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Assessing the innovative skills and competencies required of construction management graduates

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Abstract: The construction industry has been experiencing high waves of revolutionised innovative technologies globally. These resulted from the highly innovative demands of the 4th industrial revolution (IR), which does not exclude the construction industry. These technologies do not rely on traditional design and build principles, and they require sophisticated skills and competencies. Currently, the construction industry is still struggling to find professionals with innovative competencies and the skills needed to manage the building lifecycle process. These have been a major concern in developing countries' construction industry sector. Employers in the construction industry are now looking for construction management graduates (CMG) who are academically qualified and also possess considerable construction-related innovative skills and competencies in related technological software or tools. This study investigates the expected core skills and competence required by CMG. The methodology entails a well-structured systematic literature review, wherein 13 expected core competencies and 27 expected core skills were identified. Based on these, primary data were elicited through an online Google Forms survey distributed to professionals in the Nigerian construction industry. A total of 330 valid responses were obtained. Relative Important Index (RII) and principal component analysis (PCA) were carried out and presented. The result reveals the industry's expectations and provides guidance to CMG seeking employment in the construction industry. Understanding the industry expectations and possessing the required core competencies will enable the CMG to remain relevant in the dynamic built environments. This study contributes to building information modelling (BIM) knowledge and the current innovative competencies and skills required in the built environment.

Keywords: BIM, competency, challenges, skills, management, employment drive, Nigeria, students

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1 Introduction

In this study context, 'construction management graduates' are also called 'building graduates'. Construction management (CMt) is the discipline that entails managing a construction project or projects as effectively as possible (Arditi and Alavipour 2019). Construction Manager (CM) duties entail and are not limited to making the best use of available finances; efficient project scheduling; controlling the scope of work; avoiding delays, revisions and conflicts; improving project design and construction quality; and contracting and procurement flexibility (Arditi et al. 2009). The revolution in the construction industry has resulted in a tremendous amount of skill being demanded of the construction management graduate (CMG). Moreover, the need for construction managers arose centuries ago – in fact, such a need has probably been prevailing ever since the time when humans first created shelters to protect themselves from threats such as weather and animals. Since then, construction process management has been of such a vital importance that it cannot be neglected, regardless of how rudimentary or modest the structures requiring to be constructed might be. We have arrived in the 21st century (4th industrial revolution [IR]) because of this progress.

Besides, Yogeshwaran et al. (2018) and Yap et al. (2021) noted the need to evaluate the expected skills and competencies of quantity surveyors (QS). Similar research (Wang and Cheng 2022) was reported in China, and Abdullah et al. (2017) researched in Australia, focusing on construction managers. However, all indication shows that the current IR entails incorporating information technology (Toyin and Mewomo 2023) in the management of construction activities. Thus, this has left the construction industry with no option but to adopt such innovative technology that is capable of managing information throughout the lifecycle of the construction process. Building information modelling (BIM) technology has been seen, tested and proven as an innovative technology that can function perfectly well in the construction industry (Dossick et al. 2014; Kolarić et al. 2018; Toyin and Mewomo 2021). Notwithstanding, several researchers highlighted the 'need for BIM skills' (Hodorog et al. 2019) in the built environment. For example, Mohd and Latiffi (2013), Wang et al. (2020), Hodorog et al. (2019) and Toyin and Mewomo (2023) stated that using a BIM workforce aids in cost savings and enhanced time management through clash detection.

Innovation in construction is defined as changes that lead to an improved input–output relationship for products and processes, as well as changes within the technical, management or legal organisation of a project that can be monetised (Brockmann et al. 2016). Thus, the construction industry is still faced with the challenges of getting innovatively skilled professionals with the required competencies to manage the construction lifecycle process. These have remained difficult to find. The construction managers (CM) are under tremendous pressure as most struggle to align themselves with the evolving innovative technology in the construction industry (Demirdoven and Arditi 2014a). Based on their good degree of familiarity with this emerging technology, a few fresh CMG could secure employment offers in reputable construction companies; in contrast, some old construction managers are being retrenched (Torres-Machí et al. 2013; Abdullah et al. 2017) since they cannot meet the evolving innovative technology trends in the construction industry. Such innovative trends in construction include but are not limited to BIM, robotics, digital twin technology, artificial intelligence (AI), augment reality (AR), the use of drone, etc. (Brockmann et al. 2016; Hodorog et al. 2019; Toyin and Mewomo 2022; Wang and Cheng 2022).

Therefore, construction industry employers now seek to employ CMG who are academically sound as well as possess necessary construction-related innovative skills and competencies in related technological software or tools, such as 'BIM', Microsoft Project (MSP), etc., that can be used to manage the project throughout its lifecycle. Although very few studies focus on this area, none have tried to conduct such related research in Nigeria. Therefore, this study investigates the expected core skills and competence required of CMG in the Nigerian construction industry. The specific objectives are to: (a) 'identify and appraise the critical competencies needed to keep pace within the revolving industry'; and (b) 'examine the core innovative skills expected of CMG'.

2 Theoretical background

CM is both a demanding and challenging profession. The responsibilities of a construction manager include the following, as documented in the literature (Baharudin 2006; Arditi et al. 2009; Yaman et al. 2015; Maina 2018):

- Supervise and direct construction projects from start to finish
- Review the project in-depth to schedule deliverables and estimate costs
- Coordinate and direct construction workers and subcontractors
- Select tools, materials and equipment and track inventory
- Prepare internal and external reports about job status
- Negotiate terms of agreements, draft contracts and obtain permits and licences
- Ensure quality construction standards and the use of proper construction techniques

As a result of these responsibilities, being relentless and prudent in achieving goals is a key attribute of a construction manager; as such, they need to be informed of everything that happens during the project. Thus, determining the precise truth is also necessary for them to work successfully (Pellisé Tintoré 2014).

2.1 Expected critical competencies of CMG

Competency is defined by GWA (2022) as the combination of behavioural qualities, skills, abilities and knowledge required to generate adequate results on the job. Buvik and Rolfsen (2015) see competence as 'the abilities, skills, and capabilities that a person has in a particular domain'. Yap et al. (2021) agreed with Wao and Flood (2016), who refer to competency as the major criterion utilised to improve the performance of professionals in their different occupational sectors.

Based on the preceding definition, competence may be understood as the capacity to use a specific characteristic of knowledge, skills, talent or personal qualities to accomplish/deliver critical activities or tasks effectively. Turner (2017), Arditi et al. (2013) and Mühlbacher et al. (2013) see leadership characteristics, technical knowledge, behaviours and competence in strategic and corporate management as part of the critical skill sets for good project managers. Torres-Machí et al. (2013) conducted a study focussing on CMG in Spain; their opinion was sought to understand why the unemployment rate among young graduate of CMt professionals is very high. The main reasons given were lack of adequate communication (due to the mixed nature of professionals in their industry), inadequate university program design (lack of BIM knowledge), lack of eagerness to work, a refusal to relocate, inadequate master's degree to meet market demands, an economic crisis and too many universities offering similar graduate degrees.

The study by Wang and Cheng (2022) in China identified 40 general competencies expected of CMG. The author's findings reflected that the current academic curriculum of tertiary institutions in China could not cater for the construction industry's expectations. Moreover, it tends to be too theoretical and lacks practicality. The industry expected the graduates to be able to 'write a comprehensive technical report, to analyse the technical issues and to provide ongoing feedback to the teams'. Vaz-Serra and Mitcheltree (2021) conducted research in Australia; the aim was to understand the competencies expected of project management graduates as required by the industry. Their study reveals that more significance is laid on interpersonal skills, competencies within core technical knowledge, sustainability and life cycle analysis, and knowledge of environmental waste management systems. The study of Mitcheltree et al. (2019) concluded that good communication; commitment to personal development; emotional intelligence; resilience and persistence; and commitment to professional development are the top five traits the construction industry looks out for when recruiting graduates. Table 1 shows the competencies gathered from various published articles on construction managers. The variables documented in this table was used to elicit respondent opinion towards the study objective on expected competency.

2.2 Expected core innovative skill

The CMG must possess special skills that allow them to face complex constructability difficulties, as well as the ability to visualise a finished product in an empty three-dimensional (3D) space (Martin-Gutierrez et al. 2012; Ahmed et al. 2014; McCuen 2015; Kim and Irizarry 2021). Ahmed et al. (2014) submit that the CMG that possess these skills are likely to meet up with the innovative evolving needs of the industry when they join the workforce. However, Williamson and Andrew (2018) point out 'spatial skill' as one of the terms used to describe core skills construction practitioners use to make informed decisions. These assist them in transforming abstract images into the finished creation. Dennis and Tapsfield (2013) state that spatial ability is 'the ability to generate, retain, retrieve, and transform well-structured visual images'.

As discussed in the introduction section, construction managers require basic skills in innovative technology. BIM is one of these revolutionised technologies evolving in the construction industry. Nevertheless, individual BIM core skills are the personal characteristics, technical talents and professional expertise required to perform a BIM activity or deliver a BIM-related output. These capabilities, achievements or actions should be quantifiable in performance standards and might be obtained or improved through education, development and training (Succar et al. 2013; Plawgo and Ertman 2021). According to Hodorog et al. (2019), traditional analytic approaches cannot capture the dynamic process of BIM. The expanding required number of new roles, such as BIM manager, BIM director and BIM technician, demonstrates the growing demand for BIM experts (Yalcinkaya 2013). Construction managers are more likely to pick up the role of BIM managers. BIM managers act as intermediaries between other construction professionals, working with architects, designers, engineers and clients to gather specifications and overseeing the creation of detailed structural plans (Construction 2021). Looking at the role of a construction manager on a project, it is immediately perceptible that they are expected to deal with the management of the entire resources on a construction project, and they act as an intermediary among all construction teams. Thus, they are close to being the BIM manager. They only need to obtain little knowledge in the coordination of BIM. However, according to Rahman et al. (2016), construction managers and BIM managers require distinct skill sets. Various scholars also emphasise the importance of skills such as collaboration and effective communication in the curricula. According to Dossick et al. (2014), a BIM syllabus should include an understanding of computer application principles and BIM procedures. Individual qualities such as aptitude, credentials, skills/abilities, knowledge and attitude are examined by Barison and Santos (2011). They note the professional necessity for the role in both fundamental and functional aspects. Rahman and Ayer (2017) assessed the capabilities of BIM in an organisation; the authors highlighted the following skills as required from construction managers: information and communication technology (ICT) skills, teamwork, a basic understanding of the BIM process, and analytical and problem-solving skills.

Tab. 1: Critical competencies expected of CMG

S/N	Coding	Expected competency	References
1.	CMC1	Team leadership and management	Love et al. 2001; Dainty et al. 2004; Male et al. 2010; Affandi et al. 2013; Benhart and Shaurette 2013; Jabar et al. 2013; Mühlbacher et al. 2013; Abdullah et al. 2017; Mitcheltree et al. 2019; Wang and Cheng 2022
2.	CMC2	Knowledge of the biding and tendering process	Benhart and Shaurette 2013; Wang and Cheng 2022
3.	CMC3	Risk management	Abdullah et al. 2017; Wang and Cheng 2022
4.	CMC4	Pre-contract planning and programming	Affandi et al. 2013; Wang and Cheng 2022
5.	CMC5	Honesty and integrity	Love et al. 2001; Dainty et al. 2004; Benhart and Shaurette 2013; Jabar et al. 2013; Pellisé Tintoré 2014; Mitcheltree et al. 2019
6.	CMC6	Site survey and analysis of construction site	Love et al. 2001; Jabar et al. 2013; Abdullah et al. 2017; Wang and Cheng 2022
7.	CMC7	Analysing design solutions	Affandi et al. 2013; Benhart and Shaurette 2013; Jabar et al. 2013; Wang and Cheng 2022
8.	CMC8	Basic knowledge of procurement	Affandi et al. 2013, Benhart and Shaurette 2013; Jabar et al. 2013; Wang and Cheng 2022
9.	CMC9	Client care	Dainty et al. 2004; Affandi et al. 2013; Jabar et al. 2013; Abdullah et al. 2017; Wang and Cheng 2022
10.	CMC10	Basic knowledge of various forms of building and construction contracts	Jabar et al. 2013; Abdullah et al. 2017; Wang and Cheng 2022
11.	CMC11	Conflict avoidance and management or interpersonal understanding	Affandi et al. 2013; Jabar et al. 2013; Abdullah et al. 2017; Vaz-Serra and Mitcheltree 2021
12.	CMC12	Ability to set up an expediting log and procurement, submittal of log	Benhart and Shaurette 2013; Vaz-Serra and Mitcheltree 2021
13.	CMC13	Basic knowledge of health and safety in construction practice	Love et al. 2001; Affandi et al. 2013; Benhart and Shaurette 2013; Abdullah et al. 2017
14.	CMC14	Basic understanding of construction drawing interpretation	Male et al. 2010; Benhart and Shaurette 2013; Plawgo and Ertman 2021
15.	CMC15	Contract administering and managing subcontracts	Affandi et al. 2013; Abdullah et al. 2017; Mitcheltree et al. 2019
16.	CMC16	Competency in the reviewing and selection of qualified subcontractors	Benhart and Shaurette 2013; Jabar et al. 2013; Vaz-Serra and Mitcheltree 2021
17.	CMC17	Tool and machine maintenance and quality management competency	Male et al. 2010; Affandi et al. 2013; Benhart and Shaurette 2013; Abdullah et al. 2017
18.	CMC18	Labour and resource management	Affandi et al. 2013; Benhart and Shaurette 2013; Jabar et al. 2013; Abdullah et al. 2017
19.	CMC19	Ability to manage project variations, cash flow forecasting and monitoring	Jabar et al. 2013; Mitcheltree et al. 2019; Wang and Cheng 2022
20.	CMC20	Knowledge and understanding of project specifications	Love et al. 2001; Male et al. 2010; Benhart and Shaurette 2013; Vaz-Serra and Mitcheltree 2021
21.	CMC21	Ability to prepare the schedule of work and project progress and technical report	Affandi et al. 2013; Benhart and Shaurette 2013; Wang and Cheng 2022
22.	CMC22	Basic understanding of construction code and regulation	Benhart and Shaurette 2013; Jabar et al. 2013; Abdullah et al. 2017; Vaz-Serra and Mitcheltree 2021
23.	CMC23	Understand and apply construction-related software knowledge	Love et al. 2001; Abdullah et al. 2017; Mitcheltree et al. 2019
24.	CMC24	Knowledge of sustainability in construction	Affandi et al. 2013; Jabar et al. 2013; Vaz-Serra and Mitcheltree 2021
25.	CMC25	Knowledge of project brief preparation	Jabar et al. 2013; Abdullah et al. 2017

(*Continued*)

Tab. 1: Continued.

S/N	Coding	Expected competency	References
26.	CMC26	Computer skills – Excel, MS Office, Adobe, Internet-based, etc.	Love et al. 2001; Male et al. 2010; Benhart and Shaurette 2013; Plawgo and Ertman 2021
27.	CMC27	Good communication	Mühlbacher et al. 2013; Rahman and Ayer 2017; Kolarić et al. 2018; Hodorog et al. 2019; Mitcheltree et al. 2019; Plawgo and Ertman 2021; Vaz-Serra and Mitcheltree 2021; Wang and Cheng 2022

CMC, construction management competencies; CMG, construction management graduates.

In addition, feedback and critical thinking are also essential skills set for a CMG. Nevertheless, an intelligent construction manager may have sufficient industry experience, but it does not mean they no longer need feedback. Experienced field workers see problems that even the smartest construction managers may overlook (Turner 2017). Thus, a construction manager should be open to feedback from clients, supervisors and professional peers (Benhart and Shaurette 2013; Mitcheltree et al. 2019). Furthermore, because the work comprises significant obligations, being a construction manager necessitates a wide range of skills and characteristics. As construction projects get larger and more sophisticated, it is up to the employer to hunt for qualified candidates who are willing to be trained to acquire these skills. Table 2 shows the identified core innovative skills gathered from published articles on construction managers. The variables documented in this table were used to elicit respondents' opinion towards the study objective on innovative core skill.

3 Methodology

This study uses two distinct ways to source data. Firstly, secondary data were sourced from previously published literature. An extant review of the literature was conducted. The hypothesis that, in any study context, conducting a literature review would be an ideal means for obtaining a suitable contextual backdrop against which the present study's findings might be evaluated, has been scientifically proven. Such a practice sheds more light on what has been done and is yet to be done and research trends for decades. Therefore, this study systematically reviews published articles sourced from the Scopus and Web of Science (WoS) databases. These databases were selected because they are two of the most credible and largest scientific databases; they ensure a high degree of quality control and encompass a broader range of research disciplines (Ullah et al. 2019; Toyin and Mewomo 2021). Lastly, the extant review yielded 27 competencies and 13 core skills. These can be seen in Tables 1 and 2. Thus, the identified variables are based mainly on competencies and skills that have received significant consideration in similar studies previously documented by scholars. Employing well-known variables for a research study is preferable since this allows respondents to react quickly. A questionnaire survey was constructed grounded on the identified 27 and 13 variables found during the extant literature review, and the snowball sample techniques method was used to locate respondents. As a result, the study presented in this article is quantitative. The questionnaire survey consists of two major processes to examine the questionnaire's relevance and reliability. Firstly, the questionnaire was reviewed by five construction-related personnel. This comprises of two real estate human resource managers, two contractors with over 10 years of practising experience and one registered graduate member of the Nigerian Institute of Building (NIOB), confirming that unclear expressions were not contained in the survey. Suitable technical terms were used, and the questionnaire covered the expected competencies and skills required of CMG. Secondly, before the questionnaire was widely distributed, a pilot study with 20 respondents was done to examine its comprehensibility and design. The expected BIM competencies and skills were measured on a 5-point Likert scale from 1 ('not significant') to 5 ('strongly significant').

One reliable method to validate quantitative questionnaire reliability is the use of Cronbach's α technics (Vaz-Serra and Mitcheltree 2021; Toyin and Mewomo 2022). These technics are used to determine the average relationship or internal regularity amongst factors/variables in a questionnaire. The Cronbach's α result will determine if the instrument used in collecting data is reliable and if the collected data can be suitable for further descriptive and inferential analysis. A Cronbach's α of 0.7 or above is deemed suitable for conducting inferential statistical analysis (Yap et al. 2021). The 20 pilot test respondents were excluded from the primary data before continuing with

Tab. 2: Core innovative skill

S/N	Coding	Expected skills	References
1.	CMES1	Critical thinking and openness to feedback	Yogeshwaran et al. 2018; Hodorog et al. 2019; Mitcheltree et al. 2019; Wang and Cheng 2022
2.	CMES2	Technical problem-solving and analytical skills	Ku and Taiebat 2011; Rahman and Ayer 2017; Uhm et al. 2017; Yakami et al. 2017; Hodorog et al. 2019
3.	CMES3	Basic modelling specification, validation, access management and control	Ku and Taiebat 2011; Bozoglu 2016; Uhm et al. 2017; Kolarić et al. 2018; Hodorog et al. 2019; Wang et al. 2020
4.	CMES4	ICT skill	Ku and Taiebat 2011; Demirdoven and Arditi 2014b; Uhm et al. 2017; Yakami et al. 2017; Hodorog et al. 2019; Wang et al. 2020; Plawgo and Ertman 2021
5.	CMES5	Teamwork skill	Raiola 2016; Rahman and Ayer 2017; Uhm et al. 2017; Yakami et al. 2017; Hodorog et al. 2019
6.	CMES6	Basic understanding of the BIM process	Barison and Santos 2010; Ku and Taiebat 2011; Bozoglu 2016; Raiola 2016; Rahman and Ayer 2017; Uhm et al. 2017; Yakami et al. 2017; Wang et al. 2020
7.	CMES7	Knowledge over the construction process	Bozoglu 2016; Raiola 2016; Uhm et al. 2017; Mitcheltree et al. 2019; Vaz-Serra and Mitcheltree 2021
8.	CMES8	Design coordination	Bozoglu 2016; Raiola 2016; Uhm et al. 2017; Yakami et al. 2017
9.	CMES9	Ability to coordinate BIM	Ku and Taiebat 2011; Demirdoven and Arditi 2014b; Bozoglu 2016; Uhm et al. 2017; Kolarić et al. 2018; Wang et al. 2020
10.	CMES10	Passion for learning new software	Demirdoven and Arditi 2014b; Bozoglu 2016; Yakami et al. 2017; Wang et al. 2020
11.	CMES11	Experience in the use of VDC/big room method	Yakami et al. 2017; Mitcheltree et al. 2019; Vaz-Serra and Mitcheltree 2021
12.	CMES12	Quality and document management	Yakami et al. 2017; Mitcheltree et al. 2019; Vaz-Serra and Mitcheltree 2021
13.	CMES13	Technical decision-making	Mühlbacher et al. 2013; Bozoglu 2016; Yakami et al. 2017; Kolarić et al. 2018

BIM, building information modelling; CMES, construction management expected skills; ICT, information and communication technology; VDC, virtual design and construction.

further analysis. Thus, 330 valid responses were employed for the analyses. Principal component analysis (PCA) and Relative Important Index (RII) were used to analyse the findings of the survey data. Subsequently, the conclusions were comprehensively discussed, and conclusive closing remarks were drawn. Firstly, the survey results were tested using the Cronbach's α reliability analysis test. This was used to validate the respondents' opinion on the 5-point Likert scale used in terms of its applicability and suitability for this study context, a process adopted in the study of Isa et al. (2020). Table 3 sets out the minimum criteria guide used in this study for the conduction of PCA. These have also been adopted in multiple studies in the literature (Joseph et al. 2010; Nilashi et al. 2015; Kapsoulis et al. 2018; Isa et al. 2020).

Tab. 3: Criteria guide for EFA

S. No.	Criteria	Parameter
1.	Factor loading value	≥0.35
2.	Eigen factor value	>1
3.	KMO test	≥0.5
4.	Correlation matrix of variables	≥0.05
5.	Test of sphericity anti-image	<0.05
6.	Percentage of variance	≥50%
7.	Variable communality value ≥0.05	Variable communality value ≥0.05
8.	Parallel analysis test	Real eigenvalue factor > random order eigenvalue factor

KMO, Kaiser–Meyer–Olkin.

Typically, when an opinion is required to be sought from a larger number of respondents, employing a web-based snowballing data generation approach would be a better option. This is because having a small number of valid responses may result in reliability issues involving the value of the relationship between variables. The valid response rate for this study was $N = 330$, which is larger than the minimum ($N = 50$) criterion usually considered by many scholars. In the case of this study, the response rate is not an issue. Based on these considerations, a factor loading value of 0.35 was fixed as the benchmark. Thus, as recommended by Hussin et al. (2014) and Bujang and Baharum (2017), it has been demonstrated that the adequacy of the response rate received is within the acceptable measure. This study further validates the determination of factor loading based on response rate, which has been adapted from the study of Isa et al. (2020), as shown in the guidelines in Table 4.

4 Result and discussion

4.1 Demographic information of respondents

The results, shown in Figures 1 and 2, present respondents' data according to their gender, wherein 70% were male and 30% female, categories of respondents and years of experience.

4.2 Cronbach's α test

Table 5 shows Cronbach's test. The -value ranges from 0 to 1. According to Vaz-Serra and Mitcheltree (2021), the greater the -value, the more reliable the output result or scaling becomes. The measuring scale is reasonable if the -value ranges from 0.7 to 1. A Cronbach's α of ≥0.7 means that the measuring scale has comparatively great internal reliability. Using SPSS 27.0 (IBM), Table 5 shows that the 27 variables have an α-value of 0.881, and the 13 variables 0.813. These indicated that the measurement is reliable at a 5% significance level based on the 5-point Likert scale. These imply that the Cronbach α coefficient of all the 27 and 13 variables (competencies and skills) at 0.881 and 0.813 is above 0.7, as suggested by Pallant (2005). The author stated that all the variables had high internal consistency and reliability.

Tab. 4: Guide for factor loading selection based on response rate

S. No.	Value of factor loading	Response rate
1.	0.75	50–59
2.	0.70	60–69
3.	0.65	70–99
4.	0.55	100–119
5.	0.50	120–149
6.	0.45	150–199
7.	0.40	200–249
8.	0.35	250–349
9.	0.30	350 and above

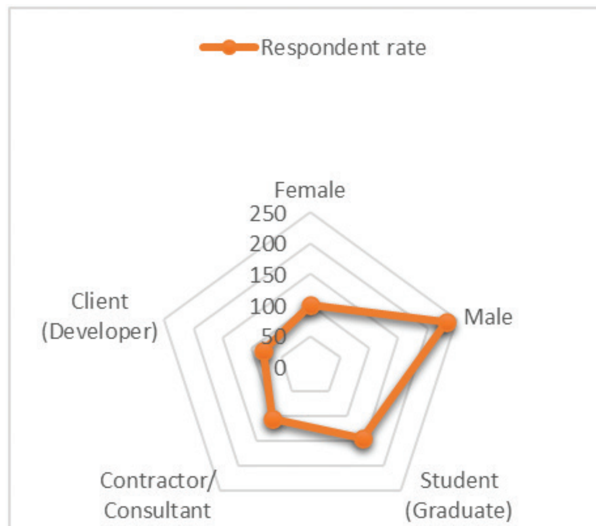

Fig. 1: Categories of respondents.

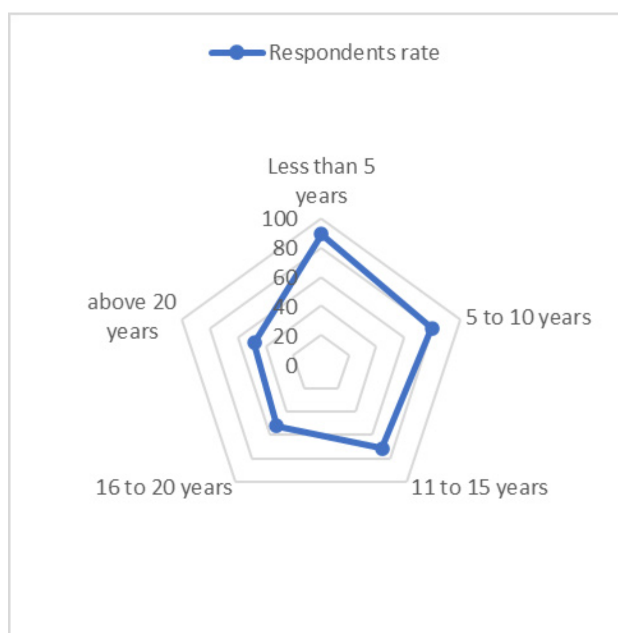

Fig. 2. Years of experience.

Tab. 5: Cronbach's α test

	Reliability statistics		
	Cronbach's α	Cronbach's α based on standardised items	*N* variable
Expected competency	0.881	0.880	27
Expected skills	0.813	0.813	13

Tab. 6. Significance level

RII values	Significance level	
0.81 ≤ RII ≤ 1.00	High	H
0.61 ≤ RII ≤ 0.80	High-medium	H-M
0.41 ≤ RII ≤ 0.60	Medium	M
0.21 ≤ RII ≤ 0.40	Medium-low	M-L
0.00 ≤ RII ≤ 0.20	Low	L

4.3 Descriptive statistics

Tables 7 and 8 list the results of the 27 and 13 variables for competencies and skills, respectively, in descending order based on their mean item score (MIS) and RII, which enables a presentation of the descriptive statistics of the questionnaire data. The expression in Table 6 was used to rate the significance level. Thus, all 27 and 13 variables (100%) are deemed statistically highly significant at 0.81 ≤ RII ≤ 1, wherein lies the range from 0.85 to 0.95 as perceived by the respondents. Therefore, all the variables are highly significant.

Tables 7 and 8 show the MIS and RII ranking results for the variables identified under the expected competencies and skills of construction manager graduates. These were obtained from the survey data and analysed using SPSS 27.0. The input of clients, students and contractor/consultant perspectives summarises these data. The use of MIS and RII enabled the calculation of the ranking for selecting the significantly essential competencies and skills. All the variables have a high significance level ranging from MIS from 4.25 to 4.73 and RII from 0.85 to 0.95. However, due to the high ranking of the MIS, which is far above the minimum recommendation of 3.50, previous scholars have considered ranking the criticality or importance of a variable in a data set. This study, therefore, proposed an RII rating of 0.90 to select the most critically important competencies and skills. Thus, this proposal may be considered for subsequent findings related to such a high rating. Based on it, 10 competencies and 2 skills have been assessed as meeting this threshold.

Tab. 7: Construction manager competencies variable analysis

Descriptive statistics (variables = 27; *N* = 330)				
Coding	Mean	Std. deviation	RII	Ranking
CMC27	4.73	0.466	0.95	1st
CMC5	4.71	0.528	0.94	2nd
CMC23	4.68	0.615	0.93	3rd
CMC18	4.62	0.599	0.92	4th
CMC21	4.59	0.657	0.91	5th
CMC1	4.55	0.657	0.91	6th
CMC26	4.52	0.685	0.90	7th
CMC14	4.50	0.694	0.90	8th
CMC20	4.50	0.672	0.90	9th
CMC17	4.49	0.681	0.90	10th
CMC13	4.42	0.702	0.88	11th
CMC24	4.42	0.694	0.88	12th
CMC15	4.40	0.722	0.88	13th
CMC25	4.40	0.659	0.88	14th
CMC12	4.39	0.720	0.87	15th
CMC11	4.39	0.676	0.87	16th
CMC6	4.38	0.701	0.87	17th
CMC22	4.38	0.648	0.87	18th
CMC19	4.37	0.716	0.87	19th
CMC4	4.35	0.707	0.87	20th
CMC16	4.35	0.691	0.87	21st
CMC2	4.34	0.739	0.86	22nd
CMC10	4.33	0.762	0.86	23rd
CMC8	4.30	0.793	0.86	24th
CMC3	4.30	0.722	0.86	25th
CMC7	4.27	0.789	0.85	26th
CMC9	4.26	0.836	0.85	27th

CMC, construction management competencies; RII, relative importance index.

Tab. 8: Construction manager competencies expected skills variable analysis

Descriptive statistics (variables = 13; *N* = 330)				
Coding	Mean	Std. deviation	RII	Ranking
CMES5	4.68	0.567	0.93	1st
CMES1	4.51	0.681	0.90	2nd
CMES13	4.41	0.693	0.88	3rd
CMES12	4.38	0.727	0.87	4th
CMES6	4.37	0.686	0.87	5th
CMES11	4.37	0.650	0.87	6th
CMES10	4.33	0.746	0.86	7th
CMES2	4.33	0.733	0.86	8th
CMES4	4.33	0.694	0.86	9th
CMES3	4.30	0.789	0.86	10th
CMES8	4.28	0.721	0.85	11th
CMES7	4.26	0.776	0.85	12th
CMES9	4.25	0.824	0.85	13th

RII, relative importance index.

Thus, the competencies would be the following: CMC 27 – Good communication; CMC 5 – Honesty and integrity; CMC 23 – Understanding and application of ICT knowledge; CMC 18 – Labour and resource management; CMC 21 – Ability to prepare schedules of work and project progress reports; CMC 1 – Team leadership and management; CMC 26 – Computer skills; CMC 14 – Basic understanding of construction drawing interpretation; CMC 20 – Knowledge and understanding of project specifications; and CMC 17 – Maintenance and quality management competency. The two skills that are perceived as most critical are: CMES 5 – Teamwork skills and CMES 1 – Critical thinking and openness to feedback. These competencies and skills are critically important for CMG and managers to embrace, considering the high significant mean weight. These will keep them relevant and productive in the construction industry.

4.4 Factor analysis (FA)

PCA and principal axis factoring (PAF) are the two common reductions and rotated grouping factor analyses used by scholars, which can be conducted with SPSS. In PCA, it is assumed that the total variance in the data equals the shared variance between the items. In PAF, the assumption is that the total variance in the data equals two things: common variance and unique variance. However, unique variance does not exist in PCA, making it slightly different. Moreover, this study met the assumption of conducting PCA. Furthermore, correlation matrix, unrotated factor solution and eigenvalue greater than 0.35 were selected based on the criteria in Table 4, as recommended in the studies of Bujang and Baharum (2017) and Isa et al. (2020). Therefore, the PCA approach is deemed sufficient to conduct the inferential analysis. Malhotra and Birks (2006) reported that in FA, Bartlett's test of sphericity and the Kaiser–Meyer–Olkin (KMO) test are commonly used in measuring sample adequacy. 'When Bartlett's test of sphericity significant is ($P \leq 0.05$) and the KMO index is > 0.5, the dataset is generally acceptable for factor analysis' (Mane and Nagesha 2014). The KMO test provided values of 0.892 and 0.893, and Barlett's test of sphericity yielded a statistically significant result (chi-square = 2006.213 and 775.901, Sig. (p) = 0.000), as seen in Table 9. These computations were based on the results in Tables 7 and 8. Therefore, the fact of statistical significance, as demonstrated above, also serves to substantiate the decision to opt for performing PCA.

The PCA conducted encompasses three phases, namely: (a) to generate a correlation matrix across all

Tab. 9: Data reliability test

KMO and Bartlett's test			
		Competencies variables 27	Skills variables 13
KMO measure of sampling adequacy		0.892	0.893
Bartlett's test of sphericity	Approx. chi-square	2006.213	775.901
	Df	351	78
	Sig.	0.000	0.000

KMO, Kaiser–Meyer–Olkin.

variables involved to discover elements in clusters that have the most in common with one another; (b) to extract factors to establish the numbers of created factors and the qualities represented by each factor, and (c) to rotate the factors for them, in such a way that they become clearer, by clustering them into a component group (Isa et al. 2020; Babaie et al. 2022; Duras 2022). Therefore, highly correlated variables were grouped within the same component since they seem to measure the same perception. In contrast, variables in different components correlate less with each other as they measure perceptions differently. Furthermore, PCA was used to reduce the variables and group them into more manageable clusters. Factor rotation and extraction were executed using SPSS 27.0 software. Figure 3 shows the total variance calculated for the 27 variables.

4.4.1 Extracted eigenvalues variance discussion

Figure 3 shows the extracted seven components with eigenvalues greater than 1. Only items with a factor loading of ≥0.35 were included in each component (factor). This seven-component factor clustering solution explained the 27 variables of expected competencies in the Nigerian construction industry, which accounted for 51.57% of the overall variance. Isa et al. (2020) suggested that an acceptable percentage of commutative variance allowable should not be less than 50% since this is deemed required for practical importance. Therefore, it may be concluded that the model's reliability is acceptable. Figure 4 shows that the seven-component factor described the overall variance, with the first component clustering amounting to 24.788% of the variance involving four variables. The second component comprises five variables, which contribute to 5.96%. The third component includes four variables contributing 4.60%; and the fourth component contains five variables contributing 4.38%. The fifth component has four variables

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	6.693	24.788	24.788	6.693	24.788	24.788	2.564	9.494	9.494
2	1.608	5.956	30.744	1.608	5.956	30.744	2.307	8.543	18.037
3	1.243	4.602	35.347	1.243	4.602	35.347	2.215	8.205	26.242
4	1.183	4.380	39.727	1.183	4.380	39.727	1.944	7.200	33.442
5	1.149	4.255	43.981	1.149	4.255	43.981	1.942	7.194	40.636
6	1.045	3.870	47.852	1.045	3.870	47.852	1.688	6.250	46.887
7	1.004	3.720	51.572	1.004	3.720	51.572	1.265	4.685	51.572
8	.976	3.616	55.187						
9	.935	3.464	58.651						
10	.870	3.220	61.871						
11	.842	3.117	64.989						
12	.812	3.008	67.997						
13	.777	2.878	70.875						
14	.756	2.801	73.676						
15	.724	2.682	76.358						
16	.675	2.499	78.857						
17	.660	2.443	81.299						
18	.622	2.305	83.604						
19	.614	2.272	85.876						
20	.586	2.170	88.046						
21	.527	1.951	89.997						
22	.509	1.885	91.883						
23	.486	1.799	93.681						
24	.465	1.723	95.404						
25	.455	1.685	97.089						
26	.408	1.512	98.602						
27	.378	1.398	100.000						

Extraction Method: Principal Component Analysis.

Fig. 3: Competencies variable extraction.

contributing to 4.26%; and the sixth and seventh components contain two and one items contributing 3.87% and 3.72%, respectively. Also, Figure 4 displays the 27 remaining variables' results in the seven factors, together with their connected factor loadings, eigenvalues and explained variances of the seven factors.

4.4.2 Rotated component matrix

This section discusses and interprets the factors extracted in Table 10. It is required to check the appropriate FA rotation method to use before proceeding. The available two types in SPSS are Oblique rotation (Direct Oblimin or Promax) and Orthogonal rotation (Varimax or Quartmax or Equamax). It is best to start with direct oblimin to conduct a rotated solution. For conducting a rotated solution, starting with direct oblimin would be an ideal approach. After the result of this study revealed that orthogonal rotation is appropriate, the researchers adopted orthogonal rotation using the varimax method. The same method has been adopted in management-related studies (Aluko and Mewomo 2021). However, to interpret factor loading, the variables factor loading matrix is rotated to bring the smallest loadings to nearly zero and its largest loading towards unity (Enshassi et al. 2018). Isa et al. (2020) claimed that an apparent component structure is usually revealed when a variable's factor loading is significantly based on the number of valid responses received for the study, as seen in Table 3. However, the factor value with a loading of 0.35 and above was retained and used to suitably name the component cluster. Furthermore, Table 11 shows the interpretation of the required data generated from Table 10.

The results presented in Table 10 indicated that 25 out of the 27 surveyed variables meet the significant (0.35) level for the PCA-rotated component grouping for this study. These, are the critical expected competencies to be attributed by intending CMG in the Nigerian construction industry, from which components 2 and 4: 'Pre-contract planning and hazard management' and 'Basic construction management component' contained five variables each; components 1, 3 and 5: 'Project management and planning-related component'; 'On-site construction management component' and 'Peace-making and management-related component' contained four each; component 6: 'ICT-related component' contained two; and component 7: 'Communication component' had only one. Overall, component 7 has the highest factor loading of 0.820 and CMC26 has 0.751, and CMC8 has the least factor loading of 0.405.

4.4.2.1 Component 1: Project management and planning-related component

These clustered variables, referred to as the project management and planning-related component, are the required competencies that deal with understanding the drawing, the capability of noticing and identifying additional work and the ability to bring it to booking by notifying the QS, and the ability to know the competencies to look out for in selecting a sub-contractor, labour requirements, etc. (Jabar et al. 2013; Wang and Cheng 2022). Thus, possessing this attribute will go a long way in improving the company or organisation's productivity and quality of work done and also increase the employability of construction managers (Benhart and Shaurette 2013). Moreover, construction managers are expected to have substantial knowledge in evaluating work done based on the bill of quantity (BOQ) (Abdullah et al. 2017). In this group, CMC7 has the highest factor loading with 0.659; at the same time, CMC22 had 0.469, which is the least factor loading.

Tab. 10: Component clustering (competencies)

Rotated component matrix							
	Component						
	1	2	3	4	5	6	7
CMC7	0.659						
CMC19	0.641						
CMC16	0.596						
CMC22	0.469						
CMC2		0.708					
CMC3		0.6200					
CMC20		0.496					
CMC4		0.495					
CMC8		0.405					
CMC18			0.657				
CMC21			0.566				
CMC17			0.534				
CMC24			0.424				
CMC5				0.733			
CMC14				0.564			
CMC13				0.423			
CMC12				0.423			
CMC6				0.358			
CMC9					0.640		
CMC11					0.593		
CMC10					0.468		
CMC1					0.459		
CMC15	X	X	X	X	X	X	X
CMC26						0.751	
CMC23						0.550	
CMC25	X	X	X	X	X	X	X
CMC27							0.820

CMC, construction management competencies.

Tab. 11: Rotated component factor loading interpretation of the 25 retained variables

Component	Component naming	Competencies	Code	Factor loading
1	Project management and planning-related component	Analysing design solutions	CMC7	0.659
		Ability for managing project variations, cash flow forecasting and monitoring	CMC19	0.641
		Competency in the reviewing and selection of qualified subcontractors	CMC16	0.596
		Basic understanding of construction code and regulation	CMC22	0.469
2	Pre-contract planning and hazard management	Knowledge of the biding and tendering process	CMC2	0.708
		Risk management	CMC3	0.620
		Knowledge and understanding of project specifications	CMC20	0.496
		Pre-contract planning and programming	CMC4	0.495
		Basic knowledge of procurement	CMC8	0.405
3.	On-site construction management component	Tool and machine maintenance and quality management competency	CMC17	0.534
		Labour and resource management	CMC18	0.657
		Ability to prepare the schedule of work and project progress and technical report	CMC21	0.566
		Knowledge of sustainability in construction	CMC24	0.424
4	Basic construction management component	Honesty and integrity	CMC5	0.733
		Site survey and analysis of construction site	CMC6	0.358
		Ability to set up an expediting log and procurement, submittal of log	CMC12	0.423
		Basic knowledge of health and safety in construction practice	CMC13	0.423
		Basic understanding of construction drawing interpretation	CMC14	0.564
5	Peace-making and management-related component	Team leadership and management.	CMC1	0.459
		Client care	CMC9	0.640
		Basic knowledge of various forms of building and construction contracts	CMC10	0.468
		Conflict avoidance and management or interpersonal understanding	CMC11	0.593
6	ICT-related component	Computer skills – Excel, MS Office, Adobe, Internet-based, etc.	CMC26	0.751
		Understanding and application of construction-related software knowledge	CMC23	0.550
7	Communication component	Good communication	CMC27	0.820

CMC, construction management competencies; ICT, information and communication technology.

4.4.2.2 Component 2: Pre-contract planning and hazard management

Pre-contract planning and hazard management refer to the competencies associated with understanding the activities involved in getting set for the project. The construction managers are expected to have in-depth knowledge in reviewing tender drawings and documents to check for discrepancies (Dainty et al. 2004; Wang and Cheng 2022) and to cross-check the quoted quantity of works against the proposed volume to be executed. Also, they need to understand what is expected before moving to the site to discharge their duties, such as coordinating materials required for procurement (Male et al. 2010; Torres-Machí et al. 2013) and arrangement of skilled and unskilled labour planning charts. In addition, the construction manager is expected to understand the building process throughout the construction phase (Ying et al. 2015; Turner 2017). Thus, it is required of them to prepare a programme of work to be executed during this phase. Hazard management cannot be left out in the pre-contract planning phase. The earlier the possible hazard is identified and planned for, the better it will be mitigated or prevented from occurring. Therefore, the CMG is expected to know about all the classes of hazards that could occur on-site, such as: falling due to unstable work surfaces, unavailability of fall protective equipment, slipping and tripping, excessive noise, possible electric incidents, etc. These will enable risk management and avoid disrupting the working pace and process.

CMG are expected to have a basic knowledge of the preventive maintenance of tools and machines, such as making provisions for machine consumables (oil/grease) and quick identification of faulty tools. In addition, most are versatile in quality management and possess adequate knowledge of sustainable construction processes. Honesty and integrity are core personal competencies any firm or company is looking out for in their employee. For a CMG to thrive in the industry, these personal attributes are essential and their importance cannot be understated. Nevertheless, the quality of being truthful and sincere is regarded as honesty, while integrity is the value of doing the right thing at all times. A CMG is expected to know health and safety practices and first aid administration processes. These will help to prevent possible fatality on-site.

4.4.2.3 Components 3 and 4: On-site construction management and Basic construction management components

The activities expected to be performed at this stage are the construction manager's primary core anticipated duties. The level and quality at which these activities are managed will predict whether or not the project will succeed. Therefore, a CMG is expected to possess competencies in labour and resources management (Ahmed et al. 2014; Mitcheltree et al. 2019). The management of labour and resources is vital in every construction site, as they are the driving force of on-site construction activities. Labour and materials costs could amount to around 90% of the project construction costs. If not well managed, it could result in waste of materials, capital, workforce, etc.; a CMG is expected to be up to date with the labour laws, regulations and procedures, to ensure that the working hours allowable in accordance with labour legislation are complied with. The accomplishment of a construction project depends on getting all the right resources for every task on-site. The proper management of construction resources will help the contractor achieve the project's main goal with maximum quality and efficiency. A CMG's ability to prepare a work schedule is essential as this would assist in adequately organising tasks to be carried out on-site, thereby improving resource and labour management. A basic understanding of construction drawing interpretation is essential. Weekly progress report writing competencies are important. It will enable the construction manager to know if there is substantial progress; if not, the management could easily identify the cause of the delay to ensure that this cause is promptly eliminated as well as prevented from occurring again, at least in the near future.

4.4.2.4 Component 5: Peace-making and management-related component

These component elements refer to the peaceable management and coordination of construction team workers, and their aim is the prevention of occurrence of serious disputes in the construction site between the labour force and the management representatives, since such an eventuality can be expected to exercise an adverse impact on the construction workflow. The client's needs must be met based on the available allocated fund. It is imperative to be on the same page with the client and construction professional teams involved in the project. It will strengthen the relationship between the client and construction firm and may lead to the client referring such firm to friends. As a construction manager, one of the primary responsibilities is the coordination and management of all team members involved in the project. As such, the ideal characteristic of a good leadership is that the leader must present at all times a portrait of being reasonable and receptive to all parties involved, and this can be accomplished concomitant with the adoption of an approach by the leader wherein, to verify compliance with schedule, feedback regarding the work progress is collected on a regular basis, together with inadequate compliance or non-compliance being promptly investigated.

4.4.2.5 Component 6: ICT-related component

ICT in construction involves communication through computers and hardware, cell phones, satellite systems, etc., through which the construction teams can collaborate successfully and communicate the actual message. Computer-based documentation is essential for running day-to-day site work smoothly, using the following software or applications: Microsoft Office power pack, Adobe and construction-related CAD software (Auto card, Archicad, Orion, etc.). Therefore, it is crucial for a CMG to understand and be able to apply ICT knowledge. These will enhance fast decision-making.

4.4.2.6 Component 7: Communication component

In the context of the construction industry, communication encompasses any mode of imparting or exchanging information, including but not limited to the mediums of writing, speaking or virtual display. These could be subdivided into active listening, written, oral, nonverbal, visual and contextual communication (Mexico 2022). All these communication forms are required to be well understood by a CMG. Such an effective understanding would enable a CMG to function proficiently during the course of discharging of duties. The manner in which a construction manager communicates with others to present and receive ideas makes a lasting impact on the parties with whom the manager interacts, and also significantly influences the mental image that people form of the construction firm on the whole. In Nigeria, where there are diverse languages, it would be imperative for a CMG to understand the country's unified language (English) (Quora 2022).

5 Conclusion

This research investigated the innovative skills and competencies expected of CMG in the discharge and management of their professional responsibilities within the Nigerian built environment. Globally, CMG employment is increasingly coming to be characterised by the exhibition of a highly demanding tendency by the construction firm or employer, and Nigeria is no exception to this phenomenon. Moreover, the influx of innovative technology in the industry keeps evolving. For the upcoming CMG to remain employable in a reputable construction firm or industry, they need to know what core skills and competencies are being demanded from the industry. A thorough examination of related literature revealed 13 innovative skills and 27 expected core competencies. A survey questionnaire was developed to collect primary data for the study. The survey data were analysed using descriptive and inferential statistics.

MIS and standard deviation were conducted on the data to statistically rank the variables associated with the innovative skills and expected core competencies, while the RII was used to rate their significance level. Nevertheless, all the 13 and 27 variables were perceived to be significantly important, with MIS ranging from 4.25 to 4.73 and RII from 0.85 to 0.95. This shows that the industry is unwilling and not ready to employ half-baked graduates, possibly due to the project's highly intensive capital and the construction process's sophisticated nature. The findings of the survey result with regard to skills indicate that a significant emphasis is manifest for the following aspects: (a) Teamwork skills – it is mandatory for CMG to possess this skill, as it plays an indispensable and major role in the coordination of activities during the construction stage. (b) Critical thinking and openness to feedback – the construction manager is expected to be a fast thinker; the ability on the manager's part to take swift technical decisions based on the feedback received from time to time speeds up the work concomitant with good quality being maintained. Additionally, other skill variables are also important.

The PCA was conducted, which reduced the 27 variables to 25 and grouped them into seven-component clusters.

Based on this study's findings, we can conclude that the current demand and expectations of the industry from recent and upcoming graduates are high; these could reflect that the industry does not give room for low-skilled graduates. Consequently, for construction managers or CMG to remain employable or relevant in the industry, they must embrace the innovative skills and competencies essential for the project's current and future success in the built environment. In addition, they must familiarise themselves with the innovative technology evolving in the industry and possess a high level of personal capability to tackle the core professional task ahead of them. According to the survey report, all the previously identified innovative core competencies in the literature, considered to be revolutionaries' competencies expected of the CMG, are significantly critical in the Nigerian construction industry. The PCA eliminated 'Contract administering and managing subcontracts' and 'Knowledge of project brief preparation' from the required competencies peculiar to Nigeria, as perceived by the respondents. This implies that the two eliminated variables are not necessarily crucial for construction managers in the Nigerian construction industry, but may be considered very relevant for other construction professionals. Although this study is limited to the Nigerian construction industry, the identified variables could be modified and used in other regions to generate a comprehensive result using a mixed method of data collection approach.

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