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DIGITAL TRANSFORMATION FRAMEWORK FOR CONTRACTORS' PROJECTS: A COMPREHENSIVE STRUCTURED REVIEW

Jamaliah Mohamad Sopi[1*], Ahmad Najid Omar[2], Mohd Hanizun Hanafi[3]

[1] Faculty of Architecture and Ekistics, Universiti Malaysia Kelantan, Malaysia
Email: i23e001f@siswa.umk.edu.my
[2] Jabatan Matematik Sains dan Komputer, Politeknik Kota Bharu , Malaysia
Email: najid@pkb.edu.my
[3] Faculty of Architecture and Ekistics, Universiti Malaysia Kelantan, Malaysia
Email: hanizun.h@umk.edu.my
[*] Corresponding Author

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Abstract:

This systematic literature review aims to provide a comprehensive and structured analysis of the current state of digital transformation in construction management, focusing on integrating digital technologies. The construction industry is significantly impacted by Industry 4.0, transforming buildings into complex productions through innovative technologies. This study seeks to evaluate the adoption and impact of digital transformation within construction management by employing a methodology based on descriptive and the PRISMA protocol; 309 papers published between 2021 and 2025 from Scopus and Science Direct were retrieved and analysed. The descriptive analysis highlighted the increase in publications over the years, distribution of papers by country, and the content focus of the publications conducted using Excel and meta-syntheses, examined keyword co-occurrence, country-based publications, sources, and citations. Findings indicate a growing interest in digital technologies in construction management, with a notable emphasis on building information modelling (BIM). This review underscores the need for further research on the potential applications of digital transformation in construction management beyond architectural design. The results these technologies' importance in enhancing efficiency and effectiveness in construction projects.

Keywords:

Digital, Technology, Adoption, Construction

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Introduction

Digital transformation is revolutionising the construction industry, particularly in contractors' projects (S. Jiancheng *et.al.*, 2023). This article explores the critical components of digital transformation, including data management, automation, collaboration, and technology adoption. It highlights the benefits, challenges, and prospects, providing a detailed analysis supported by current research and industry practices. Digital transformation involves the integration of digital technologies into all aspects of business operations. In the construction industry, this shift is pivotal for improving efficiency, reducing costs, and enhancing project outcomes. Contractors, who play a central role in project execution, stand to gain significantly from adopting digital tools and processes. Digital transformation in contractors' projects involves integrating digital technologies into all construction processes to improve efficiency, productivity, and project outcomes. The framework for digital transformation should focus on several key components: data management, automation, collaboration, and technology adoption (A. Bris *et al.,* 2021). Data Management is effective data management is crucial. This includes using Building Information Modeling (BIM) to create digital representations of the physical and functional characteristics of facilities. BIM enables better planning, design, and management of building projects by providing a shared knowledge resource. Automation is adopting automation technologies, such as robotics and drones, that can significantly enhance construction processes. Drones can be used for site surveys and inspections, while robotics can automate repetitive tasks, reducing labour costs and increasing precision. Collaboration is enhancing collaboration through digital tools is essential. Cloud-based platforms allow for real-time communication and data sharing among all stakeholders, including architects, engineers, contractors, and clients. This ensures transparency and more efficient decision-making. Technology Adoption is where contractors should invest in emerging technologies such as the Internet of Things (IoT), Artificial Intelligence (AI), and Augmented Reality (AR). IoT devices can monitor site conditions and equipment performance in real-time, while AI can predict project risks and optimise resource allocation. AR can be used for virtual walkthroughs and clash detection, improving project visualisation and reducing errors. In conclusion, contractors can create a robust digital transformation framework that drives innovation, reduces costs, and improves project delivery timelines by focusing on these components. Embracing digital transformation enhances competitiveness and ensures that contractors are well-prepared for the future of construction.

Literature Review

Digital transformation has become imperative in the construction industry, driven by technological advancements and the need for enhanced efficiency and productivity. Automation technologies, including robotics and drones, are revolutionising construction practices, increasing productivity and precision (Azhar, 2011) Furthermore, collaboration facilitated by cloud-based platforms and digital communication tools is crucial for effective project management and decision-making processes (Azhar, 2011). Emerging technologies like the Internet of Things (IoT), Artificial Intelligence (AI), and Augmented Reality (AR) offer significant benefits, such as real-time monitoring, risk management, and project visualisation.
The construction industry faces numerous challenges, including labour shortages, volatile material prices, and the imperative to improve productivity and efficiency. The COVID-19 pandemic has accelerated the digital transformation process, with 75% of construction professionals in Malaysia seeking to increase technology adoption post-pandemic (Azhar, 2011). Key barriers to adoption include a preference for established technologies, skilled labour shortages, high initial costs, and justifying ROI (Azhar, 2011). However, technologies like

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drones, 3D printing, and construction management platforms are driving change with the global Construction 4.0.

Automation-Enhancing Productivity and Precision

Automation technologies, such as robotics and drones, are transforming construction practices. Drones provide aerial surveys and inspections, while robots handle repetitive tasks like bricklaying and welding, increasing productivity and precision.

Collaboration: Leveraging Digital Tools for Enhanced Communication

Collaboration is crucial in construction projects, where multiple stakeholders must coordinate effectively. According to Azhar, S. (2011), cloud-based platforms and digital communication tools facilitate real-time collaboration, improving transparency and decision-making processes.

Technology Adoption: Embracing IoT, AI, and AR

Emerging technologies such as the Internet of Things (IoT), Artificial Intelligence (AI), and Augmented Reality (AR) offer significant benefits. IoT devices provide real-time monitoring, AI enhances risk management and resource allocation, and AR improves project visualisation. Digital transformation is a technological upgrade and a strategic shift that can redefine the construction industry. For contractors, embracing digital tools and processes means enhanced efficiency, reduced costs, and improved project outcomes. As technology continues to evolve, the potential for innovation in construction will expand, paving the way for smarter, more sustainable projects.

Challenges and Opportunities

The construction industry faces labour shortages, volatile material prices, and the need to improve productivity and efficiency. The COVID-19 pandemic has served as a wake-up call, speeding up the digital transformation. 75% of construction professionals in Malaysia are looking to increase technology adoption post-pandemic. Key barriers include a preference for established technologies, skilled labour shortages, high initial costs, and justifying ROI. Drones, 3D printing, construction management platforms, and payment technologies are driving change. Smart construction leverages IoT, AI, and cloud computing to improve processes, products, services, and operational costs. The global Construction 4.0 market is projected to reach $62.2 billion by 2031, growing at a CAGR (*compound annual growth rate)* of 17.7%. A study found the overall digital maturity of the Malaysian construction industry stands at 60%. Software applications are more prevalent, with data management exhibiting the highest maturity. Consultancy services have the highest digital maturity while contracting businesses have the lowest. While the Malaysian construction industry has embraced digital transformation, challenges remain in implementing IR 4.0. Overcoming barriers and leveraging emerging technologies will be crucial for the industry to improve productivity and efficiency and remain competitive in the future.

Digital Design and Fabrication at the Service of Social Equity: Analysing the ROOM Framework

Digital technologies have revolutionised the construction industry, enabling significant advancements in design, fabrication, and project management. Gardiner and Colabella (2024) discuss the ROOM framework, emphasising the potential of digital design and fabrication to enhance social equity, particularly for disadvantaged communities. This literature review delves

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into the core aspects of their study, highlighting the transformative capabilities of digital technologies in promoting social justice and inclusion.

Digital Technologies and Social Equity

The ROOM framework explores how digital technologies, traditionally used to enhance industrial efficiencies, can be redirected to address social inequities. Gardiner and Colabella (2024) argue that digital design and fabrication can be utilised to create affordable housing solutions, particularly for at-risk youth. This approach aligns with the broader goals of Industry 4.0, which advocates for technological advancements to improve economic and social outcomes (Eastman et al., 2011; Bock, 2015; Redmond et al., 2012). By leveraging digital tools, the construction industry can bypass traditional barriers and create more inclusive solutions.

Challenges and Opportunities in Digital Construction

Several studies have identified challenges in adopting digital technologies in the construction sector, particularly in different geographical contexts. Alwashah et al. (2024) examine the barriers faced by the Jordanian construction industry, including a lack of qualified workers, high initial costs, and low investment in research and development. Similarly, Pham et al. (2024) highlight challenges in Vietnam, emphasising the need for strategic implementation to maximise the benefits of digital transformation. These challenges underscore the importance of tailored approaches, such as the ROOM framework, which addresses specific socio-economic conditions to enhance social equity.

Integration of Digital Twin Technology

Digital Twin (DT) technology represents a significant advancement in digital construction, bridging physical and virtual spaces. Liu et al. (2024) discuss the Digital Twin Maturity Model (DTMM), which offers a systematic framework for assessing and enhancing DT capabilities. This model aligns well with the ROOM framework's emphasis on scalability, modularity, and sustainable practice (Gardiner & Colabella, 2024). By integrating DT technology, the construction industry can improve project planning, execution, and monitoring, ultimately contributing to more equitable and efficient outcomes.

Performance-Based and Circular Architecture

Gardiner and Colabella (2024) advocate for performance-based and circular architecture, which combines digital design and fabrication tools to create sustainable and adaptable housing solutions. This approach resonates with the historical context of prefabrication and self-build practices in the Australian housing sector. By incorporating participatory design and customisation, the ROOM framework empowers individuals to participate in the construction process, enhancing their skills and employability (Bock, 2015; Redmond et al., 2012; Bilal et al., 2016). This participatory approach addresses immediate housing needs and contributes to long-term social and economic empowerment. The ROOM framework demonstrates the potential of digital technology to construct scalable and sustainable housing solutions, offering a workable answer to the problems of social fairness and housing affordability. Gardiner and colleagues offer a thorough examination of how digital resources might be utilised to tackle social disadvantage, emphasising the significance of performance-based architecture and community engagement. Subsequent studies should concentrate on improving these strategies and investigating novel technologies to augment social justice in the construction sector.Digital design and fabrication offer significant potential to address social inequities in the construction industry. As discussed by Gardiner and Colabella (2024), the ROOM framework provides a

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compelling case for leveraging digital technologies to create affordable and sustainable housing solutions. The construction industry can achieve more inclusive and equitable outcomes by integrating Digital Twin technology, performance-based architecture, and participatory design. This review underscores the importance of continued research and innovation in digital construction to enhance social equity and empower disadvantaged communities. The study also categorized the applications of DT into the following six groups: applications relating to architecture and urban planning, risk management, safety and health, sustainability and the environment, structural performance, and facility management. The difficulties in implementing DT were further classified according to the following factors: industry-specific, social and organizational, technological, political, and legal. Future research directions and useful suggestions were made based on the findings to help ensure the technology is deployed successfully. Although digital technologies have been adopted by the construction industry slowly, the pace of digital transformation has quickened recently due to innovations in the construction industry. Driven by digitalization, this transformation includes significant adjustments to company structures, value chains, services, products, and procedures. To increase productivity and efficiency, digital transformation combines emerging technologies with standard approaches like building information modeling (BIM).The construction industry has been slow to adopt digital technologies, but recent advancements have accelerated the pace of digital transformation. This transformation encompasses profound changes in products, services, processes, business models, and value chains driven by digitalisation. Digital transformation involves the integration of emergent technologies with traditional practices, such as BIM, to enhance efficiency and productivity. Adopting digital models is a key aspect of digital transformation, which can significantly impact various factors, including efficiency and productivity. Descriptive qualitative methods are commonly used to examine the impact of digital models, while quantitative methods are employed in case studies to assess the success of digital transformation. Integrating digital technologies, such as BIM and Geographic Information Systems (GIS), can enhance collaboration and optimise project activities. Digital transformation also involves the development of new business models and value chains. For instance, integrating digital technologies with traditional construction practices can lead to the creation of new services and products, such as digital architecture and thought. Furthermore, digital transformation can lead to changes in organisational structures and strategies as companies adapt to the challenges and opportunities presented by new technologies. The construction industry is characterised by a high degree of fragmentation, with numerous companies collaborating on projects involving diverse stakeholders. This fragmentation can hinder the adoption of digital technologies, as companies may struggle to integrate new systems and processes into their existing operations. However, digital transformation can facilitate collaboration and communication among stakeholders, leading to more efficient and effective project execution. Digital transformation is a critical aspect of the construction industry, driven by integrating digital technologies with traditional practices. This transformation involves profound changes in products, services, processes, business models, and value chains and can significantly improve efficiency and productivity. The construction sector can enhance its economic benefits and production efficiency by implementing lean construction (LC) and digital technology integration. In recent years, it has also become a popular topic for theoretical research and innovative applications. To date, only a small number of academics have methodically summed up the idea. Therefore, critical literature analysis is used to analyze the pertinent research articles in academic journals published both domestically and internationally on lean construction and the digital technology used in the construction field. It has been proven that digital technology, particularly BIM technology, has progressively evolved into a crucial

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tool for advancing lean construction applications. Thoroughly integrating the two technologies can have beneficial synergistic effects that lower project management costs and increase efficiency. Although digital technologies have been adopted by the construction industry slowly, the pace of digital transformation has quickened recently due to breakthroughs in the construction industry that has been slow to adopt digital technologies, but recent advancements have accelerated the pace of digital transformation. This transformation encompasses profound product, service, process, business model, and digitalisation-driven value chain changes. Digital transformation involves the integration of emergent technologies with traditional practices, such as Building Information Modelling (BIM), to enhance efficiency and productivity. Digital transformation is a critical aspect of the construction industry, driven by integrating digital technologies with traditional practices. This transformation involves profound changes in products, services, processes, business models, and value chains and can lead to significant improvements in efficiency and productivity. Lean construction（LC）and digital technology integration are the critical paths to improving the economic benefit and production efficiency of the construction industry It is also a hot field of theoretical research and practical innovation in recent years. It has been shown that digital technology (especially building information modelling BIM technology）has gradually become a key support for implementing and promoting lean construction. The in-depth integration of the two technologies can produce positive synergistic effects, further improving efficiency and reducing the cost of project management. Adopting digital models is a key aspect of digital transformation, which can significantly impact various factors, including efficiency and productivity. Descriptive qualitative methods are commonly used to examine the impact of digital models, while quantitative methods are employed in case studies to assess the success of digital transformation. Integrating digital technologies, such as BIM and Geographic Information Systems (GIS), can enhance collaboration and optimise project activities.Digital transformation also involves developing new business models and value chains. For instance, integrating digital technologies with traditional construction practices can create new services and products, such as digital architecture and thought. Furthermore, digital transformation can lead to changes in organisational structures and strategies as companies adapt to the challenges and opportunities presented by new technologies. The construction industry is characterised by high fragmentation, with numerous companies collaborating on projects involving diverse stakeholders. This fragmentation can hinder the adoption of digital technologies, as companies may struggle to integrate new systems and processes into their existing operations. However, digital transformation can facilitate collaboration and communication among stakeholders, leading to more efficient and effective project execution.

Review Method

A standardised literature review was conducted according to Hu *et. al*. (2019) based on the PRISMA principles and methods. Because they assess the state of the art with relation to pertinent literature in the scientific domain, these systematic reviews constitute a significant component of research. In addition, future directions, unmet research needs, and existing difficulties might be noted and explored. Two databases were used to retrieve materials for the following literature study. The literature was then chosen, compiled into an overview, and subjected to a qualitative review. Primary literature materials, such as research articles published in scholarly journals or conference proceedings, were the goals of the retrieval process. Using Science Direct and Scopus databases, literature for a qualitative literature study was first gathered by searching for keywords both separately and together. To answer the research topic, the following search keywords were chosen: digital technologies, construction

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industry, obstacles/difficulties/barriers, and implementation procedure. This process reduced the literature base to 110 papers. The search range in keywords, abstracts, and titles implied that the selection process needed to be more strictly specified. Therefore, all literature in the following six categories were excluded from the qualitative review: 1) Less than five pages, 2) Grey literature, 3) Languages other than English, 4) Non-peer-reviewed journals 5) Articles that do not directly relate to the stated keywords 6) Lack of information about the authors, etc., or the full text. In order to select a large number of pertinent publications for this study, the review technique comprises three important procedures.A thorough literature review involves several steps, the first of which is identification. This phase entails looking for study materials that could be pertinent to the chosen research issue. To choose which papers to include and exclude from the total number of searches, screening is then carried out. The third and final step is to assess the paper's eligibility by looking over the abstract to find the pertinent subject. After that, a review and summary of the scientific literature is conducted in order to identify, select, and assess the important studies that have aided in the digital transformation of the construction industry. After that, a review and summary of the scientific literature is conducted in order to identify, select, and assess the important studies that have aided in the digital transformation of the construction industry. Not to mention, this paper seeks to address the concerns brought up in this work by offering recommendations for additional research. This study employs a specific approach that is acknowledged as a recommended practice to perform an extensive literature review. Publication norms essentially provide relevant and essential information to authors in order to assist them evaluate the accuracy of a review.

Preliminary Identification

The identification phase involves searching for study materials relevant to the predetermined research issue of digital transformation. The keywords used are Technology, Digital technology, Digitalisation and Industry 4.0. Therefore, the first step was to detect keywords and search for similar, equivalent phrases in dictionaries, thesauri, encyclopaedias, and previous research. As a result, after determining all relevant phrases, search strings for the Web of Science and Scopus databases were created (see Table 1). Thus, during the first part of the advanced searching procedure, this study effectively obtained 3048 publications from the databases.

Table 1: The Search String

Scopus	Construction AND TITLE-ABS-KEY (“Technology*” OR “Digital technology*” OR “Digitalisation” OR “Industry 4.0”) AND TITLE-ABS-KEY (“Barrier*” OR “Challenge* Date of Access: May 2024
Science Direct	Construction AND TITLE-ABS-KEY (“Technology*” OR “Digital technology*” OR “Digitalisation” OR “Industry 4.0”) AND TITLE-ABS-KEY (“Barrier*” OR “Hindrance*” OR “Constraint*” OR “Obstacle*” OR “Challenge* Date of Acess : May 2024

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Screening

During the screening process, the collection of potentially pertinent research items is reviewed for content that aligns with the predetermined research topic or questions. The selection of research items based on the database is one of the content-related criteria that is commonly utilized in the screening phase. All duplicate papers will be eliminated from the list of papers that were searched in this step. First, 309 articles were screened out; second, 110 papers were screened in accordance with the study's inclusion and exclusion criteria (refer to Table 2). Since research articles are the main source of useful recommendations, this criterion was applied before any other. Reviews, meta-synthesis, meta-analyses, and publications excluded from the most recent study are also included. It is vital to remember that the strategy only focused on the year 2024. In all, zero publications were rejected based on duplication criteria. Excluding duplicated papers should be the initial step in the screening process. The primary criterion for selection was literature in the form of research articles, as it provides practical information. This led to the exclusion of publications like systematic reviews, reviews, meta-analyses, meta-syntheses, books, book chapters, and conference proceedings from the study. Additionally, the review focused solely on papers written in the English language. It's important to highlight that the chosen timeframe for the study was five years (2021–2025). Moreover, only studies conducted within the geographical scope of Malaysia were included to align with the analysis objective.

Table 2: The Selection Criterion Is Searching

Criterion4	Inclusion	Exclusion
Language	English	Non-English
Time line	2021 – 2025	< 2025
Literature type	Journal (Article)	Conference, Book, Review
Publication Stage	Final	In Press
Subject	Social Science and Computer Science	Besides social science and computer science

Eligibility

In the third phase, referred to as the eligibility assessment, a compilation of 69 articles was assembled. During this stage, the titles and core content of all the articles were meticulously examined to confirm their alignment with the inclusion criteria and relevance to the ongoing study's research objectives. Consequently, 36 data/papers/ articles were excluded as they did not qualify due to the out-of-field, title not significantly, abstract not related to the study's objective and no full-text access founded on empirical evidence. As a result, 35 articles remain for the upcoming review.

Data Abstraction and Analysis

An integrative analysis was used as one of the assessment strategies in this study to examine and synthesise a variety of research designs (quantitative methods). The goal of the competent study was to identify relevant topics and subtopics. The data collection stage was the first step

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in developing the theme. Figure 1 shows how the authors meticulously analysed a compilation of 35 publications for assertions or material relevant to the topics of the current study.

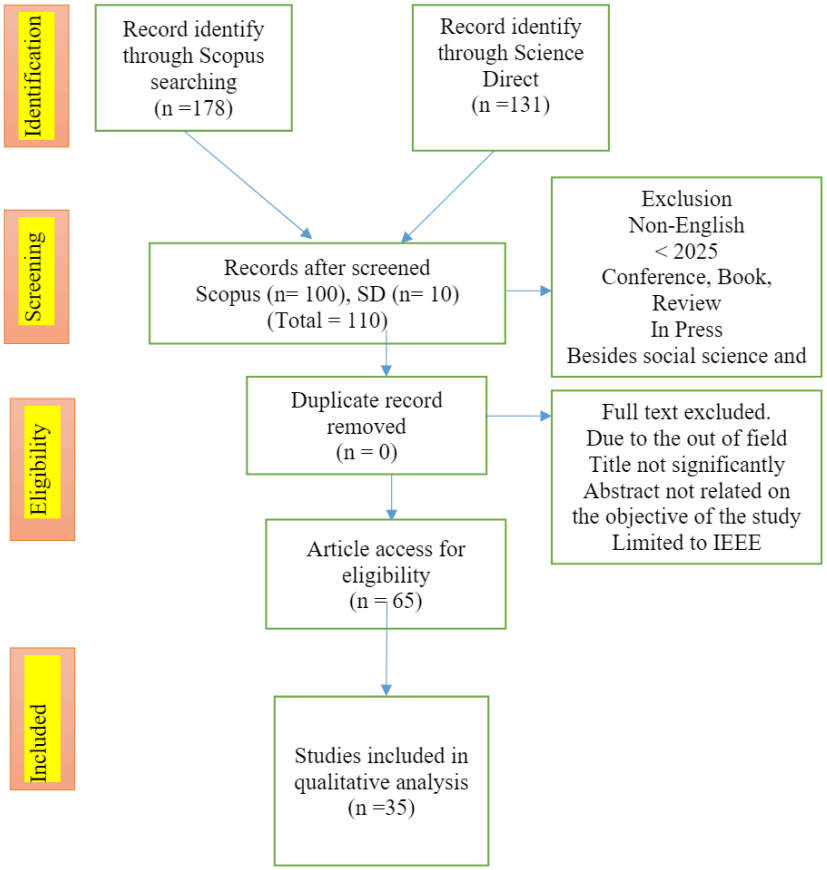

Figure 1. Flow Diagram Of The Proposed Searching Study (Moher et al., 2009

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Result and Finding

All articles were categorised based on three main themes: knowledge and awareness (110 articles), refer (Tab. 4).

Subtheme 1: Integration of Digital Technologies in Project Management

The application of digital technologies in project management within the construction industry has been growing rapidly. Technologies such as Building Information Modeling (BIM), cloud computing, and the Internet of Things (IoT) enable real-time data sharing, improved project coordination, and enhanced decision-making processes. However, integrating these technologies presents several challenges, including resistance to change, high implementation costs, and a lack of skilled professionals. Effective strategies and training programs are essential to overcoming these barriers and maximizing the benefits of digital transformation.

Research Question:

What are the key challenges and effective strategies for integrating digital technologies in the project management processes of construction projects?

Subtheme 2: Impact of Digital Transformation on Project Performance

Digital transformation has a significant impact on the performance of construction projects. The use of digital tools and platforms can lead to improved project outcomes, such as increased efficiency, reduced costs, and enhanced quality. Adopting digital technologies facilitates better communication, streamlined workflows, and more accurate project tracking. However, the extent of these benefits varies depending on the level of digital maturity within organisations and their ability to adapt to new technologies. Further research is needed to quantify the impact of digital transformation on project performance and identify the factors influencing its success.

Research Question:

How does digital transformation affect the performance of construction projects, and what factors influence the successful adoption of digital technologies?

Subtheme 3: Role of Stakeholders in Digital Transformation

The role of stakeholders is crucial in the digital transformation of construction projects. Stakeholders, including clients, contractors, and suppliers, must collaborate effectively to successfully implement digital technologies. Their involvement is essential in the planning, execution, and monitoring phases of projects. Resistance from stakeholders can hinder the adoption of digital tools, while active participation can facilitate smoother transitions and better outcomes. Understanding different stakeholders' perspectives and expectations can help develop strategies that align with their interests and promote cooperation.
Research Question:

What is the role of different stakeholders in the digital transformation of construction projects, and how can their collaboration be enhanced to ensure successful technology adoption?
By focusing on these subthemes and research questions, the paper can explore the multifaceted aspects of digital transformation in contractors' projects, providing valuable insights and practical recommendations for the industry.

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Table 4: The Research Article Finding Based On The Proposed Searching Criterion

Authors	Title	Searching Criterion	Publication Year	Vol.	Issue	Date Published
Yilmaz G,Salter L,Mcfarlane D,Scho B	Low-Cost (Shoestring) Digital Solution Areas For Enabling Digitalisation In Construction SMEs	Computers In Industry	2023	150		2023-09
Chauhan C,Singh A,Luthra S	Barriers To Industry 4.0 Adoption And Its Performance Implications: An Empirical Investigation Of Emerging Economy	Journal Of Cleaner Production	2021	285		2021-02-20
Sadeghi M,Mahmoudi A,Deng X	Adopting Distributed Ledger Technology For The Sustainable Construction Industry: Evaluating The Barriers Using Ordinal Priority Approach	Environmental Science And Pollution Research	2022	29	7	2022-02
Arroyabe MF,Arranz CF,De Arroyabe IF,De Arroyabe JC	The Effect Of IT Security Issues On The Implementation Of Industry 4.0 In Smes: Barriers And Challenges	Technological Forecasting And Social Change	2024	199		2024-02
Soltani S,Maxwell D,Rashidi A	The State Of Industry 4.0 In The Australian Construction Industry: An Examination Of Industry And Academic Point Of View	Buildings	2023	13	9	2023-09
Jaafar M,Salman A,Ghazali FE,Zain MZ,Kilau NM	The Awareness And Adoption Level Of Emerging Technologies In Fourth Industrial Revolution (4IR) By Contractors In Malaysia	Ain Shams Engineering Journal	2024	15	5	2024-05

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From Table 4 research articles addressing various aspects of digitalization and Industry 4.0 adoption across different industries and geographical contexts. Here are some discussion points based on the provided data:

Diverse Perspectives: The authors come from various countries and backgrounds, highlighting the global interest and impact of Industry 4.0. This diversity enriches the discussion, as different regions may face unique challenges and opportunities in adopting digital technologies.

Barriers to Adoption: Many articles focus on identifying and analyzing barriers to the adoption of Industry 4.0 technologies. These barriers range from technological challenges to organizational and socio-economic factors. Understanding and addressing these barriers are crucial for successful implementation.

Sector-specific Challenges: The research covers a wide range of industries, including construction, manufacturing, agriculture, and supply chain logistics. Each industry faces its own set of challenges and opportunities in adopting Industry 4.0 technologies. For example, the construction industry may encounter difficulties in implementing digital solutions due to its traditionally conservative nature and fragmented supply chain.

SME Focus: Several articles specifically examine the adoption of Industry 4.0 technologies by small and medium-sized enterprises (SMEs). SMEs often face unique challenges, such as limited resources and expertise, which can hinder their digital transformation efforts. Understanding these challenges is essential for designing targeted interventions to support SMEs in adopting digital technologies.

Environmental Sustainability: A significant portion of the research explores the intersection of Industry 4.0 and environmental sustainability. Digital technologies have the potential to enhance sustainability by optimizing resource usage, reducing waste, and enabling more efficient production processes. However, there are also concerns about the environmental impact of digitalization, such as increased energy consumption and electronic waste generation.

Methodological Approaches: The articles employ various methodological approaches, including empirical investigations, literature reviews, conceptual frameworks, and mathematical modeling. This methodological diversity reflects the interdisciplinary nature of research on Industry 4.0 and enables a comprehensive understanding of the topic.

Policy Implications: Understanding the barriers to Industry 4.0 adoption has implications for policymakers, industry stakeholders, and researchers. Policy interventions may be needed to address regulatory hurdles, promote collaboration between industry and academia, and provide financial incentives for technology adoption.

Overall, the research presented in the diagram contributes to our understanding of the challenges and opportunities associated with the adoption of Industry 4.0 technologies across different industries and contexts. By addressing these challenges, stakeholders can unlock the full potential of digitalization to drive innovation, improve productivity, and promote sustainable development.

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Conclusion

In conclusion, the construction sector plays a significant role in the global economy, but it also has a substantial impact on the environment. To address climate change and other environmental challenges, it is crucial for the sector to adopt sustainable practices, despite the financial constraints and digital transformation offers immense opportunities for contractors' projects in the construction industry. By embracing automation technologies, collaboration platforms, and emerging digital tools, contractors can enhance efficiency, reduce costs, and improve project outcomes. However, challenges such as skilled labor shortages and initial costs must be addressed to fully realize the benefits of digital transformation. The ROOM framework provides a promising approach for leveraging digital technologies to address social inequities and create more inclusive housing solutions. Continued research and innovation are essential to advancing digital construction practices and promoting social equity in the industry.

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