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RESEARCH ARTICLE

Bridging the Digital Divide: Overcoming Challenges in Technology Adoption in Malaysia's Construction Industry

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ABSTRACT

The integration of advanced digital technologies within Malaysia's construction industry represents a transformative step toward enhancing efficiency, sustainability, and global competitiveness in line with the Industry 4.0 revolution. Despite advancements in digital tools like Building Information Modeling (BIM), Internet of Things (IoT), and artificial intelligence, the sector faces challenges such as poor communication, high costs, and resistance to change. This study examines the key factors driving digital technology adoption, the challenges hindering its implementation, and the strategies to accelerate digital transformation within the industry. Using a structured survey method, data was gathered from 141 respondents, including consultants, subcontractors, and project owners actively engaged in Malaysia's construction sector. Enhanced budgeting, cost management, and improved risk management emerge as critical drivers, while lack of process standardisation and digital expertise are noted as secondary concerns. Data-driven decision-making, infrastructure investment, and structured change management are identified as pivotal strategies for successful technology integration. Findings suggest that widespread adoption requires collaboration among stakeholders, comprehensive training programs, and phased implementation plans to address barriers and foster acceptance. This research contributes to Malaysia's Construction 4.0 framework, emphasising the need for targeted interventions to modernise practices, improve productivity, and achieve national development goals.

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Contribution/Originality: This study contributes to the existing literature on Malaysia's Construction 4.0 framework by identifying key barriers to digital technology adoption. The paper's primary contribution is finding that overcoming communication gaps and fragmented processes is crucial for improving productivity and achieving national development goals in the construction sector.

1. Introduction

The five-year Construction 4.0 Strategic Plan is a short-term initiative by CIDB, as outlined in their Annual Report 2022, designed to provide a foundational framework aimed at advancing the construction sector's capabilities within the Industry 4.0 Revolution (4IR). Industry 4.0 focuses on the digitalisation of industrial processes, creating a flexible and interconnected network of production and services (Hallward-Driemeier & Nayyar, 2017; Lu, Xu, & Wang, 2020; Chen et al., 2018). The integration of Industry 4.0 technologies has become especially beneficial in response to the challenges posed by the COVID-19 pandemic. The pandemic accelerated the adoption of digital and contactless operations due to the necessity of physical distancing and evolving consumer demands. According to a McKinsey poll conducted six months into the pandemic, 94% of respondents affirmed that Industry 4.0 technologies had helped their businesses remain operational, and 56% identified these tools as critical to crisis response (Agrawal et al., 2021).

The implementation of 4IR technologies creates an ecosystem where automation systems are interconnected, enabling seamless data exchange and operations without human intervention, thereby improving efficiency. The concept of a "smart factory" exemplifies this, where cloud computing and cognitive computing store data and facilitate decision-making. Cyber-physical systems, supported by the Internet of Things (IoT), allow real-time process monitoring, even remotely, demonstrating the potential of 4IR advancements.

The construction sector's future hinges on integrating innovative ideas and advanced technologies into existing processes. The delivery of buildings and infrastructure will evolve with the adoption of these technologies and new approaches. Beyond creating energy-efficient structures and infrastructure, these advancements aim to improve societal living standards. With increasing complexity and interconnected demands in construction projects, the sector must leverage cutting-edge technologies and innovative business models to provide greater value. However, technology is just one of several disruptive factors that will significantly influence construction productivity and operations.

Numerous studies have examined the application of digital technologies across various domains of the construction industry. For example, innovations in health and safety (HSE Network, 2023) and supply chain management (Güngör & Leindecker, 2024) highlight the extensive impact of digitalisation in these areas. To remain competitive, construction stakeholders must continue adopting advanced technologies and methodologies as digitisation progresses. In this context, the widespread adoption of digital technologies is essential for enhancing efficiency, safety, and sustainability in the Malaysian construction industry.

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1.1. Problem Statement

Digital technology has significantly transformed industries worldwide, driving innovation and improving efficiency. Industries have been progressively replacing manual processes with digital solutions or upgrading older technologies to remain competitive. While sectors like manufacturing, retail, and agriculture have experienced rapid digital advancements, the construction industry has been slower to adopt such changes. Many construction companies continue to rely on traditional practices, including mechanical technologies, extensive physical labour, and legacy operational structures. This lack of technological integration has hindered productivity improvements in the sector. Specifically, low adoption of digital tools and poor planning have contributed to the stagnation of productivity levels, positioning the Malaysian construction industry behind others in terms of technology adoption.

Despite these challenges, the construction industry is beginning to embrace the potential of digital transformation. Digitisation offers opportunities to improve efficiency, reduce costs, and enhance profitability. However, barriers such as high technology costs, resistance to change, and a lack of expertise continue to impede widespread adoption. While Malaysia has demonstrated a reasonable rate of new technology adoption, particularly in deploying digital tools, the construction sector still faces significant hurdles. These challenges highlight the need for comprehensive strategies to facilitate the transition from traditional to digital processes. The current body of research has provided valuable insights into the potential of digital technologies in construction, yet critical gaps remain.

Research has shown that digital technologies are essential at various stages of construction. Despite growing awareness, adoption levels remain inconsistent, particularly during certain phases of construction projects. Recent research underscores the significance of understanding the factors influencing technology adoption to promote sustainable industry development (Ma et al., 2024; Bandara & Athapaththu, 2024). However, limited research focuses on these factors, creating a need to explore how companies can effectively integrate digital tools into their workflows.

The adoption of new technologies is a complex process that often encounters several significant challenges. While existing research addresses implementation factors such as training and technological capabilities, limited attention has been given to the barriers that impede the successful integration of new systems. Unexpected implementation difficulties, including technical malfunctions or misalignment with organisational processes, can significantly disrupt the adoption timeline and lead to inefficiencies (Demirkesen & Tezel, 2022). Additionally, organisational resistance, often rooted in a lack of trust or fear of change, poses another substantial challenge. Such resistance can hinder cooperation across teams, delaying the adoption process. The Malaysian construction industry exemplifies these challenges, where companies struggle with these barriers despite recognizing the potential benefits of new technologies.

Resource constraints further compound the problem, as many organisations lack adequate financial and human resources to implement and sustain new technologies effectively. Rinchen et al. (2024) emphasize that resource constraints significantly hinder the adoption of Building Information Modeling (BIM) in developing countries, limiting both access to advanced systems and the development of necessary skills for effective implementation. This challenge is particularly acute in industries such as construction,

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where projects are often constrained by tight budgets and schedules. Research suggests that organisational leaders often underestimate the total cost of technology adoption, including training, maintenance, and potential disruptions during the transition period (Masood & Sonntag, 2020). Without addressing these constraints, the likelihood of successful technology adoption decreases substantially.

Understanding these challenges is crucial to improving adoption rates and realizing the potential benefits of new technologies. Researchers advocate for a comprehensive approach to address these barriers, including early stakeholder engagement, resource allocation strategies, and robust implementation frameworks (Demirkesen & Tezel, 2022; Masood & Sonntag, 2020). In the Malaysian construction industry, such measures could mitigate resistance and align organisational processes with technological advancements, ultimately driving higher adoption rates. These insights underscore the need for ongoing research and practical solutions to bridge the gap between technology potential and implementation success.

The adoption of digital technologies aligns with the Construction 4.0 framework, which emphasises the integration of advanced tools and methods into construction processes. This framework is rooted in the broader concept of Industry 4.0, advocating for the application of technologies such as Building Information Modeling (BIM), robotics, and Internet of Things (IoT) to revolutionise construction practices (Bosch-Sijtsema et al., 2019; Garyaev & Garyaeva, 2019). Studies underscore the transformative potential of digitalisation in improving project efficiency, reducing costs, and enhancing collaboration across stakeholders (Osorio-Gomez et al., 2024). Despite these advantages, the practical adoption of these technologies remains limited, as construction firms often lack the necessary frameworks to effectively implement these innovations.

While existing research highlights the opportunities associated with digitalisation, there is a paucity of studies focusing on the practical strategies needed for adoption in construction (Bosch-Sijtsema et al., 2019; Osorio-Gomez et al., 2024). Challenges such as financial constraints, resistance to change, and inadequate technical expertise remain significant barriers in the construction industry, particularly in emerging economies (Shahzaib et al., 2024). Digital transformation in the construction sector necessitates integrating advanced technologies and aligning organizational structures to foster effective leadership, enhance adaptability, and overcome resistance to change (Osorio-Gomez et al., 2024). The lack of actionable guidelines creates a barrier to entry for many firms, limiting the industry's overall capacity to embrace Construction 4.0 fully.

This study addresses critical gaps in understanding the factors influencing digital technology adoption in the construction industry, particularly within the Malaysian context. While existing studies often provide a broad overview of digitalisation challenges, this research delves deeper into industry-specific issues such as communication barriers and fragmented processes. By doing so, it offers actionable insights to overcome these hurdles, aligning with the frameworks and recommendations of Succar (2009) and similar analyses of barriers to digital adoption in construction by Azhar et al. (2012).

By focusing on the Malaysian construction sector, the study identifies key challenges and proposes strategies for structured integration of digital tools to enhance efficiency, sustainability, and competitiveness. The findings not only contribute to the broader literature on digital transformation but also offer insights that are relevant to both developed and emerging markets. This approach provides the strategic guidance needed

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to navigate the complexities of digitalisation effectively and aligns with industry efforts to embrace technological advancements in line with Construction 4.0 objectives.

2. Literature Review

2.1. Digital Technology in Construction

Digital transformation has become a pivotal element in revolutionizing industries worldwide, and the construction sector is no exception. In Malaysia, the adoption of digital technology in construction holds the potential to overcome longstanding challenges such as inefficiencies, low productivity, and safety concerns. Despite its benefits, the Malaysian construction industry has been slow to adopt digital solutions, largely due to high costs, fragmented industry practices, and resistance to change. This literature review explores the current state of digital technology adoption in the Malaysian construction industry, focusing on the key technologies in use, factors influencing their adoption, challenges impeding their implementation, and strategies for overcoming these barriers.

The integration of digital tools in the construction sector is reshaping traditional workflows, enabling stakeholders to enhance productivity, safety, and project outcomes. Technologies such as Building Information Modeling (BIM), Internet of Things (IoT), and artificial intelligence (AI) have gained traction for their ability to streamline processes and reduce inefficiencies. For instance, BIM has demonstrated its capability to lower project costs by up to 5% and shorten completion times by 7% through better design coordination and clash detection (Sacks et al., 2018). Similarly, IoT technologies facilitate real-time monitoring, significantly improving safety and minimising disruptions (Lorusso & Celenta, 2023). These advancements underscore the transformative potential of digital technologies in addressing critical inefficiencies in Malaysian construction.

2.2. Influencing Factors of Adoption

The adoption of digital technologies in construction is driven by several key factors. Real-time updates and improved communication significantly enhance project coordination and foster collaboration among stakeholders in construction projects (Chen, 2023). Cloud-based platforms allow for seamless information sharing, enabling faster decision-making and improved project outcomes (Srivastava et al., 2022). Furthermore, digital workflows for project management reduce manual errors, improve data accessibility, and enhance resource utilization (Doan et al., 2022).

Enhanced planning and predictive analytics also play a crucial role, allowing stakeholders to forecast potential risks and adjust strategies proactively. For example, the integration of AI-driven tools has proven effective in resource optimisation and risk management, ensuring greater operational efficiency (Nguyen & Akhavian, 2019). Collectively, these factors highlight the value of digital tools in transforming the construction sector.

2.3. Challenges in Digital Technology Adoption

Despite the benefits, the Malaysian construction industry faces substantial barriers to adopting digital technologies. Internal challenges such as high initial costs, a lack of digital expertise, and resistance to change are prevalent (Sawhney et al., 2020). The high upfront investments required for technology acquisition often discourage firms from transitioning

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to digital solutions (Almaiah et al., 2022). Additionally, the limited availability of skilled workers to operate these technologies hampers widespread adoption (Tan, 2023).

External challenges, including industry fragmentation and the unique nature of construction projects, further impede progress. According to Riazi et al. (2020), fragmentation complicates coordination among various stakeholders, while project-specific requirements make standardisation difficult. These issues are compounded by privacy and cybersecurity concerns, which deter firms from adopting data-intensive technologies (Mantha et al., 2020).

2.4. Implementation Strategies

Addressing these challenges requires a comprehensive approach. Education and training initiatives are critical for building a digitally competent workforce. Tailored training programs can close skill gaps and ensure that workers are equipped to utilise digital tools effectively (Chen et al., 2022). Investments in infrastructure and partnerships with technology providers can also facilitate access to advanced tools such as IoT and AI (Kang et al., 2020).

Change management strategies, including gradual implementation and replication of successful pilot projects, can mitigate resistance to change and build stakeholder confidence in digital solutions (Sepasgozar & Davis, 2019). Data-driven decision-making frameworks further enhance implementation by leveraging analytics to optimize processes and outcomes (Wang et al., 2019). By focusing on these strategies, the Malaysian construction industry can overcome existing barriers and accelerate digital transformation.

Digital technology offers transformative potential for addressing inefficiencies and boosting productivity in the Malaysian construction industry. However, the path to widespread adoption is fraught with challenges that require targeted interventions. From fostering a skilled workforce to implementing robust change management practices, the success of digital transformation hinges on a collaborative and strategic approach. Aligning with Malaysia's Construction 4.0 Strategic Plan, these efforts can pave the way for a more modern, efficient, and sustainable construction industry. By overcoming these barriers, the industry can not only enhance its competitiveness but also contribute significantly to national development goals.

3. Research Methods

3.1. Research Design

This study adopts a quantitative approach to systematically investigate the research problem through the collection and analysis of numerical data. This approach, as highlighted by Creswell and Creswell (2017), is particularly effective for testing hypotheses, exploring relationships between variables, and generating measurable, generalisable results through structured data collection and rigorous statistical analysis.

3.2. Sampling

The location of the study is Klang Valley, Malaysia. The exact size of the target population, comprising Malaysian construction professionals adopting digital technologies, is

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unavailable due to the lack of comprehensive records or an authoritative database. The study employed snowball and convenience sampling, methods well-suited for exploratory research where the target population is not easily accessible or well-defined (Biernacki & Waldorf, 1981; Etikan et al., 2016). These methods are practical and ethical for gathering insights into specific phenomena when achieving full generalisability is not the primary goal. Snowball sampling enables the inclusion of hard-to-reach respondents through referrals, while convenience sampling allows efficient data collection from accessible participants. The sample size of 141 respondents aligns with established guidelines for survey research, which recommend a minimum of 100 to 200 participants to provide meaningful insights while maintaining practicality in data collection (Creswell & Creswell, 2017; Hair et al., 2010). These methods and sample size considerations ensure the study's findings are robust and provide generalisable insights within the context of the Malaysian construction industry.

3.3. Research Instruments

A Google Form questionnaire was employed as the primary data collection tool due to its user-friendly interface, automatic data organisation, and compatibility with statistical analysis software, making it ideal for collecting structured responses (Almaiah & Al-Khasawneh, 2020). The questionnaire was designed to include sections on respondent demographics, preferred digital tools, challenges in digital adoption, and strategies for effective implementation, utilising Likert-scale questions to measure perceptions and attitudes (Boone & Boone, 2012).

To ensure clarity, reliability, and validity, a pilot test was conducted with 15 participants. Cronbach's Alpha values for influencing factors, challenges, and strategies were 0.935, 0.846, and 0.882, respectively, demonstrating high internal consistency (Tavakol & Dennick, 2011). Feedback from the pilot study informed minor revisions to improve question clarity.

For data analysis, SPSS software was used to conduct descriptive statistical analyses, including frequency distributions, Cronbach's Alpha reliability tests, and mean rankings. These methods facilitated the identification of key patterns, consistency of Likert-scale items, and prioritisation of factors, challenges, and strategies (Pallant, 2020).

4. Results and Discussion

The survey was conducted for a month from 20 May 2024 to 20 June 2024. A total of 141 valid questionnaires were collected to bolster the validity of the study and testing.

Figure 1 highlights the uneven adoption of digital tools in Malaysian construction companies, reflecting a broader trend of slow integration in the industry. Over one-third of respondents indicated no use of digital technology tools, signalling a significant gap in adoption. The relatively high usage rates of Building Information Modeling (BIM) and project management software, each cited by 44 participants, indicate their perceived value in enhancing operational efficiency (Sacks et al., 2018; Wang et al., 2019). Tools like cloud computing and drones or 3D printing also show moderate adoption, with 35 and 31 mentions, respectively, underscoring their growing but limited acceptance (Lorusso & Celenta, 2023). Advanced technologies, including Internet of Things (IoT) and augmented/virtual reality (AR/VR), are less prevalent, with fewer than 20 participants reporting their use, reflecting barriers such as high costs and expertise shortages

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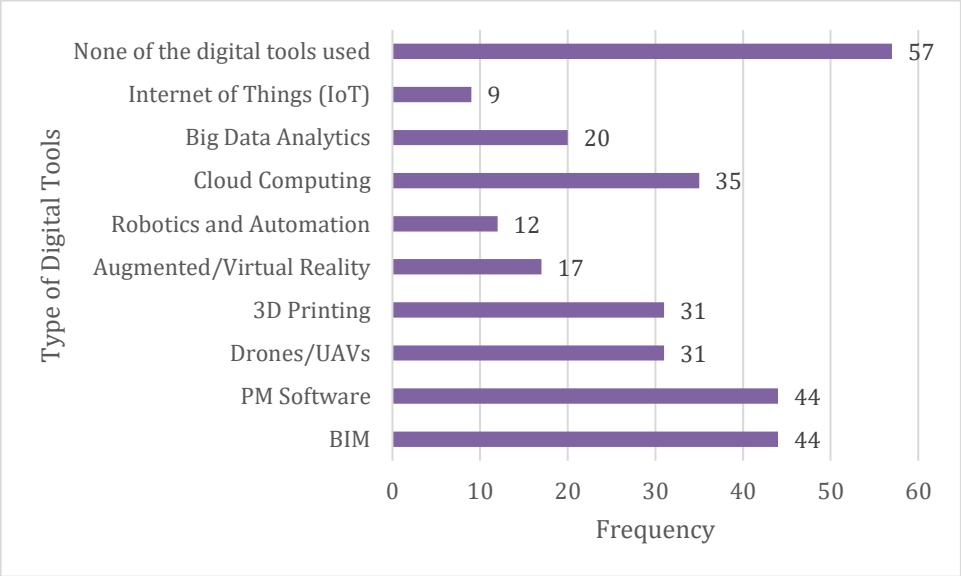
(Almaiah et al., 2022; Tan, 2023). These findings suggest the need for targeted strategies, such as education initiatives and gradual implementation, to bridge the adoption gap and align the industry with global digitalisation trends (Chen et al., 2022; Sepasgozar & Davis, 2019).

According to Figure 1, more than one-third of construction respondents (57 out of 141) reported not using any digital technology tools. This highlights a significant gap in awareness and adoption, suggesting considerable potential for growth and improvement in the integration of digital technologies within the industry.

Figure 1: Frequency of Current Digital Technology Tools Usage in Construction Company



Among the digital tools currently used in organisations, BIM and PM software are the most widely adopted, each garnering 44 responses, representing nearly one-third of the participants. Cloud computing follows with 35 votes, indicating moderate adoption. Drones/UAVs and 3D printing received 31 votes each, showing that these technologies are also gaining traction but remain underutilised compared to the leading tools.

The remaining tools show much lower adoption rates. Big Data Analytics, Augmented/Virtual Reality (AR/VR), Robotics and Automation, and Internet of Things (IoT) received 20, 17, 12, and 9 votes, respectively. These figures indicate that these advanced technologies are still in the early stages of adoption within the construction industry.

The findings suggest that awareness and acceptance of digital technology tools among construction practitioners remain low. None of the tools achieved more than half of the participant votes, highlighting the need for greater education, promotion, and incentives to accelerate the adoption of these technologies in the sector.

Table 1 shows the results of respondents rating the efficacy of 10 influencing factors affecting technology adoption in their companies, using a 5-point Likert scale. These ratings provide insights into how these factors impact digital technology adoption within the construction industry.

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Table 1: Factors Influencing Digital Technology Adoption in Construction

Code	Item	Mean	Std. Deviation	Rank
IF5	Enhanced budgeting and cost management	4.08	1.086	1
IF10	Improved risk management and opportunity capture	4.04	1.288	2
IF4	Improved planning, scheduling, and forecasting	3.79	1.373	3
IF9	Enhanced project performance and delivery	3.79	1.082	4
IF8	Enhanced decision-making and proactive adjustments	3.85	1.098	5
IF2	Improved communication and collaboration	3.77	1.146	6
IF3	Digital workflows for project management	3.67	1.043	7
IF7	Improved progress tracking and reporting	3.67	1.145	8
IF1	Real Time Updates	3.65	0.891	9
IF6	Enhanced quality control and assurance	3.61	1.242	10

The analysis identifies enhanced budgeting and cost management (IF5) as the most significant factor influencing digital technology adoption in the Malaysian construction industry, with a mean score of 4.08. This finding aligns with Abioye et al. (2021), who emphasized that effective cost management is critical for adopting digital tools, particularly in budget-sensitive industries. Improved risk management and opportunity capture (IF10) follows closely with a mean score of 4.04, reflecting the role of digital tools in mitigating uncertainties and capitalizing on opportunities (Nguyen & Akhavian, 2019). Improved planning, scheduling, and forecasting (IF4), with a mean score of 3.79, highlights the growing reliance on AI and predictive analytics to enhance project efficiency (Wang et al., 2019).

Conversely, enhanced quality control and assurance (IF6) ranks the lowest, with a mean score of 3.61. While important, its lower ranking may indicate that stakeholders prioritize cost and risk factors over quality enhancements during the initial adoption phase (Zhang et al., 2013). Real-time updates (IF1) and improved progress tracking and reporting (IF7) scored lower, suggesting that while these features are valuable, they are perceived as supplementary to primary adoption drivers like budgeting and risk management (Pal et al., 2024).

The analysis highlights the top three and lowest-ranked factors influencing the adoption of digital technologies. Enhanced budgeting and cost management (IF5) ranks highest, with a mean score of 4.08 and a relatively low standard deviation of 1.086. This indicates that effective budgeting and cost control are widely regarded as the most critical factor for successful digital technology adoption, with consistent agreement among respondents. Improved risk management and opportunity capture (IF10) is the second-highest factor, with a mean of 4.04 and a slightly higher standard deviation of 1.288. This reflects its importance in managing uncertainties and seizing opportunities, although opinions on its significance are somewhat varied. Ranking third is improved planning, scheduling, and forecasting (IF4), which ties in mean score (3.79) with enhanced project performance and delivery (IF9) but has a slightly higher standard deviation (1.373 compared to 1.082). This indicates that planning and forecasting are crucial but subject to more varied perceptions of importance.

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The lowest-ranked factor is enhanced quality control and assurance (IF6), with a mean score of 3.61 and a standard deviation of 1.242. This suggests that while quality control remains relevant, it is not prioritised as highly as other factors in the context of digital technology adoption. Real-time updates (IF1) ranks second-lowest, with a mean of 3.65 and the lowest standard deviation (0.891) among all factors, showing a smaller range of opinions but less urgency compared to other considerations. Improved progress tracking and reporting (IF7) and digital workflows for project management (IF3), both with a mean score of 3.67, are also lower priorities, though they remain important for operational efficiency.

Overall, the top factors underline the importance of financial and risk management, as well as planning and forecasting, in driving digital adoption in construction projects. Conversely, while lower-ranked factors like quality control, real-time updates, and progress tracking are not seen as immediate priorities, they contribute to the long-term success of digital transformation efforts.

The findings, as presented in Table 2, identify poor communication and coordination (CH5) as the most critical challenge, with a mean score of 4.31. This underscores the widespread recognition of communication barriers as a major hindrance to digital technology integration, corroborating research by Takyi-Annan and Zhang (2023). The lack of clear value propositions (CH7), ranking second with a mean of 4.12, indicates that many stakeholders are uncertain about the tangible benefits of adopting digital tools, a challenge noted by Sawhney et al. (2020). High initial costs (CH2), with a mean score of 3.92, remain a significant barrier, reflecting the financial constraints highlighted by Almaiah et al. (2022).

Table 2: Challenges to Implement Digital Tools in Construction Industry

Code	Item	Mean	Std. Deviation	Rank
CH5	Poor Communication and Coordination	4.31	0.989	1
CH7	Lack of Clear Value Propositions	4.12	1.120	2
CH2	High Initial Costs	3.92	1.191	3
CH10	Privacy and Security Concerns	3.98	1.291	4
CH6	Low Acceptance of Digital Technologies	3.95	1.216	5
CH1	Resistance to Change	3.90	1.163	6
CH8	Industry Fragmentation	3.88	1.235	7
CH9	Project Uniqueness	3.94	1.166	8
CH3	Lack of Digital Knowledge and Expertise	3.54	1.206	9
CH4	Lack of Process Standardisation	3.40	1.373	10

The least critical challenge is the lack of process standardisation (CH4), with a mean score of 3.40. This indicates varied perceptions among respondents, likely due to differing levels of standardisation across organisations. Similarly, the lack of digital knowledge and expertise (CH3), with a mean score of 3.54, highlights a secondary barrier, as training and upskilling initiatives may mitigate this issue (Chen et al., 2022).

It reveals that poor communication and coordination (CH5) is the most critical challenge in adopting digital technologies within the construction sector, with a mean score of 4.31 and a low standard deviation of 0.989, indicating consistent agreement among respondents. This emphasises the widespread recognition of communication issues as a major obstacle. Following this, the lack of clear value propositions (CH7) ranks second,

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with a mean of 4.12 and a slightly higher standard deviation of 1.120. This suggests that while many respondents see the need for clearer justifications for digital technology investments, perceptions of its severity vary somewhat. High initial costs (CH2) rank third, with a mean of 3.92 and a standard deviation of 1.191, highlighting the financial burden as a key concern. The variability in responses reflects that this challenge may affect organisations differently, depending on their financial resources.

Lower-ranked factors include lack of process standardisation (CH4), which is perceived as the least critical challenge, with a mean of 3.40 and the highest standard deviation (1.373). This suggests a wide range of views, likely reflecting differences in the level of process standardisation already achieved across organisations. Similarly, the lack of digital knowledge and expertise (CH3), with a mean score of 3.54 and a standard deviation of 1.206, is the second-lowest factor. This indicates that while digital knowledge gaps exist, they are not seen as the most pressing issue compared to other challenges.

Overall, the top challenges highlight the need for improved communication, clear value propositions, and financial strategies to overcome cost barriers. Addressing these issues is critical to advancing digital technology adoption in the construction sector. Meanwhile, lower-ranked challenges such as standardisation and expertise, though less urgent, remain important for ensuring long-term success in digital transformation efforts.

Table 3 presents data showing that data-driven decision-making (ST4) ranks as the top strategy, with a mean score of 4.43, emphasising the significance of analytics in guiding decisions, as supported by Wang et al. (2019). Investment in infrastructure and partnerships (ST2), with a mean of 4.31, underscores the need for robust technological foundations and collaborative efforts, aligning with findings by Kang et al. (2020). Comprehensive change management (ST3), ranking third at 4.30, highlights the necessity of addressing resistance to change through structured processes (Sepasgozar & Davis, 2019).

Table 3: Strategies to Accelerate Digital Transformation within the Industry

Code	Item	Mean	Std. Deviation	Rank
ST4	Data-driven decision-making	4.43	0.870	1
ST2	Investment in Infrastructure and Partnerships	4.31	0.868	2
ST3	Comprehensive Change Management	4.30	0.889	3
ST5	Customizable and Cost-Effective Digital Solutions	4.23	0.970	4
ST6	Gradual Implementation and Replication	4.08	0.931	5
ST1	Education and Training Initiatives	4.01	1.038	6

At the lower end, education and training initiatives (ST1) scored a mean of 4.01. While relevant, respondents may perceive immediate operational strategies as more critical. Gradual implementation and replication (ST6), with a mean score of 4.08, reflects the practical need for phased approaches to adoption, minimising risks associated with abrupt transitions (Sawhney et al., 2020).

The analysis highlights the key strategies ranked by their importance. Data-driven decision-making (ST4) emerges as the top-ranked strategy, with a mean of 4.43 and a relatively low standard deviation of 0.870, demonstrating strong agreement among respondents. This underscores the critical role of leveraging data to guide decisions

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effectively. Following closely is investment in infrastructure and partnerships (ST2), with a mean of 4.31 and a standard deviation of 0.868, reflecting its significance in creating a supportive foundation for digital transformation. The third-ranked strategy, comprehensive change management (ST3), has a mean score of 4.30 and a slightly higher standard deviation of 0.889, indicating that managing change effectively is vital to successful implementation of new technologies.

At the lower end of the ranking, education and training initiatives (ST1) holds the sixth position, with a mean of 4.01 and the highest standard deviation of 1.038. While it remains relevant, its lower score suggests that respondents view other strategies as more immediate priorities. Gradual implementation and replication (ST6), with a mean of 4.08 and a standard deviation of 0.931, ranks slightly higher but is still less emphasised compared to the top-ranked strategies.

In summary, data-driven decision-making, infrastructure investment, and change management are seen as the cornerstones of effective digital adoption. Although strategies like education, training, and gradual rollouts are not given as much emphasis, they still play a supportive role in ensuring the long-term success of digital initiatives.

The results emphasise the critical role of financial and risk management factors in driving digital technology adoption while highlighting poor communication and high costs as significant barriers. Strategies such as data-driven decision-making, infrastructure investments, and change management are pivotal for successful integration. Addressing these challenges and leveraging key strategies can accelerate the adoption of digital technologies, enhancing efficiency and sustainability in the Malaysian construction industry. These findings align with Malaysia's Construction 4.0 framework, which aims to modernize the sector through digital transformation.

5. Conclusion

The adoption of digital technologies in the Malaysian construction industry holds significant potential to enhance efficiency, sustainability, and competitiveness. However, the journey towards widespread digital transformation is challenged by issues such as poor communication, high initial costs, and resistance to change. Enhanced budgeting and cost management, along with improved risk management and planning, emerge as critical factors driving adoption. Addressing these challenges requires the implementation of strategic initiatives such as data-driven decision-making, investment in infrastructure, and robust change management strategies (Sawhney et al., 2020; Wang et al., 2019).

Collaboration among stakeholders—including government agencies, industry players, and academia—is crucial to fostering innovation and overcoming barriers to digital adoption. As mentioned by Chen et al. (2022), efforts should prioritise education and training initiatives to address the lack of digital expertise, ensuring a competent workforce capable of utilizing advanced technologies effectively. Moreover, phased implementation and pilot projects can build stakeholder confidence and minimise resistance to change (Sepasgozar & Davis, 2019). By addressing these challenges and leveraging the identified strategies, the Malaysian construction sector can align itself with the global trends of Industry 4.0 and contribute significantly to national economic growth.

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Ethics Approval and Consent to Participate

This research adhered to all ethical standards governing studies involving human participants. Ethical approval was secured prior to conducting the study, ensuring compliance with institutional and international guidelines. All participants provided informed consent after being briefed about the study's purpose, procedures, and their rights. Participation was entirely voluntary, and respondents were assured that they could withdraw at any time without facing any negative consequences. These measures were implemented to uphold the principles of respect, autonomy, and confidentiality, with all information disclosed, treated with the utmost confidentiality and anonymised to protect participants' identities.

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Conflict of Interest

The authors declare there are no conflicts of interest.

References

Abioye, T. E., Oyedele, L. O., Akanbi, L. A., Ajayi, A. O., Delgado, J. M. D., Bilal, M., & Akinade, O. O. (2021). Artificial intelligence in the construction industry: A review of present status, opportunities and future challenges. *Journal of Building Engineering,* 44, 103299. https://doi.org/10.1016/j.jobe.2021.103299

Agrawal, V., De Smet, A., Lacroix, S., & Reich, A. (2021). *COVID-19: An inflection point for Industry 4.0*. McKinsey & Company. Retrieved from https://www.mckinsey.com/capabilities/operations/our-insights/covid-19-an-inflection-point-for-industry-40

Almaiah, M. A., & Al-Khasawneh, A. (2020). Investigating the main determinants of mobile cloud computing adoption in university campus. *Education and Information Technologies, 25*(6), 3087–3107. https://doi.org/10.1007/s10639-020-10120-8

Almaiah, M. A., Al-Khasawneh, A., Althunibat, A., & AbuShanab, E. (2022). Challenges in adopting digital technologies in construction. *Journal of Construction Innovation, 18*(2), 145–165. https://doi.org/10.1007/s10639-020-10120-8

Azhar, S., Khalfan, M., & Maqsood, T. (2012). Building information modelling (BIM): Now and beyond. *Australasian Journal of Construction Economics and Building, 12*(4), 15–28. https://doi.org/10.5130/ajceb.v12i4.3032

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Bandara, W. A. A. M., & Athapaththu, J. C. (2024). Factors influence on e-procurement adoption in tea processing factories in Sri Lanka. *International Journal of Supply Chain and Logistics, 8*(4), 1–27. https://doi.org/10.47941/ijscl.2362

Biernacki, P., & Waldorf, D. (1981). Snowball sampling: Problems and techniques of chain referral sampling. *Sociological Methods & Research, 10*(2), 141-163. https://doi.org/10.1177/004912418101000205

Boone, H. N., & Boone, D. A. (2012). Analyzing Likert data. *Journal of Extension, 50*(2), 1–5. https://doi.org/10.34068/joe.50.02.48

Bosch-Sijtsema, P. M. & Gluch, P. (2019). Challenging construction project management institutions: the role and agency of bim actors. *International Journal of Construction Management, 21*(11), 1077-1087. https://doi.org/10.1080/15623599.2019.1602585

Chen, B., Wan, J., Shu, L., Li, P., & Mukherjee, M. (2018). Smart Factory of Industry 4.0: Key technologies, application case, and challenges. *IEEE Access,* 6, 6505–6519. https://doi.org/10.1109/ACCESS.2017.2783682

Chen, H. (2023). Analysis of construction industry information management to improve project management. *Journal of Logistics, Informatics and Service Science, 10*(3), 249-263. https://doi.org/10.33168/jliss.2023.0319

Chen, X., Chang-Richards, A. Y., Pelosi, A., Jia, Y., Shen, X., Siddiqui, M. K., & Yang, N. (2022). Implementation of technologies in the construction industry: A systematic review. Engineering, *Construction and Architectural Management, 29*(8), 3181-3209. https://doi.org/10.1108/ECAM-02-2021-0172

Creswell, J. W., & Creswell, J. D. (2017). *Research design: Qualitative, quantitative, and mixed methods approaches (5th ed)*. Sage publications.

Demirkesen, S., & Tezel, A. (2022). Investigating major challenges for Industry 4.0 adoption among construction companies. *Engineering, Construction and Architectural Management, 29*(3), 1470–1503. https://doi.org/10.1108/ECAM-12-2020-1059

Doan, T., Bingert, S., & Yahyapour, R. (2022). Using a workflow management platform in textual data management. *Data Intelligence, 4*(4), 398–408. https://doi.org/10.1162/dint_a_00139

Etikan, I., Musa, S. A., & Alkassim, R. S. (2016). Comparison of convenience sampling and purposive sampling. *American Journal of Theoretical and Applied Statistics, 5*(1), 1-4. https://doi.org/10.11648/j.ajtas.20160501.11

Garyaev, N., & Garyaeva, V. (2019). Big data technology in construction. *E3S Web of Conferences,* 97, 01032. https://doi.org/10.1051/e3sconf/20199701032

Güngör, B., & Leindecker, G. (2024). Digital technologies for inventory and supply chain management in circular economy: A review study on the construction industry. In V. Ungureanu, L. Bragança, C. Baniotopoulos, & K. M. Abdalla (Eds.), *4th International Conference "Coordinating Engineering for Sustainability and Resilience" & Midterm Conference of CircularB "Implementation of Circular Economy in the Built Environment"*. CESARE 2024 (Vol. 489, pp. 123-134). Lecture Notes in Civil Engineering. Springer. https://doi.org/10.1007/978-3-031-57800-7_65

Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2010). *Multivariate data analysis (7th ed)*. Pearson Prentice Hall.

Hallward-Driemeier, M., & Nayyar, G. (2017). *Trouble in the making? The future of manufacturing-led development*. The World Bank. https://doi.org/10.1596/978-1-4648-1174-6

HSE Network. (2023). *The impact of digital technologies in construction*. HSE Network. https://www.hse-network.com/the-impact-of-digital-technologies-in-construction/

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Kang, J., Xiong, Z., Niyato, D., Zou, Y., Zhang, Y., & Guizani, M. (2020). Reliable federated learning for mobile networks. *IEEE Wireless Communications, 27*(2), 72–80. https://doi.org/10.1109/MWC.001.1900119

Lorusso, A., & Celenta, G. (2023). Internet of Things in the construction industry: A general overview. In M. Papadrakakis, M. Fragiadakis, & C. Papadimitriou (Eds.), *New Technologies, Development and Application VI* (pp. 577–584). Springer. https://doi.org/10.1007/978-3-031-31066-9_65

Lu, Y., Xu, X., & Wang, L. (2020). Smart manufacturing process and system automation – A critical review of the standards and envisioned scenarios. *Journal of Manufacturing Systems*, 56, 312–325. https://doi.org/10.1016/j.jmsy.2020.06.010

Ma, X., Ren, T., & Islam, S. M. N. (2024). Multi-party collaboration in agricultural green technology innovation and adoption: An evolutionary game approach. *Sustainability, 16*(23), 10236. https://doi.org/10.3390/su162310236

Mantha, B. R. K., García de Soto, B., & Karri, R. (2020). Cyber security threat modeling in the construction industry: A countermeasure example during the commissioning process. *OSF Preprints*. https://doi.org/10.31224/osf.io/gn78a

Masood, T., & Sonntag, P. (2020). Industry 4.0: Adoption challenges and benefits for SMEs. *Computers in Industry*, 121, 103261. https://doi.org/10.1016/j.compind.2020.103261

Nguyen, P., & Akhavian, R. (2019). Synergistic effect of Integrated Project Delivery, Lean Construction, and building information modeling on Project Performance Measures: A quantitative and qualitative analysis. *Advances in Civil Engineering, 2019*(1). https://doi.org/10.1155/2019/1267048

Osorio-Gomez, C.-C., Herrera, R. F., Prieto-Osorio, J. M., & Pellicer, E. (2024). Conceptual model for implementation of digital transformation and organizational structure in the construction sector. Ain Shams Engineering Journal, 15(7), . https://doi.org/10.1016/j.asej.2024.102749

Pal, A., Lin, J. J., Hsieh, S. H., & Golparvar-Fard, M. (2024). Activity-level construction progress monitoring through semantic segmentation of 3D-informed orthographic images. *Automation in Construction*, 136, 105157. https://doi.org/10.1016/j.autcon.2023.105157

Pallant, J. (2020*). SPSS Survival Manual: A Step by Step Guide to Data Analysis Using IBM SPSS (7th ed)*. Routledge.

Riazi, S. R. M., Zainuddin, M. F., Nawi, M. N. M., Musa, S., & Lee, A. (2020). A critical review of fragmentation issues in the construction industry. *Talent Development and Excellence, 12*(2s), 1510–1521.

Rinchen, S., Banihashemi, S., & Alkilani, S. (2024). Driving digital transformation in construction: Strategic insights into Building Information Modelling adoption in developing countries. *Project Leadership and Society,* 5, 100138. https://doi.org/10.1016/j.plas.2024.100138

Sacks, R., Eastman, C. M., Lee, G., & Teicholz, P. (2018). *BIM Handbook: A Guide to Building Information Modeling for Owners, Designers, Engineers, Contractors, and Facility Managers*. John Wiley & Sons, Inc. https://doi.org/10.1002/9781119287568

Sawhney, A., Riley, M., & Irizarry, J. (2020). *Construction 4.0: An innovation platform for the built environment.* Routledge. https://doi.org/10.1201/9780429398100

Sepasgozar, S. M., & Davis, S. (2019). Digital construction technology and job-site equipment demonstration: Modelling relationship strategies for technology adoption. *Buildings, 9*(7), 158. https://doi.org/10.3390/buildings9070158

Shahzaib, M., Aziz, A. A., Fayyaz, K., Irfan, M., Alaloul, W. S., & Musarat, M. A. (2024). Analyzing the nexus between project constraints and social sustainability in

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construction: A case for a developing economy. *Sustainability, 16*(22), 9875. https://doi.org/10.3390/su16229875

Srivastava, Y. C., Srivastava, A., Granata, C., & Garg, T. (2022). Digital control tower – Instantaneous visibility, granularity and decision support for an LNG mega project. *Paper presented at the ADIPEC, Abu Dhabi, UAE, October 2022*. https://doi.org/10.2118/211056-ms

Succar, B. (2009). Building information modelling framework: A research and delivery foundation for industry stakeholders. *Automation in Construction, 18*(3), 357–375. https://doi.org/10.1016/j.autcon.2008.10.003

Takyi-Annan, G. E., & Zhang, H. (2023). A bibliometric analysis of building information modelling implementation barriers in the developing world using an interpretive structural modelling approach. *Heliyon, 9*(8), e18601. https://doi.org/10.1016/j.heliyon.2023.e18601

Tan, K. W. (2023). Addressing labor shortages in construction. *NST Online*. Retrieved from https://api.nst.com.my/authors/kin-weng-tan?utm_source=chatgpt.com

Tavakol, M., & Dennick, R. (2011). Making sense of Cronbach's alpha. *International Journal of Medical Education, 2*(53-55). https://doi.org/10.5116/ijme.4dfb.8dfd

Wang, B., Wu, C., Huang, L., & Kang, L. (2019). Using data-driven safety decision-making to realize smart safety management in the era of big data: A theoretical perspective on basic questions and their answers. *Journal of Cleaner Production,* 210, 1595-1604. https://doi.org/10.1016/j.jclepro.2018.11.181

Zhang, S., Teizer, J., Lee, J.-K., Eastman, C. M., & Venugopal, M. (2013). Building Information Modeling (BIM) and safety: Automatic safety checking of construction models and schedules. *Automation in Construction,* 29, 183–195. https://doi.org/10.1016/j.autcon.2012.05.006

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