An Investigation of the Challenges Impeding Industry 4.0 Implementation in Construction Projects[1]

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Abstract

This study evaluated the main challenges impeding industry 4.0 implementation in construction project delivery in Delta state, Nigeria. The study adopted a survey and exploratory research design methods of investigation, while a simple random sampling technique was deployed in selecting the sample size of 189 from a population of 358 using the Slovin's formular for sample size determination from construction project professionals located in Delta state. The instrument for data collection and measurement consist of a well-structured questionnaire modeled in Likert scale used in eliciting information from the construction professionals. The questionnaires were validated for reliability using the Cronbach's alpha test. The data collected were presented using descriptive statistical tools in the form of frequency distribution tables. Severity index was used in analyzing the main subject of discourse in the study with the aid of statistical tools (a Microsoft programmed software). The findings from the study indicate that the main challenges impeding industry 4.0 implementation in construction project delivery in Delta state include; the need to raise awareness of industry 4.0 with a SI of 18.4; professionals need to be aware with SI of 18.1, implementation costs are very high with SI of 17.5; training and skill development and lack of technical competence. The study recommendations included; that the professionals in Delta state construction industry should familiarize themselves with Industry 4.0 technologies to improve project cost, schedule, quality and ensure subsidized implementation costs.

Keywords: *Challenges, construction projects, industry 4.0, Delta state.*

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1.Introduction

Industry 4.0 denotes an advanced phase of organizing and managing all the processes in the construction industry. It might also be referred to as 'the fourth industrial revolution'. According to Ribeiro, Amaral, and Barros (2021), the terms "Industry 4.0," "Smart factory," "Intelligent factory," and "Factory of the future" refer to a conceptualization of how factories will be designed in the future. From this perspective, the factories will possess enhanced intelligence, adaptability, dynamism, and agility. Industry 4.0 can be defined as a manufacturing facility that produces intelligent products using advanced machinery and operates within intelligent supply chains. Industry 4.0 will facilitate horizontal integration among adaptable units, which will be interconnected with partners in the value chain (Ndubuka, 2026).

The adoption of industry 4.0 technologies is seen as a catalyst that will propel the construction sector's evolution and transform its practices and methods. The multitude of activities that take place in construction sites presents numerous intriguing research challenges. The construction sector is planning to achieve these goals by implementing industry 4.0 tools (Turner et al., 2021).

Therefore, the construction industry will benefit from improved production methods through the intelligent implementation of digitalization. The utilization of digital technology to process relevant data, prompt problem-solving, and foster a collaborative working environment in the design, construction, and operation of projects. This approach aims to optimise resource utilization and improve quality and safety. This will lead to reforms in the design, construction, and maintenance of physical structures, as well as in their subsequent utilization (Ndubuka, 2026).

The fourth industrial revolution is currently underway, aiming to integrate the physical world with the information era in order to enhance industrial processes. The research provides a significant theoretical contribution to understanding the challenges and opportunities of industry 4.0 in construction projects. The objective of this study is to examine the integration of the industry 4.0 concept into the construction industry, specifically by identifying and discussing the primary challenges and opportunities currently faced by the industry. Therefore, a novel and distinct production arrangement for construction industrialization, specifically focused on BIM technology, is proposed.
There has been significant resistance to implementing industry 4.0 in the construction industry in Africa, as determined from a comprehensive overview. Although the construction value chain is made up of various fragmented counterparts at all levels, each with a diverse background to meet the specific needs and uniqueness of each project,

this has only made project execution more challenging and has further restricted the ability of small and medium-sized enterprises (SMEs) to invest in new technologies. Consequently, the lacklustre reception of industry 4.0 has led to these outcomes (Ndubuka, 2026).

In recent decades, the majority of industries have experienced a transformation and have integrated advancements in products and processes as a fundamental part of their operations (Maskuriy, Selamat, Ali, Maresova & Krejcar, 2019). The construction industry, in particular, has not adequately embraced technological advancements that could enhance production and productivity, leading to a lack of progress in labour productivity. This situation can be attributed to various internal and external challenges. These challenges include the industry's consistent fragmentation, difficulties in recruiting a workforce with the necessary talent, insufficient connections with contractors and suppliers, and inadequate transfer of knowledge between projects. Efforts to enhance effectiveness and productivity in the industry can only be achieved through the implementation of digitalization, adoption of new construction techniques, and introduction of innovative practices. This study is set to identify and evaluate the main challenges impeding industry 4.0 implementation in construction project delivery in Delta state.

2. Literature Review

Industry 4.0 was initially introduced in Germany in 2011 and is commonly known as the fourth industrial revolution (de Almeida Barbosa Franco, 2022, Ndubuka, 2026). The objective of this concept is to combine various technologies, including the Internet of Things (IoT), Industrial Internet of Things (IoT), Intelligent Objects, Big Data, Cloud Computing, Artificial Intelligence, 3D printing, Sensors, Actuators, Virtual and Augmented Reality, in order to establish a digital and intelligent manufacturing environment. The antecedence of the first industrial revolution, also known as industry 1.0, serves as the fundamental basis upon which the second, third, and ultimately the fourth industrial revolution are built. This chapter will extensively examine the fourth industrial revolution, with a particular emphasis on the challenges and opportunities it presents for construction projects. (Ashton, 1997). The initial industrial revolution was marked by a distinct shift from manual production methods to the utilisation of machines powered by hydropower and steam energy. The advent of novel technologies occurred during the industrial revolution, which took place between 1760 and 1820 or 1840 in the United States and various parts of Europe. (Agarwal & Agarwal, 2017; Allen, 2009; Berlanstein, 2003).

The fourth industrial revolution emerged in 2011 as a high-tech strategy implemented by the German government to automate production. In the same year, it gained attention at the Bureau of Industry Exhibitions with the introduction of the term "Industry 4.0" to the

public (Ndubuaka, 2026). The adoption and integration of disruptive technological tools and cyber-physical systems have been facilitated by the 4th Industrial Revolution 4.0. This revolution, in contrast to the third industrial revolution, encompasses various advanced technologies such as artificial intelligence (AI), advanced robotics, the internet of things (IoT), autonomous vehicles, 3D printing, nanotechnology, biotechnology, big data analytics, materials science, energy storage, quantum computing, new materials like graphene, and Fintech. These technologies are capable of containing and transmitting digital information (Ndubuka, 2026).

2.1 Concept of Industry 4.0

Industry 4.0 involves a wide range of technologies, such as the Internet of Things (IoT), artificial intelligence (AI), big data analytics, robotics, and cloud computing, that are used to digitise various processes. Integrating these technological advancements enables the collection, analysis, and utilisation of large data sets, ultimately enhancing the efficiency of operations, productivity, and strategic decision-making in construction management. In addition, they can improve sustainability by maximising resource efficiency, minimising waste, and enhancing the environmental impact of construction projects.

2.2 The catalyst for the revolution of Industry 4.0

The key drivers of the fourth industrial revolution are the internet, big data, cloud computing, advanced robotics, artificial intelligence, autonomous vehicles, new materials, new additive manufacturing technologies (especially 3D printing), hybrid manufacturing, machines, and generic and synthetic microbiology (Ndubuka, 2026). Within these "Smart Factories", machines and consumables combine seamlessly during industrial processes to enhance the manufacturing process with increased flexibility and customisation. This is achieved through a highly digital and integrated approach (Ângelo et al., 2017). However, the concept of Industry 4.0 encompasses not only production and distribution processes, but also all aspects of the value chain and innovative product development processes (Gokalp et al., 2016).

The objective of industry 4.0 is to leverage these technologies to consistently and progressively enhance efficiency and optimise production processes, resulting in increased productivity, quality, and customisation. The swift progression of technological advancements in sensors, devices, information networks, and machine learning has greatly contributed to the rapid development of robotics and automation. This has led to significant enhancements in various productive industries (de Almeida Barbosa Franco, 2022).

2.3 The challenges impeding Industry 4.0 adoption in construction projects

Although Industry 4.0 presents numerous advantages, the construction sector has not yet fully embraced these cutting-edge technologies. It is crucial to comprehend the significant obstacles that are unique to construction projects, which hinder the integration of new technologies. These challenges must be appropriately addressed. (Hossain & Nadeem, 2019). The construction sector is conventionally perceived as a business characterised by limited innovation, typically lagging behind other industries such as manufacturing or energy infrastructure. Nevertheless, the incorporation of cutting-edge construction technologies is highly significant, as it has the potential to revolutionise this industry, introducing it to novel frameworks. Multiple studies have demonstrated that the construction industry has not effectively embraced innovative practices to enhance its performance, unlike other sectors (Olsson et al., 2021). The subsequent obstacles impeding the implementation of industry 4.0 are discussed below.

1. Raising awareness of Industry 4.0

This crucial for policymakers, businesses, academics, employees, authorities, and consumers. A thorough awareness among authorities and policymakers will boost economic growth and development; businesses and industries will promote productivity, production flexibility and control, efficiency, and competitiveness; academia and employees will drive the growth of high-skilled and well-paid jobs; and consumer awareness will drive improved customer satisfaction and product customisation. The current state of consciousness regarding revolutionised disruptive technologies of industry 4.0 is not widespread in Owerri, Imo State, Nigeria, but it is critical to accelerate the country's current economic progress and meet international standards (Ndubuka, 2026). Employees, SMEs, factories, and national economies are not prepared to adopt Industry 4.0 and will thus be pushed to the background. As a result, policymakers and promoters should implement awareness-raising initiatives such as seminars, trade fairs, and international training programmes for their stakeholders.

2. Capital Formation

Capital formation is the most important factor required for such digital technological development, transformation, and implementation because it necessitates significant investment in the construction industry (Ndubuka, 2026). Because Industry 4.0 requires significant capital for the implementation of smart economic infrastructure, smart business model adaptation, economic benefits, and competitors, the banking industry has not focused on financing high-tech industries because the industry is relatively new and risky. Furthermore, the relatively low cost of labour has resulted in widespread reluctance among the workforce, discouraging nearly every effort towards automation because it requires a significant investment. The government should incentivize the banking industry to provide adequate loans to high-tech industries.

3. Socioeconomic challenges

Industry 4.0 is the culmination of digitization and automation, allowing machines to perform intelligently, interactively, and easily. These novel technologies have a significant impact on how jobs are performed (Faller & Feldmüller, 2015). They will be programmed robots capable of interacting with humans and performing a variety of jobs. The application of this technology will help to reshape and redefine human activity, particularly cognition, culminating in future technologies that will provide us with entirely new computer models (Crafts et al., 1985). To bridge the gap between engineering and computer science, the following issues must be addressed: automatic learning and artificial intelligence, privacy concerns, surveillance and distrust, stakeholders' general reluctance to change, the threat of redundancy, and the loss of many jobs to automated and it-controlled processes (Ndubuka, 2026).

Adopting new tools can cause unintended changes in the way tasks are completed. These changes can have an impact on workplace organisation, culture, and productivity (Aripin et al., 2019). There are experienced employees who are eager to adopt innovative solutions, but the burden of acquiring the skills required to successfully implement those new technologies may also be a challenge.

4. Training and Skill Development

Routine jobs will be replaced by disruptive technologies such as robots, IoT, and intelligent machinery, among others. According to a recent McKinsey study, 5.7 million workers, the majority of whom are unskilled, will be out of work as a result of manufacturing industry automation in recent decades. This will dramatically increase the number of opportunities for jobs requiring cognitive abilities, technical skills, complex problem solving, resource management skills, content, process, and social skills, among others. Surprisingly, computing power continues to grow exponentially, and sooner than expected, the work of professionals such as lawyers, financial analysts, doctors, journalists, accountants, insurance underwriters, and librarians may be partially or completely automated (Ndubuka, 2026). As a result, government policymakers, academia, and training institutes should act quickly to increase investment in human capital and skills to drive industrial transformation for up-skilling, re-skilling, long-term training, and capacity-building to meet the demands of the fourth industrial revolution and bridge the education-industrial gap. Moving forward or transforming into new Industry 4.0 technologies necessitates a certain level of expertise. Hence, the need for employee training and development (Aripin et al., 2019), together with the increasing need for integration skills, because there are low technical competency of the construction workers on site; thus, there will be a huge challenge in order to create and develop new competencies to ensure the project organisation is optimised as well as to attract new

talents to the workforce, such as employees with shared technical knowledge and integration experience.

5. Infrastructure Development

Infrastructural development is emerging as critical because it is difficult to apply industry 4.0 technologies due to security and risk concerns (Davali, Belli, Cilfone, & Ferrari, 2016). However, online integration will help to assess security breaches and data leaks (Du et al., 2017). Internet hacking has been a major security concern that exacerbates data interconnectedness and weak digital infrastructure (Becker & Stern, 2016; Cheng et al., 2016; Gokalp et al., 2016; Ndubuka, 2026). Furthermore, the country's poor infrastructure, including poor roads and transportation, makes it more vulnerable to natural disasters. Furthermore, the introduction of industry 4.0 technologies necessitates increased investment and research in a variety of areas, including Internet broadband disbursement, IT security, cybersecurity, and cyber lay, as well as an impact on education in particular as a new industry requiring new skills (Becker & Stern, 2016; Cheng et al., 2016; Faller & Feldmüller, 2015; Gokalp et al., 2016; Gorecky et al., 2014).

6. Lack of Technical Competence

Competences include capabilities (officially recognised), abilities and experience, and demeanour (in terms of responsibilities, guidelines, collaborators, and leaders, but also strategies or new ideas). New innovation regions, associated with the concept of Industry 4.0, necessitate new skills from expert personnel (Ndukuba, 2026). Another major reason that employees are concerned about adopting new technologies is the job losses that come with it. Their concern about being replaced by machines, computers, or robotics causes them to reconsider accepting those technologies (Aripin et al., 2019).

7. Professional's Awareness

The industry 4.0 technologies are critical in construction projects, but most professionals are unaware of the skills and training required for industry 4.0 operations. Lack of awareness of professional skills and trainings will discourage the use of industry 4.0 in construction projects. (Santi & Lawrence, 2017). Awareness is the first step towards implementation or adoption. Awodele et al. (2024) defines awareness as information, knowledge, or perception of a specific phenomenon. The literature shows that the developed economy is aware of new technological innovation and adoption. The health and manufacturing sectors, among others, are benefiting from the adoption of Industry 4.0. However, the construction and rail industries have not seen the same level of adoption. While the construction industry in developed economies appears to be making good progress in terms of new technological innovation and adoption, the situation in developing economies is quite different.

8. Various complexities

Most construction companies are hesitant to implement industry 4.0 technologies because their adoption and practice will necessitate the hiring of a 4.0 engineer who must be able to process and analyse large amounts of data from multiple sources, assess the validity of the information, their credibility, and draw relevant conclusions (Ndubuka, 2026). Though industry 4.0 will help him know this information, including the use of Bigdata tools and electronic media, the engineer(s) and the organisation as a whole face the challenge of managing enormous data (Santi & Lawrence, 2017).

9. Implementation costs are high

According to Bring, lack of technical training and the high cost of education is a major challenge that discourages construction company owners from adopting and utilising industry 4.0 technologies. Adopting industry 4.0 technologies results in very high implementation costs that include technical equipment, training and education, external consultancy fees, and maintenance (Santi & Lawrence, 2017).

According to Aripin, Zawawi, and Ismail (2019), the Industry 4.0 technology implementation challenges include the high cost of owning and using the technologies on site, and because some of the machines are still under development, keeping up with technological advances can be costlier. The following section discusses some of the opportunities related to industry 4.0 in the context of construction projects.

10. Industrial Expansion

This refers to the process of increasing the size and scope of industrial activities. The 4th Industrial revolution is widely acknowledged as the primary catalyst that promotes and accelerates profound industrialization in any global economy since its inception (Santi & Lawrence, 2017). Industry 4.0 provides a platform for the integration and ongoing development of advanced technology in various industries, including the construction industry.

11. Enhancements in operational management for construction projects

By incorporating Industrial cameras and BIM, such as jet scanners, into the quality inspection system, the manufacturing and on-site installation standards can be further improved. 3D visualisation techniques can help familiarise the construction workforce with the sequence of component assembly, facilitating the efficient transmission of industrialization knowledge (Ndubuka, 2026). Industry 4.0 also serves as a facilitator and tool for promoting sustainability and enhancing flexibility in industrialised construction projects. According to the research conducted by Jin and Aboagye-Nimo (2018), it is suggested that incorporating new technologies will significantly enhance the performance of top-level management in industrial construction projects.

Emerging trends in workforce dynamics and implementing industry 4.0 in construction projects offers advantages in terms of reducing construction costs, minimising construction time, decreasing the need for labour, and enhancing the quality of construction project outcomes (Bing et al., 2020). The utilisation of optimisation and algorithms can lead to a reduction in both construction cost and time (Bortolini, Formoso & Viana, 2019). Similarly, digital fabrication and automation techniques can eliminate the need for manual labour.

According to de Almeida Barbosa Franco et al. (2022), in early 2020, during the COVID-19 pandemic in Brazil, the utilisation of technologies has demonstrated its significance by employing Big Data in Geographic Information Systems (GIS). This pertains primarily to the quick representation of data on epidemics, monitoring of verified cases, prediction of transmission, coordination and control of material resources, and utilisation of artificial intelligence (AI) to determine the contagiousness of the virus, vulnerable populations, and consequently establish the infection cycle and propose efficient preventive measures.

12. Enhancement of productivity and increase in growth

Technological advancements have significantly boosted industrial productivity since the beginning of the Industrial Revolution. Subsequently, industrial technological progress was predominantly gradual in the ensuing decades, particularly when contrasted with the significant advancements that revolutionised IT, mobile communications, and e-commerce (Ndubuka, 2026). Currently, we are experiencing a fourth wave of technological progress called Industry 4.0, which is characterised by the emergence of new digital industrial technology. This transformation is driven by nine fundamental advancements in technology. In this process, sensors, machines, workpieces, and IT systems will be interconnected throughout the value chain, extending beyond the boundaries of a single enterprise. These interconnected systems, also known as cyber-physical systems, have the ability to communicate with each other using standard Internet protocols. They can analyse data to anticipate failures, automatically adjust their settings, and adapt to changes. According to Ndubuka (2026), industry 4.0 will facilitate the collection and analysis of data from various machines, resulting in accelerated, adaptable, and efficient processes that yield superior goods at lower expenses. Consequently, this will enhance the efficiency of manufacturing, alter the financial dynamics, promote the expansion of industries, and reshape the composition of the workforce—ultimately transforming the competitiveness of companies and regions.

13. Decrease in operational expenses

Implementing industry 4.0 in construction projects offers advantages in terms of reducing construction costs, minimising construction time, reducing labour requirements, and enhancing the quality of construction project outcomes (Bing et al., 2020). The utilisation

of optimisation and algorithms can achieve a reduction in construction cost and time (Bortolini, Formoso, & Viana, 2019). Similarly, digital fabrication and automation techniques can eliminate the need for labour.

14. Encouragement of creativity and innovation

The competencies and skills frameworks developed by researchers and scientists are designed to match their chosen research scope and objectives. The Acatech study, conducted for the industry 4.0 platform, examines the skill profile of a future technology-enabled worker. This study focuses on the characteristics required to learn how to use Industry 4.0 technologies effectively, integrate digital and physical solutions in smart manufacturing, and understand business networking. The set of attributes attributed to an Industry 4.0 worker is concluded by the social and environmental demands that the worker must consistently adjust to. This entails being cognizant of ongoing changes and recognising the potential for technology to bring about alterations in the workplace and beyond (Ndubuka, 2026). The employees' basic technical knowledge in the field of working with Industry 4.0 technologies was expanded to include management knowledge related to operational processes and technological installations at different levels of management within an organisation. In order for an employee to engage in knowledge management, they must possess conceptual skills, critical thinking abilities, and a perception that is aligned with the various aspects of digital business. The competency profile includes a section that focuses on human wellbeing and awareness, which is determined by the level of industrial development.

15. Reducing the duration of operations

Implementing industry 4.0 in construction projects offers advantages such as reducing construction costs, minimising construction time, decreasing the need for labour, and enhancing the quality of construction project outcomes (Bing, 2020). The utilisation of optimisation and algorithms can achieve a reduction in construction cost and time (Bortolini, Formoso, & Viana, 2019). Similarly, digital fabrication and automation techniques can eliminate the need for labour.

16. Presence of proficient individuals within the team

To ensure that team members possess the necessary expertise at the appropriate time and location, organisational leaders must demonstrate commitment by developing and implementing a strategy that encompasses various crucial elements such as acquisition, training, growth, engagement, and recognition (Giannetti, 2017). Recruiting skilled individuals for the industry the 4.0 era poses challenges, as you will frequently hear. We must cease our search for unicorns (Nduuka, 2026). Instead, seek individuals who possess a harmonious blend of technical and interpersonal abilities, as well as a wide range of capabilities. Subsequently, offer them a mechanism to rapidly develop the

required expertise within your company. Involve them from the outset in the process of identifying the problem and developing technical solutions. Allow them to collaborate with cross-functional teams involved in developing the SM solution, enabling them to contribute to the development of practical and feasible solutions. Incorporate them into the success stories and minor victories. Commend their achievements and triumphs. Although it may appear daunting, the rewards you will receive in exchange will be invaluable. According to Bauernhansl (2014), investing in talent and expertise is a reliable strategy that will not disappoint.

3. Methodology

Leedy and Ormrod (2005) define a descriptive survey as a research method that involves the collection of data by asking individuals questions and then analysing and summarising their responses. The research methodology employed for this chapter encompassed a blend of quantitative and qualitative research approaches. The purpose of this method is to gain a deeper understanding of one or more specific groups of people. According to Leedy and Ormrod (2005), survey research aims to gain an understanding of a large population by surveying a representative sample and then summarising the results using statistical methods. This study is grounded in survey-based research. A survey will be conducted to consult various construction professionals, including Architects, quantity surveyors, Builders, and Engineers. The purpose of the survey is to identify the primary challenges and opportunities in the industry. 4.0 refers to a high level of proficiency or achievement in the context of construction projects. The survey sought some consultations with different construction professionals, such as Architects, Quantity surveyors, Builders Civil Engineers, Builders, Project Managers and Estate surveyors. In a whole the population of the respondents as gotten from the relevant government and public documents was three hundred and fifty-eight (358) professionals as shown in table 1. The study was conducted to ascertain the obstacles and prospects associated with industry 4.0 in construction projects. The population consisted of registered construction professionals, including Architects, Builders, Quantity surveyors, Civil Engineers, Project Managers and Estate surveyors.

Table 1: The population of the respondents

Respondents	Population
Architects	87
Builders	**57**
Quantity surveyors	49
Civil engineers	45
Builders	43
Project managers	32
Estate surveyors	45

Total	**358**

This research survey employed the simple random sampling technique where different construction professionals, such as Architects, quantity surveyors, Builders and Engineers are randomly picked for the purpose of the study.

The sample size for this study will be determined using the Slovin's Formula, which is a method for calculating the required sample size (n) based on the population size (N) and desired margin of error (e). The formula for estimating the sample size is based on a random sampling technique. The population size is specifically aimed at 358 construction professionals

It is computed as $n = \frac{N}{[1+ N (e)^2]}$

Where;
n = Sample size
N= total population
e = error margin

$$n = \frac{358}{[1+ 358 (0.05)^2]}$$

$$n = 188.92$$

Upon analysing the output, it is evident that a total of 189 questionnaires was distributed to the respondents.

The selection of these professionals is based on the chapter's primary objective of identifying the challenges and opportunities in industry 4.0 within construction projects. To achieve this objective, data was gathered using a questionnaire and a semi-structured interview were conducted in the context of industry 4.0 in construction projects within the study area. The questionnaire was divided into three sections. Section A encompasses the personal information of the respondents, while Section B comprises of the state of awareness and adoption readiness of industry 4.0 in construction project delivery. Section C encompassed the various types of industry 4.0 technologies being deployed in construction project delivery. While section D consist of the main challenges impeding industry 4.0 adoption in construction project delivery.

The necessary data for this study were collected from various construction professionals, including Architects, quantity surveyors, Builders, and Engineers, using a proposed questionnaire. The survey questionnaire utilized both closed and open-ended formats. The various construction professionals were asked to respond. They were given multiple-choice options to select from, as well as the opportunity to provide their own written responses. The questionnaire encompassed essential inquiries and data pertaining to the

primary obstacles and prospects in industry 4.0 in construction project delivery. In order to consolidate the research, additional significant findings were sought through consultations with various sources such as the internet, books, journals, magazines, published and unpublished dissertations and other documents.

Questionnaires were disseminated to various construction professionals, including Architects, quantity surveyors, Builders, and Engineers at the various Construction firms situated in the three geographical zones of Delta State. The questionnaires were delivered in both person to person as well as sent via email to the professionals for their response. The data collection process spanned approximately two months taking into consideration the size of the population involved and allowing ample time for individuals to provide their responses.

This study utilised the use of quantitative research method to enhance the entire comprehension of the research. The feedback obtained from the questionnaires were analysed utilising the IBM Statistical Package for the Social Sciences (SPSS), version 2.5. 0 for data analysis. To analyze the objective, which is identify the main challenges impeding industry 4.0 implementation in construction project delivery in Delta state, severity index (SI) was used. The SI is a method used in ranking factors. As a non-parametric technique, it aggregates the weight and frequency score of each factor and as such has been deployed for analysis by most researchers (Amade, 2017; Ndubuka, 2026)

$$S.I = \left(\sum_{i=1}^{i=n} \frac{[wifi)x100}{n} \right] \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where: fi is the frequency of response, wi is the weight for each rating = (rating in scale/number of points in a scale), and n is the total number of responses. n is the valid number of respondents. Severity Index analysis is preferred because of its ability to provide a meaningful interpretation of ranks among factors. In the study, the SI was used via a Microsoft programmed software.

4. Results

A total of 189 questionnaires were distributed and 172 copies were returned, while fully 14 were found with some error, where 158 were later found to be error-free and adequate. The 158 questionnaires were used for the analysis. The table below shows the details of the questionnaire response.

Table 2: The sample and responses of respondents

Respondents	Number distributed	Number Returned	Number analyzed
Architects	37	35	33
Builders	28	26	23
Quantity surveyors	32	30	29
Civil engineers	29	26	24
Builders	31	28	26
Project managers	12	10	08
Estate surveyors	20	17	15
Total	**189**	**172**	**158**

This section presents the outcomes and discoveries derived from the questionnaires received from professionals in the construction industry, specifically architects, builders, quantity surveyors, project managers, estate surveyors and civil engineers with regards to the deployment of these emerging technologies such as 4.0 in construction project delivery within the study area.

4.1 Challenges impeding industry 4.0

The challenges impeding industry 4.0 was analyzed using severity index as depicted in the table below.

Table 3: Severity index score for challenges impeding industry

S/N	Challenges	SA	A	N	D	SD	SUM	S.I.	RANK
		5	4	3	2	1			
1	Various complexities	38	55	24	11	30	**534**	16.02	9th
2	Industrial expansion	47	51	10	26	24	**545**	16.35	8th
3	Lack of the presence of proficient individuals within teams	45	38	14	36	25	**516**	15.48	10th
4	Enhancement of productivity and increase in growth	38	12	56	22	30	**480**	14.4	14th
5	Lack of technical competence	47	56	19	14	22	**566**	16.98	5th
6	Training and skill development	45	66	8	19	20	**571**	17.13	4th
7	Implementation costs are high	55	56	10	18	19	**584**	17.52	3rd
8	Raising awareness of Industry 4.0	65	52	12	14	15	**612**	18.36	1st
9	Professional's awareness	69	42	16	10	21	**602**	18.06	2nd
10	Need for encouragement of creativity and innovation	43	39	15	33	28	**510**	15.3	11th
11	Socioeconomic challenges	50	49	11	20	28	**547**	16.41	6th
12	Decrease in operational expenses	42	23	35	30	28	**495**	14.85	13th
13	Reducing the duration of operations	39	35	13	26	45	**471**	14.13	16th
14	Capital Formation	42	37	17	29	33	**500**	15.0	12th
15	Absence of enhancements in operational management for construction projects.	37	39	18	26	33	**480**	14.4	14th
16	Infrastructure development deficit	57	39	11	21	30	**546**	16.38	7th

Legend: SA=Strongly agree; A=Agree; N=Neutral; D=Disagree; SD=Strongly disagree; SI=Severity index

4.0 implementation

The findings presented in table 3 above indicates that the most severe challenges impeding the implementation of industry 4.0 in construction project delivery in Delta state, Nigerian is the need to raise awareness of industry 4.0 with a SI of 18.4 and ranked first. While the results show that professional's to be aware has the next SI of 18.1 and ranked second. Implementation costs are very high with a SI of 17.5 and ranked third. Training and skill development, lack of technical competence, socioeconomic challenges, infrastructure development deficit, industrial expansion, are the next in the line and ranked 4th,5th,6th,7th, and 8th, while reducing the duration of operations was ranked 16th.

4.2 Discussion

The findings presented in table 3 above indicates that the most severe challenges impeding the implementation of industry 4.0 in construction project delivery in Delta state, Nigerian is the need to raise awareness of industry 4.0 with a SI of 18.4 and ranked first.

The outcome these findings corroborates with that of Awodele et al. (2024). They argued that lack of technical expertise, and lack of training and resources, have a substantial impact on awareness and readiness. The study asserts that concentrated endeavours in training and communicating the benefits of industry 4.0 are crucial in stimulating the adoption of the technology in Nigeria and other developing economies. While the results show that professional's to be aware has the next SI of 18.1 and ranked second. Implementation costs are very high with a SI of 17.5 and ranked third. Training and skill development, lack of technical competence, socioeconomic challenges, infrastructure development deficit, industrial expansion, are the next in the line and ranked 4th,5th,6th,7th, and 8th, while reducing the duration of operations was ranked 16th.

5. Conclusions and recommendation

The study concludes that the main challenges impeding industry 4.0 implementation in construction project delivery in Delta state, Nigeria includes in this order; the need to raise awareness of industry 4.0, professional's needs to be aware, implementation costs are very high, training and skill development as well as lack of technical competence. The study recommends that the construction industry in Delta state should ensure its professionals are conversant with the use and deployment of industry 4.0 and its technologies as this would enable them compete with their peers in the industry with regards to delivering their projects to cost, schedule and quality perspective. Government and professional bodies should see to it that the cost of implementing industry 4.0 and its technologies are subsidized to enable industry practitioners access and make use of them.

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