ASSESSMENT OF THE AWARENESS OF SMART BUILDING CONCEPT AMONG CONSTRUCTION PROFESSIONALS IN ABUJA

BY

OJONUBA GOODNESS ENYO-OJO

2016/1/59605TI

DEPARTMENT OF INDUSTRIAL AND TECHNOLOGY EDUCATION

FEDERAL UNIVERSITY OF TECHNOOGY, MINNA

APRIL, 2023

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A RESEARCH PROJECT SUBMITTED TO THE

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DECLARATION

I **OJONUBA GOODNESS ENYO-OJO**, with Matric No: 2016/1/59605TI an undergraduate student of the Department of Industrial and Technology Education certify that the work embodied in this project is original and has not been submitted in part or full for any other diploma or degree of this or any other university

Ojonuba Goodness Enyo-Ojo
2016/1/59605TI

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sign

CERTIFICATION

This project has been read and approved as meeting the requirements for the award of B. Tech degree in Industrial and Technology Education, School of Science and Technology Education, Federal University of Technology, Minna.

______________________ ______________________

Dr. I. Dauda Sign & Date
Project Supervisor

______________________ ______________________

Prof. T.M. Saba Sign & Date
Head of Department

______________________ ______________________

External Examiner Sign & Date

DEDICATION

This research is dedicated to the Lord God Almighty, who created and granted me with this opportunity and gave me strength and patience throughout my undergraduate journey. This research is also dedicated to my late dad, for his unwavering support and prayers up until the end of this program.

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ABSTRACT

Technological innovations has impacted the way and manner in which our built environment are developed and designed. The construction industry as evolved overtime with the induction of modern technologies in building construction giving rise to various innovations such as the internet of things (Iot), 4D stimulations, building information modelling (BIM), artificial intelligence (AI) etc. to carryout operations and reduce the complexity of construction activities and enhance productivity. Smart building concept is critical to the development of sustainable and energy-efficient structures. In Abuja, the awareness of this concept among construction professionals is crucial to the realization of sustainable and energy-efficient structure. This research aimed to assess the awareness of smart building concept among construction professionals in Abuja, specifically focusing on Builders and Architect. Measuring their awareness of smart building concepts through their knowledge of smart building components. The research made use of a quantitative research approach to collect data through questionnaires and analyze the data using descriptive statistics. The findings from the study discovered that construction professionals are fairly aware of smart building concept, and barriers limiting implementation and possible solution were also discussed. Based on the research findings, the research recommends that construction professionals should be open to innovation and embrace the use of modern technologies to carry out task. Furthermore, the research also encouraged the implementation of government policies and regulatory guidelines to promote the use of smart building technology among construction professionals. This study contribute to knowledge by identifying the barriers to awareness and implementation of smart buildings, while also exploring potential benefits and providing actionable solutions. Thus serving as a solid base for future research.

TABLE OF CONTENT

Contents page

Cover Page	
Title Page	
Declaration	i
Certification	ii
Dedication	iii
Acknowledgements	iv
Abstract	v
Table of Content	vi
List of Tables	x
CHAPTER ONE	
1.0 INTRODUCTION	**1**
1.1 Background of Study	1
1.2 Problem Statement	3
1.3 Purpose of study	4
1.4 Significance of Study	4
1.5 Scope of the study	5
1.7 Hypothesis of study	6

CHAPTER TWO 7

2.0 LITERATURE REVIEW 7

2.1 Conceptual Framework 7

2.1.1 The concept of smart building 7

2.1.2 History and evolution of smart building 10

2.1.3 Component of smart building 13

2.1.4 Benefits of Smart Building 17

2.2 Review of Empirical Studies 19

2.3 Summary of Literature Review 21

CHAPTER THREE 23

3.0 RESEARCH METHODOLGY 23

3.1 Introduction 23

3.2 Design of Study 23

3.2 Area of the Study 23

3.3 Population of the Study 24

3.4 Sample and Sampling Technique 25

3.5 Instrument for Data Collection 25

3.6 Validation of the Instrument 26

3.7 Administration of the Instrument 26

3.8	Method of Data Collection	26
3.9	Method of Data Analysis	26
CHAPTER FOUR		28
4.0	PRESENTATION AND DATA ANALYSIS	28
4.1	Research Question I	28
4.2	Research Question II	29
4.3	Research Question III	30
4.4	Research Question IV	32
4.5	Hypothesis I	34
4.6	Hypothesis II	36
4.7	Hypothesis III	38
4.8	Findings of the study	40
4.9	Discussion of findings	42
CHAPTER FIVE		45
5.0	SUMMARY CONCLUSION AND RECOMMENDATION	45
5.1	Summary of the Study	45
5.2	Implication of the Study	46
5.3	Contribution to Knowledge	46
5.4	Conclusion	46

5.5	Recommendation	47
5.6	Suggestion for Further Studies	48
REFERENCES		49
APPENDIX I		53
APPENDIX II		54

LIST OF TABLES

Table		Page
4.1	Mean response of construction professionals (Builders and Architects) in Abuja on the components of smart building	28
4.2	Mean responses of construction professionals (builders and architects) on the level of awareness of smart building components among construction professionals in Abuja.	29
4.3	Mean responses of construction professionals on challenges and barriers to the successful implementation of smart building concept in construction projects in Abuja.	31
4.4	Mean responses of construction professionals on the solutions to the challenges and barriers to the successful implementation of smart building concept in construction projects in Abuja	32
4.5	mean standard deviation and t-test on the awareness level of smart building components among construction professionals in Abuja.	35
4.6	mean standard deviation and t-test on the challenges and barriers facing the successful implementation of smart building concept in construction projects in Abuja	36
4.7	Mean standard deviation and t-test on the solutions to the challenges and barriers to the successful implementation of smart building concept in construction projects in Abuja	38

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of Study

Building construction is an ancient human practice. It all started with the primary goal of creating a controlled environment that would help reduce the effects of weather. Earlier humans erected temporary shelters with natural materials available to them, which enabled them to adapt to various weather conditions. With the passage of time and advancement of civilization other needs for buildings emerged and new methods of design and construction were introduced replacing the old and traditional methods with advent of innovations and technology.

Technology contributes greatly to our daily lives and drives us towards an advanced social development. Through the usage of the internet, technology has brought the world closer together as a small global village. We communicate, send messages, move from place to place and carry out various tasks by means of technology. In numerous industries today, most firm and organization uses ICT extensively to improve their services and prospects of being world leader in customer services (Berawi, *et al.,* 2017). The construction industry is not left out of this global wave of technological revolution as ICT is being incorporated into buildings in form of Automated, intelligent and smart buildings.

Smart buildings originated from intelligent building which were first developed in the U.S in the early 1980s. Which have ever since spread its root as an integral element of information technology in the construction industry. It began with the idea of giving a building some level of intelligence to enable it interact with its user and its surrounding environment. On its own a building cannot be intelligent it requires some human intervention to give it some level of artificial intelligence (Iwagwu & Iwagwu, 2014).

Artificial intelligence integrated into buildings by means of smart features and gadgets enables a building adapt and interact with its environment while satisfying the needs of it users. Every building is part of an environment. Its either the building influences its environment or the environment influences the building. A smart building is a building with absolute control of its own environment (Buckman, *et al.,* 2014). An enhance ability to control change has sparkled developments in the way our physical environment are designed, giving rise to growth in the areas of smart buildings.

Buildings nowadays are required to perform certain functions apart from just shelter, building designs and performance and now very dynamic and more complex than they were in the past century with longevity, energy/efficiency, comfort and satisfaction as the core drivers of modern design and construction. These drivers for development of buildings can be said to revolve around adding value to a structure (Smith, 2002). This value depending on the building purpose, refers to the areas relating to performance, total cost of building, comfort and satisfaction of the needs and demands of its inhabitants (CABA, 2008). For a building to be an advance performing building and carry out its required function it has to implement this driver right from design to construction.

There is a rapid growth of technological advancement and innovations ongoing in the world, and the construction industry has not been left out. There is a demand for more project visibility and better risk management at lower cost from project owners. Resulting to a high surged in the use of modern technologies for project delivery (Ogwueleka & Ikediashi, 2017). The need to provide a comfortable and efficient environment at low cost has led to a rapid increase in the adoption and usage of smart buildings.

Smart building refers to infrastructures built with systems and facilities that integrate new technologies for management automation and control of their air conditioning, lighting, security, electricity, communication entertainment and access. Smart buildings are computerized to minimize Heating, Ventilation and air conditioning (HVAC) alongside lighting and energy usage for other conveniences (Cook & Das, 2005).The interconnectivity and automation of these systems enhance energy efficiency, security, accessibility and usability, taking advantage of available resources. An idea smart building provides a dynamic and responsive infrastructure using technology so as to optimize process, comfort, effectiveness, flexibility, energy efficiency, cost and environmental benefits (Gadakari, et. al., 2014).

According to experts, smart buildings trend will become more of a requirement for modern construction. These infrastructures will be key to improving the quality of life and personal well-being while improving efficiency, productivity and economic growth.

1.2 Problem Statement

While the world is experiencing a global rise in the usage and adaptability of smart buildings, In Nigeria today, it is evident that the concept of smart building has not been fully utilized. This according to key players in the field has been said to be as a result of many factors among which is notably the low level of awareness and understanding of smart building concepts among user/consumers. Before full adoption of any new technology can take place, knowledge of such technology concepts much be readily available and accessible to the consumers.

This study attempts using professionals knowledge of smart building components to assess their level of awareness of smart building concepts. This is with the view of assisting the building sector with key information of professional's awareness and understanding of smart building concept.

1.3 Purpose of study

The general objective of the study is to assess the awareness level of smart building concept among construction professionals. While the specific objectives of this study includes;

1. To investigate construction professionals level of awareness of smart building concept.
2. To investigate the barriers to the successful implementation of smart building concept in Abuja
3. To identify solutions to the challenges facing the successful implementation of smart building concept in Abuja.

1.4 Significance of Study

Technology has taken central stage in our lives, as we depend on it largely for our day to day activities ranging from automobiles to telecommunications. Technology tends to speed up and optimize every process, either to give us comfort or to contribute to the efficiency in the use of resources.

Humans activities around the world has impact the environment negatively causing serious damage to the ecosystem. Therefore smart building provides a more sustainable and suitable environmental to modern lifestyles.

Building construction and design are changing in response to diver's global and technological advancement in the construction industry. The demand for comfort, energy efficient and environment friendly building has given rise to new innovations in the field of construction has led to new methods of design and construction of our buildings. The knowledge and understanding of these new technologies and ideas by professionals has a significant impact on their level of appreciation.

With modern technologies just evolving, the level of awareness of smart buildings in developing countries is relatively very low. The commonest smart feature in Nigeria today is the sensor controlled glass door in commercial buildings (Iwagwu & Iwagu, 2014). The low level of awareness of smart building in Nigeria is a concern because technological innovations are ever dynamic and Nigeria should not be left out.

This research tries to investigate the awareness of smart building among construction Professionals in Abuja and provide ways of promoting awareness.

1.5 Scope of the study

This study focuses on the assessment of the awareness of smart building concept in Abuja, Nigeria. This study will be limited to a survey of the awareness of smart building concept among construction professionals involving builders and architects practicing in FCT, Abuja. The awareness level of smart building will be measured through professional's knowledge of smart building components.

1.6 Research Questions

The study will answer the following research questions:

1. What are the components of smart buildings?
2. What is the level of awareness of smart building components among construction professionals in Abuja?
3. What are the challenges and barriers to the successful implementation of smart building technology in construction projects in Abuja?
4. What are the solutions to the challenges and barriers to the successful implementation of smart building technology in construction projects in Abuja?

1.7 Hypothesis of study

To further achieve the objectives of this study the following hypothesis are postulated and are to be tested in this study at 0.05 level of significance.

Ho_1: There will be no significant difference between the means response of construction professionals on the level of awareness of smart building components among construction professionals in Abuja.

Ho_2: There will be no significant difference between the means response of construction professionals on the challenges and barriers to the successful implementation of smart building concept in construction projects in Abuja

Ho_3: There will be no significant difference between the means response of construction professionals on the solutions to the challenges and barriers to the successful implementation of smart building concept in construction projects in Abuja

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Conceptual Framework

2.1.1 The concept of smart building

Buildings just like food, water and clothing are one of the basic needs of humans. In the primitive age, buildings were made to protect humans from harsh weather conditions. The early humans relied on hunting and were always migrating so the erected temporary structures made from materials such as animal skins, stones, straws, sticks and any other natural material available to them. However, overtime the early humans began agriculture and other needs for buildings aroused and they began to settle and erected more permanent structures to meet such needs. Today with the passage of time and the advancement in technology buildings are erect to serve various purpose and each aspect of a building has been improved and developed, allowing modern building owners to select various systems such as security, lighting, heating, ventilation and air conditioning systems independently to meet their desired needs from the building. For whatever purpose a building is erected to serve, they carry with some level of problems that needs to be addressed. The need to adopt and implement smart building concept in building construction is of utmost importance especially in developing economies like ours that are confronted with various environmental challenges. Insecurity and energy crisis which are very common housing sector issues in most part of the word could be alleviated by incorporating smart buildings concepts (Oyewole *et al.*, 2019).

Smart Building refers to various technologies incorporated into buildings. While there may not be a clear explanation of what turns a structure into a smart building. The term “Smart building” has been defined by various research and it is sometimes interchangeably used as intelligent building or automated building, which are not really the same as a result of the evolution of buildings from “conventional”, to “automated”, to “intelligent”, and then “smart” (Hoy, 2016).

Powell (1990) defined intelligent building as a building that controls its environment. Such mode of control didn’t include any interaction made by the user.

Capacity and Institution Building (CIB) in 1995 proposed the definition of a dynamic and responsive architecture for intelligent buildings which offers the users a cost-efficient, productive and competent environment by four fundamental components; i.e., place, process, people and management with the interrelations involved.

In 2002 Continental Automated Buildings Association (CABA) defined it as a building that offers safe, efficient, flexible and comfortable environment to its user by utilizing technological systems of control and communications integrated together.

Croome (2004) described intelligence as an innate, general cognitive ability underlying all processes of conventional reasoning. He described the term as not just an attribute but as a complete structure of information processing skills, creating an adaptive equilibrium between individual and their environment.

According to Garry (2004), the concept of intelligent building or intelligent homes, or building management system (BMS) embraces several technologies, spanning institutional, domestic, commercial, industrial building control and management systems.

Frank (2007) summarized previous definitions and explanations of intelligent building and described it as an automated building managed centrally to provide occupants with a safe, conducive, productive and energy efficient environment through technological devices that promotes sustainability and cost-efficiency.

The term "Intelligent building" was used more frequently up until 2011 when the term "Smart building" began to gain popularity over the previously-used term. Buckman *et al.*, 2014 described smart buildings as intelligent buildings with additives and combined elements of adjustable control, enterprise, materials and construction

Sinopoli (2010) described smart building as the integration design, construction and execution where applicable information is acquired within a smart building to control the management of its surrounding by the user.

In most recent researches smart building are defined has structures that provide high efficiency. Efficiency with respect to providing the highest possible output from the lowest available output while fitted with cutting edge sensors and electronic devices. What distinguish a smart building from highly electronic fitted buildings is the inter-connectivity of this devices which enables them to provide a conducive, safe, and flexible environment for its occupants (Owen 2016).

Modern construction has evolved, and smart building indicates this by incorporating artificial intelligence (AI), automated control systems and data computing into structures. A smart building can learn and adapt itself to its environment (Panchalingam & Chan 2019). Interaction and adaptability to the occupants and their needs is a game changer compared what we've seen from conventional buildings.

2.1.2 History and evolution of smart building

The concept of smart buildings has been around for decades. With much of today's built environment a product of previous generations' interests and influences, there are a few moments in history that have shaped our path towards smart buildings. Recognizing these moments is instrumental to both our understanding of smart buildings and their future development.

Smart buildings are not a really a brand new concept, the idea of smart buildings dates back to 80s in the United States (Wong & Li 2008) and the first intelligent buildings were constructed Hartfort, the United states in 1984 (Frank 2007). However Fantana (2013) believed the intelligent building concept refers to building automation which originated at a much earlier time in the industrial sector, when buildings was equipped with automation system which automates production processes and optimize plant performance. The energy crisis that occurred in 1973, raised concerns and awareness on energy consumption which led to the formation of smart features for energy consumption and crime prevention. The emergence of personal computers and telecommunications devices assisted the development of intelligent buildings. Buildings were regarded to as intelligent when the used computer technologies to continually maximize its occupants comfort, energy consumption, productivity, and safety (Coggan 2001). At this state multiple system integration was not possible and many subsystems such as access control, lighting control, fire system, and communication and lift control operated as individual units because the devices were produced by different manufacturers with no standard means of communication between them. In the 2000s the problem of integration and separation of subsystems was actualized. Individual systems could be accessed and controlled centrally as a unit even though the components were physically isolated from each other (Ahmed 2009).

Major Timeline in the History of Smart Buildings

The evolution of smart building were characterized by key timelines such as;

The Digital Revolution

The invention of the transistor which dates back to the late 1940s paved way for the digital revolution. Which was followed by the invention of the first computer in 1951, one of the most essential aspects of smart building. The next key development in the digital revolution came in the mid-1960s with development of ARPANET or as it known today, the internet. At the period this was a government project and only used for the military.

Environment Changes in the '70s

Towards the late 60's people started becoming more environmentally conscious. With the oil spill off the coast of California, there was a public outcry a more efficient build environment. The US government then introduced legislation to introduce eco-infrastructure which is referred to as the Green Building Movement. Throughout the '70s these environmental concerns grew due to the energy crisis which saw oil prices rise significantly. With this shift in mentality, another building block was put in place for the rise of smart buildings.

Major Advancements in the '80s

Both the technological and environmental advancements previously discussed lead to the creation of automated building system. In 1981, United Technology Building Systems described them as "intelligent buildings. The first intelligent buildings were mainly used to control heating, ventilation, and air conditioning (HVAC). These buildings enhanced low energy consumption and paved way for better building performance/efficiency. The 80's also brought about other major technological innovations, namely the mobile phone and the personal computer which turn out to be significant aspects of a smart building along the line.

The Property Boom

The '80s saw a shift towards intelligent buildings which perfectly coincided with the worldwide property boom towards the end of the '80s. With this rising development, there was also a demand for these new buildings to be as efficient as possible, and "intelligent buildings" could fill this void. Just to be clear, these intelligent buildings were not smart buildings yet but rather they contained some core elements of a smart building but lacked the connectivity, which would come further down the road.

The 90's and the World Wide Web

In the 1990s probably the most significant aspect of a smart building came about. In 1991, the internet was available to the public for the first time. Previously the internet was only available to the military as stated above. This invention changed so many aspects of our lives, including the way we communicate, work, and how we interact with technology. Buildings began to change as well. As businesses become more digitally connected with each other and their customers. Offices moved to a more open-plan environment to encourage people to be more collaborative. This aligned with the property boom, which continued into the '90s, saw buildings need to be as energy efficient as possible

Smart buildings in the 21st century

With the introduction of the internet, these intelligent buildings were coined "Smart Buildings" in the 2000s. Although it not until quite recently was we started to see Smart Buildings being introduced. It is now clear what benefits these buildings can provide, and we are seeing more and more smart buildings pop up. People have become much more conscious of the changing environment and want to reduce our effect on it. One of the main benefits of Smart Buildings is their ability to adapt to change. For example, many smart buildings take advantage of cloud computing which can significantly reduce a building's carbon footprint. As technology progresses, Smart Buildings will continue to take advantage of these developments.

What is the future of smart building?

There are some new and exciting advancements in technology that Smart Buildings may take advantage of in the future. One of these developments will focus on the people within the building. IoT (Internet of Things) could gather data about people's body temperature, heart rate, and perspiration to automatically match the building conditions, such as temperature, to make it a more comfortable environment for the people in it. This consequently enhance health and mental well-being of humans thereby enabling them to be as productive as possible.

2.1.3 Component of smart building

Identifying smart building components is critical to determining and measuring the level of awareness of smart building concept among construction professionals.

Indrawati *et al.,* (2017) and Qolomany et al., (2019) identified some of the components to measure the smart building: Theses componenets includes ;

I. Sensors and Actuators
II. Hvac and Lighting systems
III. Energy Management system
IV. IT network connectivity
V. Security and Access Control
VI. Building Automation system

Sensors and Actuators

Sensors and actuators are mechanical components that monitor and regulate their surroundings environmental parameters. Sensors gather data from the environment and prepare it for the system. IR sensors, for instance, can be used to detect human presence in a room (Qolomany et al., 2019). While an actuator is a device that converts an electrical control signal into physical action, it also makes judgments and executes appropriate actions in accordance with the environment, allowing for automatic and remote contact with the environment The explosive growth of micro mechanics, microelectronics, integrated optics, and other related technologies has facilitated the emergence of various types of embedded sensors integrated into daily objects and infrastructure at smart building contexts or worn by users, and are connected by network technologies in order to gather context information on daily activities more efficiently and quickly, with reduced energy consumption and computer resources.

Hvac and Lighting system

The HVAC and lighting systems in a smart building function with sophisticated control to maximize their efficiency. Occupancy sensors, for instance, may determine when a room is empty and automatically turn off the lights or lower the temperature to conserve energy.

In order to use less energy, the HVAC system can also modify its operation depending on the weather condition outside the building.

Additionally, cutting-edge technology like machine learning algorithms can examine data from these systems to find usage trends and further improve their performance. An intelligent HVAC and lighting system integrated into a smart building increases energy efficiency, boosts occupant comfort, and lowers operational costs for building owners.

Energy management system (EMS)

An energy management system (EMS) improves energy efficiency and maximizes energy savings over time (Batov 2015). According to Sgrò (2018), an energy management system ensures that energy consumed in the building is controlled and monitored. Amaral, Reis, and Brandao (2013) further explained that EMS is a system that monitors the cost of energy at home and controls how much energy is used, such as lowering the costs of operations and maintenance or even lowering the costs of fixed appliances. The EMS collects data on the building's energy consumption from various sources such as sensors, meters, and other monitoring devices. The system then uses this data to analyze energy consumption patterns, identify areas of energy waste, and propose strategies for optimizing energy use.

Overall, the EMS is an essential component of a smart building, helping to enhance energy efficiency, save costs, and reduce the building's environmental impact.

IT network connectivity

The IT network connectivity system of a smart building is the backbone of its digital infrastructure. It is responsible for linking all the devices and systems in the building to enable them to communicate and exchange information seamlessly. With the rise of the IoT, it is now possible to monitor and gather any data that is necessary for smart buildings (Laryea and Laryea, 2012). The connectivity system typically comprises a range of wired and wireless technologies such as Wi-Fi, Bluetooth, fiber optic cables, and Ethernet networks. It connects various components such as sensors, controllers, gateways, and servers to establish a unified network that can be accessed and managed easily.

A robust and reliable IT network connectivity system is integral to the functioning of a smart building. It enables seamless communication and collaboration between various digital systems, leading to improved efficiency, reduced downtime, and enhanced occupant experience.

Security and Access control

According to Zhao *et al.,* (2019) Smart building security component comprises of physical, cyber and digital security. Integrated into the building with the aid of advanced hardware and software technologies to secure the building from external breaches like theft and vandalism. Access control refers to the ability to control and manage access to specific areas within the building (Wang *et al.,* 2020). Security and access control are critical components that must be considered when designing and implementing smart building. By using advanced technologies to manage these aspects effectively, property owners can create safer and more secure environments for their occupants while reducing costs associated with theft or damage caused by unauthorized entry.

Building Automation System (BAS)

According to Ogunde et al. (2018), building automation systems employ computers and information technology (IT) to manage building appliances for improved building performance. Building Automation System (BAS) is a computer-based control system that manages and monitors the mechanical, electrical, and plumbing systems in a building. Smart buildings utilize BAS to create an efficient and sustainable environment for occupants. One of the key benefits of a BAS is improved energy efficiency. By monitoring energy consumption in real-time, the system can identify areas where energy is being wasted and make adjustments accordingly. This does not only saves money on utility bills but also reduces the building's carbon footprint. Building Automation System is an essential component of smart buildings that improve energy efficiency while enhancing occupant comfort. With continued advancements in technology, we can expect even more sophisticated BAS solutions that will further optimize our built environment

2.1.4 Benefits of Smart Building

Makarifi (2015), highlighted some of the benefits of smart building as follows;

i. Reduce Energy Consumption

Arguably one of the major benefits of smart buildings, the reduced energy consumption will not only benefit the users in terms of reduced carbon footprint and cost, but it also impact the planet positively. In smart buildings, energy usage can be controlled and automated per section, meaning no part of the building is heated or cooled when not in use. Thus significantly reducing energy wastage and unsustainable practices in standard buildings.

ii. Reduce Overall Costs

Costs are minimized by a more efficient building as a result of better, more informed, and frequently automated decision-making. One advantage of smart buildings is that you can lower your overall costs by just using the necessary energy in the portions of the building that are needed.

iii. Enhanced Security

A smart building combines various smart security features and devices to monitor, control and secure the building, such as smart locks, fire detectors, CCTV, alarms and so on, thereby boosting the security architecture of the building effectively. All this devices integrated with other systems can be automated in cases of emergency and provide crucial building insights.

iv. Automation

With all the system and devices integrated and communicating with each other, it creates room for automation. The ability to set custom automation is one of the major benefits of smart building, this enhance building performance and safety. For instance in case an intruder breaks in while the occupants are away, the security system could deny the intruder escape by locking down the building, thereby denying the intruder escape while locking down that section of the building on its own without the need for individual interference.

v. Predictive Maintenance

Maintenance is very crucial in buildings to ensure it is always operating at maximum efficiency. Thereby reducing the need for expensive repairs and replacements. Smart building collects data from each connected system and tends to predict when each device/sensor will need to undergo a maintenance check, thus preventing fully breakdown.

vi. Real-Time Data

Another major benefit of smart building is the ability to access real-time data, which can trigger timely and effective actions to take place. As a result, the building becomes responsive and adaptive, enabling it to operate at full potential.

vii. Improve User Comfort & Wellbeing

Smart building ability to manage and control key environment factors such as lighting and room temperature, improving indoor air quality. Factor such as carbon detection and ventilation flow can also be measured. The adaptation attribute of smart building along with data collected from occupants behavior will ensure the best conditions are always set for occupants.

2.2 Review of Empirical Studies

The smart building concept has gained recognition among construction professionals and academics working to preserve the environment and advance the construction industry's building sector (Ogunde *et al.*, 2018). Kashada, Li, and Kashadah (2016), stated that the adoption of smart building concept is considered in the five stages which includes: the awareness stage, conviction stage, decision-making stage, implementation stage, and confirmation stage. The awareness stage involves the end-users and professionals acquiring information and knowledge about the technology. In contrast, the conviction stage involves the end-users and professionals choosing to adopt the new technology, while the decision-making phase involves the end-users and professionals deciding to adopt the new technology. Both parties finally implement the new technology in the implementation stage. Conclusively, in the confirmation stage, both the end-users and professionals assess the result of new technology and expect better outcomes.

Renaud and van Biljon (2008) noted that adoption of smart building begins with the awareness of smart building concept among clients and professionals. According to Ahiabor (2019) many professionals and organization lack proper understanding of smart building concepts, thus limiting the implantation and use of smart building features in the construction industry.

Usman and Khamidi (2012) revealed that awareness of the smart building concept refers to strategies and exercises that help professionals understand the concept. Findings from previous research in the construction industry of developing countries revealed that the adoption of smart building concepts, attributed to a low level of awareness and understanding of Smart Building Concept amongst construction professionals, is still very low (Ghansah, *et al.*, 2020).

Ahiabor (2019), in his study, opined that the smart building concept needs better understanding by the professionals in the adoption of smart building technologies and creates clear opportunities for development by the real estate agent and developer. Mensah (2016) opined that awareness of environmental construction sustainability as part of smart building among professionals is still low due to a lack of knowledge on how to execute the practice.

In Nigeria, as a developing country, there seem to be scare literature on smart buildings; previous researchers worked on the awareness of building automations, intelligent buildings and smart building features in the Nigeria construction industry.

Makarfi (2015), in her study, “An assessment of the level of awareness of intelligent building amongst Nigerian architects, a case study of Kaduna metropolitan area,” concluded that despite the intelligent building being part of the smart building concept, her study discovered that the awareness of intelligent building is low among the architect in the construction industry of the Kaduna metropolitan area. But her study was limited to architects in Kaduna as the opinion of other professionals was not included in the study.

Ogunde et al. (2018) assessed the integration of building automation systems in Nigeria’s residential areas and discovered a low level of awareness among construction professionals, building automation system are also essential components of smart building.

In a more recent study Oyewole et al. (2019) evaluated the awareness of smart building among and the level of appreciation of smart building features among Lagos state residents and professionals and also noted that there exist a low level of awareness of smart building concepts.

2.3 Summary of Literature Review

This reviewed literature covered the conceptual framework with the aim of providing a relatively comprehensive description of contents and studies that relates the present research with a view of exploring past studies in order to reveal the deep of work undertaken that relates to the present research. As such, in seeking to assess the awareness of smart building among construction professionals in Abuja. The study based on the following conceptual studies: smart building, history and evolution of smart building, components of smart buildings, benefits of smart building.

Findings from the recent studies revealed there is a low level of awareness of smart building and construction professionals in the building sector of the Nigerian construction industry have not taken full advantage of smart building concepts despite its numerous benefits. This is therefore a gap. That necessitated the study on the assessment of the awareness of smart building concept in Abuja.

CHAPTER THREE

3.0 RESEARCH METHODOLGY

3.1 Introduction

This chapter discusses the methodology deployed to carry out the study. In light of this, the study's areas and the factors that influenced the choice of location are described. This chapter provides explanation on the research design and approach, population, sample and sampling procedures, validation of instrument, data collection and the method for data analyses and data presentation.

3.2 Design of Study

Osanloo and Grant (2016) defined research design as the method for structuring an inquiry or carrying out investigation to find variables and their relationships. It is a strategy that specifies how, when, and where data will be collected and analyzed (Creswell and Poth, 2016). However, the design to be selected is based on the research approach that is more suitable for the study.

This study deployed a descriptive survey research design approach where a small group or an entire population is observed through organizing, collection and analyzing data from the information gathered through the use of questionnaire. The Descriptive survey research design through the use of questionnaires gathers information and seeks the opinions of respondents, hence the reason this approach was deployed and considered suitable for the Assessment of the awareness of smart building concepts among construction professionals in Abuja. Since the study seeks data from a sample drawn from a population using questionnaire.

3.2 Area of the Study

The target location for the purpose of this study is Federal Capital Territory (FCT) Abuja, Nigeria. Abuja located at latitude 9.06 and longitude 7.05 and situated at elevation 476 meters above sea level. The federal capital territory located within the middle belt region of Nigeria shares it borders on the north with Kaduna state, at the west with Niger State, south-east with Nasarawa and Kogi state at south-west.

Abuja is a rapidly growing city with a thriving construction industry. The city is home to numerous commercial and residential structures, including office buildings, government facilities, hotels, shopping malls, and private homes. It is therefore important to evaluate the level of awareness of smart building concept among construction professionals in the city.

The study will be conducted through a survey of construction professionals, including builders, and architects. The selected professionals will be from different sectors such as public, private, and non-governmental organizations involved in construction activities.

Abuja is an ideal location for the study due to the rapid growth of the construction industry and the need for sustainable and innovative building practices. The aim of the study is to assess the level of awareness of smart building concept among construction professionals in Abuja and to determine the extent to which smart building practices are being embraced in the city.

3.3 Population of the Study

According to Bornstein, *et al.,* (2013) defined study population as the entirety of all the elements under observation, which constitutes all the things in any field of investigation. Thus, in carrying out research the population of study refers the entire group of people in a geographical region whose characteristics are estimated. The study population for this research study comprises of construction professionals which involves builders and architects practicing in Abuja as they are the primary participants at the fore front of the Nigerian construction industry

3.4 Sample and Sampling Technique

According to Nardi (2018), the sampling technique is the most effective way to estimate the amount of data needed and understand how data is gathered within a population to meet the study objectives. The random probability sampling techniques was adopted for this study. In a random probability sampling each respondent has an equal chance and likelihood of being selected for the questionnaire.

3.5 Instrument for Data Collection

The survey research design was used in this study due to the nature of the study. The questionnaire is the most common instrument used to gather descriptive data from a sample group in a survey research (Nardi, 2018) because the respondents have the advantage of providing data and information from the source. The questionnaire consisted mainly of closed end questions to ensure that quantitative data ere adequately captured. This study employed the use of questionnaire as its primary instrument for data collection. According to Abawi (2013), questionnaire is a method of data collection which consists of a series of questions with multiple options of response intending to gather information from respondents. The questionnaire used for this study consisted of two parts designed to answer the research questions. Part I seeks to obtain background information of the respondents. Part II is divided into four sections. Section A contains information about the components of smart building, section B consists of information on respondent’s level of awareness of smart building components, section C contains factors limiting the awareness and implementation of smart building among professionals and section D consists of solutions to the challenges of implementing smart building.

The response categories for the questionnaire was structured on a four point rating scale as follows:

Strong Agree (SA)	4 points	Very High Level (VHL)	4 points
Agree (A)	3 points	High Level (HL)	3 points
Disagree (D)	2 points	Low Level (LL)	2 points
Strong Disagree (SD)	1 points	Very Low Level (VLL)	1 points

3.6 Validation of the Instrument

The instrument was validated by the project supervisor and two other lecturers from the department of Industrial and Technology Education at Federal University of Technology Minna to determine the appropriateness of the item before it was administered to the respondents. Necessary corrections and adjustments were made before the final questionnaires were produced.

3.7 Administration of the Instrument

The administration of the research instrument was carried out by the research through physical distribution and retrieval to professionals. Questionnaires were distributed to construction professionals involving Builders and architects practicing within Abuja both in private and public organizations. The Questionnaire took between 15 and 20 minutes to complete.

3.8 Method of Data Collection

Data were collected through well-structured questionnaires with closed-end questions. Among the 110 copies of questionnaires distributed, 80 copies were retrieved and used for analysis. The possibility of retrieving back most questionnaires was as a result of the face to face distribution carried out by the researcher.

3.9 Method of Data Analysis

Data obtained from the questionnaire was analyzed using mean, standard deviation and t-test as statistical tool via Microsoft excel. The mean was used to answer the research questions one, two and three, while the null hypothesis was tested using t-test at 0.05 level of significance. The cutoff point for decision making on each item was 2.50 based on the four-point rating scale, items with mean score of 2.50 or above were regarded as needed while items with mean score below 2.50 were regarded to as not needed. Each t-value calculated that was less than the critical value at 0.05 level of significance was accepted while t-value that is equal to or less than the critical value was rejected.

CHAPTER FOUR

4.0 PRESENTATION AND DATA ANALYSIS

This chapter presents the analyses and discussion of the findings emanating from the data obtained from the field survey. Data were obtained and analyzed according to the research questions formulated for the study, the result of this data analysis for the research question are:

4.1 Research Question I

What are the components of smart building?

Table 4.1: Mean response of construction professionals (Builders and Architects) in Abuja on the components of smart building.

N_1=47 N_2=39

S/N	ITEMS	$\bar{X}_1$	$\bar{X}_2$	$\bar{X}t$	Remarks
1	Sensors and Actuators	3.09	2.85	2.97	Agreed
2	Hvac and Lighting systems	3.12	3.11	3.08	Agreed
3	Energy Management system	3.13	2.87	3.00	Agreed
4	IT network connectivity	3.04	3.15	3.09	Agreed
5	Security and Access Control	3.28	3.30	3.29	Agreed
6	Building Automation system	2.80	3.23	3.02	Agreed

KEY

$\bar{X}_1$ = Mean of builders

$\bar{X}_2$ = Mean of architects

$\bar{X}t$ = Average mean of the respondents

N_1 = Numbers of builders

N_2 = Numbers of architects

RMK = Remarks

The result presented in the Table 4.1 above indicates that the constructional professionals (builders and architects agree with all the items 1, 2, 3, 4, 5, 6 with mean score of 2.50, indication that all the respondents agreed with the items on the components of smart building.

4.2 Research Question II

What is the level of awareness of smart building components among construction professionals in Abuja?

Table 4.2: Mean responses of construction professionals (builders and architects) on the level of awareness of smart building components among construction professionals in Abuja.

N_1=47 N_2=39

S/N	ITEMS	$\bar{X}_1$	$\bar{X}_2$	$\bar{X}t$	Remarks
1	Sensors and Actuators	2.80	2.69	2.75	High
2	Hvac and Lighting systems	2.72	3.02	2.87	High
3	Energy Management system	3.02	2.77	2.90	High

4	IT network connectivity	2.91	2.97	2.94	High
5	Security and Access Control	3.30	3.23	3.26	High
6	Building Automation system	2.65	3.05	2.85	High

KEY

$\bar{X}_1$ = Mean of builders

$\bar{X}_2$ = Mean of architects

$\bar{X}t$ = Average mean of the respondents

N_1 = Numbers of builders

N_2 = Numbers of architects

RMK = Remarks

The result presented in table 4.2 indicates that the awareness level of smart building components is fairly high among construction professionals in Abuja with all the items 1, 2, 3, 4, 5, 6 with mean score above 2.50, indicating that all respondents have a high level of awareness of smart building components.

4.3 Research Question III

What are the challenges and barriers to the successful implementation of smart building concept in construction projects in Abuja?

Table 4.3: Mean responses of construction professionals on challenges and barriers to the successful implementation of smart building concept in construction projects in Abuja.

N_1=47 N_2=39

S/N	ITEMS	$\bar{X}1$	$\bar{X}2$	$\bar{X}t$	REMARK
1	Lack of training and education on smart building technology among construction professionals	3.41	3.44	3.43	Agreed
2	Limited Access to stable power supply	3.06	3.10	3.08	Agreed
3	Lack of interest from clients	2.83	2.92	2.88	Agreed
4	High cost of implementing smart building	3.15	3.10	3.13	Agreed
5	Lack of local facilities for research	3.07	3.10	3.09	Agreed
6	Limited access to reliable and high-speed internet	3.15	3.08	3.16	Agreed
7	Cybersecurity concerns	3.28	3.03	3.16	Agreed
8	Limited availability of skilled manpower to maintain the building	3.37	3.26	3.32	Agreed
9	Limited availability of technical support	3.37	3.33	3.35	Agreed
10	Resistance to change from traditional building practices	3.04	3.03	3.04	Agreed
11	Lack of government policies and regulations	3.02	2.72	2.87	Agreed

KEY

$\bar{X}_1$ = Mean of builders

$\bar{X}_2$ = Mean of architects

$\bar{X}t$ = Average mean of the respondents

N_1 = Numbers of builders

N_2 = Numbers of architects

RMK = Remarks

The result presented in Table 4.3 above revealed that construction professionals agree with all the items 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 and 11 with the mean score of 2.50, indication that all the respondents agreed with the items on the challenges and barriers to the successful implementation of smart building concept in construction projects in Abuja.

4.4 Research Question IV

What are the solutions to the challenges facing the successful implementation of smart building technology in construction projects in Abuja?

Table 4.4: Mean responses of construction professionals on the solutions to the challenges and barriers to the successful implementation of smart building concept in construction projects in Abuja

				N_1=47	N_2=39
S/N	**ITEMS**	**$\bar{X}_1$**	**$\bar{X}_2$**	**$\bar{X}t$**	**REMARK**
1	Availability of comprehensive educational training and workshop for professionals, developers, and policy makers	3.59	3.56	3.58	Agreed

2	Collaboration with educational sector to include smart building concepts in school curriculums	3.39	3.38	3.39	Agreed
3	Collaboration among stakeholders	3.22	3.27	3.24	Agreed
4	Availability of professional network to support smart building	3.47	3.41	3.44	Agreed
5	Promotional offers and trade shows	3.26	3.36	3.31	Agreed
6	Create public awareness	3.54	3.48	3.51	Agreed
7	Availability of stable power supply	3.17	3.36	3.27	Agreed
8	Develop new policies and regulations to support smart building	3.37	3.43	3.40	Agreed
9	Availability of better information on cost and benefits	3.24	3.28	3.26	Agreed
10	Availability of local facilities for research	3.52	3.49	3.51	Agreed
11	Collaboration with government agencies to promote the use of smart building technology	3.46	3.54	3.50	Agreed
12	Availability of skilled manpower	3.48	3.51	3.50	Agreed

13	Develop certification programs on smart building for construction professionals	3.67	3.59	3.63	Agreed
14	Availability of fast and reliable internet connection	3.17	3.10	3.14	Agreed

KEY

$\bar{X}_1$ = Mean of builders

$\bar{X}_2$ = Mean of architects

$\bar{X}t$ = Average mean of the respondents

N_1 = Numbers of builders

N_2 = Numbers of architects

RMK = Remarks

The result presented in Table 4.4 above revealed that construction professionals agree with all the items 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 with the mean score of 2.50, indication that all the respondents agreed with the items on the solutions to the challenges and barriers to the successful implementation of smart building concept in construction projects in Abuja.

4.5 Hypothesis I

There will be no significant difference between the means response of construction professionals on the level of awareness of smart building components among construction professionals in Abuja.

Table 4.5: mean standard deviation and t-test on the awareness level of smart building components among construction professionals in Abuja.

N_1=47 N_2=39

S/N	ITEMS	SD_1	SD_2	t-Cal	Remarks
1	Sensors and Actuators	0.85	0.85	0.24	NS
2	Hvac and Lighting systems	0.71	0.66	-0.69	NS
3	Energy Management system	0.82	0.80	0.51	NS
4	IT network connectivity	0.62	0.70	-0.13	NS
5	Security and Access Control	0.69	0.69	0.14	NS
6	Building Automation system	0.89	0.64	-0.90	NS

KEY

SD_1 = Standard deviation of Builders

SD_2 = Standard deviation of Architects

T-cal = t-calculated

T- Critical =

NS = Not significant difference

S = Significant difference.

The data obtain from Table 4.5 above indicate that the calculated t-value of all items were less than the critical value (±1.990) at 0.05 level of significant. Thus, the null hypothesis which says there is no significant difference between the mean responses of construction professionals on the level of awareness of smart building components among construction professionals in Abuja is accepted.

4.6 Hypothesis II

There will be no significant difference between the means response of construction professionals on the challenges and barriers to the successful implementation of smart building concept in construction projects in Abuja

Table 4.6: mean standard deviation and t-test on the challenges and barriers facing the successful implementation of smart building concept in construction projects in Abuja

N_1=47 N_2=39

S/N	ITEMS	SD_1	SD_2	t-Cal	RMK
1	Lack of training and education on smart building technology among construction professionals	0.53	0.55	-0.04	NS
2	Limited Access to stable power supply	0.56	0.63	-0.07	NS
3	Lack of interest from clients	0.79	0.80	-0.21	NS
4	High cost of implementing smart building	0.69	0.78	0.10	NS
5	Lack of local facilities for research	0.69	0.71	-0.55	NS
6	Limited access to reliable and high-speed internet	0.76	0.80	-0.02	NS
7	Cybersecurity concerns	0.78	0.80	0.24	NS

8	Limited availability of skilled manpower to maintain the building	0.54	0.54	0.05	NS
9	Limited availability of technical support	0.57	0.65	0.07	NS
10	Resistance to change from traditional building practices	0.72	0.77	0.04	NS
11	Lack of government policies and regulations	0.79	0.90	0.61	NS

KEY

SD_1 = Standard deviation of Builders

SD_2 = Standard deviation of Architects

T-cal = t-calculated

T- Critical =

NS = Not significant difference

S = Significant difference.

The data obtain from Table 4.6 above indicate that the calculated t-value of all items were less than the critical value (±1.990) at 0.05 level of significant. Thus, the null hypothesis which says there is no significant difference between the mean responses of construction professionals on the challenges and barriers to the successful implementation of smart building concept in construction projects in Abuja is accepted.

4.7 Hypothesis III

There will be no significant difference between the means response of construction professionals on the solutions to the challenges and barriers to the successful implementation of smart building concept in construction projects in Abuja

Table 4.7: mean standard deviation and t-test on the solutions to the challenges and barriers to the successful implementation of smart building concept in construction projects in Abuja

N_1=47 N_2=39

S/N	ITEMS	SD_1	SD_2	t-Cal	RMK
1	Availability of comprehensive educational training and workshop for professionals, developers, and policy makers	0.49	0.50	0.04	NS
2	Collaboration with educational sector to include smart building concepts in school curriculums	0.61	0.58	0.01	NS
3	Collaboration among stakeholders	0.41	0.44	-0.08	NS
4	Availability of professional network to support smart building	0.54	0.54	0.12	NS
5	Promotional offers and trade shows	0.67	0.58	-0.18	NS
6	Create public awareness	0.50	0.64	0.10	NS

7	Availability of stable power supply	0.79	0.73	-0.35	NS
8	Develop new policies and regulations to support Smart building	0.64	0.63	-0.12	NS
9	Availability of better information on cost and benefits	0.56	0.50	-0.08	NS
10	Availability of local facilities for research	0.54	0.63	0.06	NS
11	Collaboration with government agencies to promote the use of smart building technology	0.65	0.55	-0.15	NS
12	Promote the use of ICT in building construction	0.54	0.55	-0.06	NS
13	Develop certification programs on smart building for construction professionals	0.51	0.59	0.14	NS
14	Availability of fast and reliable internet connection	0.56	0.56	0.14	NS

KEY

SD_1 = Standard deviation of Builders

SD_2 = Standard deviation of Architects

T-cal = t-calculated

T- Critical =

NS = Not significant difference

S = Significant difference.

The data obtain from Table 4.7 above indicate that the calculated t-value of all items were less than the critical value (±1.990) at 0.05 level of significant. Thus, the null hypothesis which says there is no significant difference between the mean responses of construction professionals on the solutions to the challenges and barriers to the successful implementation of smart building concept in construction projects in Abuja is accepted.

4.8 Findings of the study

Based on the data collected and analyzed, the following findings were made;

1. Finding related to what are the smart building components revealed that smart building components consist of:

    - ✓ Sensors and Actuators
    - ✓ Hvac and Lighting systems
    - ✓ Energy Management system
    - ✓ IT network connectivity
    - ✓ Security and Access Control
    - ✓ Building Automation system.

2. Findings relating to the level of awareness of smart building components among construction professionals in Abuja revealed that there is a high level of awareness of smart building component among construction professionals. Although there is a high level of awareness of this components the level of awareness of each component varies among professionals.
3. Findings related to the challenges and barriers to the successful implementation of smart building concept in construction projects in Abuja identified the barriers as;
    - ✓ Lack of training and education on smart building technology among construction professionals
    - ✓ Limited Access to stable power supply
    - ✓ Lack of interest from clients
    - ✓ High cost of implementing smart building
    - ✓ Lack of local facilities for research
    - ✓ Limited access to reliable and high-speed internet
    - ✓ Cybersecurity concerns
    - ✓ Limited availability of skilled manpower to maintain the building
    - ✓ Limited availability of technical support
    - ✓ Resistance to change from traditional building practices
    - ✓ Lack of government policies and regulations
4. Findings relating to the solutions to the challenges and barriers to the successful implementation of smart building concept in construction projects in Abuja includes;
    - ✓ Availability of comprehensive educational training and workshop for professionals, developers, and policy makers

- ✓ Collaboration with educational sector to include smart building concepts in school curriculums
- ✓ Collaboration among stakeholders
- ✓ Availability of professional network to support smart building
- ✓ Promotional offers and trade shows
- ✓ Create public awareness
- ✓ Availability of stable power supply
- ✓ Develop new policies and regulations to support
- ✓ Availability of better information on cost and benefits
- ✓ Availability of local facilities for research
- ✓ Collaboration with government agencies to promote the use of smart building technology
- ✓ Promote the use of ICT in building construction
- ✓ Develop certification programs on smart building for construction professionals
- ✓ Availability of fast and reliable internet connection

4.9 Discussion of findings

The discussion of findings was based on the research question posed for the study. The findings from the first research question revealed that all the items listed are vital and relevant in determining the level of awareness of smart building concept among construction professionals. The respondents agreed to all the items and identified smart building components as Sensors and Actuators, Hvac and Lighting systems, Energy Management system, IT network connectivity, Security and Access Control, Building Automation system. This is in agreement with Indrawati *et al.*, (2017) and Qolomany et al., (2019), on the components of smart building.

The findings from the second research question revealed that there is a high level of awareness of smart building components among construction professionals in Abuja. This study disagrees with Makarifi (2015) and Ogunde (2019) findings that there is a low level of awareness and understanding of smart building concepts. As it is evident from data analyzed from table 4.2. While there is a high level of awareness of smart building components among respondent the ranking of each components varies as showed in table 4.2. Security and Access control is ranked higher with a mean total score of 3.26 while Sensors and Actuator with mean total score of 2.75 is the least ranked item. The null hypothesis as shown in table 4.5 indicates that the calculated t-value of all items were less than the critical value (±1.990) at 0.05 level of significance. Therefore, the null hypothesis which says there is no significant difference between the mean responses of construction professionals on the level of awareness of smart building components among construction professionals in Abuja is accepted.

Findings obtained from the third research question highlighted the challenges and barriers to the implementation of smart building concept in construction projects in Abuja. The findings identified Lack of training and education on smart building technology among construction professionals, limited access to stable power supply, lack of interest from clients, high cost of implementing smart building, lack of local facilities for research , limited access to reliable and high-speed internet, cybersecurity concerns, limited availability of skilled manpower to maintain the building, limited availability of technical support, resistance to change from traditional building practices, lack of government policies and regulations as the challenges to implementing smart building concept in construction projects. The null hypothesis as shown in table 4.6 reveal that the calculated t-value of all items were less than the critical value (±1.990) at 0.05 level of significance. Therefore, the null hypothesis which says there is no significant difference between the mean responses of construction professionals on the challenges and barriers to the successful implementation of smart building concept in construction projects in Abuja is accepted.

Findings from the fourth research question considered the solutions to the challenges and barriers to the successful implementation of smart building concept in construction projects in Abuja. All the items listed in table 4.4 was agreed upon by respondents. Thus the solutions to the challenges are; Availability of comprehensive educational training and workshop for professionals, developers, and policy makers, collaboration with educational sector to include smart building concepts in school curriculums, collaboration among stakeholders, availability of professional network to support smart building, promotional offers and trade shows, create public awareness, availability of stable power supply, develop new policies and regulations to support, availability of better information on cost and benefits, availability of local facilities for research, collaboration with government agencies to promote the use of smart building technology, promote the use of ICT in building construction, develop certification programs on smart building for construction professionals, availability of fast and reliable internet connection. The null hypothesis was tested in table 4.7 where the calculated t-value of all items were less than the critical value (±1.990) at 0.05 level of significance. Therefore, the null hypothesis which says there will be no significant difference between the means response of construction professionals on the solutions to the challenges and barriers to the successful implementation of smart building concept in construction projects in Abuja is accepted.

CHAPTER FIVE

5.0 SUMMARY CONCLUSION AND RECOMMENDATION

5.1 Summary of the Study

This study assesses the awareness of smart building concept among construction professionals in Abuja. Four research questions and three hypotheses guided the study. Research questions were answered using mean and standard deviation. A mean of 2.50 was used as the cutoff points. Any question item with mean 2.50 and above is regarded as accepted while mean below 2.50 is rejected. The research hypothesis was tested using the t-test analysis. Also any hypothesis with t-value less than the t-critical is not significant whereas t-value equal or above the t-critical were regard to as significant.

The descriptive survey design was adopted for the study. And a sample size of 86 respondents comprising of 47 builders and 39 architects. The questionnaire was used as the instrument for data analysis and was titled Assessment of the Awareness of Smart Building Concept among Construction Professionals in Abuja. The questionnaire was based on a four point rating scale of Strongly Agree (SA), Agree (A), Disagree (D), and Strongly Disagree (SD) with numerical values 4, 3, 2, 1 respectively. Very High Level (VHL), High Level (HL), Low Level (LL) with numerical values 4, 3, 2, 1 respectively. Questionnaires were administered personally by the researcher. And data collected was analyzed and the findings discussed appropriately.

Findings from the study revealed that there is a high level of awareness of smart building concept among construction professionals in Abuja. And some of the challenges to the adoption of smart building such as lack training, resistance to change, cyber security concerns, and lack of local facilities for research and so on were discussed alongside the solutions to these challenges.

5.2 Implication of the Study

The study on the awareness of smart building concept among construction professionals in Abuja has significant impact for the construction industry in Nigeria. The findings from the study revealed there is a high level of awareness of smart building among construction professionals disapproving previous claims that construction professionals are ignorant of smart building concept. The study also highlights the potential benefits of smart implementing smart building concepts. Overall, the finding provided valuable insights into the state of knowledge and awareness of smart building concepts among construction professionals in Abuja, this will be useful to researcher, policy makers and other relevant stakeholders in the construction industry interested in smart building.

5.3 Contribution to Knowledge

This study made significant contribution to knowledge regarding the awareness of smart building concepts among construction professionals in Nigeria. By measuring the awareness level, identifying barriers to implementation, exploring the potential benefits, and highlighting actionable solutions to the challenges, the study can inform policy and practice in the construction industry. The findings of this study provide a critical foundation for future research, education, and policy development related to smart building concepts in Nigeria.

5.4 Conclusion

The study on the awareness of smart building concept among construction professionals in Abuja has shown that although the majority of the respondents were aware of the concept of smart buildings, they had varying levels of knowledge and understanding of smart building components.

This study also revealed some of the challenges and barriers to the implementation of smart building concepts. This barriers includes; Lack of training and education on smart building technology among construction professionals, limited access to stable power supply, Lack of interest from clients, High cost of implementing smart building, lack of local facilities for research, limited access to reliable and high-speed internet, cybersecurity concerns etc. as some of the challenges to implementing smart building concepts. Solutions to this challenges were also discussed and agreed upon by respondents, these solutions include; Availability of comprehensive educational training and workshop for professionals, developers, and policy makers, Collaboration with educational sector to include smart building concepts in school curriculums, Collaboration among stakeholders etc.

Smart building offers sustainability, energy efficiency and reduce carbon emission to the atmosphere and has been described by many researchers as the future of building construction. Therefore increased collaboration among stakeholders and government agency should be encouraged to develop guidelines and policies to aid the adoption of smart building in Nigeria construction industry

5.5 Recommendation

In light of the research findings, and data collected the following recommendation were made;

1. Construction professionals and individuals should be educated about smart building concept through organized workshops seminar, conference meeting and training programs to boost professionals understanding and knowledge of smart building concept.

2. Construction professional should be open to innovation and embrace the use of modern technologies to carry out task.
3. Implementation government policies and regulatory guidelines to promote the use of smart building technology.
4. Collaboration among relevant stakeholders and university communities should be encouraged to develop educational programs based on smart building technology and design.
5. Media campaigns, promotional offers and trade shows should be carried out periodically in order to sensitize the public about smart building concept
6. The government should establish a common platform to encourage collaboration among relevant stakeholders, research communities, and industry policy makers to generate development funds to implement these smart technologies.

5.6 Suggestion for Further Studies

1. An investigation into residential Awareness and Aspirations of smart building Features.
2. Assessment of the implementation of modern technologies and innovative practices in the construction industry.
3. Assessment of the level of adoption of smart building technology in construction industry.

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APPENDIX I

APPENDIX II

FEDERAL UNIVERSITY OF TECHNOLOGY MINNA,

SCHOOL OF SCIENCE AND TECHNOLOGY EDUCATION

DEPARTMENT OF INDUSTRIAL AND TECHNOLOGY EDUCATION

QUESTIONNAIRE

ON

ASSESSMENT OF THE AWARENESS OF SMART BUILDING CONCEPT AMONG CONSTRUCTION PROFESSIONALS IN ABUJA

Dear Respondent,

I am a 500-level student of the department of industrial and technology education of Federal University of Technology, Minna undergoing a research on the awareness of smart building concepts among construction professionals in Abuja. The aim of this research is to assess the level of awareness of smart building with a view of identifying possible method of promoting the awareness of smart building concept.

PART 1:

BACKGROUND INFORMATION ON RESPONDENTS

a) Builder [ ]
b) Architect [ ]

Instruction for Part 2

For each **Research question**, please kindly tick (✓) appropriately in the spaces of your choice in the option provided;

Strong Agree (SA)	4 points	Very High Level (VHL)	4 points
Agree (A)	3 points	High Level (HL)	3 points
Disagree (D)	2 points	Low Level (LL)	2 points
Strong Disagree (SD)	1 points	Very Low Level (VLL)	1 points

PART 2
SECTION A

Research Question 2: What are the components of smart building?

S/N	ITEMS	SA	A	D	SD
1	Sensors and Actuators				
2	Hvac and Lighting systems				
3	Energy Management system (EMS)				
4	IT network connectivity				
5	Security and Access Control				
6	Building Automation system (BAS)				

SECTION B

Research Question 2: What is the level of awareness of smart building components among construction professionals in Abuja?

S/N	ITEMS	VHL	HL	LL	VLL
1	Sensors and Actuators				
2	Hvac and Lighting systems				
3	Energy Management system				
4	IT network connectivity				
5	Security and Access Control				
6	Building Automation system				

SECTION C

Research Question 3: What are the challenges and barriers facing the successful implementation of smart building technology in construction projects in Abuja?

S/N	ITEMS	SA	A	D	SD
1	Lack of training and education on smart building technology among construction professionals				
2	Limited Access to stable power supply				
3	Lack of interest from clients				
4	High cost of implementing smart building				
5	Lack of local facilities for research				
6	Limited access to reliable and high-speed internet				
7	Cybersecurity concerns				
8	Limited availability of skilled manpower to maintain the building				
9	Limited availability of technical support				
10	Resistance to change from traditional building practices				
11	Lack of government policies and regulations				

SECTION D

Research Question 4: What are the solutions to the challenges facing the successful implementation of smart building concepts in construction projects in Abuja?

S/N	ITEMS	SA	A	D	SD
1	Availability of comprehensive educational training and workshop for professionals, developers, and policy makers				
2	Collaboration with educational sector to include smart building concepts in school curriculums				
3	Collaboration among stakeholders				
4	Availability of professional network to support smart building				
5	Promotional offers and trade shows				
6	Create public awareness				
7	Availability of stable power supply				
8	Develop new policies and regulations to support				

9	Availability of better information on cost and benefits				
10	Availability of local facilities for research				
11	Collaboration with government agencies to promote the use of smart building technology				
12	Promote the use of ICT in building construction				
13	Develop certification programs on smart building for construction professionals				
14	Availability of fast and reliable internet connection				