

Barriers to the Adoption of Emerging Technologies for Quality Management in Construction Projects in Nigeria

Innocent Chigozie Osuizugbo¹, Chikezirim Okorafor² and Victor Olukayode Iyanda³

^{1&3}Department of Building Technology, Bells University of Technology, Ota Nigeria

²Department of Civil Engineering & Construction Studies Midland, Durban University of Technology Scottsville, South Africa

Abstract

The aim of this study is to examine the barriers to the adoption of emerging technologies for quality management in construction projects. A questionnaire was designed to examine the barriers to the adoption of emerging technologies for quality management in construction projects. Questionnaires were distributed, and 127 valid responses were elicited. Thereafter, data were analysed using descriptive and inferential statistics. The study was limited to barriers to the adoption of emerging technologies in construction quality management in Nigeria utilising a quantitative research method. The study's findings can serve as a model for tackling similar barriers in other countries in the global south. The results from the study revealed that cost (high costs of software and hardware), resistance to change, and risk of technology obsolescence were the top most three barriers to the adoption of emerging technologies in construction quality management in Nigeria. From a practical viewpoint, overcoming these barriers to adoption of emerging technologies for quality management will lead to broader spread adoption of emerging technologies for quality management, enhancing project efficiency and outcomes.

Keywords: Adoption, Barriers, Construction projects, Emerging technologies, Quality management

1. Introduction

Construction industry plays a significant function in the economic and national growth of a country. However, the impact of this sector has been affected by productivity problems and poor performance of projects as reported by Osuizugbo and Alabi (2021). Factors responsible for the poor construction project performance have been identified by past studies to include industry complexity, poor quality, safety issues, low productivity, slow innovation, high costs, client dissatisfaction, and skill shortages among others (Osuizugbo & Ojelabi, 2020). Notably, poor-quality in construction project delivery has been reported as the most challenging and prevalent issue within the construction industry (Luo *et al.*, 2022). Meanwhile, the growth of the sector relatively depends on the quality of projects. Thus, effective management of construction projects' quality should be paramount to construction stakeholders. In other words, quality management is a key indicator which affects the value of construction projects.

More recent attention has focused on developing emerging technologies for enhancing construction quality management and inspection, which can improve the image of construction industry. Emerging technology in this study refers to innovative, cutting-edge advancements that are in the early phases of construction and have the possibility to extensively impact society, industries, and economies. Blockchain, Photogrammetry and laser scanning, Augmented Reality (AR), Building Information Modelling, Internet

of Things (IoT), and Computer Vision (CV) among others are some of the emerging technologies employed in construction quality management (Luo *et al.*, 2022; Safa *et al.*, 2015; Wang, 2008). These emerging technologies are designed to provide remarkable benefits to safety on site, quality, and productivity improvement. Adopting these emerging technologies in construction projects help eliminate information barriers between design, prefabrication, and construction, enhance training, safety, and communication, reduce rework, enable process monitoring, preventive maintenance, site productivity assessment, real-time structural health tracking, and enhance defect detection and quality management (Luo *et al.*, 2019).

Despite many benefits that are linked with these digital tools, there are some challenges that hinder its adoption and application in the construction sector which includes resistance to change, security concerns, high costs of hardware and software, absence of standardised guidelines and practices, lack of financial need, lack of market data for technology incorporation, and low level of knowledge among others (Tam *et al.*, 2024; Chen *et al.*, 2023; Maqsoom *et al.*, 2023; Kamaruddeen *et al.*, 2022). According to Saka and Chan (2019), the construction industry has been accused for lagging behind in terms of technology implementations compared to other industries. The common approach to assessing new policies and their execution is studying the barriers/challenges they face, which typically requires identifying the root causes of resistance to change (Osuizugbo *et al.*, 2024). Using

¹ Corresponding Author

Email address: icosuizugbo@bellsuniversity.edu.ng

Nigeria as a representative case, these barriers are specifically important because of economic constraints, and poor-quality in construction project delivery. These barriers to emerging technologies are intensified by a shortage of technical expertise and insufficient commitment in research and development, hindering the application of advanced construction projects' quality management practices. Secondly, high costs of software and hardware, and low knowledge of digital tools formed additional barriers. These barriers overlap with economic and regulatory factors, where monetary limitations hinder way in to cutting-edge technologies, and regulatory guidelines might lack the necessary enforcement and encouragement methods to drive the adoption and application of emerging technologies in construction quality management. Addressing these interconnected barriers is vital for enhancing construction projects' quality in Nigeria and other nation in global south.

Over the course of time, several studies have been conducted on quality management. For instance, Keenan and Rostami (2019) examined the influence of quality management systems on construction performance. Wickramarachchi *et al.* (2018) studied total quality management execution in Sri Lankan construction industry. In contrasts, Wang and Wei (2020) investigated BIM-based technology implementation on quality management in construction engineering. Wang (2008) proposes Radio Frequency Identification (RFID)-based technology for enhancing construction quality inspection and management. The study by Safa *et al.* (2015) presented an automated approach to construction quality management, utilising advanced technologies to detect defects. Majority of these existing researches have largely domicile in global north. Moreover, not all African countries have derived the same benefit from emerging technologies, including digitalisation processes (Badaru & Mphahlele, 2023). Thus, study that addresses barriers to the adoption of emerging technologies for quality management in construction projects in Nigeria is scarce. This implies that, there is little or no understanding of factors that hinder the adoption of emerging technologies for quality management in construction projects in Nigeria. In addition, industry characteristics influence the adoption of emerging technologies for construction practices (Kamaruddeen *et al.*, 2022). This indicates that, the adoption and

application of emerging technologies for quality management practices may vary from one country to another. Hence, to tackle the identified gap in existing knowledge, this study aims to examine the barriers to the adoption of emerging technologies for quality management in construction projects in Nigeria.

The study's findings contributed to more effective quality management studies by highlighting critical barriers to the adoption of emerging technologies in construction quality management. An understanding of these barriers could aid construction practitioners, organisations, government, and policymakers in developing strategies for minimising these barriers and promoting the application of emerging technologies for quality management in the sector. Overcoming these barriers enhances efficiency, reduces delays and costs, and improves build quality, leading to increased investor confidence and sustainable infrastructure development while also stimulating job creation, enhancing local skill development, and attracting foreign investments, ultimately driving industry growth and economic advancement in Nigeria and other developing countries.

2. Theoretical Framework

This section explains the theoretical foundations that encourage the adoption of emerging technologies for quality management in construction. The theoretical framework offers a broad representation of the associations between elements within a particular subject. In order to deepen the knowledge on how emerging technologies for quality management in construction are adopted, the study draws on established theories. Specifically, the **technology acceptance model** seems to be appropriate.

2.1. Technology Acceptance Model

Technology acceptance model (TAM) is the commonly used theory to explore user acceptance behaviour, rooted in social psychology, particularly drawing from reasoned action theory (Ma & Liu, 2004). This theory explains how technology's users arrive at accepting and utilising technology as shown in Figure 1 (Ma & Liu, 2004). TAM can be used to analyse the perceived usefulness and perceived ease of use of emerging technologies in construction quality management before accepting the technologies by either

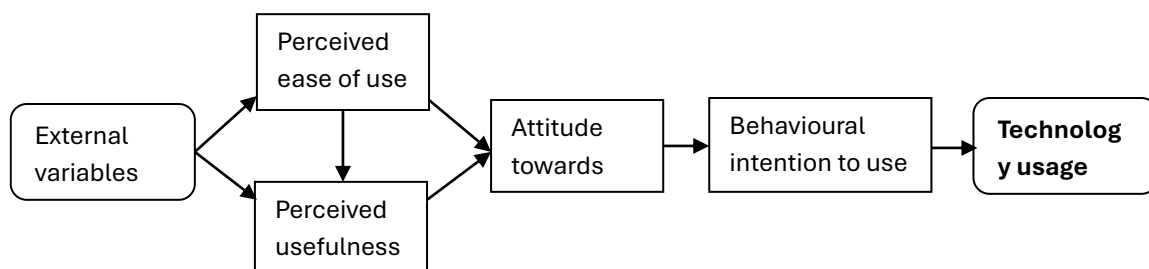


Figure 1: Technology acceptance model (Source: Ma & Liu, 2004)

organisations or individuals (Ma & Liu, 2004). In the context of quality management in construction, emerging technologies like quality management software, BIM, Blockchain, or Computer Vision are often encounter resistance as a result of challenges in these aspects (Tam *et al.*, 2024; Saka & Chan, 2019). For example, construction firms or workers may perceive these technologies as unnecessary or complex to use, resulting to low adoption rates. Factors such as security concerns, high costs of software and hardware, absence of standardised guidelines and practices, lack of market data for technology incorporation or the low level of knowledge/lack of training further compound this resistance, making it more difficult for the construction sector to take full benefit of emerging technologies.

Implications of technology acceptance model in surmounting barriers to emerging technologies in construction quality management are significant. Construction firms can develop approaches that encourage adoption of emerging technology by tackling both perceived ease of use and usefulness. This may include better training and education programmes to demonstrate the advantages of emerging technologies in enhancing quality control, or simplifying user interface to make the digital tools more instinctive and user-friendly for construction practitioners. TAM highlights the role of organisational culture and leadership in promoting a positive attitude towards technological change (Ma & Liu, 2004). Thus, construction organisations can mitigate barriers to adoption of emerging technology as well as improve project management quality by clearly communicating long-term benefits and promoting innovation.

3. Research Methodology

The study used quantitative research approach to determine the barriers to adoption of emerging technologies for quality management in construction projects in Nigeria. This research approach elicits numerical data for analysis, ranking, or grouping (Creswell, 2014) and allows broad population insights within a short time (Daniel, 2016). Quantitative research relies on statistical analysis for conclusions and predictions (Yilmaz, 2013), making it ideal for this study's broad sampling approach. A literature review on barriers to emerging technologies for quality management in construction was conducted so as to identify these barriers. A list of these barriers which was identified in the literature was utilised to develop questionnaire to attain the aim of the research. The questionnaire was utilised to gather data from the survey participants regarding the barriers to emerging technologies for quality management in construction. The study adopted purposive sampling technique in identifying the survey sample for distribution of questionnaire. The purposive sampling method is a non-probability approach, which based on features of

study population. The research utilised key construction professionals and the respondents focus were builders, architects, electrical engineers, structural engineers, quantity surveyors and mechanical engineers, operating in construction projects within consulting, client and contracting firms in Nigeria. The study considered Nigeria because, the construction industry of Nigeria faces enormous challenges including poor management, project delays, and poor quality control among others which may be reason for the slow adoption of sustainable construction (Ogunmakinde *et al.*, 2019). These survey participants were selected due to their construction experience. A total of two hundred and nine (209) questionnaires were dispersed to survey participants, after scrutinising the collected questionnaires, only 127 were useful, representing a 60.8% response rate. The respondents completed the questionnaire by providing their feedback on the barriers to emerging technologies for quality management in construction, based on a 5-point Likert scale. The scale ranged from 1 (not critical) to 5 (very critical), with 2 representing slightly critical, 3 representing moderately critical, and 4 representing critical. Data collection of this research commenced in May 2024 and was completed in July 2024. The statistical package for social sciences analysed respondents' data using Cronbach's Alpha test, frequency, percentage, mean value and ranking. A reliability score of 0.904 exceeded the 0.70 minimum threshold (Taherdoost, 2016), guaranteeing strong internal consistency for the scale.

4. Findings and Discussion

4.1. Demographic Characteristics of Respondents

From the study, majority of respondents that involved in the survey are within the age bracket of 31-40 years, representing 40.93% (52). This is followed by age bracket 41-50 years, representing 37.8% (48), 21-30 years representing 15.7% (20) and 51 years and above, representing 5.5% (7). This shows that the survey participants are mature to involve in the research. Based on the respondents' professional background, builders are 54 (42.5%), followed by architects with 28 (22%), quantity surveyor with 20 (15.7%), electrical engineers 12 (9.4%), structural engineer 9 (7.1), and mechanical engineer 4 (3.1%). For the academic qualification of the respondents, 46.5% of the study population were bachelor degree holders, followed by postgraduate diploma holder with 30.7%, masters degree holder with 13.4%, higher national diploma with 5.5%, and doctorate degree holder with 3.9%. For work experience, 11-15 years and 16-20 years have same number of participants with 40 (31.5%), 21 years and above have 27 (21.3%), 6-10 years have 17 (13.4%), and 1-5 years experience have 3 (2.4%). These results confirmed respondent's eligibility to involve in the research. Furthermore, the consulting, contracting, and

client firms have 62 (48.8%), 62 (48.8%), and 3 (2.4%) respectively.

4.2. Barriers to Emerging Technologies in construction quality management

This section gives the data analysis of barriers to emerging technologies for quality management in the Nigerian construction industry. As shown in Table 1, “Cost (high costs of software and hardware)” has the highest mean value of 4.1260 and was ranked first. Then, followed by “resistance to change” with a mean value of 3.9764, ranked second, and “risk of technology obsolescence” with a mean score of 3.9055, and thus ranked third. From the rear, “limited resources” was ranked lowest with a mean score of 3.1417. The mean scores presented in Table 1 indicate that the barriers to emerging technologies for quality management are prevalent within Nigeria's construction industry.

financial limitations, making it difficult for the enterprise to assign resources to these emerging technologies (Nkwinika & Akinola, 2023). This lack of enthusiasm is driven by the perception that investments in emerging technologies may not yield immediate returns, because the industry is still majorly relies on traditional approach that may seem more economical in the short run (Owolabi *et al.*, 2019). In order to tackle this, government interference is a necessity, like tax incentives, public-private partnerships or subsidies to reduce the cost burden on construction organisations. This could facilitate greater access to essential technology, improve buildability, and enhance overall project quality in construction industry (Liu *et al.*, 2023).

The second in rank of barriers to emerging technologies for quality management in the Nigerian construction

Table 1: Ranking of barriers to emerging technologies in construction quality management

No.	Barriers	Mean Value	Rank
1	Cost (high costs of software and hardware)	4.1260	1
2	Resistance to change	3.9764	2
3	Risk of technology obsolescence	3.9055	3
4	Uncertain return on investment (ROI)	3.7953	4
5	Technology availability	3.7795	5
6	Integration Issues	3.7402	6
7	Regulatory and legal challenges	3.6850	7
8	Complexity	3.6693	8
9	Limited industry collaboration and standards	3.6693	8
10	Industry fragmentation	3.4646	10
11	Overreliance on technology	3.3858	11
12	Skills gap	3.3543	12
13	Data security concerns	3.3465	13
14	Lack of awareness (low level of knowledge)	3.3307	14
15	Dependency on technology providers	3.1575	15
16	Limited resources	3.1417	16

4.3. Discussion on Key Findings

Ranking of the sixteen (16) barriers to emerging technologies for quality management in construction demonstrates that cost (high costs of software and hardware) was considered the most critical barriers to emerging technologies for quality management in the Nigerian construction industry. This finding could be because of the high cost of initial investment to procure advanced technologies like quality management software and BIM among others (Maqsoom *et al.*, 2023). This finding is in support of previous studies that identified cost as a major factor that hinders the use of advanced technologies in construction (Tam *et al.*, 2024; Maqsoom *et al.*, 2023). The acquisition of these technologies involves not only the initial costs of software and hardware but also recurring expenses for specialised staff training, system maintenance, and upgrades. Several construction organisations, mostly small and medium sized enterprise, often encounter

industry is resistance to change. The finding by Tam *et al.* (2024) is similar to this finding, which revealed that the most significant barrier to advanced construction technology in Vietnam was social and usual resistance to change. This resistance frequently stems from deep-rooted practices and a preference for traditional approaches, which several construction practitioners are more familiar with and perceive as less disruptive (Lines *et al.*, 2015). Moreover, the adoption of advanced technologies such as quality management software and BIM among others requires a major transformation in mindset, skill sets, and workflows (Doubouya *et al.*, 2016). In addition, the construction industry in Nigeria values personal expertise and manual practices, creating unwillingness to trust digital equipments over traditional human judgment (Olanrewaju *et al.*, 2024). Addressing this barrier will need focused initiatives like leadership support to promote a culture of innovation and adaptability, demonstrations of the long-term benefits of technology

application, and industry-wide education programmes in the construction sector (Askar *et al.*, 2021). Providing incentives and encouraging a gradual transition for early adopter could aid reduce resistance and foster a smoother incorporation of emerging technologies in construction.

Another significant factor that hinders the adoption and implementation of emerging technologies for quality management in the Nigerian construction industry is risk of technology obsolescence. This barrier was ranked third. This finding could be that hardware and software of these innovations can quickly become outdated, forcing organisations to continually invest in new systems to remain current, mainly as a result of fast pace of technological advancement. For construction firms in Nigeria, which usually operate on tight budgets (Ikechukwu & Akiobnbare, 2017), this poses a major operational and financial challenge. The fear of investing in digital tools that could quickly become obsolete leads to hesitation, as companies fear the costs of upgrading systems within a short time. Construction organisations should therefore focus on scalable, adaptable technologies with continual updates to ensure longevity and alleviate obsolescence risks so as to address this barrier (Askar *et al.*, 2021). Also, government policies fostering technology adoption and providing incentives could ease the financial tension of keeping up with emerging technologies (Hua *et al.*, 2023).

In summary, these identified barriers differ when compare to those identified in developed countries. Take for example; Chen *et al.* (2023) identified “status quo industry standards”, “lack of client interest” and “lack of financial need/drive” as top three critical barriers to digital technology application in New Zealand. Barriers such as “lack of financial need/drive” and “status quo industry standards” stem from well-developed construction practices and profitability, reducing the urgency for digital technologies. On the other hand, in developing countries like Nigeria, financial constraints, high costs of software and hardware, and technology obsolescence present more fundamental obstacles, as construction organisations struggle with affordability and sustainability of digital tools. Furthermore, while resistance to change exists in both countries (i.e. Nigeria and New Zealand), it is often more pronounced in developing countries as a result of limited technical expertise and lower exposure to digital innovations in construction quality management.

5. Conclusion and Further Research

Nigerian construction industry is facing several factors that hinder the adoption and implementation of emerging technologies for quality management in construction projects. The Adoption of emerging technologies in construction projects help eliminate

information barriers between design, prefabrication, and construction, enhance training, safety, and communication, reduce rework, enable process monitoring, preventive maintenance, site productivity assessment, real-time structural health tracking, and enhance defect detection and quality management. Emerging technologies have not been successfully integrated in construction sector of Nigeria as it has in global north. The study aimed at examining the barriers to the adoption of emerging technologies for quality management in construction projects in Nigeria. A questionnaire survey of 127 respondents comprising of builders, architects, electrical engineers, structural engineers, quantity surveyors and mechanical engineers, operating in construction projects within consulting, client and contracting firms in Nigeria was conducted to determine barriers to the adoption of emerging technologies in construction quality management in Nigerian construction industry. The results from the study have shown that cost (high costs of software and hardware), resistance to change, and risk of technology obsolescence are the top most three barriers to the adoption of emerging technologies for quality management in the Nigerian construction industry. The findings of the research offer detailed insights into the factors hindering emerging technologies in construction quality management. An understanding of these barriers could aid construction practitioners, organisations, government, and policymakers in developing strategies for minimising these barriers and promoting the application of emerging technologies for quality management in the sector. Overcoming these barriers enhances efficiency, reduces delays and costs, and improves build quality, leading to increased investor confidence and sustainable infrastructure development while also stimulating job creation, enhancing local skill development, and attracting foreign investments, ultimately driving industry growth and economic advancement in Nigeria and other developing countries.

Based on the data analysis, it is evident that cost (high costs of software and hardware) was the major factor hindering adoption of emerging technologies in construction quality management. The present findings suggest the need for government involvement, through tax incentives, or subsidies to reduce the cost burden on organisations. Such intervention could facilitate greater access to essential technology, improve buildability, and enhance overall project quality in construction industry. The study focuses on the views from Nigeria regarding barriers to adoption of emerging technologies in construction quality management which has not been sufficiently understood previously. The research was limited to barriers to adoption of emerging technologies in construction quality management in Nigeria using a quantitative research method. Hence, this research outlined the following area for further research. Future study can take a more comprehensive method by

incorporating qualitative insights from focus groups or in-depth interviews with a wider range of stakeholders, including policymakers, vendors, government officials, to enhance and complement the quantitative results. Secondly, future research may consider including case studies or best practices from other regions to enhance its impact. This information will add to the body of knowledge by providing comparative understanding into the effectiveness of emerging technologies in

construction quality management across diverse nations, facilitating the adaptation of best practices and enhancing industry standards.

References

- Askar, R., Bragança, L. & Gervásio, H. (2021), 'Adaptability of Buildings: A Critical Review on the Concept Evolution', *Applied Sciences*, 11, 4483, <https://doi.org/10.3390/app11104483>.
- Badaru, K.A. & Mphahlele, R.S. (2023), 'Effects of Emerging Technologies on African Development: A Narrative Review on Selected African Countries', *Research in Social Sciences and Technology* 8(3), pp. 36-51.
- Chen, X., Chang-Richards, A.Y., Yiu, T.W., Ling, F.Y.Y., Pelosi, A. & Yang, N. (2023), 'A multivariate regression analysis of barriers to digital technologies adoption in the construction industry', *Engineering, Construction and Architectural Management*, DOI 10.1108/ECAM-11-2022-1051.
- Creswell, J. (2014), *Research design – qualitative, quantitative, and mixed method approaches*, 4th ed. CA: SAGE Publications Inc.
- Daniel, E. (2016), 'The Usefulness of Qualitative and Quantitative Approaches and Methods in Researching Problem-Solving Ability in Science Education Curriculum', *Journal of Education and Practice*, 7(15), pp. 91-100.
- Doumbouya, L., Gao, G. & Guan, C. (2016), 'Adoption of the Building Information Modeling (BIM) for Construction Project Effectiveness: The Review of BIM Benefits,' American', *Journal of Civil Engineering & Architecture*, 4(3), pp.74-79.
- Hua, J., Lin, J., Wang, K. & Liu, G. (2023), 'Government interventions in new technology adoption to improve product greenness', *International Journal of Production Economics*, 262, 108924.
- Ikechukwu, A.C. & Akiobnbare, W. (2017), 'Factors Affecting Cost of Construction in Nigeria', *International Journal of Advancement in Engineering Technology, Management and Applied Science*, 4(6), pp. 48-61.
- Kamaruddeen, A.M., Rui, L.S., Lee, K.L., Alzoubi, H.M. & Alshurideh, M.T. (2022), 'Determinants of Emerging Technology Adoption for Safety Among Construction Businesses', *Academy of Strategic Management Journal*, 21(S4), pp. 1- 19.
- Keenan, M. & Rostami, A. (2019), 'The impact of quality management systems on construction performance in the North West of England', *International Journal of Construction Management*, DOI: 10.1080/15623599.2019.1590974.
- Lines, B.C., Sullivan, K.T., Smithwick, J.B. & Mischung, J. (2015), 'Overcoming resistance to change in engineering and construction: Change management factors for owner organizations', *International Journal of Project Management*, 33, pp. 1170–1179.
- Liu, L.X., Clegg, S. & Pollack, J. (2023), 'The Effect of Public-Private Partnerships on Innovation in Infrastructure Delivery', *Project Management Journal*, 55(1), p. 1-19.
- Luo, H., Lin, L., Chen, K., Antwi-Afari, M.F. & Chen, L. (2022), 'Digital technology for quality management in construction: A review and future research directions', *Developments in the Built Environment*, 12, <https://doi.org/10.1016/j.dibe.2022.100087>.
- Ma, Q. & Liu, L. (2004), 'The Technology Acceptance Model: A Meta-Analysis of Empirical Findings', *Journal of Organizational and End User Computing*, 16(1), pp. 59-72.
- Maqsoom, A., Zulqarnain, M., Irfan, M., Ullah, F., Alqahtani, F.K. & Khan, K.I.A. (2023), 'Drivers of, and Barriers to, the Adoption of Mixed Reality in the Construction Industry of Developing Countries', *Buildings*, 13, 872.
- Nkwinika, E. & Akinola, S. (2023), 'The importance of financial management in small and medium-sized enterprises (SMEs): an analysis of challenges and best practices', *Technology Audit and Production Reserves*, 54(73), pp. 12–20.

- Ogunmakinde, O.E., Sher, W. & Maund, K. (2019), 'Challenges of the Nigerian construction industry: A systematic review'. In: *Conference: iiSBE Forum of Young Researchers in Sustainable Building*, 195-204, July, 2019, Prague, Czech Republic.
- Olanrewaju, O., Bello, A.O., Semiu, M. & Mudashiru, S. (2024), 'Critical barriers to effective communication in the construction industry: evidence from Nigeria', *International Journal of Construction Management*, DOI: 10.1080/15623599.2024.2362018.
- Osuizugbo, I. C. & Alabi, A. S. (2021), 'Built Environment Professionals' Perceptions of the Application of Artificial Intelligence in Construction Industry', *Covenant Journal of Research in the Built Environment*, 9(2), pp. 48-66.
- Osuizugbo, I. C. & Ojelabi, A.R. (2020), 'Building Production Management Practice in the Construction Industry in Nigeria', *Engineering Management in Production and Services*, 12(2), pp.56-73.
- Osuizugbo, I. C., Omer, M. M., Rahman, R. A., & Oshodi, O. S. (2024). A systematic search and review of early contractor involvement in construction project development. *Built Environment Project and Asset Management*, 14(6), 835-857.
- Owolabi, J.D., Faleye, D., Eshofonie, E.E., Tunji-Olayeni, P.F. & Afolabi, A.O. (2019), 'Barriers and Drivers of Innovation in the Nigerian Construction Industry', *International Journal of Mechanical Engineering and Technology*, 10(2), 334-339.
- Safa, M., Shahi, A., Nahangi, M., Haas, C. & Noori, H. (2015), 'Automating measurement process to improve quality management for piping fabrication', *Structures* 3, pp. 71-80. DOI: 10.1016/j.istruc.2015.03.003
- Saka, A.B. & Chan, D.W.M. (2019), 'A Scientometric Review and Metasynthesis of Building Information Modelling (BIM) Research in Africa', *Buildings*, <https://doi.org/10.3390/buildings9040085>.
- Taherdoost, H. (2016), 'Validity and reliability of the research instrument; how to test the validation of a questionnaire/survey in a research', *International Journal of Academic Research in Management*, 5(3), pp. 28-36.
- Tam, N.V., Toan, N.Q. & Phong, V.V. (2024), 'Investigating potential barriers to construction digitalization in emerging economies: A study in Vietnam', *International Journal of Information Management Data Insights*, 4, 100226.
- Wang, L.C. (2008), 'Enhancing construction quality inspection and management using RFID technology', *Automation in Construction*, 17(4), pp. 467-479.
- Wang, J. Z. & Wei, G. A. (2020), 'BIM-based Technology Implementation on Quality Management in Construction Engineering', *Journal of Physics: Conference Series IOP Publishing*, doi:10.1088/1742-6596/1601/4/042043.
- Wickramarachchi, H.R., Sandanayake, Y.G. & Ekanayake, B. J. (2018), 'Total quality management implementation in Sri Lankan construction industry : A study of small and medium sized enterprises', *Proceed title: MERCon 2018 - 4th International Multidisciplinary Moratuwa Engineering Research Conference*, pp.19-24. DOI: 10.1109/MERCon.2018.8421946
- Yilmaz, K. (2013), 'Comparison of quantitative and qualitative research traditions: epistemological, theoretical, and methodological differences', *European Journal of Education*, 48(2), pp. 311-325.