

CAPACITY SKILL NEEDED BY CARPENTER AND JOINERS FOR THE CONSTRUCTION OF SMART BUILDINGS IN NIGER STATE

Nehemiah, Udu & B. M. Mohammed

Department of Industrial Technology Education, School of Science and Technology Education, Federal University of Technology Minna, Niger State

Email: (Tel: +234)

Abstract: *The study examines the Capacity skill needed by carpenter and joiners in modern technology for the construction of smart buildings in Niger State. Two (2) research questions were raised and answered as well as two null hypotheses were formulated and tested at 0.05 level of significance. The study adopted a descriptive survey research design and was conducted in the Niger State, Nigeria. The population 2084 which includes 1054 registered carpenters and joiners, 157 registered architects and 873 building professionals. Krejcie Morgan's (1970) method of determining sample size was employed. The instrument for data collection was Carpentry and Joinery Skills for the Construction of Smart Buildings (CJSCSB). Two experts from the Department of Industrial and Technology Education, Federal University of Technology Minna and one from woodwork technology department Niger State College of education Minna validated the instrument and the reliability coefficient of the instrument was determined using Cronbach's Alpha statistic reliability index it yielded 0.85. instrument was administered to the respondents and data collected from the respondents were computed using mean and standard deviation to answer the research questions while Analysis for variance (ANOVA) was used to test the hypothesis at 0.05 level of significance. The findings revealed that the responses of registered carpenters and joiners, registered Architects and Building professionals jointly agreed with all the items on the current level of awareness of modern technologies for construction of super structures with grand mean of 3.66, on the capacity skills needs of carpenters and joiners in the construction of super structure of smart buildings with grand mean of 3.85, 3.65 on the capacity skills needed by carpenters and joiners in installation and maintenance of facilities for smart building in Niger State. Based on the finding of the study, the following recommendation were made: Awareness efforts should prioritize technologies already shaping super structure construction, such as off-site prefabrication, mass timber assembly and interpretation of digital models, and joiners should acquire capacity skills that enable them troubleshoot and diagnose issues with smart building components, including the ability to use digital diagnostic tools and understand system performance data to identify faults in automated fixtures and connected joinery and mobile training hubs focused on emerging technologies like mass timber construction, prefabrication, and smart building envelope installation.*

Keywords: *Capacity Skill, Carpenter and Joiner, Construction, Smart Building*

Introduction

Construction industry is a vital sector of the global economy that is responsible for providing infrastructure, shelter, and employment opportunities for millions of people. The construction industry is dynamic with new technologies are constantly emerging. With the introduction of new technologies, safety standards and regulations are also evolving. Carpenters and joiners must stay updated on the latest safety protocols and compliance requirements, particularly those related to the installation and maintenance of smart systems in buildings. In the rapidly evolving landscape of construction industry, the integration of smart technologies into building superstructures is transforming the role of carpenters and joiners.

Carpentry is the skilled trade of cutting, shaping, and installing wood to construct buildings, furniture, and other structures (Smith, 2021). Carpenters work hand in hand with joiners. Joinery craftsmen are specialized in carpentry that focuses on the precise cutting and fitting of wood joints without the use of nails or screws, relying instead on the tight fit of the wood pieces to hold the structure together (Johnson, 2022a). Carpentry and joinery craftsmen are both essential crafts in the building industry, they differ in their focus, tools, and the types of products they produce. Carpenters and joiners craftsmen need to be familiar with sustainable building practices, such as using eco-friendly materials, implementing energy-efficient designs, and adhering to green building standards

(Lan, 2022). Carpenters and joiners craftsmen usually play an important role in both the traditional building construction and also smart building construction industry. The construction industry has witnessed substantial progress in the adoption of new technologies in the development of buildings (Michael, 2020). The adoption of these technologies led to the creation of a new concept in construction industry called Intelligent buildings or smart buildings.

Smart building, also known as smart construction or intelligent building, refers to the integration of advanced technologies and systems to enhance the functionality, efficiency, and sustainability of buildings (Brown, 2022). In Nigeria, the concept of smart buildings is gaining traction as the country seeks to modernize its infrastructure and improve urban living conditions. Smart buildings are structures that integrate advanced technologies and systems to optimize operations, maintenance, and energy use (Johnson, 2022b). As smart buildings become more prevalent, these professionals must adapt to new demands and acquire a diverse set of skills to ensure the successful construction and maintenance of these advanced structures. It is important for Carpenters and joinery craftsmen to have a basic understanding of IoT principles and be capable of integrating and installing sensors and other smart devices into the building's structure. Carpenters and joinery craftsmen must be proficient in using various digital tools and software which includes computer-aided design (CAD) software for creating and modifying building plans, building information modeling (BIM) systems for collaborative project management, and project management software for tracking progress and deadlines (Andrew, 2018). These tools enhance precision, efficiency, and communication, which are crucial in the construction of smart buildings. The purpose of buildings is to fulfill the requirements and preferences of their inhabitants, with an increasing focus on enhancing comfort within the living environment. Essentially, a smart building integrates various systems such as power management, lighting, security, safety, and shared networks to efficiently manage resources and enhance building performance (Pramanik *et al.* 2019). The use of modern technology to enhance building services and operations for the benefit of users are very possible through the use of smart buildings (Ghansah *et al.* 2020). František and Ivona (2025) noted that both the design, construction and the implementation of smart building technology requires a capacity skills.

Capacity skills can also be referred to as technical skills which are the abilities, knowledge, or expertise required to perform specific job-related tasks. Capacity skills according to Rahman and Sadiq (2022) refer to the essential knowledge, abilities, and competencies that construction workers such as carpenters and joiners need to have in order to effectively perform their tasks especially in the context of modern and smart building technologies. The capacity skills required in modern building construction, as highlighted by Rahman and Sadiq (2022), are essential for ensuring high-quality, safe, and sustainable construction. The ability for a carpenters and joiners to possess this capacity skills will enable them to effectively contribute to the construction of smart buildings, meeting the demands of the modern construction industry. Capacity Skills in carpentry and joinery can be described as the human capability to perform technical work very well, an ability that comes from knowledge, practice and attitude to be able to perform all the task that is required of as professional (Okorie, 2019). In essence, a smart building requires a well-trained carpentry and joinery craftsmen with appropriate technical skills to integrates smart devices and sensors into an intelligent system that provides management, surveillance, assistance, and responsive services (Pramanik *et al.* 2019). Himeur *et al.* (2021) asserted that Smart building cities strive to achieve their net-zero emissions targets by minimizing wasted energy, enhancing grid stability, and fulfilling service demand and this is achievable by adopting advanced energy systems that utilize artificial intelligence, the Internet of Things (IoT), and communication technologies to gather and analyse large amounts of data in real time, thus efficiently managing city services.

However, there are significant impediments to smart building development and investment, particularly in Nigeria and other developing countries. Perhaps, the most significant impediment is the lack of awareness, knowledge and capacity skills of carpenters and joiners about smart building construction concepts in Nigeria and other developing countries (Bandara *et al.* 2019). Carpenters and joiners need to be proficient in using modern tools and technologies, including computer-aided

design (CAD) software, building information modeling (BIM), and advanced machinery (Kamal, 2021). The interest of building construction industry in smart buildings has risen dramatically because of technological improvement and the need for increased productivity, efficient energy management and good indoor air quality and in order for the carpentry and joinery craftsmen to meet up the current technological development there is need to investigate the Capacity skill needed by carpenter and joiners in modern technology for the construction of super structure of smart buildings in Niger State, Nigeria.

Statement of the Problem

Building industry is undergoing significant transformations, driven by advancements in technology, changing consumer demands, reduction in energy demand in a building and the need for sustainable development with smart buildings emerging as the new paradigm for sustainable, efficient, and intelligent built environments. Smart building construction, in particular, has gained prominence in recent years, offering improved energy efficiency, enhanced occupant experience, and increased property value. Chizoba (2020) pointed out that smart building technologies has help to reduce energy consumption and improve comfort conditions and human welfare.

Despite the growing demand for smart building construction, the industry faces significant challenges, including a shortage of skilled workers, inadequate training, and limited access to modern technologies carpenters and joiners lack the necessary capacity skills to work on smart building projects (Oyewole *et al.* 2019). The consequences of inadequate capacity skills among carpenters and joiners in smart building construction are far-reaching. Firstly, it can lead to delays, cost overruns, and reduced quality, ultimately affecting the overall performance of the building. Secondly, it can result in accidents, injuries, and even fatalities, due to the lack of proper training and equipment. Thirdly, inadequate capacity skills can hinder the adoption of modern technologies, such as BIM and CAD, which are essential for smart building construction. However, without the necessary capacity skills, carpenters and joiners may not be able to install and fit components correctly, leading to reduced energy efficiency, increased environmental impact, and decreased occupant satisfaction (Bandara *et al.* 2019). In addition, the problem of inadequate capacity skills among carpenters and joiners in smart building construction is not limited to Nigeria alone. Pramanik *et al.* (2019) observed that the consequences of inadequate capacity skills are far-reaching, affecting not only the construction industry but also the overall sustainability and performance of smart building projects. Today all sort types of smart building construction are taken place today by un-skilled carpenters and joiners which has led to collapse and destruction of life and properties (Kamal, 2021). Therefore, with the above problems and damages affecting life and properties, the researcher is prompted to investigate the capacity skills needed by carpenters and joiners to install and maintain smart buildings providing valuable insights into the technical skills, soft skills, and knowledge required to work effectively on smart building projects.

Purpose of the Study

The aim of the study is to examine the Capacity skill needed by carpenter and joiners for the construction of smart buildings in Niger State. Specifically, the study intends to: -

1. Investigate the current level of awareness of modern technologies for construction of super structures among carpenters and joiners.
2. Determine the capacity skills needed by carpenters and joiners the construction of super structure of smart building.

Research Questions

1. What is the current level of awareness of modern technologies for construction of smart buildings among carpenters and joiners?
2. What are the capacity needs of carpenters and joiners in the construction of smart buildings?

Hypotheses

- H₀₁:** There will be no significant difference in the mean response of registered carpenters and joiners, registered Architects and building professionals on the current level of awareness of modern technologies for construction of smart building in Niger State.
- H₀₂:** There will be no significant difference in the mean response of registered carpenters and joiners, registered Architects and building professionals on the capacity needs of carpenters and joiners in in the construction of smart buildings.

Methodology

The study adopted a descriptive survey research design. It is a widely used research design that focuses on collecting and analyzing data to describe characteristics, behaviours, opinions, or phenomena within a specific population. The study was conducted in Niger State. Niger state is located in the North Central Geopolitical Zone in Nigeria. The state is located on latitude 3.20° East and longitude 8 and 11.3° north, with Minna as its capital. It has a land area of 76,363 square kilometers, with population of 4,082,558. The population for this study was 2084 which includes 1054 registered carpenters and joiners, 157 registered architects and 873 building professionals. In determining the sample for questionnaire administration in this research, Krejcie Morgan's (1970) method of determining sample size was employed and based on the Krejcie and Morgan (1970) table total population for the study was 327. The instrument for data collection was a structured questionnaire titled: Carpentry and Joinery Skills for the Construction of Super Structure of Smart Buildings (CJSCSSSB) with response options of Strongly Agreed (SA), Agreed (A), Moderately agreed (MA), Disagreed (D) and Strongly Disagreed (SD) based on five-point rating scale and the instrument was validated by three experts, two experts from the Department of Industrial and Technology Education, Federal University of Technology Minna and one from woodwork technology department Niger State College of education Minna. The instrument for the study was pilot tested using 20 respondents which comprises of 8 registered carpenter and joiners, 5 registered Architect and 7 registered professional builder in FCT Abuja which is outside the study area and the data collected was analysed using Cronbach's Alpha statistic reliability index and it yielded 0.85. The instrument was collected by the researcher and the data collected from the respondents were computed using mean and standard deviation to answer the research questions while Analysis for variance (ANOVA) was used to test the hypothesis at 0.05 level of significance.

Results

The data collected for the study were analyzed and presented in this chapter. The analysis and presentation were organized based on research questions and hypotheses of the study.

Table 1: Mean and standard deviation of respondent on the current level of awareness of modern technologies for construction of smart buildings among carpenters and joiners.

N= 327

S/N	Items	\bar{x}	SD	Remark
1	Carpenters and joiners love working on residential buildings instead of smart buildings	3.74	0.93	Agreed
2	Carpenters and joiners have knowledge of advanced or sustainable materials like the cross-laminated timber, and engineered wood products for building superstructures	3.78	0.85	Agreed
3	Carpenters and joiners are familiar with the Building Information Modelling (BIM)	3.66	0.79	Agreed
4	Carpenters and joiners have knowledge of advanced or sustainable materials such as cross-laminated timber, engineered wood products for building of super structures	3.88	0.84	Agreed
5	Carpenters and joiners are aware of the new technologies that involves prefabricating or assembling large structural components off-site	3.58	0.94	Agreed

6	Carpenters and joiners usually work on a project where digital models or plans are used instead of traditional paper blueprints	3.72	0.80	Agreed
7	3D modeling software is mostly used by Carpenters and joiners during the construction of smart building	3.55	0.84	Agreed
8	Carpenters and joiners have the knowledge and skills on the Project management software like Procure and Aconex	3.65	0.81	Agreed
9	Carpenters and joiners use automated or robotic equipment like robotic arms and CNC machines for tasks like cutting or shaping wood during smart building construction	4.05	0.84	Agreed
10	BIM and 3D modelling are modern technologies that has the potential improve work efficiency	3.85	0.87	Agreed
Grand Total		3.66	0.81	Agreed

Note: N = Number of respondents, \bar{x} = mean, SD = Standard Deviation

Table 1 revealed that the responses of Registered carpenters and joiners, Registered Architects and Building professionals jointly agreed with all the ten (10) items on the current level of awareness of modern technologies for construction of smart buildings among carpenters and joiners with mean value ranging from 3.58 – 4.05 with grand mean of 3.66 which is over the cut-off point. This implies that the current level of awareness of modern technologies for construction of smart buildings among carpenters and joiners were appropriate. The standard deviation of the items ranges from 0.79 - 0.93 with grand total of 0.81 which indicates that the respondents were not too far from the mean and were close to one another in their responses in terms of the appropriateness of the items.

Table 2: Mean and Standard Deviation on the capacity needs of carpenters and joiners in the construction of smart building

S/N	Items	\bar{x}	SD	Remark
1	Carpentry and joinery are familiar with BIM (Building Information Modelling software and its application	3.94	0.84	Agreed
2	Carpentry and joinery can read and interpret complex digital blueprints and architectural plans for smart buildings	3.70	0.86	Agreed
3	Carpentry and joinery are familiar with the integration of wooden elements with smart technologies such as embedded sensors and wiring for smart lighting	3.63	0.80	Agreed
4	Carpenters and joiners have the skills to work with engineered wood products like the CLT and glulam which are commonly used in modern superstructures	3.85	0.92	Agreed
5	Formal training on sustainable and green building practices relevant to carpentry and joiner	3.97	0.83	Agreed
6	Carpenters and joiners have experience on the use of CNC (Computer Numerical Control) machinery for cutting and shaping wood components for a building's superstructure	3.73	0.85	Agreed
7	Carpenters and joiners have experience on the use of digital tape measure apps and Project management software like the Procure and Aconex during the construction of smart building	3.75	0.78	Agreed
8	Carpenters and joiners use laser levels, digital measuring devices, or other advanced tools in their current work	4.07	0.83	Agreed
9	Carpenters and joiners are familiar with the specific fastening and connection systems required for joining engineered wood panels in a multi-story building	4.00	0.81	Agreed
10	Cost of new tools/equipment and lack of access to training are barrier to adopting new technologies or skills in your work	3.74	0.85	Agreed

11	Carpenters and joiners are interested in continuing professional development courses focused on modern construction methods and smart building technologies	3.77	0.79	Agreed
12	Financial time off and mentorship would best enable you to upskill for smart building construction	4.08	0.82	Agreed
Grand Total		3.85	0.83	Agreed

Table 2 revealed that the responses of Registered carpenters, joiners and Building professionals jointly agreed with all the twelve (12) items on the capacity skills needs of carpenters and joiners in the construction of smart buildings with mean value ranging from 3.73 – 4.08 with grand mean of 3.85 which is over the cut-off point. This implies that the capacity skills needs of carpenters and joiners in the construction of smart buildings were appropriate. The standard deviation of the items ranges from 0.75 - 0.92 with grand total of 0.83 which indicates that the respondents were not too far from the mean and were close to one another in their responses.

Table 3: Analysis of Variance test for Comparing data Obtained from the registered carpenters, joiners and building professionals on the current level of awareness of modern technologies for construction of smart building in Niger State

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.342	2	.171	.350	.705
Within Groups	158.214	324	.488		
Total	158.557	326			

Table 3 shows the F-calculated value of .350 was obtained with associated exact Sig. tailed value of 0.705. Since the associated Sig. tailed value of 0.705 which is greater than 0.05 level of significance hence the null hypothesis is accepted. This implied that, there is no significance difference between the mean response of the registered carpenters, joiners and building professionals on the current level of awareness of modern technologies for construction of smart building in Niger State

Table 4: Analysis of Variance test for Comparing data Obtained from the registered carpenters, joiners and building professionals on the capacity needs of carpenters and joiners in in the construction of super structure of smart buildings

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2.845	2	1.423	3.673	.026
Within Groups	125.485	324	.387		
Total	128.330	326			

Table 4 shows the Analysis of Variance test (ANOVA) of difference in the response of registered carpenters, joiners and building professionals on the capacity needs of carpenters and joiners in in the construction of smart buildings. The table revealed that the significant criterion (sig.) of 0.026 which is less than 0.05 level of significance. Therefore, null hypothesis is rejected. This implies that there was a significance difference between the mean response of registered carpenters, joiners and building professionals on the capacity needs of carpenters and joiners in in the construction of super structure of smart buildings in Niger State.

Findings of the Study

The following findings emerged from the study based on the data collected and analyzed.

1. The current level of awareness of modern technologies for construction of smart buildings among carpenters and joiners which includes: Carpenters and joiners love working on residential buildings instead of smart buildings, Carpenters and joiners have knowledge of advanced or sustainable materials such as cross-laminated timber, engineered wood products for building of smart buildings and among others.

2. The capacity skills needs of carpenters and joiners in the construction of smart buildings to includes: Carpentry and joinery are familiar with BIM (Building Information Modeling software and its application, read and interpret complex digital blueprints and architectural plans for smart buildings, familiar with the integration of wooden elements with smart technologies such as embedded sensors and wiring for smart lighting, and experience on the use of CNC (Computer Numerical Control) machinery for cutting and shaping wood components for a building's smart buildings and among others.
3. There is no significant difference in the mean response of registered carpenters, joiners and building professionals on the current level of awareness of modern technologies for construction of smart building in Niger State.
4. There was a significant difference in the mean response of registered carpenters, joiners and building professionals on the capacity skill needs of carpenters and joiners in in the construction of super structure of smart buildings

Discussion of the Findings

The major findings of the study were discussed in the order of the research questions and hypotheses formulated for study. Finding on research question one revealed that the respondents agreed current level of awareness of modern technologies for construction of smart buildings among carpenters and joiners in Niger state. This finding is inline with view of Ogundare *et al.* (2023), who 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 and the awareness stage involves the end-users and professionals acquiring information and knowledge about the technology. In agreement with above Ghansah, *et al.* (2020) revealed that awareness of the smart building concept refers to strategies and exercises that help professionals understand the concept. Ahiabor (2019), in his study, also 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. Ahiabor added that there is need for awareness of environmental construction sustainability as part of smart building among professionals because lack proper understanding of smart building concepts can limit the implantation and use of smart building features in the construction industry.

Finding on hypothesis one revealed that there was no significant difference in the mean response of registered carpenters, joiners and building professionals on the current level of awareness of modern technologies for construction of smart building in Niger State. The null hypothesis of no significant difference was therefore accepted. The implication of this is that the respondents did not differ significantly in their opinions on the 10 items. Generally, the findings of the study on hypothesis one was in conformity with the findings of Cyril and Modupe, (2023) who observed that the carpenters and joiners awareness and strategic adoption of modern technologies are no longer optional but fundamental for the construction of smart, sustainable, and economically viable superstructures.

Finding on research question two revealed the capacity skills needs of carpenters and joiners in the construction of smart buildings in Niger State. The respondents agreed with all the twelve (12) items on the capacity skills needs of carpenters and joiners in the construction of super structure of smart buildings which is in-line with the view of Ezeokoli *et al.* (2023) who asserted that carpenter and joiners needs capacity skills that will enable then go beyond manual dexterity and also remain relevant, carpenters and joiners in Nigeria must be trained not just in traditional woodworking, but also in modern construction technologies. In agreement with above statement Parziale and Fischer (2019) observed that lack of capacity skills among carpenters and joiners can affect the overall sustainability of smart building projects. Inline with the view of Parziale and Fischer above, Bandara *et al.* (2019) observed that without the necessary capacity skills, carpenters and joiners may not be able to install and fit components correctly, leading to reduced energy efficiency, increased environmental impact, and decreased occupant satisfaction. In addition to above statement, Pramanik *et al.* (2019) noted that the problem of inadequate capacity skills among carpenters and joiners in smart building construction is not limited to Nigeria alone and the consequences of

inadequate capacity skills are far-reaching, affecting not only the construction industry but also the overall sustainability and performance of smart building projects. This is also with the finding of Bandara *et al.* (2019) who observed that without the necessary capacity skills, carpenters and joiners may not be able to install and fit components correctly, leading to reduced energy efficiency, increased environmental impact, and decreased occupant satisfaction.

Finding on hypothesis two revealed that there was a significant difference in the mean response of registered carpenters, joiners and building professionals on the capacity skill needs of carpenters and joiners in the construction of super structure of smart buildings in Niger State. The null hypothesis was therefore rejected. The implication of this is that the respondents differ significantly in their opinions on the 12 items. The finding is similar to the findings of Osunsanmi *et al.* (2023) is observed that carpenters and joiners need relevant skills so they can be-able to read digital construction drawings and collaborate with other trades using shared software.

Conclusion

The present study examines the Capacity skill needed by carpenter and joiners in modern technology for the construction of smart buildings in Niger State. This study has undoubtedly proved that technological innovation with its effects on humans and the environment particularly in the design and construction of buildings (architecture practice) is a reality and is still changing. These changes have resulted in the development of smart buildings today. Smart buildings have been seen to adapt to both short and long term needs of humans and users with the capacity to cope effectively with social and technological changes of the 21st Century. Smart building projects are quite achievable in Nigeria if the commitment and collaborative involvement of the different stake holders namely the government, the building owners, users, the technology providers, architects, carpenters and joiners and other built environment professionals are fully harmonized.

The study identified the current level of awareness of modern technologies for construction of super structures among carpenters and joiners, the capacity skills needs of carpenters and joiners in the construction of smart buildings, capacity skills needed by carpenters and joiners in installation and maintenance of facilities for smart building, the challenges faced by carpenters and joiners in the use of modern technologies to install and maintain smart building construction, the strategies for enhancing the skills of carpenters and joiners in the construction of smart building and the training strategies and capacity-building approaches can enhance the skills of carpenters and joiners for smart building superstructure construction in Niger State. The study concluded that construction professionals still need more effort to increase the awareness of smart buildings in the construction industry to deepen the practices in a Nigerian context. The increase in the awareness and adoption of SBC would further assist in protecting lives and property by installing a smart security system that monitors the building. In addition, it will assist in energy efficiency improvement, thereby saving energy costs and protecting the environment from harm. They have also improved management by integrating building technology systems to increase operation and functionalities of the building in terms of comfort and security.

Recommendations

Based on the finding of the study, the following recommendations are made

1. Awareness efforts should prioritize technologies already shaping smart buildings construction, such as off-site prefabrication, mass timber assembly and interpretation of digital models, ensuring skills align with current industry demands.
2. Carpenters and joiners should acquire advanced skills on off-site manufacturing, modular assembly and working with high-performance materials like Cross-laminated timber (CLT) that form the smart buildings.
3. Carpenters and joiners should acquire capacity skills that enable them troubleshoot and diagnose issues with smart building components, including the ability to use digital diagnostic tools and understand system performance data to identify faults in automated fixtures and connected joinery.

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