Adoption of Digital Technologies in Construction Measurement and Estimation: Strategies for the Malaysian Construction Industry

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ABSTRACT

The adoption of digital technologies in construction measurement and estimation has become increasingly important in enhancing accuracy, efficiency, and overall project performance within the Malaysian construction industry. Despite these benefits, the industry continues to face several challenges, including reliance on traditional practices, high implementation costs, lack of skilled personnel, and resistance to organisational change. This study aims to identify effective strategies to support the successful adoption of digital technologies in construction measurement and estimation. A quantitative research approach was employed, involving a structured questionnaire survey distributed to quantity surveyors in Selangor. A total of 116 valid responses were obtained, representing a response rate of 49.15%. The collected data were analysed using Statistical Package for the Social Sciences (SPSS) based on a 5-point Likert scale. The findings reveal that enhancing skills development and training is the most critical strategy for facilitating digital adoption. This is followed by other significant strategies, including strengthening government policies and financial incentives, increasing investment in research and development (R&D), standardising processes and systems, and promoting collaboration and knowledge sharing among industry stakeholders. The results emphasise the importance of human capital development and strong institutional support in overcoming existing barriers. In conclusion, the study highlights the need for a comprehensive and integrated approach to accelerate digital transformation in construction measurement and estimation. The implementation of these strategies can significantly improve cost accuracy, reduce inefficiencies, and enhance the overall competitiveness of the Malaysian construction industry. This aligns with the national agenda of advancing towards Construction 4.0 and achieving the objectives outlined in the Construction Industry Transformation Programme (CITP).

Keywords: Digital technologies, construction measurement, cost estimation, adoption strategies, Malaysian construction industry.

INTRODUCTION

The construction industry plays an important role in Malaysia's economic growth by supporting infrastructure development, creating jobs, and boosting other related industries. It contributes significantly to the national GDP and provides work for many people, showing its importance to the country's society and economy. However, the industry has historically been slower to adopt digital technologies compared to other sectors, with many firms still relying on traditional and manual operational methods. Conventional approaches such as expert judgment, historical data analysis, and unit pricing often rest on assumptions that may not adequately address the complexities of modern large-scale urban construction projects. (Cheok et al., 2025). This digital adoption gap is particularly pronounced in construction measurement and estimation, which remain predominantly manual, labour-intensive, and prone to human error, frequently resulting in cost overruns and operational inefficiencies.

Building Information Modelling (BIM), drone surveying, laser scanning, and Artificial Intelligence (AI) have demonstrated significant potential to improve project accuracy, reduce time and cost overruns, and enhance overall efficiency (Jamalulil et al., 2025). Despite these benefits, many firms especially small and medium-sized contractors are slow to adopt these tools because of high costs, limited skilled staff, resistance to change, and compatibility issues. (Yusuf et al., 2020) These obstacles make it harder to fully adopt digital technologies to improve construction measurement and estimation.

Aligned with the Construction 4.0 Strategic Plan (2021–2025) by the Malaysian Construction Industry Development Board (CIDB), along with the Construction Industry Transformation Programme (CITP), aims to speed up digital adoption in Malaysia's construction sector. Construction 4.0 promotes the use of technologies like simulation, digital tools, and automation to improve productivity, project delivery, and competitiveness. At the same time, CITP focuses on strong governance and teamwork among stakeholders to support technology use and collaboration across the industry.

Adopting the use of digital tools in construction measurement and estimation can help Malaysian construction firm plan projects more accurately, reduce cost errors, and improve overall project performance. Considering these circumstances, this paper aims to identify effective strategies to support the successful adoption of digital technologies in construction measurement and estimation for Malaysian construction industry.

LITERATURE REVIEW

Overview of Digital Technologies Transformation in Construction Measurement and Estimation

The transformation of construction measurement and estimation through digital technologies represents a significant shift from traditional, manual practices to more integrated, automated, and data-driven processes. Traditionally, measurement and cost estimation relied heavily on 2D drawings, manual quantity take-offs, and spreadsheet-based calculations, which are often time-consuming and prone to human error. However, the emergence of digital technologies has fundamentally reshaped these processes, improving accuracy, efficiency, and collaboration across the project lifecycle (Eastman et al., 2018).

One of the most influential technologies in this transformation is Building Information Modelling (BIM), which enables the creation of intelligent 3D models embedded with detailed project information. BIM facilitates automated quantity take-offs, real-time cost estimation, and enhanced coordination among project stakeholders. By integrating design, measurement, and costing into a single platform, BIM significantly reduces discrepancies and improves decision-making during the early stages of a project (Azhar, 2011; Monteiro & Martins, 2013). In the Malaysian context, BIM has been increasingly promoted as a key enabler of Construction 4.0, although its adoption in measurement and estimation practices is still evolving (CIDB, 2021).

In addition to BIM, other digital technologies such as Artificial Intelligence (AI), machine learning, and big data analytics are gaining traction in construction estimation processes. These technologies enable predictive cost modelling, risk analysis, and optimisation of resource allocation by analysing large datasets from past projects. AI-driven estimation tools can enhance forecasting accuracy and reduce reliance on subjective judgement, thereby improving the reliability of cost estimates (Oesterreich & Teuteberg, 2016).

Advanced data capture technologies such as laser scanning and drone surveying have also contributed to the transformation of measurement practices. These tools enable rapid and highly accurate site data collection, which can be integrated into BIM models for precise quantity take-offs and progress monitoring. This reduces manual site measurement errors and enhances the overall reliability of project data (Volk et al., 2014).

Despite these advancements, the transformation process in Malaysia is still at a developing stage, with adoption levels varying across organisations. While large firms and government projects are increasingly embracing digital technologies, smaller firms often face challenges such as high implementation costs, lack of expertise, and resistance to change. This statement is supported by Yusof et al. (2020), who note that similar challenges: high implementation costs, a lack of expertise, and resistance to change. As a result, the full

potential of digital transformation in construction measurement and estimation has yet to be fully realised (Abdulqader et al., 2025).

Strategies for Successful Adoption of Digital Technologies in Construction Measurement and Estimation

The successful adoption of digital technologies in construction measurement and estimation in Malaysia requires a comprehensive and coordinated approach involving government support, organisational readiness, and industry collaboration.

Strengthening Government Policies and Financial Incentives

High initial investment costs remain a main challenge, particularly for small and medium-sized enterprises (SMEs). Therefore, government initiatives such as grants, tax incentives, and funding schemes can encourage firms to invest in digital tools like Building Information Modelling (BIM) and automated measurement systems. The availability of financial support significantly influences the rate of digital adoption, as organisations are more willing to invest in new technologies when financial risks are reduced (Zhang et al., 2024). Thus, National frameworks such as the *Construction 4.0 Strategic Plan (2021–2025)* play a crucial role in guiding and accelerating digital transformation across the industry (CIDB, 2021).

Enhancing Skills Development and Training

The lack of skilled professionals is a significant challenge in adopting digital technologies. Continuous professional development programs, technical training, and collaboration between academia and industry are essential to equip quantity surveyors and construction professionals with the necessary digital competencies (Abdulqader et al., 2025). Universities and training institutions should integrate digital tools such as BIM into their curricula to prepare future professionals. This ensures that graduates enter the workforce with relevant digital competencies, reducing the skills gap in the long term (Oesterreich & Teuteberg, 2016).

Standardised Processes and Interoperability Frameworks

In Malaysia, the absence of comprehensive national standards for digital construction processes has been identified as a barrier to widespread adoption. While initiatives under the *Construction 4.0 Strategic Plan (2021–2025)* aim to promote digitalisation, further efforts are required to develop detailed guidelines and enforce their implementation across the industry (CIDB, 2021). Establishing clear regulatory frameworks and technical standards can provide organisations with a structured approach to adopting digital technologies.

Collaboration and Knowledge Sharing

Promoting collaboration and knowledge sharing within the industry is important. Partnerships between contractors, consultants, technology providers, and government agencies can facilitate the exchange of knowledge, best practices, and lessons learned. This collaborative approach helps reduce resistance to change and accelerates digital adoption (Raman & Husain, 2025).

Investment in Research and Development (R&D)

Investment in research and development (R&D) is a key to drive the advancement and adoption of digital technologies in construction measurement and estimation. It enables innovation, improves existing tools, and ensures that technologies are better suited to industry needs. Firstly, collaboration between academia and industry. Universities, research institutions, and construction firms can collaborate to create practical solutions, test new technologies, and share knowledge. This collaboration ensures that innovations are both theoretically sound and practically applicable (Yusuf et al., 2020). In addition, R&D promotes technological innovation. Continuous investment allows for the development of advanced tools such as Building Information Modelling (BIM), Artificial Intelligence (AI), machine learning, and automated quantity take-off systems. These innovations enhance accuracy, speed, and efficiency in measurement and cost estimation processes. For

instance, AI-driven estimation tools can analyse historical project data to generate more precise cost forecasts, reducing human error and uncertainty (Jamalulil et al., 2025).

METHODOLOGY

This study adopts a quantitative research approach using a questionnaire survey method to investigate strategies for the successful adoption of digital technologies in construction measurement and estimation within the Malaysian construction industry. The questionnaire method is widely used in construction research as it enables the collection of standardised data from many respondents efficiently and allows for statistical analysis of trends and perceptions (Creswell, 2014).

The respondents of this study consist of quantity surveyors based in Selangor Darul Ehsan, as they are directly involved in construction measurement and cost estimation processes. According to the Board of Quantity Surveyors Malaysia (BQSM), there are approximately 606 registered quantity surveyors in Selangor. This area was selected due to its role as a major construction hub, characterised by rapid development and the increasing adoption of digital technologies such as Building Information Modelling (BIM) and cost management software.

The sample size was determined using the Raosoft method, which recommends 236 respondents from a population of 606 to achieve reliable and statistically significant results (Raosoft, 2004). Out of the total sample size, this study successfully obtained 116 completed questionnaires, representing a response rate of 49.15%. This response rate is considered acceptable for questionnaire-based research and sufficient for conducting statistical analysis.

The questionnaire was structured in a multiple-choice format using a 5-point Likert scale (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree) to measure respondents' perceptions. The data collected from the survey were analysed using the Statistical Package for the Social Sciences (SPSS) to identify the main strategies for the successful adoption of digital technologies in construction measurement and estimation within the Malaysian construction industry.

ANALYSIS AND FINDING

The analysis of the survey results reveals the relative importance of different strategies for the successful adoption of digital technologies in construction measurement and estimation within the Malaysian construction industry. The ranking is based on mean scores derived from respondents' perceptions using a 5-point Likert scale.

Table 1.0: Strategies for Successful Adoption of Digital Technologies in Construction Measurement and Estimation

Rank	Strategies	Nos. of Respondents	Mean	Standard Deviation
1.	Enhancing skills development and training	116	4.45	0.549
2.	Strengthening government policies and financial incentives	116	4.05	0.873
3.	Investment in research and development (R&D)	116	3.96	0.879
4.	Standardised processes and interoperability frameworks	116	3.94	0.907
5.	Collaboration and knowledge sharing	116	3.85	1.167

Firstly, enhancing skills development and training emerged as the most important strategy, achieving the highest mean score of 4.45 with a relatively low standard deviation of 0.549. This indicates strong agreement

and consistency among respondents regarding its importance. The finding highlights that the shortage of skilled personnel remains a significant barrier to the adoption of digital technologies such as Building Information Modelling (BIM), artificial intelligence (AI), and automated measurement tools. In the Malaysian construction industry, many quantity surveyors and construction professionals still rely on traditional methods due to limited exposure to digital tools. Therefore, continuous professional development programmes, structured training, and upskilling initiatives are essential to equip professionals with the required competencies. This aligns with the findings of Succar and Kassem (2015), who emphasised that human capability is a fundamental driver of BIM adoption and digital transformation. Similarly, Oesterreich and Teuteberg (2016) noted that the successful implementation of digital technologies depends heavily on the availability of a digitally competent workforce. Without adequate training, even the most advanced technologies may fail to deliver their intended benefits.

Secondly, strengthening government policies and financial incentives was ranked as the second most important strategy, with a mean score of 4.05 and a standard deviation of 0.873. Although respondents generally agreed on its importance, the higher standard deviation indicates some variation in perception. This finding suggests that while government support is recognised as crucial, its effectiveness may vary depending on the level of awareness and accessibility among industry players. In Malaysia, the government has introduced several initiatives such as the Construction Industry Transformation Programme (CITP) and the Construction 4.0 Strategic Plan to promote digitalisation within the sector. These initiatives aim to encourage the adoption of technologies through financial assistance, policy support, and regulatory frameworks. Financial incentives, such as tax reductions and grants, can significantly reduce the high initial costs associated with adopting digital technologies, particularly for small and medium-sized enterprises (SMEs). According to Kassem and Succar (2017), policy support plays a vital role in accelerating technology adoption by creating a conducive environment for innovation. Similarly, CIDB (2020) highlighted that government intervention is essential in overcoming financial and institutional barriers, especially in developing countries.

The third-ranked strategy, investment in research and development (R&D), recorded a mean score of 3.96 and a standard deviation of 0.879. This indicates that respondents generally agree on its importance, although there is moderate variability in their responses. Investment in R&D is crucial for fostering innovation and developing digital solutions tailored to the specific needs of the construction industry. Through R&D, new tools and technologies can be created to improve accuracy, efficiency, and productivity in construction measurement and estimation. Moreover, R&D supports the localisation of digital solutions, ensuring that they are compatible with local industry practices and regulatory requirements. Collaboration between universities, research institutions, and industry players is essential in driving innovation and knowledge transfer. Pan and Zhang (2021) emphasised that R&D is a key enabler of long-term digital transformation, as it allows organisations to continuously improve their technological capabilities and remain competitive. In the Malaysian context, increasing investment in R&D can help bridge the gap between academic research and practical industry applications.

Next, standardised processes and interoperability frameworks were ranked fourth, with a mean score of 3.94 and a standard deviation of 0.907. This suggests that while respondents recognise the importance of standardisation, it is slightly less prioritised compared to other strategies. The relatively higher standard deviation indicates differing opinions among respondents, possibly due to varying levels of experience with digital systems. Standardisation is critical in ensuring consistency, efficiency, and compatibility across different digital platforms and stakeholders. Interoperability frameworks enable seamless data exchange between software systems, which is essential for the effective implementation of technologies such as BIM. The lack of standardisation often leads to data fragmentation, duplication of work, and inefficiencies, ultimately hindering digital adoption. Eastman et al. (2011) highlighted that interoperability challenges are one of the main obstacles in BIM implementation, as different stakeholders may use incompatible systems. Therefore, establishing common standards and protocols is essential to facilitate collaboration and improve overall project performance.

Finally, collaboration and knowledge sharing received the lowest mean score of 3.85, although it still falls within the “agree” range. The relatively high standard deviation of 1.167 indicates significant variability in

respondents' perceptions, suggesting that this strategy is not uniformly valued across the industry. This finding implies that while collaboration is recognised as important, it may not yet be fully practised or prioritised in the Malaysian construction sector. Effective collaboration among stakeholders—including clients, contractors, consultants, and technology providers—is essential for the successful adoption of digital technologies. Knowledge sharing can enhance awareness, reduce resistance to change, and promote the dissemination of best practices. However, the fragmented nature of the construction industry often limits opportunities for collaboration. Davies and Harty (2013) emphasised that collaborative environments are critical for digital innovation, as they enable stakeholders to share knowledge, learn from each other, and collectively overcome challenges. Encouraging a culture of collaboration and openness can significantly enhance the adoption and implementation of digital technologies.

In conclusion, the findings of this study highlight that enhancing skills development and training is the most critical strategy for the successful adoption of digital technologies in construction measurement and estimation, followed by government support, R&D investment, standardisation, and collaboration. While all strategies are important, the results suggest that human capital development should be prioritised to address the current skills gap in the industry. At the same time, supportive policies, continuous innovation, standardised frameworks, and collaborative practices are essential to create a holistic ecosystem for digital transformation. These findings provide valuable insights for policymakers, industry practitioners, and researchers in developing effective strategies to accelerate digital adoption in the Malaysian construction industry.

CONCLUSION

This study set out to identify strategies for the successful adoption of digital technologies in construction measurement and estimation within the Malaysian construction industry. Based on the findings, it is evident that while digital technologies such as Building Information Modelling (BIM), Artificial Intelligence (AI), and automated measurement tools offer significant benefits, their adoption remains influenced by several critical factors.

The results indicate that enhancing skills development and training is the most important strategy, highlighting that human capital plays a central role in digital transformation. The strong consensus among respondents suggests that improving digital competencies among quantity surveyors is essential to overcome current adoption barriers. This finding reinforces the argument that digital transformation is not only a technological shift but also a workforce-driven process.

In addition, government policies and financial incentives were identified as a key enabler, demonstrating the importance of institutional support in reducing financial barriers and encouraging organisations, particularly small and medium-sized firms, to invest in digital technologies. Similarly, investment in research and development (R&D) is crucial for fostering innovation and ensuring that digital solutions are tailored to industry needs.

Although standardised processes and interoperability frameworks and collaboration and knowledge sharing ranked lower, they remain important supporting strategies. The relatively higher variability in responses for these factors suggests that their implementation may still be inconsistent across the industry. Strengthening these areas can further enhance integration, improve data exchange, and promote a more collaborative digital ecosystem.

Overall, the study concludes that the successful adoption of digital technologies in construction measurement and estimation requires a holistic and integrated approach involving skills development, policy support, technological innovation, standardisation, and collaboration. These strategies must be implemented collectively to maximise the benefits of digital transformation.

In conclusion, accelerating digital adoption in the Malaysian construction industry will not only improve the accuracy of measurement and cost estimation but also enhance overall project performance, reduce inefficiencies, and strengthen the industry's competitiveness in line with national initiatives such as Construction 4.0 and the Construction Industry Transformation Programme (CITP).

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