Skill Needs of Carpenters and Joiners for the Construction of Smart Buildings

Bala Maik Mohammed[1*], Abdul Bello Kagara[1], Wahab Bamidele Kareem[1], Binni Danjuma Beji[2], Stephen Musa[1] and Opeyemi Oladapo Alawode[1]

[1]Industrial and Technology Education Department, Federal University of Technology, Minna, Niger State, Nigeria

[2]Umaru Sanda College of Education, Minna Niger State, Nigeria

[*]Corresponding Author

DOI: https://doi.org/10.47772/IJRISS.2026.100400193

Received: 10 April 2026; Accepted: 16 April 2026; Published: 01 May 2026

ABSTRACT

Carpenters and joiners form a significant segment of the workforce in the building industry. They are often among the first to arrive at construction sites and the last to leave, as they are involved in various stages of construction, from setting out building layouts to finishing works. The construction sector is currently experiencing rapid transformation due to emerging technologies in tools, materials, and processes, particularly in the area of digitalisation. This development necessitates a reassessment of traditional skill requirements. In addition, the introduction of new technologies has led to the continuous evolution of safety standards and regulations. This study therefore examined the skill needs of carpenters and joiners for the construction of smart buildings in Niger State, Nigeria. The population of 362 construction professionals (128 registered architects, 94 engineers, and 140 carpenters and joiners) were targeted for the study. 188 respondents were selected and used for the study. Data were collected using the Carpentry and Joinery Skills Instrument for Smart Buildings (CJSISB), administered in collaboration with registered professionals through a Google Scholar-based application. The instrument recorded a reliability index of 0.85, established using test-retest and Cronbach's alpha statistics. Mean and standard deviation were used to answer the research questions, while one-way ANOVA was employed to test two null hypotheses at 0.05 level of significance using IBM SPSS version 26. Findings from the study on skills required for the use of structural insulated panels by carpenters and joiners in smart building construction revealed that nine skills were needed, with mean scores ranging from 3.69 to 3.93. The overall grand mean of 3.37 fell within the decision range of 2.50–3.49, indicating that all identified skills were considered necessary for the effective use of structural insulated panels in smart building construction. Based on these findings, it was recommended that government and relevant stakeholders in the construction industry should establish targeted training programmes aimed at enhancing knowledge and practical skills in the use of structural insulated panels and recycled materials for smart building construction among carpenters and joiners.

Key: Construction Professionals, Smart Building, Carpenters and Joiners, Competency Skills, Technology Integration.

INTRODUCTION

Buildings, like food, water, and clothing, represent fundamental human necessities. In early history, structures were primarily constructed to shield humans from harsh environmental conditions and wild animals. During this primitive era, people depended on hunting and lived a nomadic lifestyle, which led them to build temporary shelters using readily available natural materials such as animal skins, stones, straw, sticks, grasses, and other organic resources (Oyewole et al., 2019). Over time, as agriculture developed and human needs expanded, settlements became more permanent, giving rise to the construction of more durable buildings designed to meet evolving social and economic requirements. In contemporary times, advancements in technology have transformed buildings into complex systems serving multiple functions. Various components of buildings are now independently designed and integrated, allowing owners to customize systems such as security, lighting, heating, ventilation, and air conditioning to suit specific needs (Oyewole et al., 2019). Regardless of their purpose, buildings often present certain challenges that must be addressed. Consequently, the adoption and implementation of smart building concepts have become increasingly important, particularly in developing economies facing environmental and infrastructural challenges. Issues such as insecurity and energy shortages—common in many parts of the world's housing sector—can be significantly mitigated through the integration of smart building technologies (Oyewole et al., 2019).

The construction industry is a key sector of the global economy, playing a crucial role in the provision of infrastructure, shelter, furniture, and employment opportunities for construction professionals, including carpenters and joiners. Carpenters and joiners are skilled construction workers, often regarded as craftsmen, who are responsible for building walls, installing, and repairing structural frameworks, primarily using wood, though they also work with materials such as drywall, fiberglass, metal, and plastic. Their work spans residential, commercial, and industrial projects, where they carry out tasks ranging from framing walls and roofs to installing doors, windows, and cabinetry. Some carpenters enter the profession through apprenticeship systems, learning the trade through practical on-the-job experience, while others acquire formal qualifications before engaging in professional practice involving the use of tools, materials, and construction processes for woodwork structures. In recent years, the construction industry has continued to experience rapid advancements in technology, particularly in tooling, materials, and construction processes. According to the International Labour Organization (ILO, 2023), the sector is undergoing a significant transformation towards digitalisation, which requires a reassessment of traditional skill sets. This shift also implies that safety standards and regulatory frameworks are continually evolving to match new technologies and modern construction practices.

Carpentry is a skilled trade involving the cutting, shaping, and installation of wood for the construction of buildings, furniture, and other structural works (Smith, 2021). Smith further explains that carpenters work with a wide range of tools and materials, applying technical skills to create and repair wooden components such as framing, roofing, flooring, and cabinetry. They are actively involved in both new construction and renovation projects, often using an extensive array of tools, including advanced power tools, to accomplish various construction tasks. Carpenters are particularly engaged in the rough construction and framing stages of buildings, including walls, roofs, and ceilings, and may contribute to the construction of wooden structures of up to eight storeys. The construction industry has also recorded significant advancements in the adoption of modern technologies in building development (Michael, 2020). In response to these changes, carpenters are expected to be knowledgeable in sustainable building practices, including the use of eco-friendly materials, energy-efficient designs, and compliance with green building standards (Lan, 2022). Similarly, joiners are required to demonstrate competence in working with emerging smart building materials such as electrochromic smart glass, shape memory alloys (SMAs), aerogel insulation, self-healing concrete, and sensor-embedded wood, which are increasingly being integrated into modern construction systems (Hamida et al., 2022a). Although carpenters and joiners primarily focus on wood-based construction, their roles are becoming more integrated and technologically driven. They now frequently collaborate with other construction professionals and make use of digital tools and technologies, including Computer Numerical Control (CNC) systems, to enhance precision, efficiency, and overall quality in construction processes.

Joinery craftsmen are specialists in woodwork who focus on the precise cutting and fitting of timber joints, often without the use of nails or screws, relying instead on hand tools and specialized machinery to achieve accuracy and detail (Johnson, 2022a). Johnson further explains that joiners typically operate within workshop environments where they produce high-quality wooden products such as doors, windows, staircases, wardrobes, and furniture. The profession places strong emphasis on precision, craftsmanship, and the aesthetic quality of finished work. However, the role of joinery is gradually evolving from purely manual craftsmanship to a blend of traditional woodworking skills and modern digital integration. This transformation has positioned joiners as essential contributors to the development of advanced and sustainable construction systems, including smart buildings. As a result, their responsibilities are expanding to include new and emerging roles such as:

Integration of Technology and Materials: Smart buildings require high-precision, eco-friendly, and often pre-fabricated wooden components. Joiners use advanced, connected, or automated machinery (CNC machines) to produce high-quality fittings that fit the role is shifting from purely manual labour to a hybrid of skilled woodworking and digital integration, making them crucial in the construction of high-tech, sustainable structures that fits complex digital designs.

Digital Tools & BIM: Carpenters now use Digital Building Information Modelling (BIM) to plan, visualize, and map out projects, ensuring accuracy before making any physical cuts.

Installation of Smart Components: On-site, they install specialized woodwork that incorporates smart technology, such as bespoke kitchens with integrated technology, smart cabinet systems, and specialized soundproofing, which are essential for smart home functionality.

Collaborative Construction: Smart building projects require close collaboration between trades, where carpenters and joiners often work alongside technology specialists to integrate sensors and network cables into the structural components. Pre-fabrication: Many joiners work in modern factory settings (off-site construction) using robotic technology for timber framing and component manufacturing.

Advanced Tools: They utilize digital apps, smart apps, and interconnected devices to manage production in real-time.

High-Level Skill: The need for human skill remains high, especially for bespoke, customized projects that require adaptability and complex problem-solving.

Carpentry trade has contributed a lot to smart buildings in Nigeria. According to Alaloul (2021), Carpentry has created:

Enabling Sustainable Building Practices and Materials: Renewable Resource: Wood, the primary material in carpentry, is a renewable resource, making it inherently sustainable when sourced from responsibly managed forests. This aligns with the core tenets of smart buildings which prioritise environmental responsibility and reduced carbon footprint. Recent calls from stakeholders in Nigeria's construction sector emphasize the urgent need for eco-friendly building practices to reduce carbon emissions and building collapses (Smith, 2021).

a. Low Embodied Energy: Compared to high-energy materials like cement and steel, wood has a lower embodied energy (the energy consumed in its production and transportation). This directly contributes to the energy efficiency goals of smart buildings.
b. Thermal Insulation: Wood possesses natural insulating properties, which can help regulate indoor temperatures, reducing the need for excessive heating or cooling. This directly contributes to energy efficiency, a key feature of smart buildings (Wagner Meters, undated). Research also explores alternative wall materials like mud bricks and timber/brick to improve indoor comfort and reduce embodied carbon in Nigerian buildings (Hamida, *et al.,* 2022b).
c. Reclaimed and Sustainable Timber: The use of salvaged or reclaimed wood, as well as sustainably harvested timber (FSC certified), minimises deforestation and provides high-quality, unique materials for various building components like floors, walls, and furniture. This supports circular economy principles and reduces environmental impact. Bamboo, with its rapid growth, is also gaining traction as a highly sustainable alternative.
d. Biodegradable Materials: Carpentry often utilise natural and biodegradable materials, lowering the carbon footprint associated with construction waste management.

Supporting Integration of Smart Technologies:

a. Concealed Infrastructure: Smart buildings rely heavily on integrated technologies like IoT, sensors, wiring, and automation systems. Skilled joiners and carpenters are crucial for creating precise cavities, channels, and access points within wooden structures (walls, floors, ceilings, cabinetry) to discreetly

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume X Issue IV April 2026

house these complex systems. This ensures a clean aesthetic while maintaining functionality and accessibility for maintenance.

b. Customization and Aesthetics: Joinery, in particular, allows for bespoke designs and intricate detailing. This is essential in smart buildings where aesthetic appeal and personalized comfort are valued. Think of custom-built cabinets housing smart home hubs, or integrated wooden panels concealing lighting controls and automated blinds.
c. Acoustic Properties: Wood's natural sound-absorbing properties can be leveraged in smart buildings to create optimal acoustic environments, especially in spaces designed for enhanced comfort and productivity (Wagner Meters, undated). This can reduce the need for additional soundproofing materials.

Enhancing Occupant Comfort and Well-being:

a. Humidity Regulation: Wood naturally absorbs and releases moisture, contributing to healthier and more comfortable indoor air quality by regulating humidity levels (Ejidike & Mewomo, 2023). This aligns with smart building goals of prioritizing occupant well-being.
b. Biophilic Design: The use of natural materials like wood in carpentry can contribute to biophilic design, which integrates natural elements into the built environment to improve occupant health, mood, and productivity. This is becoming increasingly recognized as a benefit in modern building design.

Addressing Challenges and Future Prospects in Nigeria:

a. Skill Gap: While the potential is significant, there's a recognized skill deficit among Nigerian contractors and artisans in executing eco-friendly and technologically integrated designs including expertise in installing wood flooring or stonework materials essential for green buildings (Guardian, 2025). This highlights the need for targeted training and capacity building in carpentry specifically for smart and green building practices.
b. Awareness and Adoption: The adoption of smart building technologies in Nigeria is still somewhat low, often due to high implementation costs, poor infrastructure, and a lack of experienced workers and awareness among professionals (Oyewole *et al.,* 2019). As awareness grows and technology becomes more accessible, the demand for carpentry skills that can integrate these elements will also increase.
c. Local Material Sourcing: Nigeria has various indigenous wood species. Leveraging these local resources through skilled carpentry can reduce import dependency and promote local economies while contributing to sustainable construction.

Smart building, also referred to as smart construction or intelligent building, involves the integration of advanced technologies and systems to improve the functionality, efficiency, and sustainability of built environments (Brown, 2022). These structures incorporate intelligent systems designed to optimise operations, maintenance processes, and energy consumption (Johnson, 2022b). Johnson further explained that smart buildings make use of technologies such as the Internet of Things (IoT), Building Management Systems (BMS), and other digital innovations to enhance overall performance, energy efficiency, and environmental sustainability. As smart buildings continue to gain prominence, carpenters and related tradespersons are required to adapt to emerging demands by acquiring a broader and more diverse set of competencies necessary for the construction and maintenance of such advanced structures. In line with this development, a recent report by the International Labour Organization (ILO, 2023) highlights that the construction industry is undergoing a major shift towards digitalisation, which calls for a comprehensive reassessment of traditional skill sets to remain relevant in modern construction practices.

The concept of smartness in buildings includes key attributes such as green energy utilisation, zero emissions, flexible spatial design, occupant health, and improved operational efficiency. Smart building technologies—such as automated heating, ventilation and air conditioning (HVAC), intelligent lighting systems, and advanced security solutions—depend on extensive networks of sensors and actuators. These devices, along with their associated power and data cabling, must be physically embedded within the structural components of buildings, including walls, doors, windows, ceilings, and floors, forming part of the superstructure (Affonso et al., 2024). Affonso further notes that without the building structure itself, there would be no physical framework for deploying such technological networks. In essence, smart buildings require well-trained carpentry and joinery craftsmen that possess the technical expertise to integrate smart devices and sensors into cohesive systems that support management, surveillance, automation, assistance, and responsive services (Pramanik et al., 2019). Similarly, Himeur et al. (2021) explained that smart cities aim to achieve net-zero emissions by reducing energy waste, improving power grid stability, and efficiently meeting service demands. This is achieved through the use of advanced energy systems powered by artificial intelligence, the Internet of Things (IoT), and modern communication technologies that collect and analyse large-scale data in real time to optimise urban services. The primary function of smart technologies is to control and optimise the core operational systems of buildings, which are physically integrated within the building structure itself (Ahmed, 2025). This integration helps reduce energy consumption while improving comfort levels and overall human well-being (Affonso et al., 2024). Consequently, the installation and maintenance of smart building systems require specialised personnel, including carpentry craftsmen, who must develop relevant green skills such as digital literacy, employability skills, entrepreneurial competencies, and technical proficiency required in today's workforce (Chizoba, 2020).

Skills, according to Rahman and Sadiq (2022), refer to the essential knowledge, abilities, and competencies required by construction professionals such as carpenters, joiners, and builders to effectively carry out their tasks, particularly within the context of modern and smart building technologies. Similarly, František and Ivona (2025) observe that both the design and construction of contemporary building superstructures, as well as the implementation of smart building systems, demand strong capacity-based skills. Despite the increasing demand for smart building construction, the industry continues to face notable challenges, including a shortage of adequately skilled workers. This situation is largely attributed to insufficient training opportunities and limited exposure to modern construction technologies. Oyewole et al. (2019) further note that many carpenters currently lack the required capacity skills needed to effectively participate in smart building projects. To address this imbalance between available skills and industry demands—whether for employment or entrepreneurial purposes—it becomes necessary to identify and properly document the specific skill sets required for the installation, integration, and maintenance of smart building systems.

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 about installation and maintenance of smart systems in buildings (Bandara *et al.* 2019).

Aim And Objectives of the Study

The study was delimited to the capacity skills needed by carpentry and Joinery craftsmen for the construction of superstructure of smart buildings in Niger State. Specifically, the study:

1. Determined the skills required by carpenters and Joiners for integration of technology and materials in the construction of superstructure of smart buildings.

2. Determined the digital and BIM skills required by carpenters and Joiners for installation facilities for smart buildings.

Research Questions

1. What are the skills required by carpenters and Joiners for integration of technology and materials in the construction of superstructure of smart buildings?

2. What are the digital and BIM skills required by carpenters and joiners for installation of facilities for smart buildings?

H_{o1}: There is no significant difference in the mean responses of Architects, Engineers, Carpenters and Joiners on the skills needed in the use of recycled and sustainable materials for the construction of smart buildings.

H_{o2}: There is no significant difference in the mean responses of Architects, Engineers, Carpenters and Joiners on the skills needed in the use of recycled and sustainable materials for the construction of smart buildings.

METHODOLOGY

A descriptive survey research design was adopted for the study to collect and analyse data, providing meaningful insights into the behaviours, attitudes, and trends regarding carpenters' and joiners' involvement in smart building construction. The study was conducted in Niger State, located within the North Central Geopolitical Zone of Nigeria. The population of the study comprised 362 respondents include, 128 engineers, 94 registered architects, and 140 registered carpenters and joiners. Krejcie and Morgan (1970) sample size determination technique was used to select a sample size of 188 respondents used for the study. Data were collected using the Carpentry and Joinery Skills Instrument for Smart Buildings (CJSISB), which contained 19 items structured on a five-point rating scale to address the research questions. The instrument was validated by three experts: one from the Department of Industrial and Technology Education, Federal University of Technology Minna; one from the Department of Building Technology, Federal University of Technology Minna; and one from the Land Development Control Unit of the Niger State Urban Development Board. Their observations and recommendations were used to refine and produce the final version of the CJSISB. The instrument was also pilot-tested for reliability using the test-retest method on 20 respondents, comprising 8 registered carpenters and joiners, 5 registered architects, and 7 construction professionals in the Federal Capital Territory, Abuja. The data obtained were analysed using Cronbach's Alpha statistic, which yielded a reliability coefficient of 0.85, indicating that the instrument was highly reliable.

Method Of Data Analyses

Quantitative statistical techniques were employed for data analysis in the study. Data collected from respondents were analysed using mean and standard deviation to address the research questions. Decisions on the research questions were based on the grand mean ($\bar{X}G$), interpreted using the real limit of numbers within a five-point Likert-type rating scale. The scale was categorized as follows: Strongly Agreed (SA) ranged from 4.21–5.00, Agreed (A) ranged from 3.41–4.20, Moderately Agreed ranged from 2.61–3.40, Disagreed (D) ranged from 1.81–2.60, and Strongly Disagreed (SD) ranged from 1.00–1.80. In addition, One-way Analysis of Variance (ANOVA) was used to test two null hypotheses at the 0.05 level of significance.

RESULT

Research Question One: What are the skills needed by construction professionals in the use of structural insulated panels for the construction of smart buildings?

Table 1: Mean and Standard Deviation of Respondents on the skills needed by Carpenters and Joiners in the use of structural insulated panels

S/No	Ability to use high tech equipment to:	Mean	S D	Rem
1	work with other materials and use SIPs to replace traditional framing systems	3.78	0.69	A
2	reinforce SIPs with appropriate bracing techniques	3.45	0.87	A
3	install IoTs devices	3.69	0.69	A
4	install automation systems	3.72	0.56	A
5	install energy monitoring solutions into a SIP-built structure	3.93	0.65	A

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume X Issue IV April 2026

6	install electrical wiring, plumbing and HVAC systems	3.29	0.84	MA
7	measure, cut and fit SIPs with high accuracy	3.41	0.49	A
8	seal joints and seams between SIPs	2.42	0.83	D
9	Proficiency in using design software (AutoCAD, Revit)	2.71	0.74	MA
	Grand Mean	**3.37**	**0.87**	**A**

N = 188

Table 1 presents the mean and standard deviation scores of construction professionals' responses on the skills required for the use of structural insulated panels in smart building construction. The findings show that items 1, 2, 3, 4, 5 and 7 were agreed as needed with a mean range from 3.41 to 3.93; while items 6, and 9 were moderately considered needed with mean of 2.71 and 3.29 respectively, while item 8 was disagreed as needed with mean of 2.42. Overall, eight of the nine items were found to be needed, with mean scores ranging from 2.49 to 3.93. Furthermore, the grand mean score of 3.37 falls within the decision range of 2.61–3.40, indicating agreement that the identified skills are required by carpenters and joiners for effective use of structural insulated panels in smart building construction. The standard deviation values for all items were below 1.96, suggesting that the responses of the respondents were closely clustered and not widely dispersed.

Research Question Two: What are the skills needed by Carpenters and Joiners in the use of recycled and sustainable materials for the construction of smart buildings?

Table 2: Mean and Standard Deviation of the Respondents on the skills needed by Carpenters and Joiners in the use of recycled and sustainable materials for the construction of smart buildings.

S/No	skills needed for working recycled and sustainable materials:	Mean	S D	Remark
1	Ability to install and incorporate IoT devices and sensors into buildings	3.61	0.77	A
2	Ability to use proper techniques for handling, cutting and installing sustainable materials	3.78	0.91	A
3	Ability to use energy modelling software for simulation	3.92	0.79	A
4	Ability to incorporate sustainable elements	3.49	0.66	MA
5	Ability to integrate rainwater collection systems	2.91	0.62	MA
6	Ability to integrate grey-water reuse	3.32	0.68	MA
7	Ability to use sustainable materials with smart technologies	3.59	1.02	A
8	Expertise in integrating renewable energy systems	3.83	0.93	A
9	Ability to work closely with architects and designers	3.66	0.69	A
10	Proficiency in identifying and resolving issues related to integration of sustainable	3.02	0.81	MA
	Grand Mean	**3.51**	**0.80**	**A**

N = 188

Table 2 presents the skills required for the use of recycled and sustainable materials by carpenters and joiners in the construction of smart buildings. The mean scores and standard deviations of respondents indicates that items 1, 2, 3, 7, 8, and 9 were rated agreed as needed skills with mean that ranged from 3.59-3.92, while items 4, 5, 6, and 10 were moderately needed with mean of 2.91-3.49. Notably, no item was rated as not needed by the respondents. The grand mean value of 3.51 shows that all the items in the instrument were needed for effective practice. In addition, the standard deviation values for all items ranged between 0.62 to 1.02 and were below 1.96, indicating that the responses of the respondents were closely aligned, with no wide variation in opinion.

H_{o1}: There is no significant difference in the mean responses of Architects, Engineers and Carpenters and Joiners on the skills needed in the use of structural insulated panels for the construction of smart buildings.

Table 3: One-Way ANOVA of Mean Scores of Respondents on skills needed in the use of structural insulated panels for the construction of smart buildings.

Source	Sum of Squares	df	Mean Square	F	Sig.	Remark
Between Groups	12.400	2	11.36	.369	.06	NS
Within Groups	58.000	186	.515			
Total	78.400	188				

N = 188, NS = Not Significant

The analysis of respondents' views on whether there is a significant difference in the mean responses of architects, engineers, and carpenters and joiners regarding the skills required for the use of structural insulated panels in smart building construction revealed an F-statistic of .369 with a p-value of 0.06, which is greater than the conventional significance level of 0.05. Based on this result, the study established that there is no statistically significant difference in the mean responses of architects, engineers, and carpenters and joiners on the skills needed for the use of structural insulated panels in smart building construction.

H_{o2}: There is no significant difference in the mean responses of Architects, Engineers and Carpenters and Joiners on the skills needed in the use of recycled and sustainable materials for the construction of smart buildings.

Table 4: One-Way ANOVA of Mean Scores of Respondents on Skills Needed in the use of Recycled and Sustainable Materials

Source	Sum of Squares	df	Mean Square	F	Sig	Remark
Between Groups	3.190	2	1.595	.504	.07	NS
Within Groups	64.997	186	1.182			
Total	68.187	188				

N = 188, NS = Not Significant

Judging from the F-statistic and the p-value of 0.07, which is greater than the 0.05 level of significance, the study concludes that the null hypothesis is accepted. Thus, there is no significant difference in the mean responses of architects, engineers, carpenters and joiners regarding the skills needed for the use of recycled and sustainable materials in the construction of smart buildings. Consequently, the alternative hypothesis, which suggested otherwise, is rejected.

DISCUSSION OF FINDINGS

The result presented in Table 1 shows that all items relating to the skills required for the use of insulated panels in smart building construction were rated needed, with a grand mean score of 3.82. This indicates that respondents agreed that such skills are essential for effective practice. These include the ability to connect, align, and level integrate ICF systems with smart building technologies; coordinate the installation of systems within ICF walls; install smart sensors, Internet of Things (IoT) devices, and automation systems within building structures; and maintain energy management systems embedded within walls, among others. These findings are consistent with Kalu and Udeala (2023), who observed that construction professionals require a combination of digital, structural, and architectural skills to effectively participate in smart building projects. The results of no significant difference of hypothesis one is also supported by Ashby and Jones (2014), who found no significant difference among construction professionals on skills needed on modern construction, particularly smart building development, and reiterated that modern construction demands a diverse set of competencies to ensure efficiency, sustainability, and safety in construction projects. Such skill sets are essential for keeping construction professionals updated with emerging trends and technological innovations in the industry.

The findings presented in Table 2 indicates that the ability to install IoT devices, integrate automation systems, and implement energy monitoring solutions within SIP-built structures were agreed to be needed skills as expressed by the respondents. Other essential competencies identified include the ability to reinforce structural insulated panels (SIPs) using appropriate bracing techniques, install electrical wiring, plumbing, and HVAC systems, as well as accurately measure, cut, and fit SIPs with precision. Overall, all items relating to the skills required for the use of structural insulated panels by carpenters and joiners in smart building construction were rated needed, with an average mean score of 3.65. These findings align with the study of Yan et al. (2018), who reported that construction professionals must continuously update their knowledge of emerging trends, technologies, and best practices in smart building systems to effectively integrate modern innovations into construction projects. The result is also consistent with Mathews (2017), Straub et al. (2018), and Paluch et al. (2020), who emphasized that construction professionals require a blend of technical competencies, particularly in technology integration and energy efficiency, to remain effective in modern construction environments. The non-significance of the result of hypothesis on the skills needed in the use of recycled and sustainable materials for the construction of smart buildings affirms that of the research question and also support that of Straub et al. (2018), and Paluch et al. (2020) and suggested that the high rating of these skills may be attributed to respondents' awareness of the critical role technology plays in improving the functionality, efficiency, and sustainability of smart buildings in contemporary construction practice. The findings on the skills required by carpenters and joiners in relation to the use of recycled and sustainable materials for smart building construction revealed that competencies such as the ability to install IoT devices, apply appropriate techniques in handling sustainable materials, and integrate renewable energy systems are needed.

In contrast, Syed et al. (2016) found that many construction professionals still lack essential competencies for effective installation of insulated panels, and where such skills exist, they are often only at a moderate level. This gap in competency among carpenters and joiners may be linked to limited access to modern training programmes, continued reliance on traditional construction methods, the rapid pace of technological advancement outstripping educational updates, and economic constraints, particularly in developing regions.

CONCLUSION

The study examined the skill needs of carpenters and joiners in relation to smart building systems. The findings highlight a critical skills gap among carpenters and joiners in the application of structural insulated panels (SIPs) and recycled materials within smart building construction. Although respondents acknowledged the importance of certain competencies such as installing smart sensors, and integrating renewable energy systems, the overall results suggest that their current level of skill acquisition in these areas remains insufficient for effective implementation of modern construction practices. In particular, skills associated with smart technologies and energy management systems recorded relatively low mean scores, indicating limited competence and inadequate preparedness of carpenters and joiners for these emerging demands. Consequently, the results relating to SIPs and recycled materials underscore an urgent need for targeted upskilling among carpenters and joiners. While respondents recognize the significance of integrating advanced technologies with sustainable construction practices, the findings reveal noticeable deficiencies in essential smart building competencies, including IoT device installation and energy monitoring systems. This suggests that although carpenters and joiners' awareness of modern building systems exist, practical competence in these technologically intensive areas remains average, especially in tasks requiring high technical precision and digital integration. This underscores the need for upskilling among Carpenters and Joiners with regards to smart building construction.

RECOMMENDATIONS

The government and relevant stakeholders in the construction industry should establish targeted training programmes focused on developing essential competencies in materials and technology integration for the effective use of insulated concrete forms, structural insulated panels, and recycled materials in smart building construction.

1. Government should strengthen industry–education partnerships by collaborating with educational institutions to ensure curricula are aligned with industry demands, including advanced areas such as IoT integration and energy management systems.

2. The building industry, in collaboration with the private sector, should organize seminars and workshops aimed at keeping construction professionals updated on emerging technologies and best practices in smart building construction.

3. Structured mentorship programmes should be established to connect experienced professionals with less experienced practitioners, thereby promoting knowledge transfer and enhancing skill development in modern construction practices.

REFERENCES

1. Ahmed, O. G. (2025). Smart building systems: A Confluence of Architecture and Technology. KHWARIZMIA, 2025, 11–22.
2. Ashby, M. F., & Jones, D. R. H. (2014). Engineering materials 1: An Introduction to Properties, Applications and Design. Butterworth-Heinemann.
3. Buckman, A. H., Mayfield, M., & Beck, S. (2014). What is a smart building? Journal of Smart and Sustainable Built Environment, 3(2), 92–109.
4. Byrd, M. Y., Weathington, J. G., & Wagner, S. H. (2017). Leveraging human capital to build Capacity and sustain organizational growth. Journal of Leadership, Accountability and Ethics, 14(1), 11–23.
5. Chan, A. P. C., Darko, A., Olanipekun, A. O. & Ameyaw, E. E. (2018). Critical barriers to green Building technologies adoption in developing countries: The Case of Ghana. Journal of Cleaner Production, 172(1), 1067–1079. https://doi.org/10.1016/j.jclepro.2017.10.235.
6. Chitkara, K. K. (2015). Construction project management: Planning, Scheduling and Controlling, Tata McGraw-Hill Education.
7. Chizoba, O. (2020) Effect of skill acquisition on youth employability in Nigeria. International Journal of Research in Finance and Management, 3(1): 33-37.
8. Costa, A., Keane, M. M., Torrens, J. I., & Corry, E. (2013). Building operation and energy performance: Monitoring, analysis and optimization toolkit. Applied Energy journal, 1(01), 310–316.
9. Elattar, S. M. S. (2013). Smart structures and material technologies in architecture applications. Scientific Research and Essays, 8(31), 1512–1521.
10. Eseosa, O. & Temitope, I. (2019). Design optimization and implementation of smart building Management system in Nigeria. Journal of Instrumentation and Innovation Sciences, 4(3), 1–16.
11. European Training Foundation. (2017). Skills for the future: Effective Strategies and Policies for a Circular Economy. Luxembourg: Publications Office of the European Union.
12. Goldeh, A., Aghayari, R. & Wong, A. (2020). Skill needs of construction professionals on smart building systems. Procedia Computer Science, Volume 176, 2020, 3378–3386.

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume X Issue IV April 2026

13. Hamida, M. B., Hassanain, M. A. & Al-Hammad, A. M. (2022). Review and assessment of factors affecting adaptive reuse of commercial projects in Saudi Arabia. International Journal Building Pathology Adaptation, 40(1), 1–19. https://doi:10.1108/IJBPA-04-2020-0033.
14. Johnson, E. (2022a). Mastering joinery: Techniques and Projects for the Modern Woodworker. Craftsman Publishing. Retrieved on 5th July 2025 from http://www.stormingmedia.us/15/1554/A155480.html.
15. Kalu, U. O. & Udeala R. C. (2023) Smart building construction technology, A Digital Innovation for Enhancing Builders Entrepreneurial Sustainability, International Journal of Civil Engineering, Construction and Estate Management, 11(4), 31–40.
16. Kure, M. A. (2023). Analysing the level of smart building awareness amongst the professionalism the construction industry, 10(4), 14–38.
17. Kwon, O., Lee, E. & Bahn, H. (2014). Sensor-aware elevator scheduling for smart building environments. Building and Environment, 72(1), 332–342.
18. Liska, M., Herkel, S. & Uelkue, G. (2017). Handbook of construction materials: Their Nature and Behaviour. Springer.
19. Mathews, W. (2017). Energy simulation in building design. Routledge.
20. Ofori, G. (2013). Construction professionals and the uncertain global business environment. Engineering, Construction and Architectural Management 20(6), 531–536.
21. Paluch, S., Sokolov, D., & Mikhaylova, Y. (2020). Integrated control systems in smart cities. MATEC Web of Conferences, 329, 03080.
22. Shamsuddin, S. & Ahmad, F. (2018). Enhancing the competitiveness of Malaysia's construction industry via construction-specific skill enhancement programs. Procedia Engineering, 196, 805–812.
23. Sinopoli, J., & Van Till, J. (2010). Smart Building Systems for Architects, Owners, and Builders. William Andrew.
24. Straub, J., Bohn, S., & Rößler, S. (2018). Building Information Modelling (BIM) and Smart Construction, Contemporary Instruments for Energy, Efficient Buildings. Sustainability, 10(4), 1067.
25. Syed, W. A., Saud, A., Ibrahim, A. S., Abdullah, N. M., and Sameh, M. E. (2016). Assessment on the usage of insulated concrete forms in United Arab Emirates construction industry. International Journal of Structural and Civil Engineering Research, 5(3), 187–191
26. Vattano, S. (2014). "Smart buildings for a sustainable development", Economics World, 2(5),310–324.
27. Yan, C., Yin, Y., & Wang, S. (2018). Building Information Modelling for Smart Buildings.
28. Zhao, S., Zhang, P., & Li, W. (2021). A study on evaluation of influencing factors for sustainable development of smart construction enterprises: case study from China. Buildings 11(6), 221. https://doi:10.3390/buildings11.