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An analysis of awareness, understanding, and usage of disruptive technologies in the construction economy

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ABSTRACT

The adoption of disruptive technologies is increasingly recognized as essential to transforming the construction economy. However, the adoption in Malaysia remains limited compared to other sectors despite government initiatives such as the Construction 4.0 Strategic Plan. This study aims to examine the levels of awareness, understanding, and usage of disruptive technology among construction players in Sarawak. A quantitative research design is used. The data were collected from 132 respondents across 91 companies, representing a diverse group of mid-career professionals, mostly employed in specialized trades and higher-grade firms. The findings indicate that respondents are more aware of technologies such as cloud computing, real-time collaboration, and artificial intelligence (AI). However, awareness of blockchain and autonomous construction remains relatively low. Although usage remains relatively low, the adoption is increasing, with 35.6% of respondents using technology compared to 10% in earlier studies. These results highlight a gap between awareness and actual adoption, suggesting the need for targeted training and awareness programs to align with the industry practices with the Construction 4.0 Strategic Plan goals.

1. Introduction

The construction industry is a key driver of Malaysia's economic development, contributing significantly to the gross domestic product, increasing employment opportunities, and enhancing the overall social well-being of the population (Masyhur et al., 2024). In 2024, the gross domestic product (GDP) from construction in Malaysia totaled RM 66.58 billion, representing an increase from RM 56.66 billion in the

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previous year (Department of Statistics Malaysia, 2025). The increase is largely due to stronger domestic demand, improved manufacturing activities, and a recovery in external trade (CIDB Malaysia, 2024). The MIDF Research predicts that the Malaysian construction industry will increase by 12% in 2025 compared to 2024, supported by large government projects and the property sector getting stronger again (CIDB Malaysia, 2025). One of the major government projects is the Pan Borneo Highway, as the project serves as a foundation for social development and is very important for Malaysia's economy, progress, and future (CIDB Malaysia, 2023).

Despite its significant contribution to the Malaysian economy, the construction industry continues to face persistent challenges such as cost overruns, delays in projects (Ramly et al., 2023), low productivity rate (dropped 15.6% in 2022) (Department of Statistics Malaysia, 2022), and labour and equipment deficiencies (Mohsen et al., 2021). These ongoing issues reveal structural inefficiencies in construction processes and highlight the need for technological innovation and operational transformation in this sector. In response to these challenges, the Fourth Industrial Revolution (IR4.0) was introduced to transform all traditional processes into modern technology (Na et al., 2022). The Fourth Industrial Revolution emphasizes reshaping the digitalization of the business's procedures and activities, where the existing system is replaced with an advanced one. In other words, the implementation of the Fourth Industrial Revolution is known as disrupting existing systems with high technologies (Shahzad et al., 2023).

In line with this IR4.0, the Malaysian government, in collaboration with the Ministry of Works and the Construction Industry Development Board (CIDB), launched the Construction Strategy Plan 4.0 (Construction 4.0), a five-year short-term plan (2021-2025) designed to empower smart construction for future societies by enhancing the industry's (CIDB Malaysia, 2021). The Construction 4.0 plan identifies 12 disruptive technologies that will change the game in the construction industry (CIDB Malaysia, 2022). Disruptive technology in the construction industry refers to the new technology that changes the current system to improve it, in parallel with the construction industry's needs (Qiu et al., 2023). The 12 disruptive technologies include Building Information Modelling (BIM), pre-fabrication and modular construction, autonomous construction, augmented reality and virtual reality, cloud and real-time collaboration, 3D scanning and photogrammetry, big data, predictive analysis, internet of things, 3D printing and additive manufacturing, advanced building materials, blockchain, and artificial intelligence (CIDB Malaysia, 2022).

Undeniably, the adoption of technologies offers many opportunities for the digitization of the construction industry throughout the entire construction process, from start to finish, and increases the quality of the construction industry (Setaki & van Timmeren, 2022). By disrupting technologies, it can enhance efficiency, effectiveness, and productivity in the construction industry while reducing costs and promoting sustainability when it is fully utilized (Musarat et al., 2023). However, the adoption of disruptive technologies in the construction industry remains limited and faces numerous challenges, despite these potential benefits. Existing studies consistently report a low level of awareness, knowledge, and skills among the stakeholders to implement and manage new technology (Al-Raqeb et al., 2024); Al-Ashmori et al., 2020). For example, studies by Ashraf et al. (2021) and Othman et al. (2021) found that only 10-13% of construction companies have implemented Building Information Modelling (BIM) due to high implementation costs, slow technological adaptation, and continued reliance on traditional construction methods.

Although there is growing interest in BIM and other technologies, recent studies indicate that digital transformation in Malaysia's construction industry remains relatively slow compared to neighboring countries such as Singapore (Jaafar et al., 2024; Kong & Jie, 2024). A study by Kong and Jie (2024) further reported that industry practitioners expressed negative perceptions of Malaysia's digital transformation progress, noting that the technology adoption reached only 49% in 2019, whereas Singapore had already achieved a 71% adoption rate by 2015. In addition, a lack of policies to guide the implementation (Musharavati, 2023; Jalil et al., 2025) also leads to the slow adoption of technology. Moreover, the abilities of these 12 disruptive technologies have not been fully utilized due to the low adoption rate and a lack of awareness and knowledge among the stakeholders, due to the technologies being introduced separately

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without proper integration (Jiancheng et al., 2023). As a result, many construction companies are unable to fully leverage disruptive technologies, leading to missed opportunities for efficiency improvements, productivity gains, and enhanced industry competitiveness.

Furthermore, empirical research on disruptive technology adoption in Malaysia has predominantly focused on BIM, with limited attention given to other disruptive technologies identified under Construction 4.0. For instance, Jaafar et al. (2024) assessed the awareness and adoption of disruptive technologies across Malaysia using random sampling, providing a useful baseline for understanding current trends. Moreover, research on disruptive technologies is even more limited in Sarawak, with only two studies, Lee et al. (2022) and Tamjehi et al. (2020), specifically addressing BIM awareness, without extending to other technologies. This lack of comprehensive evidence on awareness, understanding, and usage of a broader range of disruptive technologies constrains the decision-making informer and effective policy implementation.

Therefore, this paper aims to analyze the awareness, understanding, and usage of disruptive technologies in the construction industry, with a particular focus on Sarawak. The study aims to assess the current level of adoption beyond BIM and provide updated insights to support the Construction 4.0 Strategy Plan agenda. This paper is organized into four sections. Section 2 describes the literature review, Section 3 describes the research methodology, Section 4 describes the results and discussions of the data, and Section 5 concludes this paper.

2. Literature review

2.1 Disruptive technology in the construction industry

The construction industry is currently undergoing a significant transformation with the adoption of disruptive technologies to enhance productivity and efficiency (Noor et al., 2022). In Malaysia, the adoption has already began in 2017, particularly through initiatives such as CIDB's myBIM Centre, which provides training and resources to industry players (Jaafar, 2017). These early initiatives reflect Malaysia's alignment with the Fourth Industrial Revolution (4IR), which serves as the foundation for advancing disruptive technologies in the construction industry. In the context of the Fourth Industrial Revolution (4IR), the construction industry emphasizes five key disruptive technologies, namely Artificial Intelligence (AI), Internet of Things (IoT), blockchain, cloud computing, and big data analytics, as they support the deployment and optimization of other 4IR technologies (Economic Planning Unit, 2020).

While the 4IR emphasizes five core emerging technologies, this study extends the scope to twelve (12) disruptive technologies to provide a more comprehensive and realistic assessment of disruptive technologies adoption within the construction economy. In this study, disruptive technology is operationally defined as the extent to which these technologies are adopted and used in the construction industry. Adoption is measured based on respondents' perceptions of their awareness, understanding, and actual usage of the technologies, measured through Likert-scale survey items.

Disruptive technologies contribute to efficiency and innovation in the construction industry. AI and big data analytics are used in forecasting project risks and planning the budget optimization. Augmented Reality and Virtual Reality (AR and VR) function to aid the project design and offer detailed visualization (Jaafar et al., 2024). The adoption of blockchain technology can distribute the data, as its characteristics are decentralized, traceable, transparent, and reliable (Wang et al., 2022). The IoT can provide effective control, better quality, and time-saving in decision-making due to the availability of real-time data analytics (Gamil et al., 2020). Advanced materials and technologies provide detailed information about the project site, which can help in the efficient alignment planning and optimized design project (Mohamad et al., 2022).

In addition, disruptive technologies in the construction industry secure long-term development, improving efficiency, effectiveness, and productivity. Fully utilizing technology in the construction industry can reduce costs and improve sustainability (Musarat et al., 2023). While the benefits of disruptive

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technologies are widely recognized, the successful adoption in the construction industry depends greatly on the level of awareness among stakeholders (Halvadia et al., 2025; Hwabamungu & Shepherd, 2024). This shows that awareness is a key factor in understanding that these technologies can be effectively implemented, as discussed in the next section.

2.2 Awareness of disruptive technology in the construction industry

Awareness plays a crucial role in the adoption of disruptive technologies in the Malaysian construction industry. Several studies highlight the importance of awareness and its impact on the successful implementation of disruptive technology. For instance, the adoption of Building Information Modelling (BIM), one of the earliest disruptive technologies promoted in this sector, has been slower compared to developed countries. The BIM adoption rates reached 80% in the United Kingdom, 76% in Australia, and 70% in Germany, while Malaysia lagged at 55% (CIDB, 2021). Moreover, the adoption remains limited despite a 74% awareness rate of BIM reported in the Malaysia BIM Report 2019 (Chai et al., 2025). This slow adoption has been attributed largely to the lack of trained professionals, which reduces efficiency and limits the effectiveness of BIM implementation in construction projects (Malaysia Productivity Corporation, 2023).

Despite government initiatives, such as CIDB training campaigns and conferences, awareness of BIM in Sarawak remains below satisfactory levels. The findings of Zaini et al. (2020) indicate that 75.8% of organizations had implemented BIM for less than 5 years, while a small number (4.5%) had used it for more than 20 years. It's emphasized that Malaysian construction players have only a basic level of awareness of disruptive technologies, with limited knowledge and no in-depth understanding of their implementation. This suggests that while exposure to BIM has increased, its adoption is still limited. Another study also notes that BIM adoption in Malaysia continues to be relatively low (10% only) despite its recognized benefits for project efficiency, collaboration, and cost management (Ashraf et al., 2021). Othman et al. (2021) reported that only 13% of Malaysian companies actively used BIM, due to the limited awareness, high costs, and resistance to change. Comparatively, the digital transformation of Malaysia has also progressed more slowly than in neighboring countries. For instance, BIM adoption in Malaysia was at 49% in 2019, while Singapore had already achieved 71% in 2015 (Kong & Jie, 2024).

One of the significant barriers to adopting advanced technologies like robotics and blockchain technology in the construction industry is the lack of awareness, as mentioned by Adegbembo et al. (2023) and Ding et al. (2025). This lack of awareness can lead to cautious approaches and resistance to investing in new technology due to perceived risks (Jaafar et al., 2022). Taken together, those studies show that research on awareness has been largely focused on BIM, while awareness of the other 11 disruptive technologies remains underexplored, particularly in the Sarawak context. While awareness highlights whether stakeholders are familiar with disruptive technologies, it does not guarantee that they fully understand how these technologies function or can be applied effectively. Therefore, the next section discusses the understanding of disruptive technologies in the construction industry.

2.3 Understanding of disruptive technology in the construction industry

It is important to understand disruptive technologies as they influence the success of adoption. While awareness exposes to the existence of technologies, understanding involves deeper knowledge about their functions, benefits, and effective application (Buchanan & Sparagowski, 2022). The Malaysian construction industry is currently recognizing the importance of disruptive technologies such as BIM, AI, and additive manufacturing. However, significant challenges related to knowledge need to be addressed to fully utilize these technologies for improving productivity and service quality (Balinado & Young, 2020).

In Malaysia, the construction players often have a limited to basic understanding of disruptive technology. This statement is supported by studies by Al-Raqeb et al. (2024) where there is a lack of sufficient information among industry stakeholders to fully understand how disruptive technologies can benefit construction projects. Moreover, study from Jaafar et al. (2022) stated that the lack of management understanding of the rising complexity of new technologies can result in additional challenges to adoption.

Although the construction stakeholders are familiar with blockchain technology, they do not fully understand the application and benefits of blockchain technology, especially in construction management (Adegbembo et al., 2023). In addition, the local contractors do not understand and are not ready for the adoption of addictive manufacturing technology in the construction industry (Ismail et al., 2020). This is due to insufficient knowledge and technical expertise. This indicates that the understanding of disruptive technology is uneven, depending on the type of technology.

2.4 Level of usage disruptive technology adoption in the construction industry

The level of usage of disruptive technologies in the construction industry remains low compared to other sectors due to the limited best practices, continued reliance on low-income foreign labor, and high cost of technology (CIDB Malaysia, 2022). This situation contributed to the low average productivity rate (dropped 15.6%) compared to other sectors; agriculture = -1.8%, mining and quarrying = -7.9%, manufacturing = -2.6%, construction = -15.7% (Department of Statistics Malaysia, 2022). Recent studies, however, show an improvement in progress. The State of Digital Adoption in the Construction Industry 2024 reported that Malaysian companies now actively use an average of 6.9 technologies in their projects, which is 50% higher than the Asia-Pacific average. This progress is driven by the increasing focus on integrating advanced technologies into traditional construction practices (CIDB Malaysia, 2024b).

The Internet of Things (IoT), cloud computing, advanced building materials, the Industrialized Building System (IBS), and the Building Information Modelling (BIM) technologies are mostly adopted in large infrastructure and complex building projects; meanwhile, small projects remain limited (Jaafar et al., 2025). Similarly, Kam et al. (2022) findings mentioned that the adoption of advanced technology, such as BIM and drones, is growing, but there is an inconsistency in the implementation because large companies can afford and manage them properly, while small companies are left behind due to cost and lack of skills. The ability to adopt technology is hindered by financial instability and a lack of awareness among the Small and Medium Enterprises (SMEs) (Mehdipoor et al., 2022). The main barriers to adopting technologies are limited financial resources, a lack of skilled personnel, and resistance to change in the construction industry (Abdullah et al., 2023). Therefore, greater support and initiatives are needed to ensure wider adoption across the construction industry.

3. Research methodology

This study uses a quantitative research design, where the questionnaire is designed based on a comprehensive review of past literature to ensure that the items are relevant to the objective of this study. The quantitative approach is suitable for assessing the levels of awareness, understanding, and usage of disruptive technologies among construction players, as it provides valuable insights into the current state of technology adoption. For instance, both Adegbembo et al. (2023) and Ilesanmi et al. (2024) studies use a quantitative approach to assess the awareness of blockchain and smart building technologies among construction stakeholders, revealing different levels of awareness. Furthermore, the survey items are structured according to constructs derived from the Technology Acceptance Model (TAM) and the Technology-Organization-Environment (TOE) framework, which serve as the theoretical foundations for assessing these dimensions.

3.1 Population

The population of this study consists of construction players in Sarawak who have been registered with the Construction Industry Development Board (CIDB). A purposive sampling technique was applied to

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target respondents who are directly involved in the construction industry, as they are more likely to know the necessity of disruptive technology adoption. The minimum sample size is determined using G*Power analysis, and it is suggested that at least 85 respondents are required. Then, the questionnaires are distributed during construction-related seminars organized by CIDB.

3.2 Data collection

The questionnaires are divided into four main sections. The first section focused on respondents' demographic information. The second section measures the awareness of disruptive technologies, using a five-point Likert scale ranging from "not at all aware" to "extremely aware." The third section assesses understanding of disruptive technologies, also using a five-point scale, ranging from "no knowledge" to "expert". The final section examines the level of usage, measured with another five-point scale ranging from "not in use" to "frequently used." These scales are chosen to assess different levels of perception and experience among respondents.

3.3 Data analysis

The data collected are analyzed using the Statistical Package for the Social Sciences (SPSS) software. The descriptive analysis is used to evaluate their awareness, understanding, and usage of disruptive technologies. Descriptive analysis is a method used in statistics to provide a comprehensive understanding of the data, as it can organize and evaluate the data in an easy-to-understand way (Nassaji, 2015). The study uses this analysis by calculating the frequency (i.e., how often each technology is used) and percentages (i.e., what percentage of respondents use each technology) for each disruptive technology. This analysis can help to identify which disruptive technology is commonly used by construction companies.

4. Results

The results of the data analysis that has been carried out using SPSS are presented in this chapter. The findings are organized into demographic information, the level of awareness of existing disruptive technology, the level of understanding of disruptive technology, and the level of usage of disruptive technologies. The results are presented in the form of bar charts and percentages.

4.1 Demographics respondents

This section presents the demographic profile of the respondents who participated in the survey. The demographic respondents provide an overview of the background of construction players in Sarawak. A total of 132 respondents from 91 construction companies answered the questionnaires for this study.

Based on the interpretation, the dataset has a relatively diverse sample, which are the respondents have various characteristics. In terms of age, the majority were between 31 and 40 years old (42.2%), followed by those aged 20 to 30 years (28.0%) and 41 to 50 years (25.8%), while only 3.8% were above 51 years. For education, most respondents hold a bachelor's degree (43.9%), followed by diploma holders (32.6%) and master's degree holders (14.4%), with fewer respondents having only certificates (7.6%) or PhDs (1.5%). In terms of company sector, more than half are involved in special trade activities (56.0%), while others work in civil engineering (23.5%) and non-residential building projects (18.2%), with very few in residential building (2.3%). For company grade, the largest proportion of respondents came from G7 companies (65.9%), followed by G5 (12.1%) and G3 (8.3%), while only a small group was from lower-grade firms such as G1, G2, and G4. Overall, this indicates that most respondents are mid-career professionals with higher education, largely employed in specialized trades and higher-grade construction firms.

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Table 1. Demographic profile of respondents

Demographic Factor	Category	Frequency	Percent (%)
Age Range	20 to 30	37	28.0
	31 to 40	56	42.2
	41 to 50	34	25.8
	51 and above	5	3.8
Education Level	Certificate	10	7.6
	Diploma	43	32.6
	Bachelor's Degree	58	43.9
	Bachelor's Master	19	14.4
	Doctor of Philosophy	2	1.5
Company Sector	Civil Engineering	31	23.5
	Non-residential Building	24	18.2
	Residential Building	3	2.3
	Special Trade Activities	74	56.0
Company Grade	G1	6	4.5
	G2	5	3.8
	G3	11	8.3
	G4	2	1.5
	G5	16	12.1
	G6	5	3.8
	G7	87	65.9

4.2 The level of awareness of existing disruptive technology

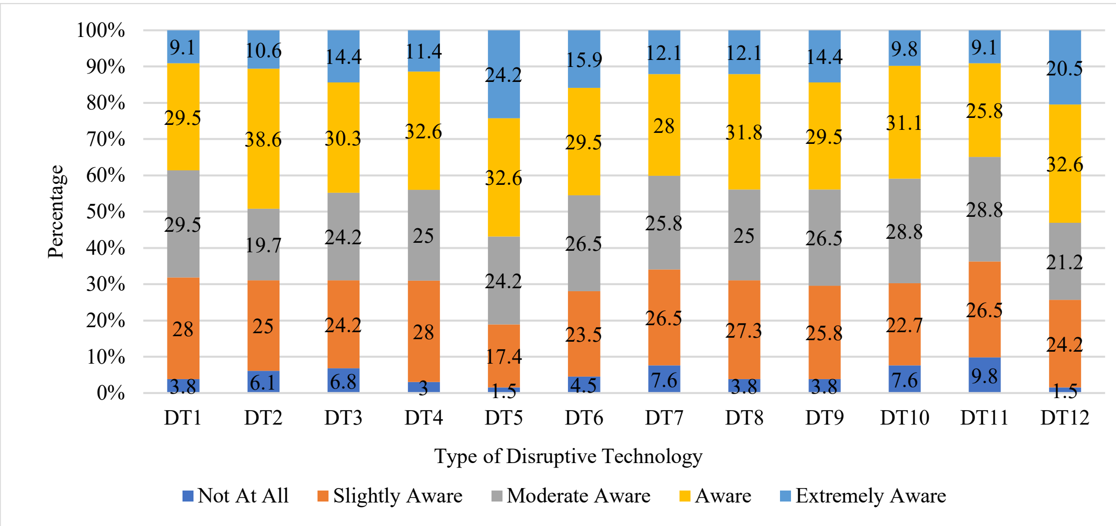

Figure 1: The Awareness Level of Existence Disruptive Technology

This section shows the descriptive analysis of the respondents' awareness of disruptive technology in the construction industry. Twelve (12) disruptive technologies are assessed using the indicator codes DT1 to DT12 and measured on a 5-point Likert scale (not at all, slightly aware, moderately aware, aware, extremely aware). The descriptions of each indicator are summarized in Table 2, which provides a clear reference for the interpretation of the results presented in the following figures.

Table 2. Summary of disruptive technology indicators

Indicator code	Type of disruptive technology
DT1	Building Information Modelling (BIM)
DT2	Pre-fabrication and Modular Construction
DT3	Autonomous Construction
DT4	Augmented Reality and Virtualization
DT5	Cloud Computing and Real-Time Collaboration
DT6	3D Scanning and Photogrammetry
DT7	Big Data and Predictive Analytics
DT8	Internet of Things (IoT)
DT9	3D Printing and Additive Manufacturing
DT10	Advanced Building Materials
DT11	Blockchain Technology
DT12	Artificial Intelligence (AI)

Figure 1 illustrates the awareness level of existing disruptive technologies to enhance and facilitate better visual interpretation. Based on the findings above, the overall awareness level of disruptive technologies among the respondents is moderate, as the mean values range from 2.98 to 3.61 (moderately aware to aware). The highest awareness level is recorded in DT5 (cloud and real-time collaboration) with a mean of 3.61, where 32.6% of respondents answered 'aware' and 24.2% answered 'extremely aware'. Then, followed by DT12 (artificial intelligence) with a mean of 3.42, where 32.6% reported being ‘aware’ and 20.5% ‘extremely aware’, and DT2 (pre-fabrication and modular construction) with a mean of 3.23, supported by 38.6% of respondents selecting ‘aware’ and 10.6% selecting ‘extremely aware’.

On the other hand, DT3 (autonomous construction), with a mean of 3.21, and DT11 (blockchain technology) recorded the lowest mean value of 2.98. In addition, DT11 (blockchain technology) had the highest percentage of respondents selecting ‘not aware at all’ (9.8%) and ‘slightly aware’ (26.5%), and with only 9.1% indicating ‘extremely aware’. Similarly, DT3 (autonomous construction) also showed a relatively high proportion of ‘not aware at all’ responses with 6.8%. These findings show that the construction players are increasingly aware of technologies like real-time collaboration and artificial intelligence, while technologies such as blockchain and autonomous construction are still lacking awareness. This highlights the need for greater exposure and targeted awareness programs to encourage broader adoption of disruptive technologies within the construction industry.

There is a small percentage in the ‘extremely aware’ category, ranging between 9% and 20%. This result indicates that awareness remains low, which is consistent with the findings from previous studies (Othman et al., 2021) and (Musharavati, 2023). This suggests that while the existence of disruptive technologies is generally recognized, an in-depth understanding remains limited, reflecting a low level of industry readiness for advanced digital transformation. Moreover, the Malaysia Productivity Corporation (2023) reported limited awareness of disruptive technologies in the construction industry, even after multiple government-led initiatives. Notably, the persistence of low awareness levels from 2021 to 2023, and continuing into 2025, suggests that existing awareness programs may not be sufficiently effective or industry-wide. In addition, this situation is not only within the Malaysian Construction Industry, but also in other countries such as Kuwait, where the finding of the study shows a low level of awareness in the adoption of disruptive technology (Al-Roumi & Al-Sabah, 2024). The consistency of these findings across different national contexts indicates a broader industry challenge, where construction practitioners may be aware of emerging technologies in general terms but lack the practical knowledge required for meaningful adoption.

4.3 The level of understanding disruptive technology

This section presents an analysis of respondents’ understanding of disruptive technology, based on 12 specific disruptive technologies. The understanding levels are categorized into five levels: Not Understand, Limited, Basic, Proficient, and Expert. Based on the findings in Figure 2, the overall understanding level of disruptive technologies among the respondents is moderate to low, as the mean values range from 2.63 to 3.14 (limited to basic understanding). The highest understanding was recorded in DT5 (cloud and real-time collaboration) (mean = 3.14), followed by DT12 (artificial intelligence) (mean = 3.07) and DT2 (pre-fabrication and modular construction) (mean = 2.83). DT5 (cloud and real-time collaboration) and DT12 (artificial intelligence) also show a higher frequency of expert understanding (DT5 = 11.4% and DT12 = 10.6%).

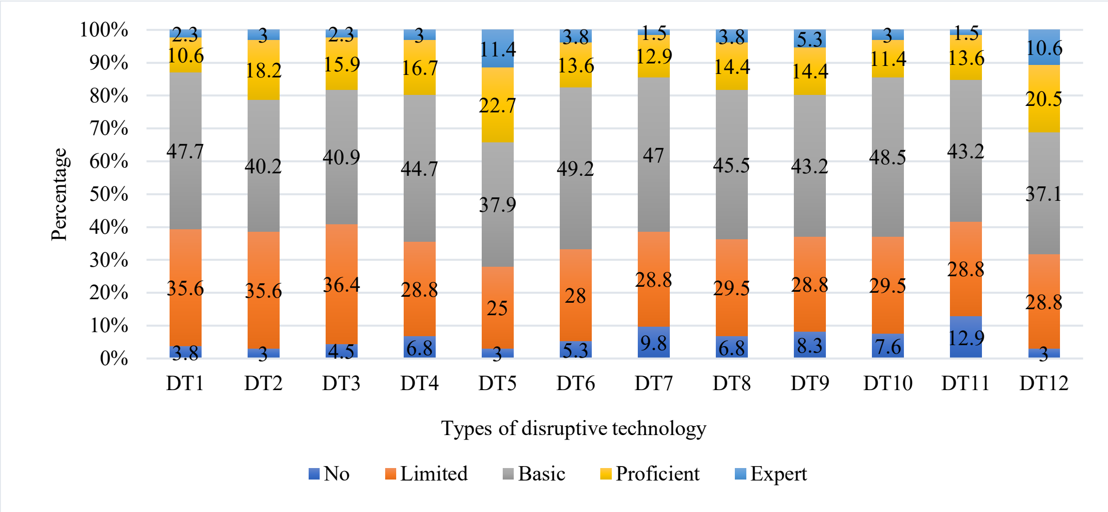

Figure 2: Level of understanding disruptive technology

On the other hand, DT7 (big data and predictive analysis) had a mean of 2.67, with 47% only having a basic level, while 9.8% reported no understanding at all. DT11 (blockchain technology) showed the lowest mean (2.62), where 43.2% had only a basic understanding, and 12.9% reported no understanding at all, making it the least understood technology. These results indicate that respondents are relatively more familiar with practical tools like cloud collaboration and artificial intelligence, while advanced tools such as blockchain and big data remain poorly understood in the construction industry. The results show that the majority of respondents only have a limited and basic understanding of disruptive technology, with only a few showing a proficient and expert understanding of disruptive technology. The basic understanding recorded the highest percentage, ranging between 37% and 49%, while the expert remained below 12% across all 12 types of disruptive technologies.

This highlights a significant gap in the industry's understanding of disruptive technologies. This suggests that the construction industry’s players are generally aware of disruptive technologies, but their understanding does not align with their awareness. The findings indicate that there is a notable lack of expert-level knowledge of disruptive technology among many construction industry companies, which may hinder informed decision-making and practical implementation of disruptive technologies. This limited level of understanding can be partly attributed to the insufficient distribution of detailed and practical information by government agencies and policymakers. This interpretation is supported by Zaini et al. (2020) and Tjandra et al. (2022), emphasizing that insufficient information contributes to the low level of understanding among industry players. Similarly, a study from Abdul-Samad et al. (2024) shows a moderate level of technological knowledge among construction contractors, indicating that the understanding of disruptive technology is limited and not yet applied in practical use.

At the technology-specific level, the understanding of DT8 (IoT) is aligned with the Radzuan et al. (2024) findings, which indicated that contractors’ understanding of IoT is largely fundamental rather than advanced. Similarly, the limited understanding observed for DT9 (additive manufacturing) is consistent with the findings of Ismail et al. (2020), which highlighted a significant lack of understanding of additive manufacturing technology among contractors, despite a small group demonstrating higher proficiency. Overall, these results suggest that the Malaysian construction industry continues to face challenges in improving the understanding of disruptive technology. The industry's ability to progress toward effective digital transformation may remain constrained without more comprehensive, structured, and practice-oriented information. Therefore, significant efforts are needed to enhance understanding across various technologies in the Malaysian construction industry. In addition, the gap between awareness and understanding explains the slow pace of disruptive technology adoption in the construction industry despite increasing digitalization initiatives.

4.4 The level of usage of disruptive technology

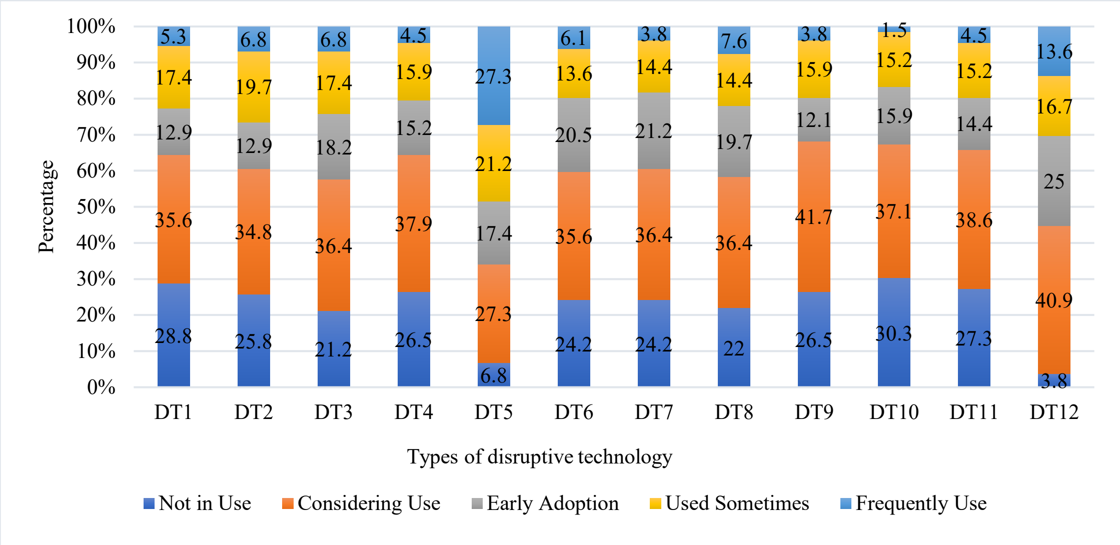

Figure 3: Level of usage of disruptive technology

This section analyzes the current level of usage of disruptive technologies in the construction industry. There are five levels to measure the usage, which are not in use, considering use, early adoption, used sometimes, and frequently used. Overall, the findings indicate that most technologies show the level of usage of 'considering use' and 'used for sometimes', with mean values ranging from 2.20 to 3.35. Based on Figure 3, the highest usage level was recorded for DT5 (cloud and real-time collaboration), with a mean of 3.35. There are 27.3% of respondents reported frequent use, 21.2% sometimes used it, and only 6.8% did not use it at all, showing that this is the most adopted technology. Then it's followed by DT12 (artificial intelligence) with a mean of 2.95, where 25% of respondents reported early adoption and 16.7% used it sometimes, although 40.9% are still only considering using it. DT3 (autonomous construction) also showed a relatively higher adoption (mean = 2.52), with 18.2% in early adoption and 17.4% sometimes using it; however, 21.2% not using it at all.

In contrast, DT10 (advanced building materials) recorded the lowest mean (2.20), with 30.3% not in use and 37.1% only considering use, while very few have moved to adoption or frequent usage. Similarly, DT11 (blockchain technology) (mean = 2.31) showed 38.6% considering use, but 27.3% not in use, and only 9.1% at frequent use. DT9 (3D printing and additive manufacturing) also scored low (mean = 2.29), with 41.7% still considering use and just 12.1% sometimes using it. These results highlight a significant gap between awareness and usage. While respondents are aware of several technologies such as AI and blockchain, actual usage remains limited, with most respondents still at the stage of consideration rather than active adoption. The results in Figure 3 reveal that the adoption of disruptive technologies in the construction industry remains low. Most of the respondents chose "not in use" categories, ranging from 21.2% to 40.9%, and "considering use", ranging from 34.8% to 41.7%. However, the frequent use of disruptive technology is consistent with its lowest category, with values below 8% for most technologies.

The findings suggest that the usage of disruptive technologies in the construction industry remains at an early stage, reflecting the initial transition from awareness and understanding to actual adoption. While some organizations have formally adopted certain technologies, particularly Building Information Modelling (BIM), individual-level usage among employees appears to be limited. This shows that company-level adoption does not always lead to regular use by employees. This interpretation is consistent with the findings of Zaini et al. (2020), who reported that 78.5% of organizations had implemented BIM technology for less than five years, indicating relatively recent adoption and limited maturity in usage. Despite the findings indicating that the overall adoption of disruptive technologies remains low, there are signs of positive growth in the implementation. Specifically, 35.6% of respondents in this study reported having implemented BIM, which shows a notable increase compared to the 10% reported by Ashraf et al. (2021). This evidence suggests that although the adoption and usage of disruptive technologies are still at an early stage, the construction industry is gradually gaining momentum toward greater implementation.

5. Discussion and conclusion

This study examines the awareness, understanding, and usage of disruptive technology adoption in the Malaysian construction industry. Despite government initiatives to promote adoption, the findings indicate that adoption levels remain relatively low compared to other sectors, primarily due to barriers such as limited awareness, resistance to change, insufficient information, and financial constraints. The results show that while respondents are increasingly aware of technologies such as cloud collaboration and artificial intelligence, awareness of blockchain and autonomous construction remains limited. Similarly, the understanding level is just basic knowledge, and fewer than 12% identify themselves as experts. Although overall usage remains low, there are encouraging signs of progress. For instance, 35.6% of respondents reported adopting BIM, reflecting a significant increase compared to the 10% adoption reported by Ashraf et al. (2021). This suggests that the industry is gradually shifting from awareness and understanding toward actual implementation. In addition, Malaysia's adoption rate of BIM is slower compared to other countries (the United Kingdom (80%), followed by Australia (76%), Germany (70%), Malaysia (55%), and Japan (46%) (CIDB, 2021), mainly due to the lack of trained professionals, which limits the efficiency and effectiveness of the technology in construction projects (Malaysia Productivity Corporation, 2023).

However, the gaps between awareness, understanding, and actual usage present significant challenges for the construction industry. Insufficient information and low levels of usage can lead to inefficient project construction, as companies are unable to fully use technologies for construction planning and decision-making (Zaini et al., 2020). As a result, potential benefits such as improving productivity and cost efficiency are not fully utilized. Moreover, reliance on traditional construction methods due to resistance to change and the limited skill of workers reduces the industry's competitiveness (Abioye et al., 2021; Guangbin et al., 2020), particularly when compared to countries and sectors that have more advanced levels of digital adoption (Malaysia Productivity Corporation, 2023). The findings of this study indicate that, although awareness of disruptive technologies is increasing, these technologies cannot be successfully adopted without sufficient understanding and practical use. Without proper knowledge and application, disruptive technologies may fail to address industry challenges such as project delays, inefficiencies, and low productivity.

This study helps policymakers and regulators about the crucial role of government and its agencies in driving disruptive technology adoption. In addition, this study helps to identify whether the adoption aligns with the Construction 4.0 Strategic Plan's aims or not, which aim to modernize the Malaysian construction

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sector by adopting disruptive technology to improve productivity. However, the results indicate that while awareness of technologies such as cloud collaboration and artificial intelligence is growing, understanding and actual usage remain limited, especially for advanced tools like blockchain, big data, and 3D printing. This gap between policy goals and current industry practice suggests that the sector is not yet fully aligned with the Construction 4.0 objectives. Without addressing these gaps, national initiatives such as the Construction 4.0 Strategic Plan struggle to achieve their intended outcomes in improving productivity and industry performance.

Therefore, targeted awareness programs and stronger support for SMEs are needed to increase the adoption of disruptive technology among all construction companies. Given the lack of sufficient information about disruptive technology, as highlighted by Al-Raqeb et al. (2024), the government should take a proactive initiative by providing national standards and guidelines for each of the disruptive technologies. Such initiatives would serve as a structured reference for the industry and could enhance awareness, understanding, and adoption across construction companies.

Nevertheless, the sample size is limited to Sarawak and may not fully represent the entire Malaysian construction industry. In addition, this survey is self-reported data and may involve bias, as respondents might give fully socially desirable answers. It is recommended for future research to expand the study across different countries or industries for cross-comparison, and also conduct longitudinal studies to examine how adoption changes over time. More advanced statistical techniques, such as Structural Equation Modeling (SEM), could be used to examine the relationship between awareness, understanding, and adoption.

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Conflict of interest statement

The authors agree that this research was conducted in the absence of any self-benefit, commercial or financial conflicts, and declare the absence of conflicting interests with the funders.

References

Abdullah, J., Marzukhi, M. A., Danial, M. H., Ghani, M. K., & Kokchang, P. (2023). Technology Adoption Among Town Planners in Malaysia. *International Journal of Sustainable Construction Engineering and Technology*, *14*(5) 161-169. https://doi.org/10.30880/ijscet.2023.14.05.012

Abdul-Samad, Z., Xin, L. L., Alaloul, W. S., & Salleh, H. (2024). Towards industrial revolution (IR) 4.0 in the construction industry: Readiness of contractors. *Results in Engineering*, *22*(2024), 102321. https://doi.org/10.1016/j.rineng.2024.102321

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

Adegbembo, T. F., Akinrolade, R., & Aghimien, D. (2023). Blockchain Technology Innovation in Supply Chain Management: Perception of Construction Stakeholders in Developing Countries. In *Towards a Sustainable Construction Industry: The Role of Innovation and Digitalisation* (pp. 122–131). Springer International Publishing. https://doi.org/10.1007/978-3-031-22434-8_13

Al-Ashmori, Y. Y., Othman, I., Rahmawati, Y., Amran, Y. H. M., Sabah, S. H. A., Rafindadi, A. D. u., & Mikić, M. (2020). BIM benefits and its influence on the BIM implementation in Malaysia. *Ain Shams Engineering Journal*, *11*(4), 1013–1019. https://doi.org/10.1016/j.asej.2020.02.002

Al-Raqeb, H., Ghaffar, S. H., Haitherali, H., & Gopakumar, A. (2024). Overcoming Barriers to Implementing Building Information Modelling in Kuwait's Ministry of Public Works: A Framework for Sustainable Construction. *Buildings*, *14*(1), 130. https://doi.org/10.3390/buildings14010130

Al-Roumi, H., & Al-Sabah, R. (2024). Exploring the rate of adoption and implementation depth of building information modeling (BIM): A case of Kuwait. *Journal of Engineering Research (Kuwait)*, *12*(1), 86–99. https://doi.org/10.1016/j.jer.2023.10.044

Ashraf, M., Fateh, M., Aiman, A., & Aziz, A. (2021). The Cost Profile of Building Information Modelling Implementation in Malaysia. In *MCRJ Special Issue*, *14*(3), 109-124.

Balinado, J. R. O., & Young, M. N. (2020). The Impact of Technology on Service Supply Chain of Toyota Dasmarinas-Cavite: A Comparative Study. *2020 7th International Conference on Frontiers of Industrial Engineering (ICFIE)*, 13–17. https://doi.org/10.1109/ICFIE50845.2020.9266736

Buchanan, P. R., & Sparagowski, C. (2022). *The Role of Emerging Technologies and Social Justice in Emergency Management Practice: The Good, the Bad, and the Future* (pp. 175–199). https://doi.org/10.1108/S2040-726220220000025008

Chai, C., Gai, M., Ang, H. Y., Lee, C. K., Chong, W. S., & Wong, M. H. J. (2025). Analytic Hierarchy Progress (AHP) for Construction Technologies Adoption in the Malaysian Construction Industry. In *Sustainable Construction and Heritage Conservation in the Digital Age* (pp. 113–144). IGI Global Scientific Publishing. https://doi.org/10.4018/979-8-3373-5278-7.ch004

CIDB. (2021). *Malaysia Building Information Modelling (BIM) Report 2021*. https://smart.cidb.gov.my/publication/malaysia-building-information-modelling-bim-report-2021-457

CIDB Malaysia. (2021). *CR 4.0 in Construction*. CIDB Official Web Page. https://www.cidb.gov.my/eng/cr-4-0/

CIDB Malaysia. (2022, March 31). *The Adoption of Technology in the Construction Industry*. CIDB Malaysia Official Web Page. https://www.cidb.gov.my/eng/the-adoption-of-technology-in-the-construction-industry/

CIDB Malaysia. (2023, October 6). *Revolutionising Connectivity: The Pan Borneo Highway*. CIDB Malaysia Official Web Page. https://www.cidb.gov.my/eng/revolutionising-connectivity-the-pan-borneo-highway/

CIDB Malaysia. (2024a, September 6). *Key Construction Projects to Drive GDP in Second Half of 2024*. Official Website CIDB Malaysia. https://www.cidb.gov.my/eng/key-construction-projects-to-drive-gdp-in-second-half-of-2024/

CIDB Malaysia. (2024b, October 23). Malaysia's Construction Sector Reaches New Heights in 2024. *CIDB Malaysia Official Website*. https://www.cidb.gov.my/eng/malaysias-construction-sector-reaches-new-heights-in-2024/

CIDB Malaysia. (2025, May 8). *Malaysia's Construction Sector in 2025 anticipates waves of growth*. Official Website CIDB Malaysia. https://www.cidb.gov.my/eng/malaysias-construction-sector-in-2025/

Department of Statistics Malaysia. (2022). *Malaysia's Labour Productivity*. https://www.dosm.gov.my/portal-main/release-content/labour-productivity-fourth-quarter-2022

Department of Statistics Malaysia. (2025). *Suku Pertama First Quarter Jabatan Perangkaan Malaysia Department of Statistics Malaysia Keluaran Dalam Negeri Kasar (KDNK)*. https://open.dosm.gov.my.

Ding, C. S., Wong, S. Y., Karim, S. B. B. A., Chieng, T. K., & Yun, H. (2025). *Modeling barriers to the adoption of robotics in construction companies in Sarawak, Malaysia. Multidisciplinary Reviews*, *9*(1), 2026031. https://doi.org/10.31893/multirev.2026031

Economic Planning Unit. (2020). *National fourth industrial revolution (4IR) Policy.* Economic Planning Unit, Prime Minister's Department. https://ekonomi.gov.my/sites/default/files/2021-07/National-4IR-Policy.pdf

Gamil, Y., A. Abdullah, M., Abd Rahman, I., & Asad, M. M. (2020). Internet of things in construction industry revolution 4.0: Recent trends and challenges in the Malaysian context. *Journal of Engineering, Design and Technology*, *18*(5), 1091–1102. https://doi.org/10.1108/JEDT-06-2019-0164

Guangbin, W., Pengfei, W., Dongping, C., & Xiaochun, L. (2020). Predicting behavioural resistance to BIM implementation in construction projects_ an empirical study integrating technology acceptance model and equity theory. *Journal of Civic Engineering and Management*, *26*(7), 651–665. https://doi.org/10.3846/jcem.2020.12325

Halvadia, H., Patel, K. A., & Patel, D. A. (2025). Evaluating Stakeholder Awareness and Prioritizing Applications of UAVs Technology for Construction Safety Management. *Journal of Engineering, Project, and Production Management*, 15(2), 1-11. https://doi.org/10.32738/JEPPM-2025-0011

Hwabamungu, B., & Shepherd, P. (2024). The Influence of Stakeholder Involvement in the Adoption of Digital Technologies in the UK Construction Industry. *Informatics*, *11*(4), 97. https://doi.org/10.3390/informatics11040097

Ilesanmi, O. O., Moyanga, D. T., Oke, A. E., & Aliu, J. (2024). Unraveling the awareness dynamics of smart building features and technologies in the Nigerian construction sector. *International Journal of Building Pathology and Adaptation*. https://doi.org/10.1108/IJBPA-04-2024-0073

Ismail, M. Z., Zakiyuddin, Z., Rashid, A., Adnan, H., & Yusuwan, N. M. (2020). The Understanding and Readiness of Malaysian Contractors to Apply Additive Manufacturing Technology in Construction Industry. In *Int. J Sup. Chain. Mgt*, *9*(4), 590-595,. https://doi.org/10.59160/ijscm.v9i4.5155

Jaafar, M., Mokhtar Azizi, N. S., Mohamed Ghazali, F. E., Mohd Zain, M. Z., Mat Kilau, N., & Ibrahim, F. S. (2025). Technology usage, challenges and strategies for Construction 4.0 from the perspective of Malaysian contractors. *Journal of Facilities Management*. https://doi.org/10.1108/JFM-04-2024-0055

Jaafar, M., Salman, A., Ghazali, F. E. M., Zain, M. Z. M., & Kilau, N. M. (2024). The awareness and adoption level of emerging technologies in Fourth Industrial Revolution (4IR) by contractors in Malaysia. *Ain Shams Engineering Journal*, *15*(5), 102710. https://doi.org/10.1016/j.asej.2024.102710

Jaafar, S. S. (2017, November 27). CIDB launched nation's first bulding information modelling centre. *The Edge Malaysia*. https://theedgemalaysia.com/node/379442?

Jalil, S. N. N. A., Ahmad, R. A., & Alias, A. (2025). Challenges and strategies in implementing 3D concrete printing (3DCP) technology in Malaysia: Materials and Design Codes. *IOP Conference Series: Earth and Environmental Science*, *1509*(1), 012008. https://doi.org/10.1088/1755-1315/1509/1/012008

Jiancheng, S., Saar, C. C., & Aminudin, E. (2023). Digital Twinning in the Malaysian Construction Industry. In *Digitalization in Construction* (pp. 271–293). Routledge. https://doi.org/10.1201/9781003408949-15

Kam, K. J., Lim, T. S., Lee, L. H., Soon, L. T., Leong, B. T., & Kamarazaly, M. A. (2022). Survival Strategies and Challenges Faced by Subcontractors in Malaysian Construction Industry. In *MCRJ Special Issue 15* (1), 22-37. https://www.cream.my/data/cms/files/MCRJ%20Special%20Issue%20Volume%2015_%20No_1_%202022.pdf?iframe

Kong, H. S., & Jie, C. W. (2024). Prospects and Challenges of Digital Transformation in The Malaysian Construction Industry. In *MCRJ Special Issue*, *21*(1), 104–126. https://eprints.tarc.edu.my/id/eprint/20295

Lee, Y. Y., Law, A. K. H., Ting, S. N., Gui, H. C., & Zaini, A. A. (2022). BIM implementation in Sarawak construction industry: Awareness, readiness and challenges. *E3S Web of Conferences*, *347*. https://doi.org/10.1051/e3sconf/202234701010

Malaysia Productivity Corporation. (2023). *Malaysia Productivity Corporation 2 Subsector Productivity Report Construction & Built Environment*. https://irp.cdn-website.com/4e78759a/files/uploaded/MPC_Construction_Artwork_Draft06.pdf

Masyhur, R. T., Alias, A. H., Haron, N. A., & Zulkafli, Z. (2024). A systematic review on green practices in the Malaysian construction industry: Status, challenges, key motivations, rating systems and technology evolution. *Energy and Buildings*, *320*. https://doi.org/10.1016/j.enbuild.2024.114550

Mehdipoor, A., Kaloorazi, S. M., & Ghadim, H. B. (2022). A Study of Critical Success Factors for BIM-FM Implementation Among Facility Managers in Malaysia. In *MCRJ Special Issue 15*(1), 248-257. https://www.cream.my/data/cms/files/MCRJ%20Special%20Issue%20Volume%2015_%20No_1_%202022.pdf?iframe

Mohamad, Z., Omar, K. A., & Mustafar, N. Sy. (2022). Smart Construction: The Next Paradigm for Malaysia Construction Industry. *SMARTCONSTRUCTION*. https://smart.cidb.gov.my/article/smart-construction-the-next-paradigm-for-malaysia-construction-industry-390

Mohsen, A., Alaloul, W. S., Liew, M. S., Musarat, M. A., Baarimah, A. O., Alzubi, K. M., & Altaf, M. (2021). Impact of the COVID-19 Pandemic on Construction Industry in Malaysia. *2021 Third International Sustainability and Resilience Conference: Climate Change*, 237–241. https://doi.org/10.1109/IEEECONF53624.2021.9667984

Musarat, M. A., Irfan, M., Alaloul, W. S., Maqsoom, A., & Ghufran, M. (2023). A Review on the Way Forward in Construction through Industrial Revolution 5.0. In Sustainability (Switzerland), 15 (18), 13862. Multidisciplinary Digital Publishing Institute (MDPI). https://doi.org/10.3390/su151813862

Musharavati, F. (2023). Optimized Integration of Lean Construction, Building Information Modeling, and Facilities Management in Developing Countries: A Case of Qatar. *Buildings*, *13*(12), 3051. https://doi.org/10.3390/buildings13123051

Na, S., Heo, S., Han, S., Shin, Y., & Roh, Y. (2022). Acceptance Model of Artificial Intelligence (AI)-Based Technologies in Construction Firms: Applying the Technology Acceptance Model (TAM) in Combination with the Technology–Organisation–Environment (TOE) Framework. *Buildings*, *12*(2), 90. https://doi.org/10.3390/buildings12020090

Nassaji, H. (2015). Qualitative and descriptive research: Data type versus data analysis. *Language Teaching Research*, *19*(2), 129–132. https://doi.org/10.1177/1362168815572747

Noor, R. N. H. R. M., Roslan, F. N., & Yunus, J. N. (2022). *Conceptualization of readiness for BIM implementation practice among construction organisations: Pulau Pinang case study*, 2532,(1), 090003. https://doi.org/10.1063/5.0113005

Othman, I., Al-Ashmori, Y. Y., Rahmawati, Y., Mugahed Amran, Y. H., & Al-Bared, M. A. M. (2021). The level of Building Information Modelling (BIM) Implementation in Malaysia. *Ain Shams Engineering Journal*, *12*(1), 455–463. https://doi.org/10.1016/j.asej.2020.04.007

Qiu, J., Cao, J., Gu, X., Ge, Z., Wang, Z., & Liang, Z. (2023). Design of an Evaluation System for Disruptive Technologies to Benefit Smart Cities. *Sustainability (Switzerland)*, *15*(11). https://doi.org/10.3390/su15119109

Radzuan, S. A. M., Brahim, J., Nguyen, Q., & Ponniah, V. (2024). Current Practices of Internet of Things (Iot): The Definition and its Integration Within Joint Ventures (JV) Company in Malaysian Construction Industry. *Malaysian Construction Research Journal*, *23*(3), 325–336.

Ramly, M. K. A., Mohamad, M. F., & Noor, S. N. A. M. (2023). *Building information modelling (BIM) as 'disruptive technology': An insights of construction service provider*. 2050006. https://doi.org/10.1063/5.0109977

Setaki, F., & van Timmeren, A. (2022). Disruptive technologies for a circular building industry. In *Building and Environment, 223*(September 2022), 109394. Elsevier Ltd. https://doi.org/10.1016/j.buildenv.2022.109394

Shahzad, A., bin Zakaria, M. S. A., Kotzab, H., Makki, M. A. M., Hussain, A., & Fischer, J. (2023). Adoption of fourth industrial revolution 4.0 among Malaysian small and medium enterprises (SMEs). *Humanities and Social Sciences Communications*, *10*(1), 1-14. https://doi.org/10.1057/s41599-023-02076-0

Tamjehi, S. D., Zaini, A. A., Zaini, N., Razali, A. W., & Gui, H. C. (2020). Exploring Building Information Modeling (BIM) Awareness in Sarawak Construction Industry. *IOP Conference Series: Earth and Environmental Science*, *498*(1), 012090. https://doi.org/10.1088/1755-1315/498/1/012090

Tjandra, K. D., Irawan, F. G., Nugraha, P., & Sunindijo, R. Y. (2022). *1 Drone Readiness in the Indonesian Construction Industry*, *22*(4), 36-58. https://doi.org/https://doi.org/10.5130/AJCEB.v22i4.8161

Wang, X., Liu, L., Liu, J., & Huang, X. (2022). Understanding the Determinants of Blockchain Technology Adoption in the Construction Industry. *Buildings*, *12*(10), 1709. https://doi.org/10.3390/buildings12101709

Zaini, A. A., Razali, A. W., Gui, H. C., Zaini, N., & Tamjehi, S. D. (2020). Assessing Strategies of Building Information Modeling (BIM) Implementation in Sarawak Construction Industry. *IOP Conference Series: Earth and Environmental Science*, *498*(1), 012086. https://doi.org/10.1088/1755-1315/498/1/012086

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