise it efficiently along the supply chain. [13] conducted a thorough analysis of IoT trends, possibilities, and constraints in Malaysia.

Despite the fact that many studies and applications of IoTs have been carried out in many fields such as educational institutions, smart homes, smart cities, public relations businesses and agencies, there are few studies and applications of IoTs in

- Sensors and actuators actively interact with the environment, sensing and conveying particular data and triggering essential actions.

Nigeria [14][15][16][17]. Although Internet of Things applications and scenarios have demonstrated a highly intriguing life that enables technology for smart things, there are a few costs associated with the notion of using the Internet of Things [18]. There is a need for technology to be affordable while still having great capacity and potential.

[19] identified leadership, company size, usability of proposed solution, and cost of implementation to be an existing approachin overcoming barriers to IoT adoption.In light of the extant research reviewed, it suffices to say that, Africa, particularly Nigeria, has a slow rate in the adoption of IoT, especially in the building technology due to the barriers that hovers the adoption of IoT in the construction industry. So far, there is a dense literature as to ways to combat this menace posing against the adoption of IoT in building technology in Nigeria. It is to this that the study aims to identify and assess existing approaches in overcoming barriers to adopting internet of things (IoT) in the Nigerian Construction Industry, specifically to ascertain the critical success factors to adoption of IoT, the level of practices of the existing approaches, and to determine their impact to IoT implementation, in the construction industry.

2. LITERATURE REVIEW

2.1 Communication Management in Construction Industry

The flow of information during the various construction phases may make or break a project's delivery. Project communications management, as defined by the Project Management Body of Knowledge (PMBOK), entails the processes required to ensure that the project's and its stakeholders' information needs are met through the creation of artefacts and the implementation of activities aimed at achieving effective information exchange [20]. Establishing a strategy, followed by the development of actions required for its implementation, is required for effective communication management. There are three aspects to communication management.

- The first stage is to decide on a strategy for meeting the project's information demands.
- The second section focuses on the management component of communication, which includes gathering, generating, distributing, storing, retrieving, managing, monitoring, and finally discarding data.
- The third and final part entails monitoring communications to ensure that the project participants' information needs are met [20]. People are heavily reliant on the current data collection practise in construction. The Internet of Things (IoT) provides an option.

2.2Prospects Accompanying the Adoption of IoT in the Construction Industry

Building Information Modeling (BIM)

One of the advantages of IoT is building information modelling (BIM). IoT is affecting building from the very beginning of the design process [21]. Intelligent design with 3D modelling enhances design correctness while also increasing production efficiency. This improves the efficiency of real-time plan modifications. The issue of lag time between the supply of fresh information and the updating on the job site has been resolved. This saves time and money by reducing the amount of time and resources needed to incorporate new design features.

BIM is a more advanced and helpful programme that is utilised beyond the design and construction phases [22]. BIM provides construction managers with useful modelling throughout and after construction, as well as when the project is in operation, such as energy use trends and patterns. IoT sensors are inserted or put on the walls of most modern buildings to monitor a variety of building systems [21]. The information gathered will be evaluated on a regular basis to determine the trend and patterns of building utilisation. This allows building managers to improve energy efficiency, manage operations strategically, recognise a certain trend or pattern, and make optimal use of a facility's security, cooling and heating system, access, and water supply, among other things [23].

Greener building

According to [24], 87 percent of customers are virtually inspired to make green construction choices, with 33 percent making green purchases on a regular basis. The two primary reasons why purchase levels do not correlate to customer demand are cost and convenience. Sustainable building approaches have been major selling elements in a number of large construction projects, and this has enabled IoT to meet consumer demand.

Greener construction approaches have sparked a lot of attention as a result of the environmental movement [25]. Engineering with IoT merit is the process of creating a smart building that detects when it is empty. Unused systems are automatically turned off, resulting in energy and natural resource saving. Intelligent window designs operate more efficiently than timer-activated blinds or basic remote controls. When IoT meets window treatments, the result is a system that can detect temperature and natural light characteristics. To save energy, louvres close automatically when there is heat or the atmosphere begins to cool [25].

Smart prefab

Prefabricated components are a cost-effective cost solution for construction projects that must be completed quickly. Complex and huge constructions were formerly difficult to organise as pre-fab projects, making each merit out to several commercial enterprises [26]. The Internet of Things (IoT) offers answers to prefabrication issues, allowing things to connect. RFID sensors make it simple to trace prefabricated components at every stage of the supply chain [27]. Regardless of the extent and magnitude of the project, there is the potential of logistically coordinating a whole pre-fab building. With the ability to alter design in real time at any stage of the project, intelligent pre-fab eliminates delays on the jobsite and improves project control [26].

Management and administration

Wasted time is extremely costly in the construction sector since time equals money. More resources will be consumed if more time is spent on the site. IoTs save money by reducing time through the use of innovative technology [28]. When time is saved for expensive heavy equipment that is crucial or critical to a project, a significant amount of money is saved.

Sensors on heavy machinery allow for remote monitoring, which is beneficial for maintenance, deployment, and security [29]. The sensor allows the organisation to instantly identify vibration or temperature fluctuations in machinery that might lead to mechanical difficulties. The odd shift/movement pattern of equipment might alert the firm to the possibility of theft [29].The sensor connected to IoT allows us to know exactly where an asset is in real time and whether it is on or off, which improves asset deployment efficiency. Aside from heavy equipment, there are a variety of tools utilised by different artists on site. Although heavy equipment is necessary, no construction project can be accomplished without simple tools such as drills [29]. When a sensor is implanted and connected to IoT, any piece of machinery or tool on site may become a smarter tool. When it is time for a repair, integrated sensors provide a signal to the operators. Tools are intelligent enough to schedule their own maintenance. With the help of IoT, tool or equipment failures that cause delays become a thing of the past.

Smarter exteriors

IoT may also be deployed in the building's outside areas. Commercial buildings feature public spaces, garages, and parking lots, all of which require adequate lighting [30]. Smart lighting can be placed instead of an exterior light or a traditional street light to increase security and illumination. There are smarter outside lighting systems that can be purchased with sensors that are connected to the internet of things. This lighting is engineered to change itself based on the information obtained [30] Lights automatically run at maximum energy efficiency regardless of the time of day, weather, or season. According to the survey, some communities that have implemented smart exterior lighting systems have saved 40% on energy expenses [23].

Cloud connection

Many new buildings are now connected to the Cloud. When a smart building is connected to the Cloud, [23] highlighted two benefits. HVAC systems that function automatically save money and time. Building managers can study data to see if modifications in the HVAC system's programming can be made over time, resulting in significant energy cost savings. The quality of a structure's structural integrity is reported to building management when sensors are installed to the foundations. This will improve the continuous monitoring of the foundation's load-bearing capacity, assisting construction project managers and building managers in preventing dangerous and costly structural breakdowns.

Some of the potential given by IoT in construction, according to [31][32], include:

- **Enabling 'just in time' delivery:** RFID chips embedded in objects can provide information in the event that supply falls short of demand. This alerts management to order additional of that item, providing just-in-time delivery and avoiding inventory issues.
- **Tool and equipment tracking:** by monitoring equipment on site, preventative maintenance may be performed, which is more cost efficient than on-demand repairs following a breakdown. This extends the useful life of equipment and tools, increasing their salvage value.
- **Wearables for remote use and activity monitoring:** Wearables may be used to measure employees' presence on-site as well as report on their current engagement. Employee alertness may also be tracked, which aids in the prevention of accidents, particularly when weariness is detected.
- **Cost-cutting**: by adding sensors to equipment, idle time may be decreased, resulting in cost savings. Furthermore, adjusting after-hours illumination can assist save money on electricity.
- **Augmented reality (AR):** AR, which integrates virtual architectural plans with real-world building site realities, has the potential to improve efficiency and accuracy while minimising human mistakes, saving money, time, and resources.
- **Building Information modelling (BIM)**: Sensors strategically positioned within buildings may continually give input to the intelligent 3D model, enabling real-time updating, thanks to the integration of IoT technology. As a result of this integration, accuracy improves since human dependency is reduced [31][32].

2.3 Challenges to Adoption of IoT in the Construction Industry

Although Internet of Things (IoT) applications and scenarios have demonstrated an incredibly intriguing life that enables technology for smart things, there are a few costs associated with the notion of using the Internet of Things (IoT) [18]. There is a need for technology to be affordable while still having great capacity and potential. As recognised and explored by [2], a number of problems now restrict the acceptance and implementation of IoT in building projects

Scalability

The Internet of Objects, which incorporates a vast notion since things are connected within an open environment, cannot be compared to the traditional Internet of computers. Communication and service discovery, which are fundamental functions, must work equally effectively in large-scale and small-scale systems [2]. To achieve scalability, IoT requires new approaches and enhanced functionality.

Self-Organizing

As the computer collects client wants and designs and adjusts them to unique scenarios, smart things should not be overlooked. Mobile items, which are vital and common, are occasionally used to form connections in an unexpected way, and they may be sorted and arranged to fit their individual context [2].

Data Volume

Some Internet of Things scenarios will involve obtaining data from logistical or sensor networks, as well as sporadic communication. Large amounts of data will be collected on central network servers or nodes by the large-scale network [22]. The occurrence is referred to as big data, and it necessitates a variety of operational procedures as well as new technology for processing, storing, and managing it.

Data Interpretation

Users of smart objects require assistance in translating the context determined by sensors as precisely as feasible. If service providers are to benefit from the various data that will be generated, some broad inferences must be drawn from the analysed data sensor [2].

Interoperability

The processing, information, and communication capabilities of each type of smart item in the Internet of Things vary. Various smart items would be susceptible to a variety of variables, including communications bandwidth needs and energy availability [10]. This is done to improve the collaboration and communication between various items, and it should adhere to common standards.

Software Complexity

To successfully manage smart objects and provide services to them, a large software infrastructure is necessary in the background servers and network. As with typical embedded systems, smart objects software solutions are supposed to operate with little resources [10].

Fault Tolerance

Internet of Things (IoT) items are more progressive and mobile than computers on the internet. They are also evolving at a breakneck pace in unimaginable ways. When built in a reliable and resilient manner, the Internet of Things will require redundancy on several levels and the ability to automatically adapt to changing situations [2][10].

Power Supply

Things move about, and the majority of them are not attached to a power source; in order to be smart, they must be self-powered from a suitable energy source. Although there are passive RFID transponders that do not require a power source, their communication and operational range is limited [2]. Future communications units and low-power CPUs hold promise for embedded systems that require less energy to operate. Not just in system architecture and hardware, but also in software, energy conservation is critical. The implementation of protocol stacks is an example, where each communication byte must justify its existence [10].

Automatic Discovery and Span

In a dynamic context, relevant services for items must be automatically recognised, which necessitates the use of semanticmeans to describe their capability. Span is concerned with the density of sensor devices as well as the network's geographical coverage. The length of a sensor network is determined by three factors: financial feasibility, policy motivation, and physical operation [2][10]. Physical operation include the selection of installation infrastructure, as well as the position and coverage of specific devices, which can be a citywide issue that necessitates coordination between urban planners, policymakers, and technologists. The better the precision of the sensor network, the higher the cost of developing the infrastructure, while the broader the network, the higher the cost of building the infrastructure [2][10].

Cost

One of the obstacles of making a new investment is the cost, but this becomes trivial when the return on that investment is clear. One of the most difficult aspects of IoT adoption has been the expense. In the construction business, the initial cost, maintenance cost, and all other costs related with IoT have hindered the rate of adoption [2][10].

3. MATERIALS AND METHODS

In this study, the descriptive survey research design is used. This is because of the absence of archival data in most Nigerian construction organizations. Also, survey is empirical and obtains what exists (Facts and Figures) and useful because of the relatively large population from which information was collected.

3.1Instrument

The instruments of primary data collection were well structured questionnaire and personal interviews. The questionnaire elicits responses on the existing approaches to barriers on IoT adoption. These questions were divided into three sections which were according to the objectives of the study.

3.2Setting

The study was carried out in Independence Layout and Emene, Enugu State. The choice of these area was purposive, because of the predominance of construction industries in the area.

3.3 Population and Sample

At the first stage, four industries in Enugu State were purposively selected, this formed the population of the study. Multi-stage sampling procedure was used to draw the sample for the study. From the sampling frame, twenty-five (25) samples were simple randomly obtained comprising engineers, surveyors, architects, and builders in each of the construction industries and engineering firms. Therefore, the sample size for the study was one hundred (100) respondents as shown in Table 1 below.

Table1: Sample size of respondents

Company	Location	Sample size
Jerac Construction Company of Nigeria	Emene, Enugu State	25
Pawid Constructs Limited	Independence Layout, Enugu	25
Akiota Works Limited	Independence Layout Enugu	25
Sylvac Construction Company	Independence Layout Enugu	25

3.4 Data Collection Procedures

The data for this study was derived from primary method of data collection obtained from the four major construction companies in Enugu State. It took three weeks to get the questionnaires distributed and collated. The difficulty of meeting the construction workers at their various offices prolonged the period of the study.

3.5 Data Analysis

The methods used are descriptive statistics of simple percentages, means, standard deviation, ranks and tables, and the students' T-test to draw valid conclusions and make accurate recommendations.

3.6 Ethics

The aim of this study, the intended use of the data obtained from them, and the repercussions of involvement in the research were all well explained to the respondents, who voluntarily provided informed permission in an explicit way. They were informed that they could withdraw from participation at any point they choose. The respondents' personal data were de-identified as their identities were not disclosed to anyone at any time. The data gotten was utilized for the purpose of research only, making use of them in a confidential manner.

4. RESULTS

This section makes a comparison and contrast between all the data received from the respondents. The outcomes of this study were based on the responses of 100 construction workers from various firms based in Enugu.

4.1Demographics

One hundred personnel participated in the survey ($n = 100$), of which 83% were males, and 17% were females. The overall response rate was 100%, implying that all the participants replied to the survey. Respondents younger than 29 and above 50 were the least represented in the survey. Participants whose age range lied between 30 and 49 were the majority (63%) in the study. Those of them in Engineering were the majority (55%), followed by Builders (23%), Architects (17%), and lastly, Surveyors (5%).

4.2 Identification of Existing Approaches in Overcoming Barriers to IoT Adoption

Table 2 below shows the identified and existing approaches in overcoming IoT implementation barriers as given by the professionals

Table 2: The identified and existing approaches in overcoming IoT implementation barriers

S/N	Factor		A (%)	D (%)	X	SD
1	**Governance and Leadership**	Creation of awareness among decision makers	25	75	1.96	0.163
2	**Technology awareness**	Awareness of technological solutions of IoT	80	20	3.35	0.999
3	**Enabling Infrastructure Availability and Access**	Fostering the physical and spectrum related assets needed to support IoT	76	24	3.13	0.022
4	**Company size**	Company size	28	72	1.92	0.063
5	**Crafting Balanced Policy and Building Coalitions**	Encouraging coordination and collaboration; influencing, analyzing, devising, and promoting norms and practices that will protect IoT users	83	17	3.30	0.937
6	**Interoperability interfaces and compatibility among technology systems**	Interoperability interfaces and compatibility among technology systems	68	32	2.87	0.132
7	**Promoting Standards and Technology Advancement**	Ensuring that the necessary technical standards are developed and in place to support global IoT interoperability	82	18	3.19	0.940
8	**Cost of implementation**	The cost of implementation	31	69	2.19	0.072
9	**Encouraging Markets**	Promoting the advancement of IoT through Department usage, application, iterative enhancement, and novel usage of the technologies	83	17	3.12	0.832
10	**Interoperability between information systems**	Interoperability between information systems	74	26	3.46	0.217
11	**Organizational Climate and Culture (OCC)**	Willingness to commit to technological investment amongst stakeholders	70	30	2.85	0.019

From table 2, a total of 75% disagreed firms' governance and leadership insight in creating awareness amongst its decision makers to be anew approach, while 25% were on the contrary, with the mean M=1.96, and standard deviation SD=0.16. About 80% agreed that awareness of technological solutions of IoT, is a new approach and would abate the effects barriers to IoT adoption has posed on the construction industry, while 20% of the participants were of contrary opinion, with mean M=3.40 and standard deviation SD=0.9. The majority of the participants (76%) agreed that enabling infrastructure availability and access, is a new approach that would undoubtedly reduce the barriers to IoT adoption to its barest minimum, while 24% did not share similar idea, with mean M=3.1 and standard deviation 0.9. About 72% of the participants were of the opinion that company size is also one of the existing approaches that policy makers take into consideration as critical success factor to IoT adoption, while 28% were on the contrary to that, with mean M=1.92 and standard deviation SD=0.06. Crafting balanced policy and building coalitions was accepted by 83% of the participants as a new identified critical success factor for IoT adoption and implementation in the construction industry, though 17% of the participants did not share that idea, with mean M=3.3 and standard deviation SD=0.9. It was also agreed by 68% of the participants that interoperability interfaces and compatibility among technology systemsis a new approach for IoT adoption, while 32% negated this view, with a mean M=2.8 and standard deviation SD=0.1. It was further shown that 82% of the participants were of the view that, promoting standards and technology advancement, is also not an already existing approach for combating the barriers to IoT adoption in the construction industry, while 18% declined from this notion, with mean M=3.2 and standard deviation SD=0.9.The cost of implementation of IoT devices in the industry was also revealed by 69% of the participants to be an existing approach towards fettering the various barriers to IoT adoption, while 31% of the participants were of contrary opinion, with mean M=2.19 and standard deviation SD=0.1. It was further indicated that, promoting the advancement of IoT through department usage, application, iterative enhancement, and novel usage of the technologies, is not analready existing approach in overcoming barriers to IoT adoption, as indicated by 83% of the participants, while 17% shared contrary idea, with mean M=3.1 and standard deviation SD=0.8. The study further asserted that interoperability between information systems, is not an existing approach in the construction industry in overcoming barriers to IoT adoption, as revealed by 74% of the participants, while 26% negated the view, with mean M=3.4 and standard deviation SD=1.3. Lastly, the 70% of the participants agreed that organizational climate and culture; willingness to commit to technological investment amongst stakeholders, is also not an already existing approach in overcoming barriers to IoT adoption, while 30% were on the contrary, with mean M=2.8 and standard deviation SD=0.02.

4.3 Level of Practices of the Existing Approaches in Overcoming Barriers to IoT Adoption

Table 2 indicated 3 already existing approach to overcoming barriers to IoT adoption. The quest to ascertain the level of practices that theexisting approaches are being used in overcoming the barriers in the construction industry was revealed. Result revealed that, 10% of the participants indicated they practice it with extremeness, 4% indicated that it is very much a practice amongst them, 24% indicated that it is slightly practiced, and lastly, 56% indicated they do not practice these existing approaches at all, with mean M=1.8 and standard deviation SD=1.2.

4.4 The Impact of the Identified Approaches in overcoming IoT implementation barriers

Table 3: The respective impact of the identified factors to overcoming IoT barriers

Identified Factor	Mean	S. D	Rank	Sig. (p)
Technology awareness	3.35	0.999	2	.000
Enabling Infrastructure Availability and Access	3.13	0.022	5	.000
Crafting Balanced Policy and Building Coalitions	3.30	0.937	3	.000
Interoperability interfaces and compatibility among technology systems	2.87	0.132	7	.003
Promoting Standards and Technology Advancement	3.19	0.940	4	.000
Encouraging Markets	3.12	0.832	6	.000
Interoperability between information systems	3.46	0.217	1	.000
Organizational Climate and Culture (OCC)	2.85	0.019	8	.025

Significance=$p < 0.05$

Table 2 identified 8 new critical success factors in overcoming the existing barriers to IoT adoption. These factors were assessed and ranked from 1st to 8th as presented in Table 3; interoperability between information systems was ranked 1st (M=3.46, SD=0.2), technology awareness was ranked 2nd (M=3.4, SD=0.9), crafting balanced policy and building coalitions was ranked 3rd (M=3.3, SD =0.9), promoting standards and technology advancement was ranked 4th (M=3.2, SD =0.9), enabling infrastructure availability and access was ranked 5th (M=3.1, SD=0.02), encouraging markets was ranked 6th (M=3.1, SD=0.8), interoperability interfaces and compatibility among technology systems was ranked 7th (M=2.9, SD=0.1) and lastly, organizational climate and culture (OCC) was ranked 8th (M=2.9, SD=0.01). The result further showed that, technology awareness (p=0.000), enabling infrastructure availability and access (p=0.000), crafting balanced policy and building coalitions (p=0.000), interoperability interfaces and compatibility among technology systems (p=0.003), promoting standards and technology advancement (p=0.000), encouraging markets (p=0.000), interoperability between information systems (p=0.000), and organizational climate and culture (occ) (p=0.025), would significantly abate the IoT barriers if implemented in the construction industry.

5. DISCUSSION

This study was carried out within the metropolis of EnuguState, and data was collected through the use of structured questionnaires. It was noted that, from the 11 critical success factors outlined, only 3 was already an existing approach, as 8 were new and had not been adopted and practiced.

Awareness of technological solutions of IoT, enabling infrastructure availability and access, crafting balanced policy and building coalitions,interoperability interfaces and compatibility among technology systems, promoting standards and technology advancement, promoting the advancement of IoT through department usage, application, iterative enhancement, and novel usage of the technologies, interoperability between information systems, and lastly, organizational climate and culture or willingness to commit to technological investment amongst stakeholders, were all indicated to be critical success factors the industry looks forward to implement and practice. This was in congruent with the findings of [19] who noted leadership, company size, usability of proposed solution, and cost of implementation to be an existing approach in overcoming barriers to IoT adoption.

The result further shows that, the existing approaches in overcoming the barriers to IoT adoption is almost not practiced, as indicated by the participants in the various construction firms. This finding agrees with [10] who opined that, the concept of IoT has not been widely used in theNigerian construction industry because of the low levelof awareness and understanding amongst Nigerian construction professionals. And thus, poses a great challenge.

Lastly, the participants indicated that the identified critical success factors, which were, interoperability between information systems, technology awareness, crafting balanced policy and building coalitions, promoting standards and technology advancement, enabling infrastructure availability and access, encouraging markets, interoperability interfaces and compatibility among technology systems and lastly, organizational climate and culture (OCC), poses a potential significant effect in abating the menace concerning IoT adoption if implemented and practiced in the industry.

6. LIMITATIONS

The study encountered a hurdle during the data collection from the various respondents, as so many were not ready to give an attention due to their very busy schedule. The study took weeks of revisiting the sites to convince themfor a compliance. This constraint limits the chances of achieving a trustworthy conclusion or generating results that can be used to make appropriate projections. It is therefore possible that some invalid responses were obtained due to nonchalance on the part of the participants, or probably lack of proper understanding of the whole context of this research and the meaning of some terms used in the questionnaire.

7. CONCLUSION

The extant literatures reviewed have shown the barriers to adoption of IoT in building technology. The paper revealed that, the discipline to practice the already existing approaches in overcoming the barriers hovering on IoT adoption by the professionals, is a challenge. However, the paper has identified some significant factors that if implemented and practiced by the professionals, would effectively abate the barriers surrounding the adoption of IoT in the construction industry. These were outlined as, interoperability between information systems, technology awareness, crafting balanced policy and building coalitions, promoting standards and technology advancement, enabling infrastructure availability and access, encouraging markets, interoperability interfaces and compatibility among technology systemsand lastly, organizational climate and culture (OCC).

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