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Critical Skills Requirement of Quantity Surveying Graduates for Fourth Industrial Revolution Readiness

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Abstract: The continued relevance of the quantity surveying profession as a cost accountant in the construction industry in the Fourth Industrial Revolution (4IR) era and beyond is dependent on the adequacy of the skills and competency of its graduates. The study examined the critical skills requirement of quantity surveying graduates (QSGs) for 4IR readiness in Nigeria; this investigation was intended to bring to the fore actionable strategies to enhance QSGs' readiness for the 4IR era. A purposive sampling method was employed to select 154 senior built environment professionals with a direct working relationship with QSGs in Lagos Metropolis, Nigeria. The professionals comprised 33 architects, 44 quantity surveyors, 42 engineers and 35 builders. An online structured questionnaire survey was used for data collection. Descriptive analysis methods included frequency, percentage and mean item scores, while inferential analysis employed Kendall's W test, Cronbach's alpha coefficient and Principal Component Analysis (PCA). The findings indicated that the QSGs' readiness for 4IR is low (MS=2.75). The only two 4IR technologies where the readiness of QSGs is moderate are the Internet of Things (MS=3.22) and building information modelling (BIM) (MS=3.13). The critical skills requirements for QSGs were estimating skills (MS=4.19), software usage skills (MS=4.04), and financial management and control skills (MS=3.99). The four PCA groups of skills for QSGs were: advanced skills, core skills, emerging/digital skills, and foundational core skills. The result of Kendall's W test indicated a weak agreement in the opinion of built environment professionals on the critical skills requirement for QSGs (W=0.152), as well as on the readiness of QSGs for 4IR (W=0.136). The study concluded that the curricula of quantity surveying training programmes need to be re-examined to integrate the teaching of foundational core skills through digital means of 4IR technologies.

Keywords: critical skills; quantity surveying graduates; Fourth Industrial Revolution; Nigeria

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Introduction

The quantity surveying profession has been regarded as one of the backbones of the construction industry globally (Ebekozien et al., 2024). The vitality of the profession to the economic and financial

survival of project participants, including the client who needs to pay fair and prevailing rates to the contractor, the contractor who needs to be remunerated economically for his expertise and resources for the facilitation of the project, the consultants who need to be reimbursed for their services and the suppliers whose payment for goods supplied to the project site needs to be determined and paid for, are all examples of the project participants who are affected in one way or another by the services of the quantity surveyor (Esenwa, 2014).

Professional quantity surveyor, according to the Nigerian Institute of Quantity Surveyors (NIQS), are trained and qualified to discharge the total cost management of construction projects (Nigerian Institute of Quantity Surveyors, 2015). Quantity surveyors are trained to manage diverse projects financial and procurement-related issues on all development projects—both maintenance and new construction—from the conceptualisation phase through to completion. Their goal is to achieve the client's project objectives, including the completion time, controlling construction costs, and ensuring predetermined project quality. Quantity surveying graduates (QSGs), unlike professional quantity surveyors are would-be quantity surveying professionals who already have the required academic training to qualify them to be inducted into the profession but have not garnered sufficient professional experience to be registered as chartered or professional quantity surveyors. Graduates's skills adequacy for employability has been a subject of debate across disciplines in recent times (Dada & Jagboro, 2012; Aliu & Aigbavboa, 2021; Tan et al., 2022; Ebekozien et al., 2024). Dada and Jagboro (2012) investigated the competencies and required skills for maximising quantity surveyors' services in Nigeria and found that information communication technology, engineering measurement, economics, and aptitude in heavy engineering works are essential skills for quantity surveyors.

Aliu and Aigbavboa (2021) examined the generic skills of built-environment graduates in South Africa and found that leadership skills, critical thinking, and analytical skills as the predominant generic skills required by built-environment graduates to function effectively in the construction industry. Tan et al. (2022) investigated the employability skills of accounting students in New Zealand. The study found that accounting graduates in the study area possessed the cognitive and behavioural skills required for employability. Ebekozien et al.'s (2024) study centred on the generic skills for future built-environment professionals and found that enhanced integrated productivity will be achieved through generic skills development. This analysis guided the direction of research on the skills required by graduates and professional skills in different parts of the globe. It is obvious from the previous studies that the critical skills required for QSGs in relation to 4IR in Nigeria have not been examined, creating a research gap. The motivation to research this gap is spurred by the revelation of Dada and Musa (2016), who found educational training is the major component affecting the competencies of quantity surveyors in Nigeria.

Scholars have opined that the world has witnessed four major industrial revolutions, each of which has distinct and significant attributes that distinguish it from others (Xu & Duan, 2019). Starting with the shift from primitive and manual features to mechanisation, where machines replaced hand tools in many industries, was the first obvious characteristic of the first industrial revolution (Osunsanmi et al., 2020). The invention of electricity and the use of electric motors and engines around 1870 to the early 20th century characterised the Second Industrial Revolution (Osunsanmi et al., 2020). Rifkin (2011) opined that the major enabler for the third industrial revolution was the discovery of the Internet and renewable energy, which came to the fore in the mid-1990s. The sophistication of human integration with software and hardware occasioned through internet connectivity and advancement in information communication technology has resulted in another global industrial disruption in the 21st century known as the fourth industrial revolution (4IR) (Schwab, 2017). The complete integration of humans with digitally remote devices has been identified as a defining characteristic of 4IR (Olatunde et al., 2023). World Economic Forum (2020) asserted that 1.2% of human jobs will be displaced all over the globe by the year 2025, while a new 1.4% of jobs will be created due to the 4IR technological disruption. The integration of and adjustment to disruptive technologies in professional training and competency is a research concern, this is because, unlike the preceding revolution that is majorly hardware driven, the 4IR is software and disruptive technologies driven. The question then arises whether the skills of graduates are amenable to the requirements of the 4IR. Inferring from the adequacy of their training, are QSGs 4IR ready to take up the challenges of cost management and procurement in construction projects? In providing answers to these questions, the study sought to achieve the following objectives: to investigate quantity surveying graduates' readiness for 4IR and identify the crucial skills required for Quantity Surveying Graduates for 4IR readiness. The outline of the remaining part of the study included literature review, research methodology, results, discussion of the findings and conclusion.

Literature review

Literature suggests that the quantity surveying profession has evolved and is still evolving since it was recognized as an identifiable profession in the construction industry (Shafiei & Said, 2008). Since its evolution, the profession—just like every other human endeavour—has been dynamic and amenable to evolution in the construction industry, and the specific country of interest. The dynamism of the profession is visible in the broader professional area of functionality and competencies rather than what was obtainable in the mid-17th century when the profession originated as a measurer to estimate the cost of building works (Ashworth et al., 2013). Opawole et al. (2012) have also affirmed that the quantity surveying profession experienced exponential growth and revolution in the 19th century. Notwithstanding the observation of Opawole et al. (2012), 21st-century quantity surveyors have acquired more skills and competencies and are now involved in complex and sophisticated heavy engineering projects as compared to their roles and competencies in the 19th and 20th centuries (Olanrewaju & Anahve, 2015; Chandramohan et al., 2020).

The quantity surveying profession is practised under different names with varying regulatory frameworks for its practice across nations. For instance, the profession is recognized under the Nigerian Institute of Quantity Surveyors Association, while Decree 31 of 1986 gave it a regulatory framework by establishing the Quantity Surveyors Registration Board of Nigeria (Ogunsemi et al., 2013). Across the globe, the possession of the Royal Institute of Chartered Surveyors' membership legitimizes an individual to practice the profession of quantity surveying. In an ideal setting, quantity surveyors are trained and equipped with the requisite knowledge and skills to provide solutions to the construction industry's problem of construction procurement and cost management from inception of a project to completion, whether it is building or engineering project (Monyane & Ramabodu, 2014; Chandramohan et al., 2020). However, the involvement of quantity surveyors in engineering projects in some climes, is low attributed to competencies and political issues (Opawole et al., 2012).

Scholars such as Dadzie et al. (2012) and Olatunde et al. (2022) have documented the vitality of the construction industry for the nations' economies. This importance has been seen in both its contribution to the national economies as well as in the provision of man's third most essential need—shelter (Ojo & Adeyinka, 2011). Other scholars have approached the industry's importance by focusing on its contributions to the job requirements of nations, especially in developing countries like Nigeria (Ofori, 2012). The 4IR is a convergence of technologies that integrate hardware and humans in real-time (Olatunde et al., 2023). However, the construction industry has generally been documented to be slow in the adoption of technologies, unlike its counterparts, such as the manufacturing, health, and aviation sectors (Newman et al., 2021). Murguia et al. (2024) posited that one of the main reasons for the low adoption of innovative technologies in the construction industry is due to a lack of knowledge or identification of the problem the technology evolution will solve.

Comparatively, the construction industry in the developed economies is increasingly adopting technologies to enhance the delivery of construction services (Murguia et al., 2021). Murguia et al. (2024), corroborating Hwang et al. (2022), opined that several developed countries have been empirically documented to possess high levels of technological readiness for adopting innovative technologies. On the contrary, developing nations have been known for low disruptive technological readiness (Moon et al., 2020). Sepasgozar (2021), supporting this assertion, found a poor awareness and adoption of disruptive technologies in third-world nations. In the same vein, Olatunde et al. (2023) assessed the adoption readiness of the Nigerian construction industry for Construction 4.0 and reported that it demonstrated a low level of adoption readiness for its implementation.

A sound understanding of the construction process is central to the core mandate of QSGs as prospective managers of construction costs. They are required to possess extensive technical acumen for various construction activities throughout the project life cycle (Wao & Flood, 2016). According to Ginigaddara et al. (2023), quantity surveyors' training must show evidence of proficiency in leadership ability in the technical and operational aspects of construction projects, especially on monetary issues. The study further asserted that measurement and pricing of construction works are core competencies expected of QSGs, as these skills are essential for the preparation and pricing of bills of quantities—major document that quantity surveyors prepare. Ashworth et al. (2013), assert that the training of QSGs must reflect competency in the procurement of construction activities, value management, and risk analysis and management. According to Olanrewaju (2016), life cycle costing, cost planning, and cost analysis are important requirements for QSGs. Pratt (2011) posited that quantity surveyors must have adequate skills and training to develop effective cost plans for every project in which they are involved. The study emphasized the importance of cost planning as a core skill that is expected of all QSGs, as

the information provided during this activity helps the project owner and the construction team to make informed decisions. Estimating skills for construction works has been noted as a critical skill that quantity surveyors must have (Peurifoy & Oberlender, 2014), even though Ginigaddara et al. (2023) argued that estimating skills is not only a product of educational training but also of professional experience. Dada (2017) reiterated the eight basic skills required by quantity surveyors for the Pacific Association of Quantity Surveyors to include measurement of works, construction technology, professional practice, information technology, resource management skills, construction contract law and regulation, interpersonal skills, and communication. The study further groups the skills requirements for quantity surveyors into three components: procurement and value management, commercial management and communication, and entrepreneurship.

Beyond the traditional core competencies required of graduates, several other skills are needed to keep abreast of emerging innovative and disruptive technologies associated with 4IR (Ginigaddara et al., 2022). According to Murguia et al. (2024), graduates need to possess digital and data skills in the 4IR era to optimize their efficiency. The literature further opines that there is a difference between the current skills of professionals and the skill sets required for the future (Murguia et al., 2024). Bridging the gap between current professional skills and those required to function effectively in the context of emerging technologies has been the subject of recent research. These efforts aim to provide clear requirements for the reskilling and upskilling of professionals (Adepoju & Aigbavboa, 2021). Just like other built environment professionals, QSGs will require a redefining of skill sets to be effective within the 4IR era, as those changes will entail a noticeable shift of roles and competencies required (Murguia et al., 2024). The World Economic Forum (2022) posited that the relevance of graduates in the job market in the 4IR era will largely depend on the quality of education they possess. This underscores the need for education providers to incorporate relevant digital modules aligned with the demands of the construction industry's digitalisation.

Research has distinguished between hard skills, soft skills, and their integration as critical requirements for professionals in 4IR readiness. Aoun (2017) identified key soft skills required for the built environment graduates to include emotional intelligence, communication skills, critical thinking, and problem-solving acumen. Complimentary studies have also found data sciences and analytics, programming competency, and proficiency in information technology tools as the critical hard skills required by graduates for 4IR readiness (MACE, 2017; Pothier & Sawhney, 2020). Corroborating this perspective, Shahruddin and Husain (2024) emphasized the importance of intangible skills, such as communication efficiency, team-building, and relationship leveraging for architecture, engineering, and construction graduates navigating the demands of 4IR.

Research methodology

Grounded in the philosophy of positivism, this study employed a quantitative research approach to assess the critical skills required by QSGs for 4IR readiness. According to this philosophical school of thought, concepts and phenomena can only be explained through facts, objectivity, and observation (Du Plooy-Cilliers et al., 2014). The quantitative research approach was considered appropriate for this study because the numerical quantification of the variables was considered immensely more important than the depth of the information (Andrade, 2021), which is the attraction to the qualitative approach (Aspers & Corte, 2019). A quota sampling method was employed to select 154 senior built environment professionals who have direct working relationships with QSGs in Lagos, Nigeria. The choice of the non-random, stratified selection process used was to ensure representation across professional groups. The choice of Lagos for the study was informed by the significance of the metropolis as the economic and technological hub of Nigeria with many ongoing construction projects of different sizes and complexity. Another motivation for the choice of the study area was based on the fact that Lagos has the highest concentration of built environment professionals in Nigeria, and a larger percentage of built environment graduates often migrate there for employment opportunities after graduation. Hence, the city provided a dynamic environment to assess the critical skills required for quantity surveying graduates to be 4IR-ready. The respondents comprised 33 architects, 44 quantity surveyors, 42 engineers, and 35 builders.

The study employed an online structured questionnaire survey for data collection. The questionnaire designed for data collection was segmented into two sections. The first section required information about the demography of the respondents, while the second section asked questions relating to the objectives of the study. Questions were asked on a five-point Likert scale (1-very low, 2-low, 3-moderate, 4-high, and 5-very high). Similar studies, including Olatunde et al. (2022) and Oke et al. (2023), used the same approach. Analysis of data was conducted with frequency and percentage for the demographic information. The mean item score, Cronbach's

alpha coefficient, Kendall's W test, and PCA were used to examine the main objectives of the study. The mean score statistics were used to rank the critical skill requirement of QSGs and their 4IR readiness, Cronbach's alpha coefficient was used to ensure reliability and internal consistency of the data collected, Kendall's W test was used to examine the degree of agreement in the opinions of the different categories of respondents, and the PCA was used to group the skills of QSGs into a more manageable category. The Statistical Package for Social Sciences software was employed in running the analysis. Cronbach's alpha coefficient for the QSGs skills requirement and QSGs 4IR readiness is 0.974 and 0.950 respectively. These figures are very close to 1.000 and judged reliable because the further the coefficient is from 1.000, the less reliable the data collected; while a 0.6 baseline is set for acceptability of data as reliable (Cho & Kim, 2015).

Test of hypothesis

Two null hypotheses were formulated to further examine the variables in quantitative terms.

> $H_0$1: There is no significant agreement among respondents regarding the readiness of QSGs for the Fourth Industrial Revolution (4IR).
>
> $H_0$2: There is no significant agreement among respondents concerning the critical skills required by QSGs for 4IR readiness.

Results

Table 1 reflects the classification of the respondents who participated in the questionnaire. The respondents represented the main professions involved in construction sites activities within the study area (quantity surveyors, engineers, builders, and architects). All the respondents were members of their different professional associations. The analysis of the membership type indicated that the majority (74.7%) are corporate members of their professional association. Respondents to the survey have garnered sufficient experience in the Nigerian construction industry, as 90.8% have work experience of more than 10 years. The academic qualification of the respondents indicated that they are knowledgeable enough to understand the intent of the study and supply the required information, as the majority (42.2%) have master's degrees and 19.5% are PhD graduates. The respondent's area of work is spread across contracting, consulting, client organizations, and academics, with the majority (29.2%) working in academic institutions. The number of QSGs under the direct supervision of the respondents varies between one and ten. While the majority (42.2%) have between three and four QSGs under their direct supervision, only 24.0% have between one and four QSGs under their direct supervision. Based on this background information, it can be inferred that the respondents are qualified to supply the information requested of them, as they have the needed education, professional experience, the required registration, and direct working relationship with QSGs. Hence, the data they supplied was adjudged adequate and reliable.

Table 1. Characteristics of respondents

Category	**Classification**	**Frequency**	**Percentage**
Profession	Quantity surveyor	44	28.6
	Engineer	42	27.3
	Builder	35	22.7
	Architect	33	21.4
	Total	**154**	**100.0**
Membership of Professional Bodies	NIQS	44	28.6
	NSE	42	27.3
	NIOB	35	22.7
	NIA	33	21.4
	Total	**154**	**100.0**
Type of membership	Probationer	8	5.2
	Corporate	115	74.7
	Fellow	31	20.1
	Total	**154**	**100.0**
Years of experience	6–10	6	9.2

(*Continued*)

Table 1. (Continued)

Category	Classification	Frequency	Percentage
	11–15	52	28.5
	16–20	57	37.0
	21 and above	39	25.3
	Total	154	100.0
Highest academic Qualification	HND	18	11.7
	PGD	26	16.9
	B.Tech/B.Sc	15	9.7
	M.Tech/M.Sc	65	42.2
	PhD	30	19.5
	Total	**154**	**100.0**
Area of work	Academic	45	29.2
	Contracting	40	26.0
	Consulting	41	26.6
	Client organisation	28	18.2
	Total	**154**	**100.0**
Number of QSGs under current supervision	1–2	37	24.0
	3–4	65	42.2
	5–6	32	20.8
	7–8	12	7.8
	9–10	8	5.2
	Total	**154**	**100.0**

Table 2 presents the 4IR readiness of QSGs. The results indicate that of the 15 constituent 4IR technologies assessed, only two (the Internet of Things and BIM) show a moderate level of readiness, with mean scores of 3.22 and 3.13, ranking 1st and 2nd, respectively. In contrast, QSG readiness for the remaining 13 technologies is low, with mean scores ranging from 2.94 to 2.39. Overall, QSG readiness for the 4IR is low (MS=2.75). The standard deviation results show only small variability (SD ranging from 0.743 to 0.997) in the respondents' ratings for 93.3% of the variables, implying that their assessments are closely aligned.

Table 2. 4IR readiness of QSGs

Constituent of 4IR	Mean	Rank	Standard Deviation(SD)
Internet of Things	3.22	1	.743
Building information modelling	3.13	2	.822
Artificial Intelligence	2.94	3	1.046
Smart decision support systems,	2.84	4	.937
Cyber security	2.83	5	.801
Machine learning	2.81	6	.997
Cloud computing	2.79	7	.840
Modelling and simulation	2.77	8	.974
Block chain	2.70	9	.841
Big data	2.68	10	.826
Cyber-physical system	2.66	11	.735
Additive manufacturing	2.55	12	.809
Automated robotic equipment	2.53	13	.894
machine learning	2.47	14	.834
Augmented reality	2.39	15	.786
Average	**2.75**		

Table 3 presents Kendall's coefficient of concordance for the 4IR readiness of QSGs. The results indicate a coefficient of concordance (W) of 0.136. This implies a weak agreement among the respondents regarding the readiness of QSGs for the 4IR, as only 13.6% agreement was recorded. The p-value is 0.000, which is less than 0.05, indicating that the observed agreement is statistically significant. Hence, the null hypothesis ($H_0$1), which stated that there is no significant agreement among the respondents on the QSGs' readiness for the 4IR, was rejected.

Table 3. Kendall's coefficient of concordance for QSGs 4IR readiness

Kendall's W	Chi-Square	df	Asymp.Sig
0.136	294.179	14	0.000

Table 4 presents the critical skills required for QSG 4IR readiness. The results of the mean score analysis indicate that estimating skills (MS=4.19) are the most critical requirement. Other highly critical skills, ranked 2nd and 3rd respectively, are software usage skills (MS=4.04) and financial management and control skills (MS=3.99). According to the respondents, all listed skills are considered important, as evidenced by their moderate to high ratings (MS ranges between 3.40 and 3.98). The standard deviation results show small variability (SD ranging from 0.739 to 0.992) in the respondents ratings for 90% of the variables. This implies that their assessments are closely aligned.

Table 4. Critical skill requirement for QSGs 4IR readiness

QSGs Skills	Mean Score	Rank	SD
Estimating skills	4.19	1	.891
Software usage skills	4.04	2	.757
Financial management and control	3.99	3	.874
Procurement skills	3.98	4	.980
Adaptability and continuous learning	3.95	5	.906
Construction technology	3.93	6	.923
Quantification of building works	3.89	7	.772
Project administration skills	3.86	8	.820
Professional practice skills	3.85	9	.765
Value management	3.85	10	.739
Communication skills	3.84	11	.867
Data analysis and management	3.82	12	.980
Building information modelling skills	3.78	13	.992
Cost control skills	3.79	14	.940
Resources Management	3.77	15	.852
Legal and regulatory knowledge in the digital age	3.76	16	.801
Quantification of engineering works	3.72	17	.960
Knowledge of smart construction technology	3.68	18	1.009
Facility management	3.66	19	.902
Entrepreneurship skills	3.65	20	.813
Dispute resolution	3.60	21	.889
Collaboration and communication skills	3.58	22	.948
Risk management and predictive analytics	3.56	23	.949
Understanding of AI and machine learning	3.56	24	1.188
Cyber security awareness	3.53	25	.965
Quantification of heavy engineering works	3.52	26	.865
Sustainability and green building practices	3.51	27	1.068
Aptitude in construction law	3.49	28	.850
Quantification of installation (electrical and mechanical)	3.45	29	.965
Marketing/commercial skills	3.40	30	.923

Table 5 presents Kendall's coefficient of concordance for the critical skill requirements of QSGs for 4IR readiness. The results indicate a coefficient of concordance (W) of 0.152. This value implies a weak agreement among the respondents on the critical skill requirement for QSGs, as only 15.2% agreement was recorded.

The p-value is 0.000, which is less than 0.05, indicating that the observed agreement is statistically significant. Therefore, the null hypothesis ($H_0$2), which stated that there is no significant agreement among the respondents regarding the critical skills requirement of QSGs for 4IR readiness, was rejected.

Table 5. Kendall's coefficient of concordance for QSGs critical skills requirement for 4IR readiness

Kendall's W	Chi-Square	df	Asymp.Sig
0.152	701.927	30	0.000

A principal component analysis (PCA) was conducted to group the 30 identified skill requirements for QSGs' 4IR readiness. The sample size of 154 respondents falls within the permissible range for PCA, ensuring the data's adequacy. The suitability of the data for PCA was further confirmed using a correlation matrix (Tabachnick & Fidell, 2007), Bartlett's test of sphericity, and the Kaiser-Meyer-Olkin (KMO) measure. The results indicated that the data set was adequate for PCA, as the correlation matrix exceeded 0.3, the KMO index exceeded 0.6, and Bartlett's test of sphericity was significant ($p<0.05$).

Table 6 presents the 4-component solution derived from the PCA. The eigenvalue for each of the 4-component groupings was greater than 1.00, and together they explain 82.71% of the total variance. Each skill factor belonged only to one grouping, with all factor loadings exceeding or equal to 0.50. The 30 skill requirements for QSGs' 4IR readiness were grouped into the following four principal components, ranked by importance: Component 1: Advanced skills (value management, facility management, building information modelling skill, project administration skills, etc.); Component 2: Core skills (quantification of building works, quantification of engineering works, cost control, etc.); Component 3: Hard, emerging digital skills (understanding of AI and machine learning, legal and regulatory knowledge in the digital age, risk management, and predictive analytics, etc.); and Component 4: Foundational core skills (procurement skills and estimating skills).

Table 6. Rotated component matrix of critical skills requirement of QSGs for 4IR readiness

Coding	Factors	Components			
		1	2	3	4
S7	Project administration skills	.513			
S11	Facility management	.533			
S12	Value management	.548			
S13	Construction technology	.595			
S16	Building information modelling skills	.737			
S17	Data analysis and management	.815			
S18	Entrepreneurship skills	1.042			
S19	Knowledge of smart construction technology	.872			
S20	Professional practice skills	.841			
S21	Sustainability and green building practices	.756			
S22	Collaboration and communication skills	.508			
S23	Adaptability and continuous learning	.628			
S1	Quantification of building works		.582		
S2	Quantification of engineering works		.734		
S3	Quantification of installation (E and M)		.731		
S4	Quantification of heavy engineering works		.727		
S9	Cost control		.537		
S10	Aptitude in construction law		.592		
S14	Resources Management		.622		
S15	Financial management and control		.528		
S29	Dispute resolution		.673		
S30	Marketing/commercial skills		.598		
S8	Software usage			.553	
S24	Legal and regulatory knowledge in the digital age			.591	
S25	Risk management and predictive analytics			.736	
S26	Understanding of AI and machine learning			.565	
S27	Communication skills			.635	

(*Continued*)

Table 6. (Continued)

Coding	Factors	Components			
		1	2	3	4
S28	Cyber security awareness			.536	
S5	Procurement skills				.818
S6	Estimating skills				.696

The decision to retain the 4-component PCA solution is further confirmed by the scree plot (Figure 1), which showed a total break after the fourth component. Hence, the adequacy of the four-component solution was confirmed using all the known parameters.

Discussion of findings

The study's findings on low readiness of QSGs for 4IR align with extant literature (Osunsanmi et al., 2020; Olatunde et al., 2023). Typically, developing nations are known for slow readiness and adoption of innovative technologies, a trend often attributed to inadequate infrastructure to support technological advancement, limited technical expertise, and insufficient budgetary funding to facilitate technology adoption from the developed nations, as well as resistance to change, which many of the developing countries are known for (Alaloul et al., 2020; Oke & Arowoiya, 2021). The moderate readiness of QSGs for the Internet of Things and building information modelling found by this study is mildly at variance with Oesterreich and Teuteberg (2016), which found the comparatively high readiness and adoption for building information modelling and cloud computing in the construction industry. The finding that estimating skill is the most critical for the 4IR readiness of QSGs implies that, despite advances in technology, the core, foundational, and traditional mandate remains dominant. Hence, it is obvious that the quantity surveyor curriculum is creating a competency lag: it teaches what a quantity surveyor does (the core mandate) but fails to teach how a modern quantity surveyor must do it (using 4IR technologies).

This study, in contrast to Dada (2017), which identified procurement management studies, value management, risk management, and social and communication skills as the most important skills for quantity surveyors, found estimating skills, software usage skills, financial management and control, and procurement skills, respectively, as the most critical skill requirements for QSGs for 4IR readiness. This study factorized the skill requirements for 4IR readiness of QSGs into four components. This paper is comparable to Dada (2017), which submitted that the competency requirement for quantity surveyors could be grouped into three components. The slight variation in

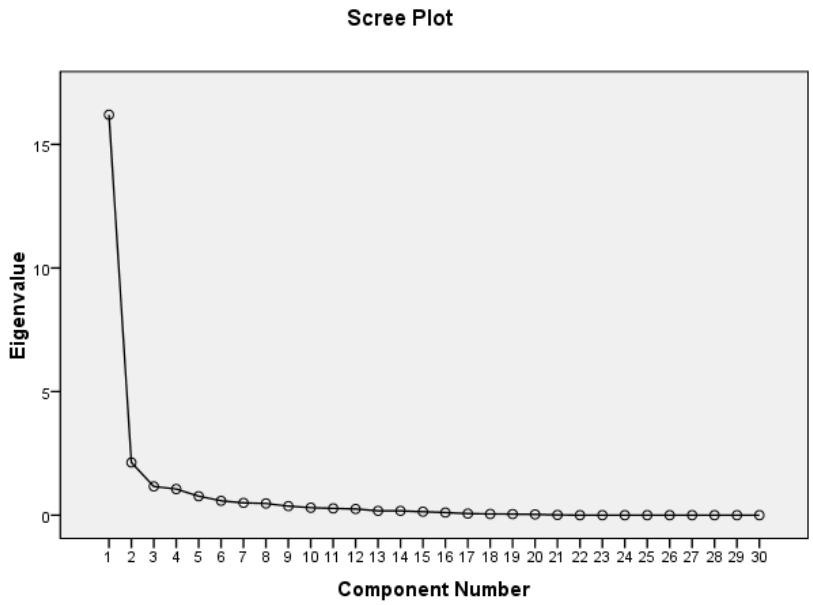

Figure 1. Scree plot of skill requirement of QSGs for 4IR readiness

the component grouping of this study from Dada (2017) could be as a result of the shift in the technological era that this study considered, which was not in contemplation in Dada's (2017) study. The finding that W=0.136 for QSGs 4IR readiness and W=0.152 for critical skills requirement implied a very weak agreement in the opinions of the built environment professionals, meaning that this weak consensus suggests that the Nigerian construction industry is fragmented and lacks a unified vision regarding the specific competencies that define a 4IR-ready QS. This fragmentation is a major barrier to implementing effective, coordinated curriculum change. The finding that software usage skills are critical to QSGs 4IR readiness, second to estimating skills is a pointer that beyond the foundational and the core skills requirement of QSGs for efficiency and effectiveness in the 4IR era, versatility in information and technology will be a major skill set.

Conclusion

The study employed the quantitative research approach to investigate the critical skills requirement for QSGs in 4IR readiness and concluded that their readiness for the 4IR is low. It was further concluded that the Internet of Things and building information modelling are the only 4IR technologies where QSGs have a moderate level of readiness. It was also concluded that respondents' level of agreement on the readiness of QSGs for 4IR is weak. Additionally, it was concluded that the most critical skills QSGs require for 4IR readiness are estimation skills, software usage skills, and financial management and control. This means that the foundational core skills of QSGs are still more dominant in their 4IR readiness than the emerging/digital skills. The 4IR readiness skills of QSGs are composed of four groups: advanced skills, core skills, emerging digital skills, and foundational core skills. Inferring from these conclusions, the study recommends enhancing capacity training for QSGs by augmenting the curriculum to include recent advances in technologies, which will improve their readiness to embrace new technologies. This could be actionable through a mandatory digital integration pedagogy of the quantity surveying curriculum with foundational core competencies such as estimating and cost control being taught exclusively through BIM and data analysis software. A targeted competency focus in form of the development of mandatory modules in artificial intelligence, machine learning, and big data analytics is recommended, as this would ensure QSGs training focus on practical, construction-specific applications rather than abstract theory.

The study further recommended a structural reform and alignment between institutions and the Nigerian Institute of Quantity Surveyors (NIQS) to establish a joint working group. This group should be tasked with creating a unified, sector-wide digital competency standard for QSGs, thereby ensuring that academic training directly addresses the agreed-upon, future-facing needs of the profession. As with every study, a few limitations could be identified with this study, including the need for caution in the generalization of results beyond the study area, as the dynamic of every culture and level of technological exposure could cause a major variation in findings in other climes and areas beyond the scope of the study area. In the same vein, the research approach, such as the sample size and research design, could impose a level of limitation that other studies can improve on. Further study was recommended to compare the readiness of different professions in the built environment for 4IR readiness.

Declarations

Interdisciplinary Scope: This article presents critical skills requirement of quantity surveying graduates (QSGs) for 4IR readiness in Nigeria: the investigation brought to the fore actionable strategies to enhance QSGs' readiness for the 4IR era. Quantitative data were collected from built environment professionals in Lagos Metropolis, Nigeria. The paper identified the extent of QSGs' readiness for 4IR and the critical skills requirements for QSGs readiness of 41R.The information provided in the article are useful to policy makers, employers and construction education stakeholders.

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References

Adepoju, O. O., & Aigbavboa, C. O. (2021). Assessing knowledge and skills gap for construction 4.0 in a developing economy. *Journal of Public Affairs*, *21*(3), Article . https://doi.org/10.1002/pa.2264

Alaloul, W. S., Liew, M. S., Zawawi, N. A. W. A., & Kennedy, I. B. (2020). Industrial Revolution 4.0 in the construction industry: Challenges and opportunities for stakeholders. *Ain Shams Engineering Journal*, *11*(1), 225–230. https://doi.org/10.1016/j.asej.2019.08.010

Aliu, J., & Aigbavboa, C. O. (2021). Key generic skills for employability of built environment graduates. *International Journal of Construction Management*, *23*(3), 542–552. https://doi.org/10.1080/15623599.2021.1894633

Andrade, C. (2021). The inconvenient truth about convenience and purposive samples. *Indian Journal of Psychological Medicine*, *43*(1), 86–88. https://doi.org/10.1177/0253717620977000

Aoun, J. E. (2017). *Robot-proof: Higher education in the age of artificial intelligence*. MIT Press. https://doi.org/10.7551/mitpress/11456.001.0001

Ashworth, A., Hogg, K., & Higgs, C. (2013). *Willis's practice and procedure for the quantity surveyors*. (13th ed.). John Wiley & Sons.

Aspers, P., & Corte, U. (2019). What is qualitative in qualitative research. *Qualitative Sociology*, *42*(2), 139–160. https://doi.org/10.1007/s11133-019-9413-7

Chandramohan, A., Perera, B. A. K. S., & Dewagoda, K. G. (2022). Diversification of professional quantity surveyors' roles in the construction industry: The skills and competencies required. *International Journal of Construction Management*, *22*(7), 1374–1381. https://doi.org/10.1080/15623599.2020.1720058

Cho, E., & Kim, S. (2015). Cronbach's coefficient alpha: Well known but poorly understood. *Organizational Research Methods*, *18*(2), 207–230. https://doi.org/10.1177/1094428114555994

Dada, J. O., & Jagboro, G. O. (2012). Core skills requirement and competencies expected of quantity surveyors: Perspectives from quantity surveyors, allied professionals and clients in Nigeria. *Construction Economics and Building*, *12*(4), 78–90. https://doi.org/10.5130/AJCEB.v12i4.2808

Dada, J. O., & Musa, N. A. (2016). Key factors affecting the competence of quantity surveyors: Evidence from construction industry stakeholders in Nigeria. *Journal of Engineering, Design and Technology*, *14*(3), 461–474. https://doi.org/10.1108/JEDT-09-2014-0060

Dada, J. O. (2017). An appraisal of paradigm shifts required of competence of the Nigerian quantity surveyors. *Engineering, Construction and Architectural Management*, *24*(6), 1269–1280. https://doi.org/10.1108/ECAM-02-2016-0038

Dadzie, J., Abdulaziz, A. R., & Kwame, A. (2012). Performance of consultants on government projects in Ghana: Client and contractor perspective. *International Journal of Business and Social Research*, *2*, 256–267.

Du Plooy-Cilliers, F., Davis, C., & Bezuidenhout, R. M. (2014). *Research matters*. Juta & Company.

Ebekozien, A., Aigbavboa, C. O., Aliu, J., & Thwala, W. D. (2024). Generic skills of future built environment practitioners in South Africa: An unexplored mechanism via students' perception. *Journal of Engineering, Design and Technology*, *22*(2), 561–577. https://doi.org/10.1108/JEDT-10-2021-0571

Esenwa, F. O. (2014). *Challenges of quantity surveying practice in Nigeria*. Proceedings of the 2014 Annual Conference of Registered Quantity Surveyors, 87–99.

Ginigaddara, B., Gajendran, T., & Beard, C. (2023). A critical review of quantity surveying education in an offsite construction perspective: Strategies for up-skilling. *Construction Innovation*, *25*(4), 1058–1084. https://doi.org/10.1108/CI-12-2022-0322

Ginigaddara, B., Perera, S., Feng, Y., Rahnamayiezekavat, P., & Kagioglou, M. (2024). Industry 4.0 driven emerging skills of offsite construction: A multi-case study-based analysis. *Construction Innovation*, *24*(3), 747–769. https://doi.org/10.1108/CI-04-2022-0081

Hwang, B.-G., Ngo, J., & Teo, J. Z. K. (2022). Challenges and strategies for the adoption of smart technologies in the construction industry: The case of Singapore. *Journal of Management in Engineering*, *38*(1). https://doi.org/10.1061/(ASCE)ME.1943-5479.0000986

MACE. (2017). *Moving to Industry 4.0: A skills revolution* MACE Group.

Monyane, T. G., & Ramabodu, M. S. (2014). *Exploration of building information modeling (BIM) concept and its effects on the quantity surveying profession in South Africa*. Proceedings of the 7th Annual SACQSP Research Conference.

Murguia, D., Demian, P., & Soetanto, R. (2021). Systemic BIM adoption: A multilevel perspective. *Journal of Construction Engineering and Management*, *147*(4). https://doi.org/10.1061/(ASCE)CO.1943-7862.0002017

Murguia, D., Soetanto, R., Szczygiel, M., Goodier, C. I., & Kavuri, A. (2024). Construction 4.0 implementation for performance improvement: An innovation management perspective. *Construction Innovation*. https://doi.org/10.1108/CI-08-2023-0184

Newman, C., Edwards, D., Martek, I., Lai, J., Thwala, W. D., & Rillie, I. (2021). Industry 4.0 deployment in the construction industry: A bibliometric literature review and UK-based case study. *Smart and Sustainable Built Environment*, *10*(4), 557–580. https://doi.org/10.1108/SASBE-02-2020-0016

Nigerian Institute of Quantity Surveyors. (2015). *Vision statement* Nigerian Institute of Quantity Surveyors.

Oesterreich, T. D., & Teuteberg, F. (2016). Understanding the implications of digitisation and automation in Industry 4.0. *Computers in Industry*, *83*, 121–139. https://doi.org/10.1016/j.compind.2016.09.006

Ofori, G. (2012). *Developing the construction industry in Ghana: The case for a central agency*. National University of Singapore.

Ogunsemi, D. R., Awodele, O. A., & Oke, A. E. (2013). *An examination of the management of quantity surveying firms in Nigeria*. QSRBN Seminar and Workshop, Abuja, Nigeria.

Ojo, G. K., & Adeyinka, F. B. (2011). Female participation in the quantity surveying profession in Nigeria. In A. O. Afon & O. O. Aina (Eds.), *Issues in the built environment of Nigeria*. Obafemi Awolowo University Press.

Oke, A. E., & Arowoiya, V. A. (2021). An analysis of the application areas of augmented reality technology in the construction industry. *Smart and Sustainable Built Environment*, *11*(4), 1081–1098. https://doi.org/10.1108/SASBE-11-2020-0162

Oke, A. E., Aliu, J., Fadamiro, P., Leo-Olagbaye, F., Jamir Singh, P. S., & Samsurijan, M. S. (2023). Evaluating the drivers for the implementation of automation techniques in the Nigerian construction sector. *Built Environment Project and Asset Management*, *13*(6), 913–928. https://doi.org/10.1108/BEPAM-04-2023-0085

Olanrewaju, A., & Anahve, P. J. (2015). Duties and responsibilities of quantity surveyors in the procurement of building services engineering. *Procedia Engineering*, *123*, 352–360. https://doi.org/10.1016/j.proeng.2015.10.046

Olanrewaju, A. (2016). Measuring the service gaps in the roles of quantity surveyors in the emerging market. *Benchmarking*, *23*(5), 1111–1131. https://doi.org/10.1108/BIJ-07-2014-0066

Olatunde, N. A., Awodele, I. A., & Adebayo, B. O. (2022). Impact of COVID-19 pandemic on indigenous contractors in a developing economy. *Journal of Engineering, Design and Technology*, *20*(1), 267–280. https://doi.org/10.1108/JEDT-11-2020-0480

Olatunde, N. A., Gento, A. M., Okorie, V. N., Oyewo, O. W., Mewomo, M. C., & Awodele, I. A. (2023). Construction 4.0 technologies in a developing economy: Awareness, adoption readiness and challenges. *Frontiers in Engineering and Built Environment*, *3*(2), 108–121. https://doi.org/10.1108/FEBE-08-2022-0037

Opawole, A., Awodele, O. A., Babatunde, S. O., & Awodele, O. O. P. (2012). Correlation of quantity surveying education to skill requirements for civil engineering projects. *Journal of Education and Practice*, *3*(16), 109–118.

Osunsanmi, T. O., Aigbavboa, C. O., Oke, O. E., & Liphadzi, M. (2020). Stakeholders' willingness to adopt Construction 4.0 technologies. *Built Environment Project and Asset Management*, *10*(4), 547–556. https://doi.org/10.1108/BEPAM-12-2018-0159

Peurifoy, R., & Oberlender, G. (2014). *Estimating construction costs*. (6th ed.). McGraw-Hill.

Pothier, D., & Sawhney, A. (2020). *Future of work in construction* Royal Institution of Chartered Surveyors (RICS) Futures.

Pratt, D. J. (2011). *Fundamentals of construction estimating*. (3rd ed.). Cengage Learning.

Rifkin, J. (2011). *The third industrial revolution*. Palgrave Macmillan.

Schwab, K. (2017). *The fourth industrial revolution*. Crown Business.

Sepasgozar, S. M. E. (2021). Digital technology utilisation decisions for Industry 4.0 implementation. *Construction Innovation*, *21*(3), 476–489. https://doi.org/10.1108/CI-02-2020-0020

Shafiei, M. M., & Said, I. (2008). Competency requirements for quantity surveyors. *Sri Lankan Journal of Human Resource Management*, *1*(2), 142–151.

Shahruddin, S., & Husain, S. H. (2024). Identity and leadership paradoxes in digital transformation of construction. *Construction Management and Economics*, *42*(7), 591–609. https://doi.org/10.1080/01446193.2023.2293901

Tabachnick, B. G., & Fidell, L. S. (2007). *Using multivariate statistics*. (5th ed.). Pearson Education.

Tan, L. M., Laswad, F., & Chua, F. (2022). Bridging the employability skills gap. *Pacific Accounting Review*, *34*(2), 225–248. https://doi.org/10.1108/PAR-04-2021-0050

Wao, J. O., & Flood, I. (2016). The role of quantity surveyors in the international construction arena. *International Journal of Construction Management*, *16*(2), 126–137. https://doi.org/10.1080/15623599.2016.1142251

World Economic Forum. (2020). *The future of jobs report* World Economic Forum.

World Economic Forum. (2022). *Catalysing education 4.0* World Economic Forum.

Xu, L. D., & Duan, L. (2019). Big data for cyber physical systems in industry 4.0: A survey. *Enterprise Information Systems*, *13*(2), 148–169. https://doi.org/10.1080/17517575.2018.1442934