# Enhancing Building Construction Practices through the Application of Artificial Intelligence and Robotics

**By**

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## Abstract

The study ascertained how to enhance building construction practices through the application of artificial intelligence and robotics. The study adopted a descriptive survey design. This study was carried out in Enugu State, Nigeria. The population was made up of 297 respondents which comprises of 57 building technology lecturers and 240 final year-students of building technology in the University of Nigeria and Enugu State University of Technology respectively. Due to the manageable size of the population, the entire population was used as the sample. A 29-item Questionnaire was used in answering research questions. The questionnaire was structured on a five point likert response options of Strongly Agree (SA), Agree (A), Undecided (UD), Disagree (D) and Strongly Disagree (SD). The instrument was validated by three experts. The Reliability of the instrument yielded a coefficient of 0.782. This shows that the instrument was reliable. Data collected was analyzed using mean and standard deviation to answer research questions. Decision on research questions were taken based on real limits of numbers. Thus, mean rating of 3.50 and above were considered as agreed, while items with mean rating below 3.50 were considered as disagreed. The study found that application of artificial intelligence and robotics will improve the building construction practices in Nigeria in several ways including: AI-driven systems can perform tasks with unmatched precision and speed, significantly accelerating construction processes and robots can perform tasks with unmatched precision and speed, significantly accelerating construction processes. The construction stakeholders and companies should prioritize investment based on areas where AI and robotics can have the most impact on their company's unique needs.

**Keywords:** Building construction, Building construction practices, Artificial Intelligence, Robotics, Project efficiency, and Project completion.

## Introduction

The construction industry stands as a bastion of progress and innovation. Embracing sustainability has become the clarion call for change, urging a shift towards sustainable construction practices within the building construction sector. At the forefront of this transformation are the building technology stakeholders such as builders, civil engineers, land surveyors, urban/regional planners, foremen, and quantity surveyors among others (Yaseen, Ali, Salih, & Al-Ansari, 2020). However, the extent of their awareness and preparedness to champion sustainable practices remains a pivotal question, as Tunji-Olayeni, Afolabi, Olowookere,

Okpalamoka, and Oluwatobi, (2019) noted that artificial intelligence and robotics is changing the face of construction and the Nigerian building construction industry needs to embrace this positive change.

Artificial Intelligence (AI), as a leading sustainable technology, is making significant contributions to improving operations, service processes, and productivity in various sectors of the economy around the globe. Abioye, Oyedele, Akanbi, Ajayi, Delgado, Bilal and Ahmed (2021) defined Artificial intelligence (AI) as the capability of a computer to learn, make decisions and perform actions characteristic of human intelligence. Basaif, Alashwal, Mohd-Rahim, Abd Karim, and Loo (2020) defined Artificial intelligence, as a broad field of computer science concerned with the development of intelligent robots able to do activities that traditionally require human intellect. AI technologies allow for the creation of algorithms and programs that train computers to solve problems independently. Eber, (2020) stated that AI is playing a crucial role in assisting construction supervisors to minimize accidents, maintain project efficiency, and dramatically improve operational safety. The adoption of AI techniques offers automated solutions and provides competitive advantages over conventional approaches.

Subfields of AI, such as machine learning, natural language processing, robotics, computer vision, optimization, and automated planning and scheduling, have successfully addressed complex problems and supported decision-making in real-world scenarios. For instance, the manufacturing industry has experienced the fourth industrial revolution, known as Industry 4.0, which emphasizes automation, data-driven technologies, and advanced AI techniques (Egwim, Alaka, Toriola-Coker, Balogun, and Sunmola, (2021). This revolution has resulted in significant improvements in processes, cost-efficiency, and reduced production times. Considering the success of AI in other industries, there is immense potential to apply AI techniques in the construction industry. Güngör (2020) noted that AI can help automate processes, improve project management, enhance safety measures, and optimize resource allocation. By leveraging machine learning algorithms, construction companies can analyze large datasets to gain valuable insights for informed decision-making and predictive maintenance. Computer vision technologies can aid in quality control and monitoring on construction sites, ensuring adherence to design specifications and identifying potential safety risks. AI-driven optimization algorithms can streamline construction schedules, minimize delays, and improve

overall project efficiency. However, several challenges must be addressed to effectively implement AI in the construction industry. These challenges include data availability and quality, integration with existing systems, ensuring ethical use of AI, and overcoming the resistance to change within the industry (Hsu, Angeloudis & Aurisicchio, 2018). Additionally, there is a need for upskilling the workforce to embrace and utilize AI technologies effectively. In addition to artificial intelligence, robotics is another sustainable technological development that is revolutionizing the building construction sector.

Robotic technologies have revolutionized various industries, and the construction sector is no exception. Akinradewo, Oke, Aigbavboa and Molau (2021) defined robotics as the interdisciplinary study and practice of the design, construction, operation and use of robots. Ajayi, Oyedele, Owolabi, Akinade, Bilal, Delgado, and Akanbi (2020) stated that robotics is a branch of engineering and computer science that involves the conception, design, manufacture and operation of robots. Robots are man-made machines which are able to replicate automatically certain human movements and functions (Johnson & Babu, 2020). Robots are machines which are capable of carrying out complex series of actions automatically, especially when programmable by a computer. With the increasing complexity and scale of modern construction projects, there is a growing interest in integrating robotics engineering solutions to improve efficiency, precision, and safety on construction sites.

In the construction industry, a persistent shortage of skilled workers has become a significant challenge, despite its substantial contribution to a country's GDP. Timely project completion and efficient execution are hindered by the scarcity of skilled laborers (Afolabi, Ibem, Aduwo and Tunji-Olayeni, (2020). To overcome these hurdles, technological innovations that combine human-like decision-making with machine efficiency have emerged. Robotics, powered by Artificial Intelligence (AI) algorithms, is demonstrated promising potential in filling this labor gap and enhancing productivity and safety in construction projects. Robots powered by Artificial Intelligence (AI) algorithms are presenting transformative potential by combining human-like decision-making with machine precision (Khobragade, Maheswari and Sivagami, 2018). These sophisticated machines are designed to mimic human actions and are capable of performing a diverse array of tasks in dynamic construction environments. From autonomous drones conducting aerial surveys to robotic arms executing precise bricklaying, the applications

of robotics in construction are far-reaching and versatile. The integration of robotics into construction projects offers several notable benefits.

One of the most significant advantages is increased project efficiency, as robots can operate tirelessly, leading to faster project completion times and optimized resource utilization. This efficiency can also translate to reduced labor costs, as robots can augment and complement the work of human workers. Moreover, these machines can handle hazardous tasks, such as working in high risk areas or handling heavy materials, thereby minimizing safety risks and ensuring a safer work environment for construction personnel (Hayati, Latief, Rarasati, and Siddik, 2017). However, despite the numerous opportunities that robotics presents, there are also challenges hindering its widespread adoption in the construction sector. High initial investment costs, complexities in integrating robotic systems with existing construction workflows, and concerns about potential workforce displacement are among the barriers that need to be addressed.

**Statement of the Problem**

The construction industry faces numerous challenges that have hindered its growth and productivity, especially when compared to more digitized industries like manufacturing. Digitization within the construction sector has been slow, primarily due to a long-standing resistance to change. This lack of digitalization and overreliance on manual processes make project management complex and unnecessarily tedious. Furthermore, the absence of digital expertise in Nigeria and technology adoption has led to cost inefficiencies, project delays, poor quality performance, uninformed decision-making, and overall low productivity and safety standards. In light of labor shortages, and the need for sustainable infrastructure, it has become increasingly clear that the construction industry must embrace digitization and enhance its technological capacity.

To overcome these hurdles, technological innovations that combine human-like decision-making with machine efficiency have emerged. Robotics, powered by Artificial Intelligence (AI) algorithms, has demonstrated promising potential in filling this labor gap and enhancing productivity and safety in construction projects. Robots, powered by Artificial Intelligence (AI) algorithms, present a transformative potential by combining human-like decision-making with

machine precision. These sophisticated machines are designed to mimic human actions and are capable of performing a diverse array of tasks in dynamic construction environments. From autonomous drones conducting aerial surveys to robotic arms executing precise bricklaying, the applications of robotics in construction are far-reaching and versatile. The integration of robotics into construction projects offers several notable benefits. This research paper aims to explore and analyze how the diverse applications of AI and robotics can improve the construction industry in Nigeria.

**Purpose of the Study**

The purpose of the study was to find out how to enhance building technology through the application of artificial intelligence and robotics. Specifically, the study sought to;

1. Find out how application of artificial intelligence will improve the building construction sector in Nigeria.
2. Find out how application of robotics will improve the building construction sector in Nigeria.

**Research Questions**

The following research questions guided the study:

1. How will the application of artificial intelligence improve the building construction sector in Nigeria?
2. How will the application of robotics improve the building construction sector in Nigeria?

**Hypotheses**

The following null hypothesis was tested at 0.05 level of significance:

1. There is no significant difference in the mean responses of lecturers and students on the how the application of artificial intelligence will improve the building construction sector in Nigeria.
2. There is no significant difference in the mean responses of lecturers and students on the how the application of robotics will improve the building construction sector in Nigeria.

**Methodology**

The study adopted a descriptive survey design. Descriptive survey research design is used for those studies which aim at collecting data and describing in a systematic manner the

characteristics, features or facts about a given population (Nworgu, 2015). This study was carried out in Enugu State, Nigeria. The population was made up of 297 respondents which comprises of 57 building technology lecturers and 240 final year-students of building technology in the University of Nigeria and Enugu State University of Technology respectively. Due to the manageable size of the population, the entire population was used as the sample.

A 29-item Questionnaire was used in answering research questions. The title of the Questionnaire is: Enhancing Building Technology through Artificial Intelligence and Robotics Questionnaire (E.B.T.A.I.R.Q). The questionnaire was made up of two parts. Part 1 which elicited information from the respondents on their demographic data, and Part 2 which was made up of two clusters. Clusters A elicited information on how the application of artificial intelligence improve the building construction sector in Nigeria, while cluster B elicited information on how application of robotics will improve the building construction sector in Nigeria. The clusters were structured on a five point likert response options of Strongly Agree (SA), Agree (A), Undecided (UD), Disagree (D) and Strongly Disagree (SD). The instrument was validated by three experts. The experts' comments and suggestions were used in modifying the questions and items. The Reliability of the instrument (E.B.T.A.I.R.Q) was subjected to Cronbach's Alpha reliability method to determine the internal consistency which yielded a coefficient of 0.782. This shows that the instrument was reliable.

The administration and retrieval of the Q.I.W.B.E.E.P questionnaire was carried out by the researchers with the help of two research assistants. 297 copies of the questionnaires were administered on the respondents, which were retrieved within one week after administration. Data collected was analyzed using mean and standard deviation to answer research questions. Decision on research questions were taken based on real limits of numbers. Thus, mean rating of 3.50 and above were considered as agreed, while items with mean rating below 3.50 were considered as disagreed. For the test of significance, the probability (p) value was used in comparison with the alpha value of 0.05, and at 90 degree of freedom (df). If any item has a probability value greater than 0.05 ($P>0.05$) it will be concluded that there is no significant difference in the mean responses of the respondents.

**Results**

**Data for answering research questions 1 to 2 were presented in table 1 to 2**

**Research Question 1:** How will the application of artificial intelligence improve the building construction sector in Nigeria?

**Table 1:** Mean responses and t-test analysis of lecturers and students on the how the application of artificial intelligence will improve the building construction sector in Nigeria. **N= 297**

| S/N | Items | Mean | t-cal | Sig. | Decision |
|---|---|---|---|---|---|
| **1** | AI-driven systems can perform tasks with unmatched precision and speed, significantly accelerating construction processes. | 3.62 | 0.95 | 0.32 | NS |
| **2** | AI algorithms can analyze construction data and optimize resource allocation, ensuring that materials and equipment are used efficiently. | 3.64 | 0.74 | 0.33 | NS |
| **3** | AI algorithms can analyze construction data and optimize resource allocation leading to reduced material waste, better equipment utilization, and cost savings. | 3.66 | 0.45 | 0.62 | NS |
| **4** | (AI) is revolutionizing architectural design by enabling the creation of intricate and highly organized 3D models and visualizations. | 3.56 | 0.65 | 0.54 | NS |
| **5** | AI generated 3D models not only showcase the aesthetic aspects of buildings but also help in identifying and rectifying potential problems before the actual construction begins. | 3.55 | 0.22 | 0.76 | NS |
| **6** | AI-powered software empowers designers to simulate and fine-tune various aspects such as lighting, HVAC systems, and energy consumption, leading to more sustainable and eco-friendly designs. | 3.62 | 0.95 | 0.32 | NS |
| **7** | Sophisticated AI algorithms analyze vast amounts of data, enabling the early detection of productivity issues or equipment problems, preventing them from escalating into crises. | 3.64 | 0.74 | 0.33 | NS |
| **8** | AI algorithms enable architects and engineers to design structures that minimize energy usage and maximize natural light. | 3.66 | 0.45 | 0.62 | NS |
| **9** | AI algorithms enable the precision and personalization of environmental performance within a building significantly reduces its carbon footprint and contributes to the global sustainability agenda. | 3.56 | 0.65 | 0.54 | NS |
| **10** | Integration of AI in sustainable construction practices is fostering an era of ‘smart’ & ‘green’ buildings, ushering in a future where construction aligns harmoniously with environment & natural resources. | 3.62 | 0.95 | 0.32 | NS |
| | **Cluster** | **3.73** | **0.24** | **0.72** | **NS** |

Table 1 shows the responses of building technology lecturers and students on how the application of artificial intelligence will improve the building construction sector in Nigeria. Data shows that all the 10 items have mean values above the 3.50 benchmark. Thus, the ten items were accepted as how the application of artificial intelligence will improve the building construction sector in Nigeria. Furthermore, the Table shows the t-test analysis comparing the mean from both groups. The five items including the cluster t-cal have p-values above .05 at 0.05 level of significance. Therefore, the hypothesis that there is no significant difference in mean responses of lecturers and students on the how the application of artificial intelligence will improve the building construction sector in Nigeria was not rejected.

**Research Question 2:** How will the application of robotics improve the building construction sector in Nigeria?

**Table 2:** Mean Responses and t-test analysis of lecturers and students on the how the application of robotics will improve the building construction sector in Nigeria. **N= 297**

| S/N | Items | Mean | t-cal | Sig. | Decision |
|---|---|---|---|---|---|
| **1** | Robots can perform tasks with unmatched precision and speed, significantly accelerating construction processes. | 3.71 | 0.23 | 0.98 | NS |
| **2** | By automating repetitive and labor-intensive tasks, construction projects can be completed more efficiently, leading to reduced project timelines and increased productivity. | 3.81 | 0.13 | 0.87 | NS |
| **3** | Robots can be deployed to handle dangerous tasks, such as working at heights, heavy lifting, and handling hazardous materials. | 3.65 | 1.09 | 0.45 | NS |
| **4** | By replacing human workers in these high-risk activities, the potential for onsite accidents and injuries is reduced, creating a safer work environment. | 3.67 | 1.23 | 0.44 | NS |
| **5** | Robots are programmed to execute tasks with consistent accuracy, eliminating human errors and variations. | 3.46 | 0.88 | 0.88 | NS |
| **6** | Whether it's bricklaying, welding, or concrete pouring, robotic systems ensure a higher level of precision, resulting in better quality construction and reducing the need for rework. | 3.71 | 0.23 | 0.98 | NS |
| **7** | Unlike human workers with limited working hours, robots can operate continuously, providing the potential for non-stop construction activities. | 3.81 | 0.13 | 0.87 | NS |
| **8** | Robots have the capability to operate round-the-clock which lead to faster project completion and reduced construction timeframes. | 3.65 | 1.09 | 0.45 | NS |

| | | | | | |
|---|---|---|---|---|---|
| **9** | Robots can be programmed and reprogrammed for various tasks, making them adaptable to changing project requirements. | 3.67 | 1.23 | 0.44 | NS |
| **10** | The flexibility of programmed robots allows construction companies to adjust to evolving project needs and challenges efficiently | 3.71 | 0.23 | 0.98 | NS |
| | **Cluster** | **3.65** | **0.28** | **0.77** | **NS** |

Table 2 shows the responses of building technology lecturers and students on the how the application of robotics will improve the building construction sector in Nigeria. Data shows concession that all the 10 items have mean values above the 3.50 benchmark. Thus, the ten items were accepted. The table also shows the t-test analysis. Comparing the mean from both groups, the ten items including the cluster t-cal have p-values above .05 at 0.05 level of significance. Therefore, the hypothesis that there is no significant difference in the mean responses of lecturers and students on the how the application of robotics will improve the building construction sector in Nigeria was accepted.

**Discussion of Findings**

The findings of the study in table 1 revealed the application of artificial intelligence improve the building construction sector. Some of them includes that AI algorithms enable architects and engineers to design structures that minimize energy usage and maximize natural light; AI algorithms can analyze construction data and optimize resource allocation leading to reduced material waste, better equipment utilization, and cost savings. These findings are in line with Hayati et al, (2017) who stated that Artificial Neural Networks are used on projects to predict price overruns supported factors like project size, contract kind and also the competency level of project managers. Historical knowledge like planned begin and finish dates are unit employed by prophetic models to ascertain realistic timelines for future comes. AI helps employees remotely access real-life coaching material that helps them enhance their skills and information quickly. This reduces the time taken to aboard new resources onto comes. As a result, project delivery is expedited. Johnson and Babu, (2020) also supported the findings by stating that There are AI and machine learning solutions today that general contractors use to observe and place risk on the job site, that the project team will focus their restricted time and resources on the largest risk factors. AI is to automatically assign priority to problems.

Subcontractors are rated supported a risk score therefore construction managers will work closely with insecure groups to mitigate risk.

The study in table 2, also investigated the application of robotics improve the building construction sector. Some of them include that robots have the capability to operate round-the-clock which lead to faster project completion and reduced construction timeframes; and unlike human workers with limited working hours, robots can operate continuously, providing the potential for non-stop construction activities. These findings are in line with Eber, (2020) who stated that robots hold the key to resolution late and over budget construction projects. The corporate uses robots to autonomously capture 3D scans of construction sites and so feeds that information into a deep neural network that classifies however so much on totally different sub-projects are. If things appear astray, the management team will step in to contend with small problems before they become major issues. Also Yaseen et al, (2020) stated that in recent years, construction robots are no longer working in isolation but can collaborate with other robots and human workers. Through cooperation and information sharing, robots can better accomplish complex construction tasks, thereby improving work efficiency and quality. Robots can be reconfigured and assembled according to different task requirements to adapt to various construction environments and task demands. For example, the robot's mechanical arm can change its tool head based on the operational needs to accommodate different types of construction tasks.

**Conclusion**

The purpose of the study was to find how to enhance building technology through the application of artificial intelligence and robotics. The study found that application of artificial intelligence and robotics will improve the building construction sector in Nigeria in several ways including: AI-driven systems can perform tasks with unmatched precision and speed, significantly accelerating construction processes and robots can perform tasks with unmatched precision and speed, significantly accelerating construction processes. The construction industry is undergoing a remarkable transformation through the adoption of AI and Robotics, propelling it into the realm of high-tech. Investing in AI and robotics can expedite construction work and reduce costs associated with manual labor. AI has the potential to enhance design processes, while robotics can increase safety and efficiency on construction sites.

## Recommendations

Based on the findings made and the conclusion drawn, the following recommendations were made:

1. To meet the demands for efficiency and safety, the future of construction will require skilled workers well-versed in new technologies, construction degrees emphasizing technical skills, trade-based technical training, and continuous development of construction skills.

2. The construction stakeholders and companies should prioritize investment based on areas where AI and robotics can have the most impact on their company's unique needs. It is crucial for the industry to make significant investments in retraining existing workers to be technologically proficient, and to actively embrace emerging trends by providing support and gradually implementing these transformative changes.

## Conflicts of Interest

The authors declare that they have no conflicts of interest.

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