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EXPLORATION OF THE TOP TEN SKILLS FOR DIGITAL CONSTRUCTION MANAGEMENT

AUTHORS:
U. Onyia[1], N. B. Madueme[2,*], and U. F. Nwankwo[3]

AFFILIATIONS:
[1,2,3]Department of Civil Engineering, University of Nigeria Nsukka, Nigeria

***CORRESPONDING AUTHOR:**
Email: nzoputa.madueme@unn.edu.ng

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Abstract
Digital Construction Management (DCM) has the potential to revolutionise Nigeria's construction industry by boosting productivity, quality, and safety. It is important that construction professionals utilise DCM in their various projects. However, adoption has been slow due to a significant skills gap among professionals. To leverage DCM benefits, companies must ensure their employees possess these crucial skills. This study aims to identify and analyse the top ten essential skills for digital construction management across various professions and company sizes. Adopting a quantitative research design, the study adapts 18 skills from previous literature review and uses a questionnaire to achieve the aim. The skills were ranked using Mean Item Scores and Relative Importance Index and subjected to further analysis using non-parametric tests and regression. The most important skill identified was continuous learning. It was also discovered that there was no significant difference in the perception of the skills, both technical and soft skills, among various professional groups and company sizes. This supported the conclusion that the identified skills were universally relevant. Construction professionals should prioritise acquisition and promotion of these skills to improve project delivery with the aid of digital tools.

1.0 INTRODUCTION
One of the biggest drivers of Nigeria's economic expansion and development is the building sector [1]. However, the industry has faced several challenges, including low productivity, poor quality, and safety concerns. In the advent of this challenge, digital construction management has been identified as a critical solution that can enhance productivity, quality, and safety in management of construction projects [2]. In the twenty-first century, technological abilities are a key differentiator that separates effective project managers from unsuccessful ones [3].

It is clear that design and management errors, unanticipated site conditions, unfavourable site weather, expansion of project scope due to design and site management errors, and inaccurate project estimates account for the majority of excessive construction project costs and time overruns in Nigeria. These issues can be mitigated by the use and application of digital tools in construction management [4].

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As the construction industry is rapidly evolving, the adoption of DCM tools has become increasingly important in improving efficiency, reducing costs, and ensuring better project outcomes. These competencies can be classified into Core, Domain and Execution competencies which are essential for effective DCM implementation in Nigeria [5]. The core competencies refer to fundamental skills and traits such as leadership and communication that allow professionals to manage projects effectively. On the other hand, domain competencies are particular to a specialised technical field such as cost estimation while execution competencies primarily focus on practical abilities [5]. These are all essential to deliver these kinds of projects effectively.

One of the most significant advancements in DCM is Building Information Modelling (BIM) which has gained popularity in the construction sector over the past 20 years. BIM can change and enhance performance by decreasing inefficiencies, increasing productivity, and encouraging collaborative participation among project stakeholders [6]. The use of BIM has been proven to have benefits like the reduced variations, better estimation of cost, and faster project delivery [7]. Additionally, in contrast to traditional schedule management, construction schedule management when used with BIM provides a communication structure which incorporates multiple information, including schedule, cost, and materials [8].

Construction projects usually have several stages before they are finished. Changes are frequent because of project limitations, especially when information or approval for implementation is pending. Since the modifications may affect the project's scope, all stakeholders affected by them must have immediate access to the most recent information through digital platforms and devices. In terms of the building project delivery process, the traditional approach fosters isolation among stakeholders and lacks collaboration among construction professionals [9].

One of the challenges in addressing these collaboration gaps and enhancing digital adoption in construction is the need for adequate training [10]. The significance of training in any endeavour cannot be overemphasised. In businesses and organisations with a professional focus, this is especially important. It is regarded as a crucial and difficult task that has become associated with deciding the future of many organisations. Without continuous, pertinent, and effective training, employees in organisations are unlikely to perform at the expected level, which would ultimately lead to business failure [10].

It has long been recognized that one of the essential and important procedures in the construction sector that can help businesses and organisations fulfil the demands of construction professionals is training [10]. Research on the application of BIM to construction processes has yielded general conclusions that point to training and skilling as important variables influencing BIM adoption [11]. While the developed economies have witnessed a rise in research activity centred on BIM and a high rate of adoption of BIM, the situation in developing nations like Nigeria is quite different [2]. This issue stems from Nigerian construction industry professionals' incapacity to stay up to date with the latest technological advancements. Given this, effective training is required to make the most of the constantly evolving technology [10].

The DCM competency of a person is their ability to successfully implement digital construction management in vital areas and produce the desired product or service. These competencies come in a variety of forms and can be learned in numerous ways. The study identifies technical competencies and managerial competencies as critical for the development of DCM and its adoption in Nigeria [5]. Relevant competencies identified for construction project managers (CPMs) from a demand-side perspective include professional and technical capability, construction site management, project goal monitoring, team leadership, communication and collaboration, stakeholder engagement, expertise and certifications, and administrative capability [8].

To effectively navigate the modern construction landscape, project managers need to possess a variety of technical skills related to digital construction management. Building information modelling (BIM) expertise and digital competencies are critical for project managers in the construction sector, according to research [11]. These abilities include mastery of three-dimensional design platforms for information model generation, allowing for the visual and information-based management of quality, schedule, and cost during construction processes [12]. In order to effectively adapt to digital technologies, construction management professionals must continuously develop their competencies. While advanced digital technology competencies are becoming more and more crucial, basic word processing and spreadsheet skills are still often required [13]. Furthermore, error screening, visual progress management, and dynamic digital project

management are made possible by the use of BIM technology in municipal infrastructure engineering construction, which ultimately enhances the effectiveness of construction management and project results [12].

In the realm of digital construction management, the role of a project manager is evolving significantly due to the impact of digital technologies like Building Information Modelling (BIM) and the necessity for enhanced managerial and digital competencies. The shift towards digitalization requires project managers to possess a blend of technical expertise and social skills to navigate the complexities of modern construction projects, emphasising the importance of continuous competence development and the acquisition of digital competencies [14].

Effective verbal, written, and visual communication skills are essential for a construction manager to ensure greater transparency in the dissemination of project data [9]. Any problems with the information model, as well as, if required, on-site, should be able to be analysed, identified, and resolved by a BIM specialist [15]. Every stakeholder is expected to participate in project decision-making even though BIM managers and consultants typically lead the workflow because each is in charge of at least one section of the shared information model [11], [15]. It is also imperative for professionals to proactively acquire new skills in order to stay current with industry trends. This is particularly true for AEC professionals who operate in a field that is changing quickly; the situation is made even more dire by the use of BIM, as the sector is now aware of its advantages and seeking to advance this methodology [15].

Nigeria's construction sector could undergo a revolution thanks to digital construction management. In construction projects, it can improve quality, safety, and productivity. Nonetheless, the country's construction industry has a large skills gap, which has hindered the adoption of these technologies. The lack of necessary skills and competencies is a major challenge that has hindered the widespread adoption of digital construction management in Nigeria [16]. This means that the implementation of digital construction management technologies requires a certain level of technical competencies, process knowledge, and management abilities that many construction professionals in Nigeria do not possess. The Nigerian construction industry is quite different from other construction industries, and digitalization of construction management is important [17]. Traditional methods frequently fail to meet these needs. The industry's overall capacity to maintain safety and regularly complete projects on schedule and within budget is hindered by the skills gap [15]. As construction projects continue to increase in complexity and scale, there is a pressing need for innovative technological approaches to enhance construction management practices. By offering a thorough methodology that identifies the most important competencies and thoroughly examines them, this study seeks to close this critical gap. It does this by combining technology-driven solutions with effective project management techniques to maximise safety, resource allocation, and scheduling efficiency in construction projects.

2.0 MATERIALS AND METHOD

The researchers used a multi-sectional research approach for this study in order to cater for the regression of identified variables. Owing to the use of independent and dependent variables, the study used a quantitative approach to accommodate collection of data and analysis from a large number of respondents [18]. The data collection process involved sending a questionnaire to construction professionals actively working in the industry targeting individuals with relevant experience working in construction-related fields including architecture, engineering, and building/construction management. Online forums and professional associations were utilised in identifying and contacting the respondents.

A sample of 200 respondents were selected using purposive sampling. Purposive sampling strategically selects specific individuals for the sample based on particular characteristics [19]. The survey response rate was 81.5%, with 163 responses. The questionnaire presented the identified competencies to the respondents clearly and concisely. To ensure data security and seamless process, Google forms, a user-friendly online form application was used for data collection.

The questionnaire was strategically constructed to collect relevant and reliable information as to the importance of the identified skills in digital construction management. The foremost section of the questionnaire included a statement to outline the aim of the study, the structure for participation, and the right to withdraw participation at any point, in accordance with ethical practices. The subsequent sections were meticulously formulated to maintain clarity and to avoid collection of any personal information. These subsequent sections were further split into two major categories. The first category

gathered demographic data from the respondents which included professional background, number of years of experience, size of company while the latter focused on the study's primary objective: identifying and examining the necessary skills for DCM in Nigeria. A meticulous review of previous literature led to the identification of 18 essential skills. These skills were categorised into two groups based on the nature of the skill [20]. The first, labelled "technical skills," encompasses skills acquired through formal training or practical experience. The second, termed "soft skills," comprises skills, traits, and abilities developed throughout one's lifetime [20].

2.1 Measures of Central Tendency/Ranking

The various variables representing the skills required for the integration of DCM were drafted from [3] [4] [5] [7].The questionnaire listed eighteen skills and asked respondents to indicate the level of significance of each skill in integration and adoption of digital construction management. A five-point Likert scale of 1 = Strongly disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree, was used for the identification.

The study calculated two key metrics in order to determine the level of agreement among the respondents of the identified skills in integration of DCM, namely: the “Mean Item Score (MIS)” and the “Relative Importance Index (RII)” [21]. The overall visualisation of importance of each variable is done by the MIS by calculating overall mean rating of all the variables. The relative importance of the variables are then calculated to rank them. In order to evaluate both metrics, the following equations were implored:

$$MIS = \sum_{i=1}^{5} RP_i \times R_i\% \quad (1)$$

Where, RP_i = rating point ‘i’ ranging from 1 – 5, R_i% is the percentage response to rating point ‘i'.

$$RII = \frac{\sum RP}{RP_{max} \times N} \quad (2)$$

Where, RP = rating point, RP_{max} is the maximum rating (5), N = number of responses (163).

Subsequently, two non parametric statistical tests were carried out, namely the Mann Whitney U test and the Kruskal Wallis test. In order to evaluate the disparity between respondents indicating the importance of technical and soft skills, the Mann-Whitney U test was utilised. In addition, the Kruskal-Wallis test was employed to determine if there were differences with respect to the perception of skills for digital construction management between professions and company sizes.

2.2 Demographic Data

The profile of 163 respondents participating in the survey is shown in Table 1. More than 84% of the respondents were male. This gender disparity is common in the construction industry, where the workforce has traditionally been male-dominated, particularly in roles involving physical labour. Given that the study primarily focused on resident professionals, a higher proportion of male respondents was anticipated [22]. In terms of experience, more than 50% of the respondents had below 5 years experience while the rest had an experience of more than 5 years. An increased participation of young professionals on construction sites is indicated by the high number of people in the construction profession with small working experience. As the young professionals move higher up the career ladder, they tend to move into more managerial roles [20]. Despite this, the distribution across the various experience groups shows a fair inclusion of professionals with diverse levels of experience in the industry. Concerning company size, 69% of respondents are employed by organisations with fewer than 50 employees, 18% by organisations with 51-100 employees, and the remainder by organisations with over 100 employees. Notably, 87% of respondents work in organisations with fewer than 100 employees, highlighting the predominance of SMEs among the respondents' employers. There were 105 participants with Engineering background representing 64.3%, 25.2% with background in architecture, and 8.6% were either builders or construction managers. This diverse professional background underscores the respondents' active involvement as stakeholders in construction projects, from inception to completion. Given this robust representation, it is reasonable to expect that the respondents can provide reliable insights into the essential skills for digital construction management.

Table 1: Demographic representation of respondents

Profile	Frequency	Percentage (%)
Gender		
Male	137	85
Female	26	15
Total	**163**	**100.0**
Work experience (years)		
< 5	104	65
6 – 10	39	23
> 10	20	12
Total	**163**	**100.0**

Size of Company		
< 50 employees	114	69
51 – 100 employees	28	18
> 100 employees	21	14
Total	**163**	**100.0**
Professional Background		
Architecture	42	25
Engineering	103	64
Building/Construction Management	15	9
Others	3	2
Total	**163**	**100.0**

3.0 RESULTS AND DISCUSSION

3.1 Results

3.1.1 Skills for effective implementation of digital construction management

The top 10 skill sets were extracted from Table 2 and categorised into technical and soft skill groups for individual analysis as depicted in Table 3. The overall mean ratings assigned by respondents to these top ten skills exhibit a narrow range, spanning from a low of 4.1 to a high of 4.3, indicating a relatively high level of perceived importance. Respondents generally viewed soft skills as more crucial than the technical skills, with a mean score of over 4.2 calculated as the average mean rating (MR) of each category (technical and soft). Using a cutoff value of 4.00, a more thorough analysis of individual abilities indicates that the following are the most important for digital construction management: time management, problem solving, integration of DCM tools, project planning and organisation, and continuous learning. Four out of these five skills are classified as soft skills, further reinforcing the respondents' perception of their paramount importance.

Table 2: Skills for effective implementation of digital construction management

S/N		MR	RII	Rank
SC-1	Expertise in DCM tools [23]	4.260	0.852	3
SC-2	Knowledge of design softwares and systems [23]	4.020	0.804	13
SC-3	Forward thinking and creative mindset [24]	4.070	0.814	11
SC-4	Teamwork [25]	4.110	0.822	7
SC-5	Effective communication [25]	4.100	0.820	9
SC-6	Continuous learning [26]	4.310	0.861	1
SC-7	Problem Solving [27]	4.240	0.848	5
SC-8	Attention to detail [28]	4.010	0.802	14
SC-9	Strategic planning and scheduling [29]	4.290	0.859	2
SC-10	Leadership and administration [15]	4.050	0.810	12
SC-11	Awareness of professional standards [30]	4.090	0.817	10
SC-12	Adaptation to emerging technologies [31]	4.130	0.827	6
SC-13	Data privacy and security [32]	3.660	0.733	18
SC-14	Analysis and Interpretation of DCM data [33].	4.110	0.822	7
SC-15	Risk assessment and management using digital tools [34]	3.930	0.787	16
SC-16	Time management [28]	4.250	0.850	4
SC-17	Good background in maths and computer-related courses [35]	3.810	0.762	17
SC-18	Ability to educate and train others [36]	3.940	0.789	15

Table 3: Classification of the top ten skills into technical and soft skills

S/N	Top 10 Identified Skills	Mean	Rank
	Technical Skills	*4.150*	
SC-1	Expertise in DCM tools	4.260	3
SC-12	Adaptation to emerging technologies	4.130	6
SC-14	Analysis and Interpretation of DCM data.	4.110	7
SC-11	Awareness of professional standards	4.090	10
	Soft Skills	*4.220*	
SC-6	Continuous learning	4.310	1
SC-9	Strategic Planning and Scheduling	4.290	2
SC-16	Time management	4.250	4
SC-7	Problem Solving	4.240	5
SC-4	Teamwork	4.110	7
SC-5	Effective communication	4.100	9

3.1.2 Difference in effectiveness of skills for digital construction management among professions

To probe deeper into the disparity between the perceived importance of technical and soft skills, a Mann-Whitney U-test was implemented. The test showed no statistically significant difference at the 5% confidence level with a U value of 7.5 and exact 2 tailed significance of 0.3520. Taking a 5% confidence level, Kruskal Wallis tests were performed to further dissect the varying perceptions of the technical and soft skills among different professions presented in Table 4. The first test used the mean technical skill rating as the dependent variable, while the second used the mean soft skill rating. In both cases, the profession (Engineering, Architecture, or Building/ Construction Management) served as the independent variable. For the initial test, which aimed to assess disparities in technical skill perceptions across professions, the null hypothesis was formulated as follows:

H_1: The relative significance of technical skills in digital construction management is the same across all professional backgrounds

This test was designed to determine if the mean rating of technical skills varies significantly between several different professional backgrounds. Engineering, architecture and building construction management were calculated to have a mean technical skill rank of 81.2, 78.0, and 71.4, respectively. In this test, no significant difference was found in mean ratings among the different professions for the technical skills needed to fulfil DCM, thus indicating that the profession has little ability to affect the technical skills that are needed to perform DCM ($H_{(1)}$ = .636, p = .728).

For the second test, to ascertain the disparity across the various professional backgrounds for relevance of the soft skills, the following null hypothesis was put up:

H_2: The relative significance of soft skills in digital construction management is the same across all professional backgrounds.

To ascertain whether professional roles influenced the perceived importance of soft skills, a Kruskal-Wallis H-test was conducted. The mean ranks for soft skills were 77.3 for engineers, 89.7 for architects, and 65.8 for builders. The results of the test ($H_{(2)}$ = 3.582, p = .167) indicated no significant differences in soft skill ratings across the various professional backgrounds. This finding suggests that professional roles do not substantially impact the perceived importance of soft skills for digital construction management.

Table 4: Kruskal Wallis test for technical skills and soft skills for digital construction management

S/N		Mean Rank			Kruskal Wallis		
		Engineering	Architecture	Building/Construction Management	X2	df	p-value
1	Technical Skills	81.2	78.0	71.4	0.64	2	0.7280
2	Soft Skills	77.3	89.7	65.8	3.58	2	0.1670

3.1.3 Significance of company size on integration and adoption of the top ten skills

This hypothesis tests whether the size of the respondent's company significantly influences their perception of the top ten skills for digital construction management. To test H3, a regression analysis was conducted with the perception of the top ten skills as the dependent variable and company size as the predictor variable. The results indicate that company size was not of significant predictive value concerning the perception of the top ten skills of the respondents (R^2 = .023, F(1,153) = 3.64, p = .058).

3.2 Discussion

This study identified and analysed the ten most critical skills required for successful digital construction management (DCM) in Nigeria. Eighteen skills were initially identified through a literature review, which were then further analysed to determine the top ten. These skills had their Mean Item score and Relative Importance Index calculated and used to rank them. As shown in Table 3, all the ten skills showed relevance for DCM, with each of the skills exceeding the slated agreement threshold of 4.00. While there was general consensus on the importance of all skills, construction professionals exhibited varying levels of agreement regarding their relative significance [37]. The most salient skills identified were continuous learning and adaptation to emerging technologies, strategic planning and organisational abilities, and expertise in DCM tools [4] [7]. As various construction technologies evolve rapidly, professionnals must embrace continuous learning and be ready to adapt smoothly to new technologies and innovations [38]. Staying informed is essential in a field constantly reshaped by innovation. Beyond technical know-how, the study highlights the need for meticulous and strategic planning and strong organisational skills to handle the complex demands of digital construction. Mastering relevant digital tools is also key as today's construction industry is highly digital, and professionals who can confidently navigate these tools are the ones best equipped to succeed in this fast-paced environment. [23].

Looking closely at Table 3, there is a slight tendency to rate soft skills as more important, based on the mean scores of both skill categories. However, no statistically significant difference was shown by Mann Whitney U-test between the perceived importance of technical and soft skills in digital construction management, highlighting the approximately equal value of both types of skills for training and development in the construction industry [39]. Among the top ten skills identified, adaptation to emerging technologies, the ability to analyse and interpret DCM data, awareness of professional standards, time management, problem solving, teamwork, and effective communication stood out as essential competencies. To statistically confirm the hypothesis that "the relative significance of technical skills in DCM is consistent across all professional

backgrounds," the study found no significant differences in how engineers, architects, and builders valued technical skills. Builders had a slightly lower mean rank of 71.4, but this difference was not statistically significant, indicating a general agreement on the importance of technical skills across professions. The same held true for soft skills: the hypothesis that "the relative significance of soft skills in DCM is consistent across all professional backgrounds" was supported. Again, builders had a non-significant minor variation at a mean rank of 65.8. The importance of the top ten skills identified in this broad alignment throughout professions aligns to the importance of technical and soft skills across this construction industry [40].

The study also explored whether perceptions of key skills varied according to company size, investigating if smaller firms valued certain competencies differently than larger organisations. Surprisingly, the analysis found no statistically significant differences in skill appraisal based on company size. This suggests that, regardless of whether a company is a small start-up or a large enterprise, the top ten skills are viewed as equally essential across the board [23]. These findings point to a shared understanding within the industry: the foundational competencies identified in the study hold universal relevance, enabling companies of all sizes to effectively navigate the demands of digital construction management.

4.0 CONCLUSION

For construction professionals, recognising and developing key skills for digital construction management (DCM) is vital. A targeted survey of construction experts identified a compelling range of skills necessary to navigate the industry's digital transformation. Soft skills such as project planning and communication received a slightly incremental priority compared to those of technical skills. The findings also showed consistent skill perceptions across professional groups, including engineering, architecture, and building/construction management. This consistency suggests that the top ten skills identified are broadly relevant across the construction industry. Government bodies and industry advocates can use these insights to create comprehensive training programmes, equipping professionals with the skills needed for effective DCM. Ultimately, this research not only pinpointed essential DCM skills but also provided valuable guidance for the Nigerian construction sector. By investing in these competencies and adopting digital methods, construction companies of all sizes stand to gain through enhanced efficiency, profitability, and project outcomes.

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