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ENHANCING WOMEN'S PARTICIPATION IN THE CONSTRUCTION INDUSTRYTHROUGH CONSTRUCTION 4.0 TECHNOLOGY ADOPTION IN NIGERIA

Fortune Aigbe[1,3], Clinton Aigbavboa[1,3], Lekan Amusan[1,2,3]

[1]Department of Construction Management and Quantity Surveying, University of Johannesburg, Maropeng 198, SOUTH AFRICA

[2] Department of Building Technology, Covenant University, P.M.B 1023, Ota, Ogun State,NIGERIA

[3]CIDB Centre of Excellence & Sustainable Human Settlement and Construction Research Centre, Department of Construction Management & Quantity Surveying, Faculty of Engineeringand the Built Environment, University of Johannesburg, Doomfortein Campus, Maropeng 198 ,South Africa

fortune.aigbe@yahoo.co.uk

Abstract

The Construction industry is labour intensive, male-dominated and the nature of work is predominantly manual. The manual jobs carried out in the construction industry are both skilled-based and unskilled-based, which require physical presence most times, the use of strength, and are too tedious for most women to fit in. Hence, the adoption of technologies like those of construction 4.0 can further encourage more women's participation in the construction industry. This study aims at promoting gender equality and encouraging more participation of women in the construction industry through the use of construction 4.0. The methodology includes survey design and purposive sampling techniques. Data were analyzed using mean and rank order. The findings revealed that Construction 4.0 technologies include Building Information Modeling (BIM), drones, etc. Among the Construction 4.0 technologies that can enhance women's participation in the construction industry are; drones/ robots for technical assistance, the Internet ofthings/semantics for interconnection and interoperability, and BIM for decentralized decision, etc.The adoption of these technologies can be encouraged by making them readily available at a subsidized rate, upskilling/ reskilling workers, and continuous sensitization of professionals. The study recommends that Government should provide the enabling environment/policies to encourage investment in these technologies.

Keywords

Male-dominated; Construction 4.0; Technologies; Sustainability; Gender Equality

1. Introduction

The construction industry is complex in nature and consists of complex projects which have a large number of divergent systems and require thorough monitoring/ coordination and control from beginning to end (Wood & Gidado,2008). Furthermore, Wood *et al* (2008) stated that the complexity of construction projects can be in terms of the managerial perspective, operative and technological perspectives. Hence, in order for the complex nature of the construction industryand its project to be effectively managed, the managerial, operative (especially the human resource), and technological aspects must be given the utmost attention. The human resource in the construction industry is mainly male-dominated, the participation of women is globally low but more women participate in developed countries than in developing countries (Jwasshaka & Amin, 2020). The construction industry has the least number of women involvement despite the performance ability of women which is at par with those of their male counterparts (Akinsiku &Ajala,2018). A number of reasons have been given for this such as; the masculine nature of jobs, long working hours, the orientation of women being not as strong as men, and the poor image of the industry (Akinsiku &Ajala,2018). The masculine nature of construction jobs, long working hours, and poor image of the construction industry can be related to the slow adoption of technology in the Nigerian construction industry which is largely characterized by its manual nature of job execution which requires physical strength, low productivity, fragmented, nature, etc.

The adoption of technology like those of construction 4.0 can effectively help in mitigating these challenges. Construction 4.0 technology refers to the technological changes in new work methods as it pertains to processes/materials/markets etc. (Forcael, et al 2020). The technologies which make up construction 4.0 allow for a smart construction site such as the use of sensors, BIM models, drones and robots, etc. Therefore, this study aims at promoting gender equality and encouraging the participation of more women in the construction industry through the use of construction 4.0 by a)identifying the various construction 4.0 technologies in use in Nigeria, b)identifying the Construction 4.0 technologies that can enhance women's participation in the construction industry and c) Assessing the ways to encourage adoption of these technologies in Nigeria so as to enhance women's participation in the industry.

2. THEORETICAL FRAMEWORK

The theoretical framework is based on the two-factor theory (**Herzberg's motivation-hygiene theory) which states** that job satisfaction or dissatisfaction is caused by two sets of separate mutually exclusive factors in the workplace (Nickerson,2021).

He further listed the motivational factors to include; work itself, opportunities for advancement, job status, etc. While, the hygiene factors are; working conditions, policies, rules, relationship with colleagues and superiors, etc.

2.1WOMEN'S PARTICIPATION IN THE CONSTRUCTION INDUSTRY

The Construction industry is male-dominated with only 16.3% representation of women in the industry's workforce (Akinsiku et al,2018). Furthermore, according to Wang, Musi, andSunindijo (2021), women's participation in the industry dropped from 17% in 2006 to 12.9% in 2020. In Nigeria, men make up more than 90% of the Construction workforce (Nigeria Bureau of Statistics,2015), while in the United State of America, women make up only 8.2% and 3.1% of those employed as Construction managers and labourers respectively (Haruna, et al,2016). The participation of women in the Australian Construction Industry is only 11% (Adeniji etal, 2022) and 10% in South Africa (Akinsiku et al,2018).

2.2Barriers to Women's Participation in the Construction Industry

There are numerous challenges that affect women's participation in the Construction Industry and this may vary from country to country, some of these barriers include; Stressful work environment (Lekchiri et al,2020), Sexual discrimination, and Physical incapability (Agapious,2002, Okeke *et al*,2018), masculine nature of jobs, long working hours, the orientation of women not been as strong as men, and poor image of the industry (Akinsiku,2018),

2.3CONSTRUCTION 4.0 AND ITS TECHNOLOGIES

Construction 4.0 is an advanced construction management method that is driven by Industry 4.0 technologies, which allows for the creation of smart construction sites and the optimum performance of the industry (Prieto,2021). It is made up of various technologies such as drones, actuators, Prefabrication, Simulation, Building Information Modeling(BIM), Internet of things, sensor, Cloud Computing Artificial intelligence,3D printing etc.

2.4CONSTRUCTION 4.0 AND WOMEN'S PARTICIPATION IN THE CONSTRUCTION INDUSTRY

The dominance of males in the Construction industry cannot be overemphasized, but the active participation of more women in the industry can be further encouraged throughthe adoption of technology such as those of Construction 4.0. Among some of the barriers which bedevil women's active participation in the industry are; Stressful work environment (Lekchiri etal 2020), Sexual discrimination and Physical incapability (Agapious,2002, Okeke et al,2018), masculine nature of jobs, long working hours, the orientation of women not been as strong as men,and poor image of the industry (Akinsiku,2018), But, these challenges can be surmounted completely or mitigated by Construction 4.0 which embeds the principles of technical assistance through technologies such as drone, robot and 3D printing (Prieto,2021), decentralization of decision through the use of BIM, Cloud computing, interoperability interconnectivity and information transparency through the use of virtual/ Augmented reality(Prieto,2021). Therefore, since the world is going digital and many other sectors are aligning, the Construction industry cannot afford to be left behind. The adoption of these technologies which encourages digitalization, industrialization, and the use of cyber-physical systems can help integrate more women into the industry, bridge the skill gap due to the low participation of women, and thereby increase productivity and efficiency of the industry (Hossain *et al*;2019, Sawhney *et al*; 2020, Forcael *et al*,2020). The adoption of Construction 4.0 technologies helps encourage the recruitment, retention, and job progress of women in the Construction industry.

2.4.1CONSTRUCTION 4.0 AND WOMEN'S RECRUITMENT INTO THE CONSTRUCTION INDUSTRY

A major barrier to the participation of women in the Construction industry is the Poor image of the industry. The adoption of Construction 4.0 can help bring about a change in business and new image fostering by transforming a "dumb" system into a "smart" system, enabling a decentralized system of decision-making through the use of Building information modeling and cloud computing, enabling systems to work together(interoperability) through the use of internet of things, connecting systems together(interconnectivity) through the use of internet of things, providing technical assistance through the use of drones, enhancing safety through the robot use (Prieto, 2021). This can help in recruiting more women into the operational phase of Construction as against the administrative phase in which most women in the Construction industry are concentrated (Haruna *et al*,2016), and more female graduates into the Construction industry (Akinsiku, *et al*,2018).

2.4.2CONSTRUCTION 4.0 AND WOMEN'S RETENTION AND JOB PROGRESS.

Another barrier to women's participation in the Construction industry is the long hours of work, the tediousness of work, and sexual discrimination. The adoption of the fourth industrial revolution

in the Construction industry has brought about new competencies such as change and workforce management (Turner, 2021), etc. and a number of Leadership competencies are associated with Construction 4.0 such as Tolerance of failure, Encouragement, Trust-building, Talent management, and Partnership development. These can help motivate, create a better workplace for women, and reduce sexual discrimination. Also, the adoption of technologies such as Drones, the Internet of Things, and Cloud computing can help in reducing long work hours and the tediousness of work as described below;

2.4.2.1DRONE TECHNOLOGY

Drone technology can help encourage more women's participation in the Construction industry. According to Shahmoradi, Talebi, Roghanchi, and Hassanalian, (2020), the monitoring of construction sites and facility management could be enhanced through the use of drones. The adoption of this technology on a Construction site could assist women in site supervision, especially where the site is large involving diverse activities and might involve monitoring high-rise construction activities. It can also help reduce long working hours i.e. save time, improve women's safety (some sites might be potentially dangerous for women, and pose a high risk), and help in assessing high-quality data (Tkáč, & Mésároš, 2019).

2.4.2.2INTERNET OF THINGS

The internet of things(IoT) can help in collecting, and processing large amounts of data, and help improve the quality of life in the Construction industry (Hossein Motlagh, Mohammadrezaei, Hunt, & Zakeri,2020). Data is needed for sustainability and is also very important at every phase of construction. Gathering data, especially at the operational/maintenance may pose a major challenge for women (since it's mainly done manually in Nigeria due to the low adoption of technology), hence the adoption of technologies like the Internet of Things can help reduce sexualdiscrimination.

2.4.2.3 CLOUD COMPUTING

Most construction and Contract documentation are paper-dominated; hence documents are stored in files that might be too many/bulky to access after a long time. The adoption of cloud computing in Construction can help eliminate paper-associated storage challenges and reduce the time spent in searching for files. Furthermore, it could also help reduce cost savings, and enhance flexibility, and security (Srivastava, & Khan,2018).

3.0 METHODOLOGY

The study was carried out among construction companies in Lagos state (Lagos was chosen because it's the commercial centre of Nigeria and a lot of construction work goes on there) with a population of 70 respondents which comprised of both male and female professionals such as Architects, Builders, Quantity surveyors, Civil Engineers, Mechanical and Electrical Engineers, etc. Both Primary and Secondary methods of data collection were used for this study. A quantitative approach was adopted using structured questionnaires (which were the primary data source), Published articles, Journals, textbooks, etc. made up the secondary sources of data collection instruments. The sampling techniques used were purposive sampling techniques because respondents had the requisite experience and were also the primary actors/recipients. Thesample size was determined through the use of the taro Yamane formula ($n = N/ 1+ N(e)^2$), WhereN is the population of the study is the sampling error, where the sample size was 60 respondents. The data were analyzed by mean score, rank order, frequency, tabulation, and percentages.

4. Results

4.1 Profession of Respondent

Table 1 **Table 1 Profession of Respondent**

S/N	PROFESSION	NUMBER OF RESPONDENTS	PERCENTAGE
1	Architect	20	33.33%
2	Builder	10	16.67%
3	Structural Engineer	3	5%
4	Quantity Surveyor	15	25%
5	Mechanical Engineer	5	8.33%
6	Electrical Engineer	7	11.67%
	TOTAL	**60**	**100**

Source: Research Survey (2023)

From table 1, it can be seen that the profession of the respondents are; Architects with a percentageof 33.33%, Quantity surveyors with a percentage of 25%, Builders with a percentage of 16.67%, Electrical engineers with a percentage of 11.6%, 5 Mechanical engineers with a percentage of 8.33% and Structural engineers with a percentage of 5%

4.2 Proportion of Male Respondents to Female Respondents

Table 2 Proportion of Male Respondents to Female Respondents

S/N	PROPORTION OF MALE TO FEMALE	NUMBER OF RESPONDENTS	PERCENTAGE
1	Male	15	25%
2	Female	45	75%
	TOTAL	60	100%

Source: Research Survey (2023)

From table 2, it can be observed that women make up 75% of the total respondents, while menmake up 25% of the total respondents

4.3 Years of Experience of Respondents.

Table 3 Years of Experience of Respondents.

S/N	YEARS OF EXPERIENCE	NUMBER OF RESPONDENTS	PERCENTAGE
1	2-10 YEARS	20	33.33%
2	10-20 Years	35	58.33%
3	20-35 Years	5	8.33%
		60	100%

Source: Research Survey (2023)

From table 3, it can be observed that respondents are mainly between 10-20 years with a percentage of 58.33%, those between 2-10 years with a percentage of 33.33%, and those between 20-35 years with a percentage of 8.33%.

4.4 Construction 4.0 technologies in use in Nigeria.

Table 4 Construction 4.0 technologies in use in Nigeria,

Construction4.0 technologies	**MEAN SCORE**	**RANK**
BIM	5.0	1
IOT	4.98	2
Drone	4.96	3
Robots	4.96	3
Augmented Reality	4.91	4
Virtual Reality	4.91	4
Mixed Reality	4.75	6
Cloud Computing	4.91	4
Big Data Analytics	4.83	5
Semantic Technology	4.83	5

Source: Research Survey (2023)

From table 4, it can be observed that respondents agree that BIM, IoT Drone, Robot, and Augmented reality with mean scores of 5.0,4.98,4.96,4.96,4.91 respectively are Construction 4.0 technologies

4.5

Table 5 Construction 4.0 technologies which can enhance women's participation in theconstruction industry.

Construction 4.0 Technologies that can enhance women's participation in the Industry	MEAN SCORE	RANK
Technical Assistance Drones/Robots	4.83	1
Interconnection/Interoperability IOT/ Semantics	4.65	2
Decentralized Decision BIM/Cloud computing	4.58	3
Information Transparency Virtual, Augmented/MixedReality	4.57	4

Source: Research Survey (2023)

From table 5, it can be observed that respondents agree that the Construction 4.0 technologies that can enhance women's participation in the construction industry are; Drones/Robots (which aids technical assistance) and with a mean score of 4.83, IOT/Semantics (which aids interconnectivity and interoperability) with a mean score of 4.65, BIM/Cloud Computing (which aids decentralized decisions)with a mean score of 4.58, Virtual/Augmented and Mixed Reality(which aids information transparency) with a mean score of 4.57.

4.6

Table 6 Ways to encourage the adoption of Construction 4.0 technologies in Nigeria so as to enhance women's participation in the industry.

Ways in which Construction 4.0 can be encouraged	MeanScore	Rank
Availability of the technologies at subsidized rate	4.3	1
Upskilling/Reskilling of workers	4.1	2
Continuous sensitization of professionals and the Populace	3.87	3
Providing enabling Policies	3.38	5
Providing the necessary political Will	3.57	4

Source: Research Survey (2023)

From table 6, it can be observed that respondents agree that among the ways in which the adoption of Construction 4.0 technologies can be encouraged so as to enhance the participation of women in the Construction industry are; Availability of the technologies at a subsidized rate with a mean score of 4.3, Upskilling/ reskilling of workers with a mean score of 4.1 Continuous sensitization of professionals and the populace with a mean score of 3.87, Providing the necessary political will with a mean score of 3.57 and Providing enabling policies with a mean score of 3.38.

5. Discussion

From the findings above, the various construction 4.0 technologies are; BIM, IoT, Drones,and Robots. This agrees with Krupik, (2022) which identified the Construction 4.0technologies to include BIM, virtual and augmented reality, drones, cloud collaboration (real-time collaboration), the Internet of Things, or wireless monitoring and device connectivity.

The Construction 4.0 technologies which can enhance women's participation in theconstruction industry are; Drones/Robots for technical assistance which agrees with Sotnikand Lyashenko, (2022) which state that robots are solving lots of problems such as low productivity, labour shortage, and

supporting people both at work/ personal lives., IoT for Interconnection/Interoperability agrees with Ibrahim, Esa, and Rahman, (2021) which statethat the interconnectivity of IoT directly/ indirectly acts as a primary medium of communication between humans and construction technology. BIM/Cloud computing fordecentralized decision agrees with Agyekum-Kwatiah, (2018) which states that BIM allows for clash detection through its information sharing capabilities between various departments, Virtual, Augmented/Mixed Reality for information transparency which agrees with Mathivanan, (2017) which states that Virtual reality is very interactive.

Ways to encourage the adoption of Construction 4.0 technologies in Nigeria so as to enhance women's participation in the industry are; Making available these technologies at a subsidized rate, Upskilling/Reskilling workers, Continuous sensitization of professionals and the populace, and providing enabling policies and Providing the necessary political will. This agrees with Nnameti and Eze, (2022) which encouraged the involvement of government and private investors in promoting smart cities through the use of smart technologies. While, Adepoju, (2021) emphasized the need for re-skilling human resources as an integral way of encouraging the adoption of these technologies.

5. Conclusions

The Construction industry is complex in nature and this complexity is both in terms of its technology and operatives. The slow adoption of technology and prevalent male dominance of the sector in Nigeria has further posed a threat to the participation of women in the industry. Therefore, the study identified Construction 4.0 technologies to include; Building Information Modeling(BIM), Internet of Things(IoT), and Drones. The study also identified the various Construction 4.0 technologies that can enhance women's participation in the Construction industry to include; Drones/Robots for technical assistance, the Internet of things(IoT)/ Semantics for interconnectivity. Furthermore, the study enumerated the ways Construction 4.0 adoption can be encouraged to include; making available these technologies at a subsidized rate, and Upskilling/Reskilling workers. Hence, the adoption of Construction 4.0 technologies such as Building Information Modeling(BIM), Internet of Things(IoT), Drones, etc., and encouraging their adoption through their subsidization, upskilling/reskilling of workers, sensitization of professionals/populace can help promote gender equality and encourage the participation of more women in the Nigerian Construction industry. This study is limited to the Construction industry (especially in Nigeria) which is male-dominated and slow in technology adoption. To this end, the study recommends that the concept of outsourcing and insourcing be encouraged within the Construction industry, which will see women knowledgeable in some of these non-construction specific technologies such as the Internet of things, and Cloud computing in other sectors like Information and Communication technology work and provide mentorship for women within the industry. While, the women with knowledge of Construction specific technology such as Building information modeling, and Prefabrication within the industry provide mentorship for those early career women and others. Professionals as well as Construction companies should be adequately sensitized on the role Construction 4.0 technology can play in eliminating these barriers militating againstthe active participation of women in the Construction industry. Also, in other to reduce the cost ofacceptance of these technologies, Construction companies should encourage collaboration withinthemselves and partnership between them and other sectors (that possess relevant skills and technologies), and the Government should provide the enabling environment/policies to encourage investment in these technologies. Further studies should be carried out on how Construction 4.0 technologies can encourage women's participation in the Industry in other climes. This study contributes to knowledge in that previous studies have emphasized the use of these technologies to encourage improved work, productivity, and efficiency in the already male-dominated industry without consideration for bridging the gap on the less involvement of women in the industry. Therefore, this study will help promote gender equality and encourage the participation of more women in the Nigerian Construction industry thereby reducing male dominance. Also, this study will help transition women from non-professional roles in the Construction industry to core professional roles.

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