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Smart Building Construction Technology, A Digital Innovation for Enhancing Builders Entrepreneurial Sustainability

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ABSTRACT: *The building construction industry is currently on the pathway to digitalization in line with the ongoing fourth industrial revolution. However, builders have been quite slow in aligning with the digitalization pathway due to lack of adequate understanding of digital innovative skills. This study aims to develop digital skills needed by builders to become enterprising in the building construction industry. Survey research design was adopted for the study. Two research questions and hypotheses were used to carry out the study. The population for the study comprised 115 male & female practicing builders from some selected building construction industry in South-east states of Nigeria. Structured questionnaire was used to deduce respondent's perception about digital innovative skills needed for constructing smart buildings. The internal consistency of the questionnaire was determined by the use of Cronbach alpha reliability test which yielded a value of 0.76. Data generated were analyzed using mean to answer research questions. T-test was used to test the hypotheses at probability level of 0.05. findings from the study revealed that BIM, IoT, BSM and data analytics are among the chief digital skills needed by builders to align with the digitalization of building construction industry. The findings further suggested that builders with possession of digital innovative skills promises to stay enterprising in the building construction industry. The study recommended that training opportunities on acquisition of digital skills relevant to the building construction industry should be sought for by all practicing builders in Nigeria to address the evolving dynamics in the built environment.*

KEYWORDS: smart building technology, digital innovation, builders, entrepreneurial sustainability

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INTRODUCTION

Smart building technology is a digital innovation introduced in the built industry to maximize energy efficiency of building structures. Smart buildings are designed and constructed by the integration of various automated systems and artificial intelligence technologies to enhance efficiency, sustainability and functionality (Vattano, 2014). The artificial intelligence systems (AIs) are designed to automatically collect and analyze data in real-time about the various structural and aesthetic members of the building structure. Information collected by the AI devices integrated in the smart building members is then utilized by the building systems to make informed decision which includes responding to changing environmental and structural conditions within the building environment (Hoffmann, 2009). Smart building construction technology encompasses a wide range of applications which includes facility management, maintenance, security, energy management and control of comfortability (Kwon, Lee & Bahn, 2014).

One major component of smart building technology is the internet of things (IoT) (Costa, Keane, Torre & Corry, 2013). The IoT connects mechatronic and electronic sensors/devices through the entire building structure to a central data-base management system. This action allows for seamless communication between different systems embedded in the building structure thereby, ensuring automated control and optimization. Building maintenance and facilities management are equally streamlined through smart building technology (Sinopoli, 2009). Sensors and other monitoring devices provide real-time information on the structural members performance and detects potential threats likely to cause building failure. By this complementary interaction between the structural members of the building and installed AI systems, predictive maintenance is activated, maintenance downtime is reduced and, the overall operational efficiency of the building structure is improved (Buckman, Mayfield & Beck, 2014). Another important feature of smart building construction technology is its ability to manage energy effectively. The technology behind smart building construction optimizes energy consumption by controlling lightening & the HVAC (Heating, ventilation and AC) systems (Elattar, 2013). Thus real-time data on residential occupancy, weather conditions and energy usage pattern are all collated and analyzed by the building itself to manage its energy. Buckman et al (2014) reported that the above phenomenon leads to substantial energy savings, reduction of operational cost, and smaller carbon footprint. Thus, smart building construction technology play a significant role in enhancing occupants security and safety. This is because it contains an integrated surveillance camera and intrusion detector. The surveillance camera and intrusion detectors are connected to a central monitoring station, which provides a proactive and quick responses to security threats. Hence, smart buildings notify its occupants the presence of any danger by sounding the fire detector alarm.

Construction of smart buildings requires the acquisition of combinational digital, structural and architectural skills and experience. As an innovative approach to the building industry, builders

need to acquire advanced digital skills in order to maintain entrepreneurial sustainability in the construction industry. Digital innovation according to Ross (2017) refers to the creation, adoption, and integration of novel technologies, tools, processes, or business models that leverage digital advancements to bring about significant improvements to various aspects of industrial products and services. Digital innovation involves the application of digital technologies such as artificial intelligence, data analytics, internet of things, software development amongst others to create new opportunities, solve complex challenges, or drive positive transformations within the identified industry. The effective means of acquiring these skills according Kalu, Udeala, Kalu & Ezeama (2023) is through collaboration and communication between builders, architects, software engineers, and other stakeholders involved in the construction process. Digital skills like building information modelling (BIM), software project management platform, and virtual reality (VR) simulations facilitates efficient information sharing, coordination and decision making. Other advanced skills which promises to improve builder's ability to build smart buildings are analytical skills, electronic trouble shooting skills, computer programming skills and data management skills amongst others. Builders gain valuable insights on the construction of smart buildings when in possession of digital skills in conjunction with the conventional structural knowledge (Gartner, 2013).

Builders interaction with smart building technology through the acquisition of digital innovative skills play significant role in enhancing entrepreneurial sustainability (Nambisan, Lyytinen, Majchrzak & Song, 2017). By making use of building information modelling (BIM) software, Builders entrepreneurial sustainability can be achieved as the software reduces construction errors by ensuring precise planning and collaboration. Thus, builders can deliver projects more effectively, stay competitive, adapt to changing market demands and new construction methodologies thereby maintaining optimal performance in the building construction industry.

The building construction industry is comprised of activities related to planning, designing, construction and maintenance of building structures. Processes such as site preparation, foundation design and construction, setting out of beams and columns are all duties performed by builders in the building construction industry (Kalu, Oluka & Udeala, 2023). Thus, a builder is a man or woman skilled professionally in the act of constructing houses, renovating houses or other architectural structures. They are engaged in all the stages of the construction processes including, planning, design and execution. Builders are adjudged to possess range of practical skills and knowledge in construction techniques, material behavior and building codes. A builder is evaluated on the level of expertise, work quality, and ability to meet project requirement (Oti, Kurul, Cheung, & Tah, 2016). In conclusion, it is the believe of the researchers that retraining builders with the needed digital skills vital in the construction of smart buildings will enable builders to integrate digital skills into structural skills for effective designing, construction and maintenance of smart building technology in Nigeria.

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Statement of the Problem

Builders play significant role in the society. They provide houses accommodation to individuals and communities, create safe, functional & comfortable living spaces for residency and businesses alike. Studies have shown that adequate provision of houses and other infrastructures are among the basic human needs which is crucial for maintaining crime free societies. Recently, the construction of energy efficient, comfortable, and environmentally sustainable buildings has outweighed the construction of conventionally known traditional building. This implies that acquisition of new skills necessary for the construction of intelligent buildings has become imperative for any builder in order to remain relevant in the building construction industry. Smart or intelligent building technology which has become the order of the day can only be designed and constructed when there is an integration of some digital skills such as electronic automation, artificial intelligence and structural skills.

Regrettably, most builders in Nigeria lack digital innovation skills. This is because building technology curriculum is rich in structural, architectural and geotechnical skills and deficit in digital skills. Hence, builders find it difficult to design and construct smart buildings with ease. This challenge has pushed a lot of builders out of business, thus, creating worrisome situation in the built industry. Identification of digital innovation skills relevance for integration into building technology curriculum capable of enhancing builder's ability to design and construct smart buildings in order to remain enterprising in the built environment was the problem the study sought to address.

Purpose of the Study

The general purpose of the study was to determine the significance of integrating digital innovation skills in the construction of smart buildings for enhancing builder's entrepreneurial sustainability in Nigeria. Specifically, the study sought to determine digital innovation skills needed for the construction of smart buildings and, relevance of the acquisition of smart building construction technology skills to builders.

Research Questions

The following research questions guided the study

1. What are the digital innovation skills needed for effective construction of smart building?
2. What are the relevance of smart building technology construction skills to builders?

Hypotheses

The following hypotheses were formulated and tested at 0.05 level of significance:

Ho_1: There is no significance difference in the ratings of male and female builders on the digital innovation skills needed for effective construction of smart buildings in Nigeria

Ho_2: There is no significant mean difference in the ratings of male and female builders on the relevance of smart building technology construction skills to builders in Nigeria.

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METHOD

The study adopted descriptive survey design. This style of research design was considered appropriate for the study as it identifies current condition of events and provides information on which to base good decision. There exists the need to determine the significance of digital skills acquisition for enhancing builder's ability to construct smart buildings. The expertise of professional builders in the building construction industries like Akiota Works Limited (AWL), Yardrock Construction Company (YCC), and Anchor-Nuel Resources Plc in Enugu, Ebonyi, and Anambra States were sought after and, purposefully selected for the study.

Area of the Study

The study covered three out of five states in the South-East Geo-political zone of Nigeria. These construction states were used for the study because of the vast presence of on-going construction of smart buildings. The construction companies sampled were those with documented evidence of deploying smart building technology for construction of smart buildings.

Population for the Study

The population for the study was professional builders in the construction industries. To ensure adequate sample representation of the population, the researchers developed certain specific selection criteria. Professional builders with at least ten years' experience in the construction of smart buildings were considered the base selection criteria for participants for the study. Hence, a total of 115 participated in the study. Participants were purposefully selected to ensure that only male and female builders with vast digital and structural skills were chosen for the study.

Instrument for Data Collection

The instrument for data collection was a structured questionnaire. It consists of two sections. Section A sought personal information from respondents which included; gender, rank and years of experience. Section B contained 13 items specifically aimed at determining digital innovation skills needed by builders to construct smart houses. Section C contained 8 items aimed at determining the relevance of smart building construction technology skill to builders in maintaining entrepreneurial sustainability. the questionnaire was structured along five point Likert scale.

Validation of the Instrument

The questionnaire was subjected to face and content validity. This was done to ensure that the entire questions covered the range of meanings and the research instrument relates to the statement of the problem, research questions and purpose of the study. Draft copies of the instrument were given to two practicing builders in the departments of Public building and Land/Housing development of ministry works Enugu state. Expert's suggestions and

recommendations were incorporated into the final draft of the questionnaire instrument. Cronbach Alpha value obtained from the instrument reliability test was 0.76.

Method of Data Analysis

Descriptive statistics was used to analyze the data. The analysis was carried out using SPSS v-25. Raw data was first coded and fed into the SPSS programme. Mean, standard deviation and t-test statistics were used to analyze the data. The cut-off set for accepting or rejecting an item was set at 3.50. Hence, items with mean values of 3.50 and above were accepted while, items below the mean value of 3.50 were rejected. The hypotheses were tested at 0.05% level of probability. whenever the t-value is equal or greater than the p-critical (0.05), the null hypothesis will be accepted. The null hypotheses will be rejected when t-value becomes less than the p-critical value. Out of the 120 copies of the questionnaire distributed to practicing builders, 115 were retrieved which indicated 95.83% return rate.

RESULTS

Table 1: Mean and SD ratings of male and female builders on digital innovative skills needed to be integrated into conventional building technology skills in order to construct smart buildings to maintain entrepreneurial relevancy. (N=115)

S/N	Item statements	Mean	SD
1.	Possession of BIM skills	4.45	0.55
2.	Possession of computer programming skills	3.83	0.91
3.	Possession of data analytical skills	4.21	0.76
4.	Possession of trouble-shooting skills	2.90	1.00
5.	Possession of devices configuration skills	2.91	1.00
6.	Possession of renewable energy skills	2.91	1.00
7.	Possession of collaborative skills	3.50	1.13
8.	Possession of IoT skills	4.21	0.76
9.	Possession of automation skills	2.91	1.00
10.	Possession of software development skills	2.70	1.18
11.	Possession of systems networking skills	2.90	1.02
12.	Possession of cyber security skills	2.90	1.01
13.	Possession of building systems management skills	4.45	0.56

Table 1 shows the responses of practicing builders on the needed digital innovative skills to sustain enterprise in the built environment. The respondents agreed to items1,2,3,7,8, & 13 shown in the table 1 and disagreed on items 4,5,6,9,10,11, & 12. The findings based on the 3.50 baseline for agreement, revealed that builders shared common opinion on the relevant digital innovative skills

such as possession of building information modelling (BIM) skill, knowledge of internet of things (IoT), possession of data analytical skills and many more as skills needed to be integrated into the conventional building technology skills to facilitate construction of smart buildings.

Table 2: **T-test on the mean ratings of male and female builders on digital innovative skills needed to be integrated into conventional building technology skills in order to construct smart buildings to maintain entrepreneurial relevancy.**

Lecturers	N	Mean	Std. Deviation	t-test	df	Sig.	Dec.
Male	95	3.49	0.57	2.92	113	0.09	Do not reject H_{01}
Female	20	3.23	0.44				

The t-value for the difference in mean ratings of male and female builders on digital innovative skills needed to be integrated into conventional building technology skills in order to construct smart buildings to maintain entrepreneurial relevancy was 2.92 significant at 0.09 level of probability. This value is higher than the set level of significance of 0.05 for the study. The null hypothesis is therefore not rejected. This implies that builders in the construction industries in Nigeria hold same opinion on the digital innovative skills needed to be integrated into conventional building technology skills for the construction of smart buildings.

Table 3 : Mean and SD ratings of male and female builders on the relevance of smart building technology skills to builder's entrepreneurial sustainability in Nigeria.
(N=115)

S/N	Item statements	Mean	SD
14.	Provides innovative building construction methods	4.18	0.66
15.	Enables builders to stay competitive in the industry	3.97	0.72
16.	Incorporation of technologies that enhances efficiency	3.16	1.02
17.	Increases customer base of the builder	3.97	0.80
18.	Enables construction of modern building project	3.56	0.77
19.	Ensures adaptability to sustainable demands	3.20	0.93
20.	Ensures real-time building monitoring	4.35	0.59
21.	Enables real-life SBC simulation	3.09	0.91

Table 3 shows respondents mean rating on the relevance of smart building technology skills to builder's entrepreneurial sustainability in Nigeria using the 3.50 cut-off point as basis for

agreement. The respondents agreed on items 14, 15, 17, 18, 20, & 21 as the relevant digital skills required to construct smart buildings. The respondents did not agree on items 16, & 19.

Table 4 : **T-test on the mean ratings of male and female builders on the relevant digital innovative skills required to construct smart buildings in Nigeria.**

Lecturers	N	Mean	Std. Deviation	t-test	df	Sig.	Dec.
Male	95	3.68	0.291	5.501	113	0.021	Reject H_{02}
Female	20	3.74	0.198				

The t-value for the difference in mean ratings of male and female builders on the relevant digital innovative skills required to construct smart buildings in Nigeria was 5.501 significant at 0.021 level of significance. This value is lower than 0.05 level of significance set for the study. The null hypothesis is therefore not accepted. This implies that builders in different construction industries have different opinion on the relevance of digital innovative skills with regards to the construction of smart buildings for sustainable entrepreneurship.

DISCUSSION

The study sought to establish the significance of integrating digital innovation skills into the conventional building construction technology skills by builders for sustainable enterprise in the construction of smart buildings in Nigeria. Findings from the study revealed that acquisition of digital skills such as building information modelling, internet of things, data analytics and professional collaborative abilities are the needed skills to be integrated into conventional structural and architectural skills for a builder to sustain entrepreneurship in the smart building technology industry in Nigeria. The findings agree with Vattano (2014) who reported that combining conventional academic studies with individual's exposure to the world-of-work through professional trainings fosters career sustainability.

Findings of the study also revealed that acquisition of digital innovative skills which is a prerequisite for smart building technology construction offers innovative building construction methods, enhances builder's visibility and therefore, enables builders to stay competitive in the building industry. The finding is congruent with the study carried out by Kalu, Udeala & Ezeama (2023) on the significance of competency based training of building technologist. The researchers reported that competencies and skills required to maintain sustainable self-employment and become competitive are usually acquired through experience and training.

CONCLUSION

The study determined the significance of digital innovative skills as a practical tool for the design and construction of smart buildings in Nigeria. The findings revealed that integration of digital innovative skills with the conventional structural and architectural skills by practicing builders is capable of ensuring sustainable entrepreneurship. The study highlighted relevant digital skills needed by builders to stay competitive in the construction industry. The researchers are optimistic that if builders can acquire digital innovative skills, they will maintain sustainable business venture in constructing smart building which is the current trend.

Recommendations

The following recommendations are made based on the findings of the study;

1. Training opportunities on the acquisition of digital skills relevant to the building construction industry should be sought for by all practicing builders in Nigeria to address the evolving dynamics in the built environment.
2. Partnership between digital training institutes and building construction industries should be encouraged. This would provide an avenue for interaction with experts thereby, providing practical innovative solutions to challenges of constructing smart buildings by builders.

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