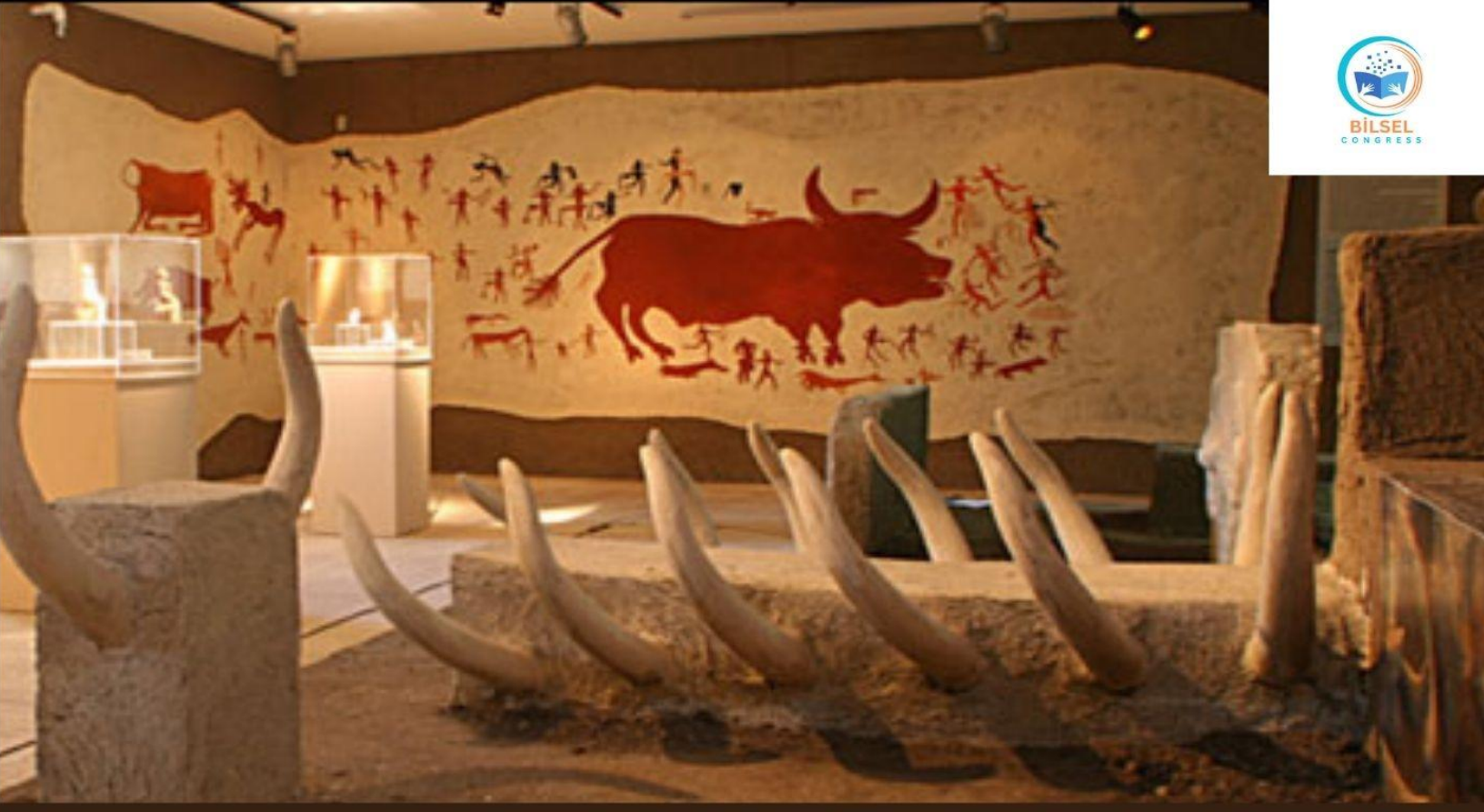

KONGRE KİTABI

I.BİLSEL ULUSLARARASI ÇATALHÖYÜK BİLİMSEL ARAŞTIRMALAR KONGRESİ

https://bilselkongreleri.com

28-29 EKİM 2023-KONYA




CONGRESS ID

CONGRESS TITLE

1. BİLSEL INTERNATIONAL ÇATALHÖYÜK SCIENTIFIC RESEARCHES CONGRESS

DATE and PLACE

28-29 OCTOBER

KONYA/TÜRKİYE

PARTICIPANTS COUNTRY

Algeria, Azerbaijan, Congo,Hungary,India ,Indonesia,Iran,Malaysia,Morocco ,Pakistan,Romania,Slovenia,Ukraine,Vietnam

ORGANIZATION

BİLSEL

https://bilselkongreleri.com

Release Date: 5 NOVEMBER 2023

Bu kitabın tüm hakları BİLGESİNA Yayınevine aittir.

Yazarlar etik ve hukuki olarak eserlerden sorumludurlar.

Yayın Tarihi: 5 KASIM 2023

ISBN: 978-625-98991-3-8

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INFLUENCE OF DIGITALISATION ON CONSTRUCTION PROJECT DELIVERY: A REVIEW

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Abstract:

The construction industry in developed and developing countries has been said to be under-digitized with organisations failing to realize the full potential and adoption of digitalisation as a driver for growth and efficiency in the industry. The delay in project delivery, cost inefficiencies, uninformed decision making, poor quality and poor performance in terms of productivity have been characterised as a result of absence of adequate digital expertise and technological adoption within the construction industry. Thus, this study reviewed selected literature on influence of digitalisation on construction project delivery and challenges faced in the Nigeria construction industry, intending to establish the current adoption level, highlights some significant challenges and suggests ways to mitigate the challenges. Findings of the study revealed that digitalisation have a substantial influence on construction project delivery. Also, the review revealed that the use of digitalisation in construction project delivery in Nigeria is still very low. With sets of challenges such as legal issues and regulations, cultural issues, lack of awareness, security, higher initial costs, project uniqueness, resistance, robotics, institutional and informational sharing. Thus, the study suggests rigorous awareness, especially among the concerned professionals and stakeholders, establishing digital knowledge, basic skills and training from grassroots, usually from the tertiary institutions and related professional bodies, and enacting government policy that will encourage and enforced the adoption and implementation of digital technology in the Nigeria construction industry.

Keywords: Construction Industry, Digitalisation, Project Delivery, Critical Success Factors, Nigeria

Introduction

The construction industry exhibits essentially the same characteristics in varied degrees in every economy globally. (Ihedigbo & Jimoh, 2022). The construction sector has strong linkages to other industries, and it has a significant impact on GDP and economic growth in addition to its direct contribution to national development (Castagnino *et al.*, 2018). According to the National Bureau of Statistics (2022) the Nigerian construction industry, which contributed 9.68% to the national economy in the first quarter of 2022, is a major player in the

national economy. The construction industry does, however, necessarily encounter a number of issues, for which today's construction professionals need to offer solutions (Okoye *et al*., 2015; Sofiat *et al*., 2021). According to Oghenemaro (2020), the construction industry is under-digitized, with organisations failing to fully exploit digital technology as a driver of efficiency and growth. Digitalisation is the act of organizing and changing data into a unique set of digital data. The input is then translated into binary data, which is comprehensible and can be processed by computers and other devices (Rouse, 2017). According to Ezeokoli *et al*. (2016) digitalisation is the process of transforming analog information into digital forms employing cutting-edge technologies that provide new possibilities for enhanced performance. Ikuabe *et al*. (2022) and Ayodeji *et al*. (2023) asserted that digitalisation entails the gathering of cutting-edge tools and software programmes that may be employed throughout the many stages of a building project, from conception to conclusion. The ability of digitalisation to increase effectiveness, efficiency, and open up new prospects has made it a widely accepted concept today. Industries, such as the manufacturing sector have all come to appreciate the advantages of digitalisation and have adapted to the future by embracing it as a new strategy to ensure competitive advantage, efficiency and project delivery success (Osunsanmi *et al*. 2018).

A project in other hand is considered successful if the expectations and goals are met. These expectations and goals may include different issues, such as technical, financial, educational, social and professional issues (Rami *et al*., 2021). In the 1980s, a construction project was deemed successful if it was completed on schedule, within budget, and to the appropriate level of quality, as well as to the satisfaction of the client (Khosravi & Afshari, 2011). According to Fadun and Saka (2018), a construction project's success is defined by how well it meets the owner's criteria for cost, time, safety, quality, and overall value. Construction projects must be planned, organized, scheduled, implemented, managed, monitored, controlled, and tracked by the construction manager in order to minimize the impact of any circumstance or event that could jeopardize project success. Hence, it is crucial for project managers in the construction industry to accomplish these goals by carefully planning, coordinating, and managing the execution of intricate construction tasks and activities using digital technologies (Okoye *et al*., 2015).

According to Sabiu and Agarwal (2016), innovative concepts and digitalisation, for example, have a major influence on the performance and success of projects delivery. Organisational performance is mostly driven by digitalisation (Waziri *et al*., 2017). Digital technology like the industrialized building system (IBS), is a change from conventional building practices that has enabled the construction industry in developed nations to decrease waste, achieve efficiency, and generate extraordinary productivity (Zakaria *et al*., 2018). Therefore, professionals

in the construction industry must employ cutting-edge technologies to get around the difficulties in job coordination and ambiguities associated with construction projects delivery (Amade *et al*., 2015). According to Young *et al*. (2021) the construction industry is one of the least digitalized in the world, and the majority of stakeholders recognise the longstanding tradition of resistance to change. The industry's lack of digitisation and excessively manual nature makes project management more complicated and needlessly tedious (Delgado & Oyedele, 2021; Bello *et al*., 2021). In a related development, Nikas *et al*. (2007) stated that the construction industry's lack of adequate digital expertise and technology adoption has also been linked to cost inefficiencies, poor quality performance, uninformed decision-making, poor performance in terms of productivity, health, and safety and delays in project delivery. This is also true in developing countries, where traditional delivery methods are still used for the majority of construction services. This has had a negative impact on the industry's development, the standard of the services provided, and client satisfaction (Douglas *et al*., 2018). Furthermore, there have been increasing instances of buildings collapsing in Nigeria as a result of inadequate risk management across the entire delivery process of construction projects (Okinda, 2019). According to Halim (2010), no industry that can effectively solve its growth difficulties unless its objectives and plans for accomplishing them are founded in the field of knowledge production and supported by digital technology. The development of systems and procedures for construction aiming at technical advancements that can successfully aid in the construction of a structure is now a reality (Diniz, 2021). The efficiency of the construction industry can be improved by the application of digital technologies in the project delivery (Salehi & Burgueo, 2018; Afolabi *et al*., 2020). Digitalisation can also enhance the process of planning, designing, monitoring, and maintaining construction sites (Allam & Dhunny, 2019). Thus, the aim of this study is to assess the influence of digitalisation on construction project delivery by espousing the current adoption level and challenges with digitalisation implementation in the Nigeria construction industry.

Digitalisation Adoption And Challenges Of The Construction Industry

According to Berger (2016), digitalisation is the use of tools and practices based on information and communication technology. Castagnino *et al.* (2016) asserted that digitalisation can be essential in the transformation of the three major life-cycle phases of construction projects; that is the design and engineering phase, construction phase and operation phase. Adopting digital technologies for the various construction processes throughout these different phases of the construction life cycle can significantly minimize uncertainty and encourage high-quality construction output. The benefits of utilizing digital technologies as part of construction development are significant (Douglas *et al*., 2018). Digitalisation is defined by Westerman *et al*.

(2011) as the adoption and use of technological tools to significantly enhance organisational performance. The improvement and transformation that result from the adoption and incorporation of cutting-edge and smart tools into an organisation's processes are highlighted by this definition. In a related development, Matt *et al*. (2015) asserted that digital technology has the potential to alter how various industries carry out their business operations. The use of communication, computer, connection, and information technology to enhance an entity's activities and operations is known as digitalisation. It has been well-documented how digitalisation is being used to enhance the operations, procedures, and outlook of the construction industry.

Because each job task or collection of related tasks may require specific technology to complete, there is no one-size-fits-all strategy to the industry's adoption of technological products. Digital technology is used in the construction industry to streamline the construction process by integrating the intricate interactions of all construction operations throughout the planning, acquisition, execution, and commissioning phases of the project. Although the use of contemporary technology in the construction sector has increased in developed and industrialized countries throughout time, developing countries like Nigeria continue to have difficulty embracing new technology (Adebisi *et al*., 2018). The planning, coordination, and execution of construction projects require a significant amount of heterogeneous data, and as a result, the construction industry is currently undergoing a revolution by adopting the big data phenomenon (Bilal *et al*., 2016).

As the world moved closer to digitalisation and an automated approach to industrialized operations, new digital technology has rendered older technologies obsolete. Construction industry personnel can use technology by integrating it into the building process. However, while technological developments in the construction sector advance noticeably more quickly in other nations, Nigerian construction industry continue to lag behind many of their counterparts in developing nations in terms of acceptance, usage, and adoption of these technologies (Buba *et al*., 2018; Fadun & Saka, 2018). The use of web-based and digital technologies, particularly in the Nigerian construction industry, is still in its infancy (Afolabi *et al*., 2018; Ezeokoli *et al*., 2016). The Nigerian construction industry must incorporate cutting-edge technologies, according to Usman and Said (2014). Low-level information technology (IT) usage is still a problem in the Nigerian construction sector (Waziri *et al*., 2017). Construction professionals in Nigeria's construction industry avoid adopting new digital technologies, despite the fact that they are available to increase project performance (Akande *et al*., 2018; Ozumba & Shakantu, 2018). Due to this reluctance to accept new technologies, the Nigerian construction industry has continued to monitor and evaluate construction project performance at a subpar level (Afolabi *et al*., 2018). Researchers have frequently noted the high rate of unsuccessful projects in the Nigerian construction industry (for instance, 66% in

a recent survey), and they have also questioned why Nigerian construction professionals are still hesitant to adopt new digital technologies for enhancing decision-making processes and project success rates (Afolabi *et al*., 2018; Hamma-Adama *et al*., 2018).

The difficulties with digitalisation adoption in the construction industry have been documented in previous studies. Studies such as Afolabi *et al*. (2018), Fadun and Saka (2018), Hamma-Adama *et al*. (2018), and Rasaq (2019) revealed that project management methods in Nigeria have been impacted by outdated and unsuitable technology utilization as well as a lack of technology. This has hampered the successful completion of projects. According to Raj *et al*. (2020), the absence of a digital strategy and problems with technology were the biggest obstacles to the implementation of digitalisation. The absence of norms and codes and the lack of incentives from decision-makers in the building industry were cited as the two biggest challenges to the adoption of BIM (Matarneh & Hamed, 2017). Lack of standardization and a lack of technical infrastructures, according to Senna *et al*. (2022), are some of the main challenges to the application of digital technology. According to Osunsanmi *et al*. (2020), inadequate capacity and competence, rising cybersecurity concerns, expensive technology implementation costs, a lack of senior management support, and an unclear digital transformation plan are some of the main challenges to acceptance of digitalisation. In a related development, Ayodeji *et al*. (2023) asserted that the main challenges to the adoption of digital technology include a shortage of knowledgeable professionals, which also contributed to a number of other issues such as adoptive reluctance, data and information exchange, organisational and process changes. Hence, the increased adoption of digitalisation will help organisations to gather more accurate human data and reflect more informed decisions, related to improving the safety of workplaces and construction sites activities (Calvetti *et al*., 2020).

Table 1: Summary of Identified Factors Influencing Digitalisation Adoption

S/N	Influencing Factors	Authors
1	Government Policy	Babu (2015); Abubakar *et al*. (2014); Ogunde *et al*. (2017); Agbata (2018); Rasag (2019)
2	Perceived Benefits	Ayodeji *et al*. (2023); Oesterreich and Teuteberg, (2016)
3	Competition	Babu (2015)
4	Firm's Characteristics	Ayodeji *et al*. (2023)
5	Digital Maturity	Ayodeji *et al*. (2023)
6	Cultural Issues	Negendra and Rafi (2018); Binder *et al*. (2016); Hard *et al*. (2005); Zavadskas (2019); Ayodeji *et al*. (2023); Osunsanmi *et al*. (2020); Chowdhury *et al*. (2019); Ebekozien *et al*. (2021); Yap *et al*. (2019)

7	Lack of Awareness	Korir (2020)
8	Security	Hasegawa (2006); Mantha and DeSoto (2019); Patel and Patel (2020); Waziri *et al*. (2017); Tarhini *et al*. (2015); Muhammed *et al*. (2015)
9	Costs Implication	Korir (2020); Afzal *et al*. (2019); Ali (2019); Alaloul *et al*. (2020); Demirkesen and Tezel (2021); Usman and Said (2014); Oesterreich and Teuteberg (2016); Shaikh and Karjaluoto (2015)
10	Project Uniqueness	Poh *et al*. (2018); Taillandier *et al*. (2015)
11	Resistance	Marr (2020); Korir (2020); Adekunle *et al*. (2021); Ayodeji *et al*. (2023)
12	Robotics	Patil (2019); Han (2011); Shukla *et al*. (2019)
13	Institutional	Cai *et al*. (2018); Mohammadpour *et al*. (2018); Xin *et al*. (2022)
14	Information Sharing	Shukla *et al*. (2019); Xin *et al*. (2022); Adekunle *et al*. (2021); Ayodeji *et al*. (2023)
15	Legal Issues and Regulations	Ayodeji *et al*. (2023); Abubakar *et al*. (2014); Ailbtoush *et al*. (2022); Korir (2020)
16	Lack of Standardization	Babatunde *et al*. (2020); Ayodeji *et al*. (2023)
17	Lack of Expertise	Ayodeji *et al*. (2023); Khin and Kee (2022); Ebekozien *et al*. (2021); Ejiaku (2014); Ebong *et al*. (2014); Faloye (2014); Muhammed *et al*. (2015)
18	Infrastructural Deficiency	Vincent and Yusuf (2014); Egoeze *et al*. (2014); Mudi *et al*. (2015); Onyeji Nwogu *et al*. (2017)
19	Decision-making Process	Sepasgozar and Davis (2018); Kamal *et al*. (2015); Ramayah *et al*. (2016); Nnadi (2018); Sabiu and Agarwal (2016); Sepasgozaar *et al*. (2017); Rojas-Mendez *et al*. (2015)
20	Ethics Issues	Oladinrin and Ho (2016); Ogunyemi and Laguda (2016); Wadhwa (2014)

Influence Of Digitalisation On Construction Project Delivery

According to Usman and Said (2014), the use and exploitation of digitalisation for better teamwork is influenced by a variety of factors, including organisational culture and subculture, communication, motivation, leadership, decision-making, and empowerment, creativity and innovation, organisational structure, training, education, and development. The behavioural practices within an organisation are impacted by organisational culture, and both organisational and personal beliefs have a significant impact on teamwork (Usman & Said, 2014). Charles *et al*. (2001) stated that the culture of an organisation has a significant influence on how digitalisation is adopted and employed. According to Brown (2005), organisational culture has a role in the slow adoption of digitalisation. In

a related development, Australian cooperative research centre for construction innovation (ACRCCI) (2001) noted that every organisation has a unique character, identity, culture, and nature. Therefore, the organisational culture may have an influence on the decision made by a construction company to choose a certain digital technology for use on the job site. Orze and Wolniak (2022) revealed that during the pandemic, when construction organisation was obliged to use digital technology to maintain a reasonable rate of labour, the comfort and well-being of employees came to light. The higher the level of well-being achieved, the higher the performance. 'Doing things by hand', according to Hallin *et al*. (2022), does not promote a secure and effective working environment, a claim that is effectively minimized through the use of technologies.

Previous studies, such as Shahzad *et al*. (2022), Ebekozien and Samsurijan (2022), Regona *et al*. (2022) revealed that digitalisation is associated with a decrease in the number of accidents that occur on the job site because it provides increased monitoring capabilities and warns higher management and supervisors when a safety problem arises. The goals required for stakeholders' comfort and well-being are met by digitalisation, which increases process intelligence and synchronizes activities to be more effective (Yousif *et al*., 2022). As a result, there is a link between the ability of digitalisation to enhance employees' safety and well-being and those qualities of a productive environment. The risky environment in the construction sector is brought on by the naturally occurring heavy activities and the requirement for machinery and equipment that have a history of causing fatalities and having a negative impact on a work environment. In order to provide a safer workplace that encourages productivity and effective project delivery, digitalisation encourages fewer labour-intensive job roles in which difficult and dangerous work conditions are handled with by systems with less impact on human life.

Zulu *et al*. (2023) revealed that digitalisation and construction projects planning have a significant relationship. This link, according to Liu *et al*. (2022), remains despite the complexity of construction jobs because networks are shaped by digitalisation in ways that can assist successful planning and efficient project delivery. Due to the extended capabilities of digitalisation and the tracking of all actions, effective planning would result in fewer tasks being abandoned (Jahanger *et al*., 2021; Aghimien *et al*., 2020). In a related development Zheng *et al*. (2021) revealed that the efficiency of digitalisation in producing significant time savings is attributable to efficient planning, which is thought to have achieved a stunning rate of over three months of time reduction on its own. About 47%-time reduction in tasks is exclusively linked to digitalisation (Barkokebas *et al*., 2021)

Hashim *et al*. (2013) revealed that using digital technology to procure construction projects has many advantages, including increased process quality, cost savings that are adequate, client and participant satisfaction that is adequate, increased responsiveness and productivity, market expansion, and project delivery that is as efficient as

possible. According to Staub-French and Fischer (2017), the use of digital technologies helps to clearly define schedules for the construction process and helps to identify design conflicts. Furthermore, it was shown that the use of digitalisation results in a decrease in the amount of rework and change orders that are documented. These pricey reworks are usually the result of numerous problems that are not noticed until they are encountered during the construction phase (Douglas *et al*., 2018).

According to Holt (2015), the project-based nature of the construction industry, the convoluted communication structure, the enormous number of stakeholders and their wide-ranging interests, combined with the massive amount of data, all necessitate technology to manage the construction process effectively. The hundreds of distinct work tasks that make up a construction project might range from being similar in nature to occasionally having a different character (Adwan & Al-Soufi, 2018). On the building site, digitalisation is being embraced gradually. In order to access information such as worksite images, materials utilized, labour hours, and equipment utilization, the use of cloud-based applications and mobile devices has expanded tremendously, which enables deeper analysis. Building information modelling (BIM) and artificial intelligence would be coordinated as part of the construction industry's continued digitalisation and automation. Real-time tracking capabilities in the cloud have been discovered to be able to give timely data on the purchase and use of materials, as well as real-time reports and dashboards to provide updates (Ayodeji *et al*., 2023). Nagitta *et al*. (2022) revealed that machine learning and Artificial Intelligence (AI) can aid in the management of procurement by tracking expenditures, removing errors, forecasting future requests, and keeping an eye on hazards. A construction project's planning can also be made more effective with the use of digital building systems (DeSoto *et al*., 2018). In addition, augmented reality technology (ART) through visualization and simulation can be helpful in contract writing, project planning, and receiving on-site real-time information on a project's viability. Infrastructure project construction is when this occurs (Ayodeji *et al*., 2023).

Adekunle *et al*. (2021) asserted that unmanned aerial systems, often known as drones, can be used to survey and check ongoing construction site, compile progress reports, locate equipment, and carry out security surveillance. Drones can offer precise and thorough data during a construction project phase. Furthermore, including the Internet of Things (IoT) into construction activities can improve predictive maintenance, monitor production, and encourage professional efficiency (Bumgardner & Buehlmann, 2022). In a related development, Ebekozien *et al*. (2021) stated that robotics, artificial intelligence (AI), and augmented reality technology (ART), machines are already developing the capacity to carry out autonomous and repetitive site activities like bricklaying and masonry work. Building information modelling (BIM), for example, can be helpful for project documentation

and building system analysis (Adekunle *et al*., 2021). Babatunde *et al*. (2020) revealed that construction prefabrication increases productivity and improves model-based cost estimation, scheduling, and onsite communication. The digital transformation of the building industry is also being sparked by the use of cryptocurrency. Cryptocurrencies enable safe online payment processing without the need for a centralized network by employing digital currencies generated by encryption algorithms. The design and construction of projects will therefore continue to be more effective and efficient as technology develops (Sadeghi *et al*., 2022; Ayodeji *et al*., 2023).

According to Zulu *et al*. (2023) digitalisation aids in fostering collaboration among the parties involved in construction projects. Digitalisation is allegedly used to provide clear and traceable information to parties involved in the delivery of construction projects, resulting in better collaboration (Li *et al*., 2019). Due to the broad ability of technologies to better connect parties involved, the function that digitalisation can play in encouraging collaboration across construction groups can hardly be limited to one element (Stojanovska-Georgievska *et al*., 2022; Regona *et al*., 2022; Atuahene *et al*., 2023). The introduction of digitalisation can be viewed from two perspectives: as a potential danger to existing jobs and as a potential opportunity that could spur performance (Gracie Desoto *et al*., 2020). The former may be explained by the ability of digitalisation to reduce the number of workers on site (Ayat *et al*., 2022). In contrast, the latter views digitalisation as having the potential to ensure that employees are significantly developing their skills, where future recruitment would then focus on the employment of competences in the workplace (Koseoglu *et al*., 2019). As a means of attempting to adjust to a new reality and maintain their roles, it is believed that digitalisation would encourage employees to upskill by seeking information and knowledge. This attitude, which is driven by the worry about losing their jobs, will result in a more capable social structure of workers within organisations in terms of knowledge and skills. It also significantly affects productivity by increasing skill intensity (Grybauskas *et al*., 2022). The proper promotion of digitalisation, however, necessitates taking steps to guarantee the right information is flowing on staff growth. According to the literature, organisation must assist their staff members in this shift by providing ongoing webinars and educational materials that will promote awareness and understanding among peers (Aghimien *et al*., 2021; Osunsanmi *et al*., 2020).

Orze and Wolniak (2022) revealed the expanded potential that digitalisation gave to support designers working remotely, a potential that implied increased productivity in comparison to the conventionally constrained co-working environments. According to Zulu *et al*. (2023) digitalisation is facilitating the improvement in design to total construction project delivery. Construction organisation can monitor design development in real time and

adjust their managerial actions with the help of digitalisation (Lappalainen *et al*., 2021; Koseoglu & Nurtan-Gunes, 2018). In a related development, Alwan and Ilhan Jones (2022) and Nikmehr *et al*. (2021) showed how choices that reduce carbon during the design process are correlated with the benefits that digitalisation offers. The ease of data flow within important models, which encourages crucial interactions with designers and other stakeholders (Lasarte *et al*., 2021) during the design phase, is one way to measure productivity in this context. This is consistent with what McNamara and Sepasgozar (2021) asserted about the ability of digitalisation to permit less conflicts within designs and with handling complicated data, all of which can be related back to the influence of digitalisation on the execution of construction projects. According to research, the usage of digitalisation has a favourable influence on project delivery. Project management enables digitalisation to have a wide range of advantages. For instance, digitalisation has been related to up to 21% of savings as a result of design improvements (Stojanovska-Georgievska *et al*., 2022). Such use is not restricted to a single piece of software; rather, digitalisation is enhancing the design phase, with advancements in areas such as digital photogrammetry (Diana *et al*., 2022), building information modelling (BIM) (Stojanovska-Georgievska *et al*., 2022), geographic information systems (GIS), and visualization (Lasarte *et al*., 2021). The value is in embracing such a wide range of digital technologies. But according to Morgan (2019), digitalisation is argued to still be far from being widely comprehended by design firms.

Also, Shahzad *et al*. (2022) revealed how digitalisation increased information management's capabilities, which allowed for the virtual application of vital behavioural data as well as its retrieval. The human aspect, which is strongly associated with errors and inaccurate data transfer, is only minimally involved in accuracy in this sense (Hallin *et al*., 2022). According to Bazán *et al*. (2021) the existence of digitalisation led to agreement among parties on the few issues that would affect the accuracy of data, indicating the trust that such innovation can impose on construction stakeholders. The ability of digitalisation to improve the delivery of construction projects can be demonstrated by the certainty that data is being delivered accurately, through excellent reporting, 3D visual potential, and information tracing (Qian & Papadonikolaki, 2021). Thus, top management personnel or practitioners in the construction industry must be prepared to educate their staff about the advantages of utilizing smart technologies. This can be accomplished by providing training to both experienced and unskilled labourers on how to use these technologies in various construction-related tasks. The knowledge and abilities of project team members on smart technologies can be greatly improved through training programmes.

Conclusion

The construction industry at large is beginning to take advantage of digital technologies through big data, data analytics, internet of things (IoT), artificial intelligence, machine learning and deep learning to enhance the efficiency and effectiveness of project delivery thereby leading to an increase in performance and overall project delivery success in the construction industry. Findings of the study revealed that digitalisation have a substantial influence on construction project delivery. Also, the review revealed that the use of digitalisation in construction project delivery in Nigeria is still at infancy level. With sets of challenges such as legal issues and regulations, cultural issues, lack of awareness, security, higher initial costs, project uniqueness, resistance, robotics, institutional and informational sharing hindering its adoptions and potential usage. Thus, the study suggests rigorous awareness, especially among the concerned professionals and stakeholders, establishing digital knowledge, basic skills and training from grassroots, usually from the tertiary institutions and related professional bodies, and enacting government policy that will encourage the adoption and implementation of digital technology in the Nigeria construction industry.

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