A SYSTEMATIC REVIEW OF THE IMPACTS OF DIGITALIZATION ON PROJECT MANAGEMENT

Ailin Zerafat, Emmanuel Daniel & Louis Gyoh
School of Architecture and Built Environment, University of Wolverhampton, UK

ABSTRACT: *This article systematically reviews digitalization's impacts on project management in the construction industry. The article discusses the challenges the construction industry in successfully applying digitalization during the construction phase, including high costs, subpar performance, low productivity, and sustainability issues. The article then outlines the research questions and methodology used to conduct the systematic review, including selecting acceptable research questions, selecting acceptable research questions, using a qualitative approach, and the content review approach. The study analyzed 21 papers and identified the primary research themes regarding the effects of digitalization on project management. The study found that digital technologies, such as smart building technology, digital twins, reality capture, and laser scanning, have positively impacted project management by increasing efficiency, accuracy, value, and safety. The study concludes that the construction industry must embrace digitalization to address its challenges and improve project management.*

KEYWORDS: *Digitalization, Systematic review, Project Management, BIM, Construction Industry,* Automation, Innovation, *Construction Sector*, *Innovation*, *AI*, *Remote, Architect, Engineering*

1. INTRODUCTION

Digitalization is changing the way construction projects are managed and impacting not only the design and construction phases but also facility management (Bazán *et al.,* 2021). It is challenging to successfully apply digitalization during the most time-consuming, expensive, and collaborative period of a project—the construction phase (Qais K. Jahanger *et al.,* 2021). With digitalization being the most promising option to address these difficulties, the construction industry faces a number of hurdles, including high costs, subpar performance, low productivity, and sustainability issues (Nikmehr *et al.,* 2021).

The implementation of Building Information Modelling (BIM) is one of how the construction industry is being digitalized, and its adoption is increasing globally, requiring the conversion of conventional building life cycle phases into BIM-integrated project deliveries (Yilmaz, Akcamete and Demirors, 2023). Strong relationships between frequently encountered independent BIM uses are a requirement for the Total BIM approach, where the principal contractual and legally binding construction document should be production-oriented BIM. Other key success elements include cloud-based model administration, user-friendly on-site mobile BIM software, and strong leadership (Disney *et al.,* 2022). However, BIM deployment frequently has limitations, such as parallel 2D drawing production, which results in wasteful effort, and the need for structural engineers on-site to develop POVs for construction because collecting measurements using the software was not supported. Additionally, Tekla, which supports a 3D model-based approach for rebar and steel structures, is used in the examples, which largely focus on infrastructure projects (Disney *et al.,* 2022).

To fully utilize BIM and digitalization in project management, it is necessary to develop tools for documentation, registration, and data management that allow for effective information sharing among all stakeholders (Bazán *et al*., 2021). Moreover, the cost of construction expert's services, including BIM services, which are now determined by established rates based on construction and equipment prices, can be more accurately predicted with the help of historical data (Nguyen, Dang and Nguyen, 2022). Using BIM-Facility Management with three-dimensional information models created during construction, BIM-based solutions offer the opportunity for collaborative, multidisciplinary workflows and full life cycle consideration (Bazán *et al*., 2021).

Apart from BIM, the construction industry is also moving towards Construction Automation and Robotics (CAR) (Pons-Valladares *et al*., 2023). This is because the upkeep and building of conventional structures account for roughly 30-40% of global energy usage and greenhouse gas emissions into the built environment, posing a threat to the environment due to the significant amount of resources and energy required in these buildings (Ejidike and Mewomo, 2023). According to the UN, the construction industry is responsible for around 40% of global energy use, nearly 40% of waste production, and roughly 30% of greenhouse gas emissions related to energy (Reinbold *et al.*, 2022).

Referee List (DOI: 10.36253/fup_referee_list)
FUP Best Practice in Scholarly Publishing (DOI 10.36253/fup_best_practice)

As part of industrial digitalization, the manufacturing sector makes use of digital technologies like AI, cloud processing, and IoT. This speaks of initiatives taken to increase output using digital technology, which can have an effect on all areas of an organization and alter current business procedures (Carlsson, 2023). Effective strategizing of organizational capabilities relies on managers' capacity to elucidate the socio-cognitive factors, and it contributes to management practice by highlighting the divergent opinions among managers concerning digital technology's influence on efforts to improve the organization (Carlsson, 2023). Additionally, a potential solution to the lack of focus on workers in digitalization research for the construction industry is digital visual management (DVM), which aims to provide real-time visual information that can be easily accessed and utilized during production activities to increase transparency and communication. However, understanding the various actors' information needs is crucial to effectively implement DVM (Reinbold *et al.*, 2022).

The growth of digital methods is transforming the design and construction business, impacting not only how the sector operates but also the range of output; yet, there is a dearth of critical analysis because the majority of research mainly concentrate on creating the approaches (Brooks, Zantinge and Elghaish, 2022). The lack of comprehensive analysis of this disaggregated knowledge on the application of digital technology in project management informed the current systematic literature review. This study aimed to comprehend how digitalization has affected project management. The study objectives are;

• To examine the project management literature currently available on digitalization.

• To determine how project management is currently using digitalization.

• To identify the obstacles preventing the use of digitization in project management

The building industry faces the challenge of creating comprehensively built infrastructures that meet the demands of a growing population, urban sprawl, and globalization. This includes implementing efficient energy management, ensuring proper water supply, providing indoor comfort for occupants, and managing construction waste (Ejidike and Mewomo, 2023). The substantial financial burden of maintaining and repairing deteriorating facilities is highlighted by the necessity for improved management and inspection systems given the size of some countries' infrastructure (Bazán *et al*., 2021). The successful use of digital technology by a construction company depends on having sufficient knowledge of the organization, including its structure, nature of work, and human resource characteristics (Nikmehr *et al.,* 2021).

2. RESEARCH METHOD

The basis for increasing knowledge in a certain discipline, such as architecture and construction, among others, is a thorough review of the scientific literature. The study employed a systematic review methodology, in accordance with the strategy described by Denyer and Tranfield, to thoroughly assess the body of literature and arrange knowledge into a trustworthy manner that can influence practices (Ejidike and Mewomo, 2023).

This literature review with a qualitative approach aims to explore the advantages of digitalization in project management in the construction industry. The review employs the Scopus search engine to locate pertinent papers. Due to Scopus's high data recovery accuracy and precision, the researcher chose to use it for their literature search. The investigation considers papers published between 2015 and 2022, using the following search strategy: (TITLE-ABS-KEY ("Digitalization" AND Construction AND Management)).

The initial search resulted in 129 articles that met the criteria. Inclusion and exclusion criteria were applied to ensure that only relevant papers were selected. The criteria stipulated that the articles must be in English and deal with engineering. Any papers that did not meet these criteria were discarded. The review specifically focused on digitalization in project management, analyzing pertinent academic journals and conference papers. Despite the thorough search, not all of the articles that were found appeared to be pertinent to the study's specific focus. Therefore, the researcher used a content review approach to further filter and select the most relevant papers for the investigation.

The content review approach involved a three-step process. First, the researcher examined the article's topical relevance to the study. Second, the researcher analyzed the abstract to determine whether the article provided sufficient information related to the study's focus. Finally, the researcher reviewed the article's findings as they were reported in the literature. After applying the content review approach, a total of 21 papers were selected for examination. These papers were analyzed in detail, and their findings were synthesized to develop a comprehensive understanding of the advantages of digitalization in project management in the construction industry.

To ensure the reliability of the literature review, the researcher used a systematic approach to the search, screening, and selection of articles(citation). The inclusion and exclusion criteria were clearly defined and consistently applied throughout the study. The content review approach provided a structured and transparent method for selecting the most relevant papers for the investigation.

The primary research themes regarding the effects of digitalization on project management were identified and categorised in this study, with the hopes that the findings will help other researchers better understand current events, trends, and potential areas for research and innovation in the AEC industry.

3. RESULT AND DISCUSSION

3.1 Qualitative Analysis and Discussion

3.1.1 The state-of-art of Digitalization in project management

Digitalization in project management is a growing trend that is transforming the Architecture, Engineering, Construction, and Facility Management (AEC-FM) sector in many ways. Digital technologies, such as IoT, UAVs, 3D printing, AR, VR, MR, BIM, AI, and DSS, are increasingly being used to solve problems with cost, rework, efficiency, safety, quality, and productivity (Nikmehr et al., 2021). Web-based project systems, digital meetings, and BIM have been available for some time, but they are not always fully utilized. However, the right digitalization approach can reverse productivity declines, and European Directives for Procurement are pushing for more radical digital transformations with support for R&D and training (Prebanić and Vukomanović, 2021).

Project managers are responsible for determining how to use ICT tools to involve project stakeholders effectively, and there is extensive research on the digitalization of construction project management practices (Prebanić and Vukomanović, 2021). Digital technology has been used in the construction industry in the past, but its scope was limited due to technological constraints. However, advancements in processing power have given construction organizations the opportunity to combine their skills and enhance their processes using digital technology (Lundberg, Nylén and Sandberg, 2022).

Digital twins, which are virtual replicas of physical things that faithfully reproduce all of their properties, including how they behave under actual use-case scenarios, can aid in the integration of various information technologies into a single digital platform and twin for construction projects (Ryzhakova *et al.,* 2022). Reality Capture (RC), a valuable tool for construction project management, can increase project efficiency, correctness, value, and safety by incorporating building geometry, build typology, and material amounts in 3D models (Fobiri, Musonda and Muleya, 2022). Similarly, laser scanning, which is safe and non-invasive and efficiently and precisely organizes space, is gaining popularity in the fields of design, engineering, and construction, all of which contribute to the achievement of sustainable development goals (Fobiri, Musonda and Muleya, 2022). Digital technologies are having an increasingly negative impact on the AEC-FM sector in two ways: the monitoring of sensor network data and the easy management of automation systems (Hosamo *et al.,* 2022).

Both industrialized and developing countries have adopted sustainable construction techniques, such as green roofs and structures, modular construction, information modeling, and smart building technology (SBT), to improve their processes (Ejidike and Mewomo, 2023).

3.1.2 The impacts of Digitalization in project management

As technology has advanced, building experts have increasingly used it to improve energy management, environmental protection, economic efficiency, and human comfort (Ejidike and Mewomo, 2023). By encouraging sustainable construction methods that limit waste output, maximize resource consumption, and minimize environmental effect, smart building technology adoption benefits professionals, clients, and the nation as a whole in developing countries (Ejidike and Mewomo, 2023). For the purpose of enhancing and facilitating a specific activity, new digital technologies like computer modeling, digitalization, and creative business processes are being developed (Brooks, Zantinge and Elghaish, 2022).

Digitalization has the ability to improve project management and delivery through the use of construction or document software solutions, which includes contractor, document management, process management, and activity monitoring and oversight (Qais K. Jahanger *et al.,* 2021). A construction company must have a strong commitment to change in order to achieve real digital transformation, as opposed to running analogue and digital systems in parallel. It also needs to develop and implement a defined digitalization transition strategy (Nikmehr *et*

al., 2021). BIM and other digital technologies have been utilized successfully in construction projects all around the world, showcasing their capacity to manage multidisciplinary teams, spot conflicts, and minimize rework in significant projects (Nikmehr *et al.,* 2021).

The development of 3D models made possible by the application of RC technologies in construction management provides clients, consultants, and contractors with a singular learning chance to interact with and define faults, structural analyses, constructability challenges, risks, and costs in real-time, in a secure, hazard-free environment (Fobiri, Musonda and Muleya, 2022). Although Big Data technology can assist with analysis and processing of the large and complex datasets created by construction projects, it is still difficult to integrate data from various automated systems to create a digital twin (Ryzhakova *et al.,* 2022). The Digital Twin can interact with other simulators and programs by incorporating data and information from throughout an asset's existence, making it a crucial decision-making tool for the duration of the asset (Hosamo *et al.,* 2022).

In order to meet market demand and improve their value offer, the UK's changing construction agenda is encouraging construction companies to adopt new business models that make use of digital technology and manufacturing processes to develop and deliver whole life value (Çıdık and Boyd, 2022). The construction industry's methods for generating and capturing value change as a result of digitalization, which causes a transition from project-based logic to production-based logic (Çıdık and Boyd, 2022). The construction industry's interdisciplinary, dispersed, and temporary project organizations, as well as the interdependencies between stakeholders, add complexity and make it difficult to meet project requirements for cost, time, and productivity. This calls for improved integration, cooperation, interaction, and coordination (Prebanić and Vukomanović, 2021).

3.1.3 How Digitalization impacts on Project Management

The push for digitization in construction highlights the need for change in the way construction is planned and carried out (Brooks, Zantinge and Elghaish, 2022). Digitalization in construction practices uses digital technologies to create new organizational practices (Lundberg, Nylén and Sandberg, 2022). A digital representation of the real world can be made using Reality Capture (RC) technology, making it easier to plan, oversee, and evaluate construction, engineering, and architectural projects (Fobiri, Musonda and Muleya, 2022). The use of digital models of buildings and planned project activities can support tasks at different levels, such as transaction conclusion, securing investment support, and thorough assessments of capital construction objects (Ekaterina Tereshko, 2021). Building assets must be managed, and facility management (FM) calls for handling a lot of data, which is currently kept in paper documents that are prone to theft (Siccardi and Villa, 2023).

Through the seamless integration of information using information-based systems like Building Information Modeling (BIM), AEC-FM operations can be improved, projects can be more efficiently completed, and their efficacy over their whole lifespan can be increased (Hosamo *et al.,* 2022). Throughout the entire building construction process, risk prevention and safety planning have advanced significantly thanks to the use of BIM methods and digital twins, which enable accurate data collection and 3D visualization (Torrecilla-García, J., Pardo-Ferreira, M., Rubio-Romero,J., 2021). A technology was created to build and analyse models of control processes as well as create strategies and tactics to apply the findings to real-world demands (Ereshko *et al.,* 2022). Digital construction-phase information management (DCIM) systems can be an effective solution for reversing the fall in productivity in the construction industry, however certain governmental agencies have not yet completely adopted this technology (Qais K. Jahanger *et al.,* 2021). An information system with an intuitive design and standardized methods for data extraction, transformation, and loading can guarantee the long-term archiving, updating, and synchronization of metadata and data from different information systems while also safeguarding it from unauthorized access by other project participants (Ryzhakova *et al.,* 2022).

Convenience, cost savings, a wider range of options, greater information, improved sustainability, higher communication quality, increased customer satisfaction, and success of economic models and investments are just a few of the advantages that digitalization brings to industries (Nikmehr *et al.,* 2021). The construction industry's interdisciplinary, dispersed, and temporary project organizations, as well as the interdependencies between stakeholders, add complexity and make it difficult to meet project requirements for cost, time, and productivity. This calls for improved integration, cooperation, interaction, and coordination (Prebanić and Vukomanović, 2021). Because of the intricate nature of projects and the involvement of several contracting parties with potentially competing interests, stakeholder management, which includes stakeholder analysis and engagement, is essential in the construction industry (Prebanić and Vukomanović, 2021).

To ensure the adoption of smart building technology in underdeveloped countries, it is essential to fully comprehend its benefits, make the concept more familiar to building experts, and promote its successful use in

those areas (Ejidike and Mewomo, 2023). The current emphasis on digitization in the agenda for transforming construction assumes that integrated digital technologies can identify coordination issues and enable better inter-organizational cooperation, but this perspective poorly articulates how value is formed and ignores the practical difficulties of digitization (Çıdık and Boyd, 2022).

4. RECOMMENDATIONS AND DIRECTIONS FOR FUTURE RESEARCH

Digital technologies have disrupted many industries, and project management is no exception. Digitalization has enabled project managers to leverage new tools and techniques to improve project outcomes and collaboration, but it has also brought new challenges related to data privacy, security, and governance. To address these challenges and leverage the benefits of digitalization, there is a need for further research in the impacts of digitalization in project management. This article provides recommendations and directions for future research in this field.

The first recommendation is to investigate the adoption rate of digital technologies in project management and identify factors influencing its adoption. This research can provide insights into the current state-of-art of digitalization in project management and help project managers understand the factors that drive or hinder its adoption. For example, research could explore the impact of organizational culture, leadership support, and digital competencies on adopting digital technologies in project management.

The second recommendation is to examine the role of digital technologies in enabling remote project management and explore the impact on team collaboration and communication. With the rise of remote work, project managers need to adapt to new ways of working and leverage digital technologies to collaborate effectively with team members who are geographically dispersed. Research could explore the impact of digital tools such as video conferencing, instant messaging, and collaboration platforms on team communication, collaboration, and performance.

The third recommendation is to analyze the impact of digitalization on project outcomes, including project completion time, cost, quality, and scope. Digital technologies can potentially improve project outcomes by enabling more efficient and effective project planning, execution, monitoring, and control. However, research is needed to understand the specific impact of digital technologies on different project outcomes and to identify best practices for leveraging digital technologies to improve project outcomes.

The fourth recommendation is to investigate the impact of digital technologies on project risk management, including identifying, assessing, and mitigating risks. Digital technologies can enable more effective risk management by providing project managers with real-time data and insights into project risks. Research could explore the impact of digital tools such as risk management software, predictive analytics, and machine learning on project risk management and identify best practices for leveraging these tools to mitigate project risks.

The fifth recommendation is to explore the impact of digitalization on project management processes, including project planning, execution, monitoring, and control. Digital technologies can enable more efficient and effective project management processes by automating tasks, providing real-time data, and enabling more effective collaboration. Research could explore the impact of digital tools such as project management software, project management dashboards, and agile methodologies on project management processes and identify best practices for leveraging these tools to improve project management processes.

5. CONCLUSION

In this systematic review, the aim was to investigate the impacts of digitalization on project management in the construction industry. The study revealed both the challenges faced during the implementation of digitalization, such as high costs and sustainability issues, and the positive outcomes resulting from the adoption of digital technologies. Through a comprehensive analysis of 21 papers, the study identified key research themes highlighting the transformative potential of digital tools like smart building technology, digital twins, reality capture, and laser scanning. These technologies have proven to enhance project management by increasing efficiency, accuracy, value, and safety.

The findings emphasize the need for the construction industry to fully embrace digitalization. Integrating Building Information Modelling (BIM) and other digital tools facilitates effective information sharing, enabling collaborative and multidisciplinary workflows throughout the construction lifecycle. Additionally, Construction Automation and Robotics (CAR) are emerging as essential components in sustainable construction practices. To

successfully leverage digitalization, organizations must adopt a defined digitalization transition strategy and genuinely commit to a digital transformation, considering the organization's structure, nature of work, and human resource characteristics.

Looking ahead, further research is recommended to explore the adoption rate of digital technologies in project management and the factors influencing their successful implementation. Understanding the role of digital technologies in enabling remote project management and their impact on team collaboration and communication is crucial in adapting to evolving work practices. Moreover, in-depth analysis of the impact of digitalization on project outcomes, risk management, and project management processes will provide valuable insights and best practices for the industry. Ultimately, embracing digitalization presents not only a necessity but also an opportunity for the construction industry to thrive in an increasingly digital world, delivering successful projects that meet the demands of a growing population and sustainability requirements.

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