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Digitalization in malaysian construction industry: Awareness, challenges and opportunities

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ABSTRACT

The construction industry is going forward by adopting digitization, but players are still battling to grasp and execute it properly. That is why, this study aims to evaluate the awareness, challenges and opportunities of digitalization in the Malaysian construction industry and provides a framework for better digital implementation. In this perspective, a questionnaire-based study was conducted, and the responses were collected from field experts who have implemented a digital system in their construction projects. The outcome shows that the Malaysian construction industry is aware of digitalization and rated the Industrialized Building System (IBS) as the most important technology. In Project Delivery, "Standardized Organization" was the utmost factor for digitalization in construction. The top Challenge in Digital Implementation is "Organizational costs are among the high initial costs of implementing technologies, standards, and specifications". The top Opportunity in Digital Transformation is "Procedures better planned and monitored". Based on the top factors, the framework was constructed which will help the practitioners to understand and implement digitalization in a much better way. Thus, this study is significant in addressing the issues related to implementing digitalization in the Malaysian construction industry and providing a perspective to catalyse the development.

1. Introduction

In our modern day, purchasers are currently focusing on a large number of nations that are developing and rapidly expanding their economies in terms of high-quality development, efficiency, and speed of work [1]. The construction industry is constantly evolving as new technologies and new materials and methods are introduced [2–4]. This is especially true in the area of digitalization, where there is a growing demand for more efficient and timely construction processes [5,6]. The construction industry employs a variety of professionals and plays a vital role in the economy, as it creates jobs, contributes to economic growth, and provides essential infrastructure and buildings that support communities and businesses [7,8].

The Fourth Industrial Revolution, also known as Industry 4.0, refers to the current era of technological advancements in the manufacturing and production industry [9,10]. It is characterized by the convergence of digital, physical, and biological systems, and the integration of technologies such as artificial intelligence, the Internet of Things (IoT), and robotics [11]. This technological revolution is predicted to bring substantial improvements to the manufacturing industry, including increased productivity, lower prices, better product quality, and greater flexibility in production processes [12,13]. Construction 4.0 refers to the application of Industry 4.0 technologies and principles to the construction industry. It involves the use of digital technologies and automation to transform how buildings and infrastructure are designed, constructed, and maintained, with a focus on increasing efficiency, reducing waste, and improving sustainability [14–16].

Digitalization refers to the process of converting analogue information into digital form, making it accessible and useable by computer systems. It involves the use of digital technologies, such as computers, software, and the internet, to transform how information is created, stored, processed, and shared [17]. The focus of digitization is on recording and converting data, while digitalization is more keen towards improving systems by developing processes and modifying

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workflows. Digital transformation is the incorporation of computer-based technologies into an organization's procedures [18,19]. Digitalization has enabled companies to improve their efficiency and effectiveness by automating processes, streamlining operations, and accessing new markets and customers [20,21]. Digitalization can improve project efficiency and enable greater collaboration and coordination among project stakeholders, reducing errors and delays, and improving overall project efficiency [22–25]. Other than that, digitalization in the construction industry is significant and can help drive innovation, improve project outcomes, and create a more sustainable and efficient construction industry [20,26].

The construction industry is important to the global economy [27,28]. Construction is one of Malaysia's most significant businesses, particularly in terms of its contribution to the GDP and its ability to boost the productivity of other industries by creating structures and equipment on their behalf. Malaysia is one of the nations that is developing the fastest in the world, and as the industry grows quickly, it will become more prosperous [14]. The growing demand for I4.0 will probably encourage the government and the private industry to invest more in this field. The new improvement needs more efficient production chains and business modes [5,11]. Malaysia's construction industry is good at using digital tools, however, they do not realize the benefits and are hesitant to invest in new technology [29,30].

Today's enterprises face what may be described as a digital transformation. Technological developments are leading to more effective internet-based technique resolutions. Nonetheless, contemporary technologies have increased the necessity for new skills and learning in the construction field [31]. As technology progresses with Industry 4.0, the construction industry must adapt to more futuristic and complicated design, material variety, green buildings, smart houses, and so on, demanding the transition of conventional processes into digital and contemporary technologies [32]. In Budget 2020, an amount of USD 105 million was allocated by the Malaysian Government for small and medium-sized enterprises (SMEs) digital transformation as this is one of the significant challenges for them. SMEs need to adopt the new norm which is the digitalization of the industry to eliminate the challenges and boost the economy [33]. Small businesses cannot afford expensive digital systems, and upgrading current technology is costly. Also, there are no clear rules for using digital tools in construction at the moment. Based on the problem stated, this study focuses on measuring the awareness level among the construction industry stakeholders about digitalization and also highlighting the challenges and opportunities associated with it. Besides, this study also demonstrates a conceptual framework that could be utilized by practitioners to specify the key challenges and implement digitalization in the construction industry more precisely.

2. Literature review

The review provides a concise summary of digitalization concepts and main points of research in this area for challenges and opportunities of implementation of digitalization. The review also includes relevant references and explains their significance in the field of study being explored. Through a comprehensive literature review, the study aims to establish a thorough understanding of the current state of knowledge on the topic and identify gaps in existing research that require further investigation.

2.1. Implementation of digitalization in the construction industry

Several key digitalization techniques exist that are been utilized in construction nowadays. Industrialized Building System (IBS) has become widely used in the Malaysian construction industry, but it covers a wide scope that includes both on-site and off-site practices, making it difficult to distinguish it from conventional construction practices. The International Council for Research and Innovation in Building and Construction (CIB) defines industrialized construction as involving the use of various technological tools and processes, including mechanical power and tools, computerized systems, and continuous production processes [34].

Building Information Modelling (BIM) is thought to represent the fusion of cutting-edge ideas and digital technologies for the digitalization of the construction industry. One is that BIM offers great opportunities for business-to-business information exchange, though it has attracted the most interest from the construction industry [23]. BIM is a digital approach used in all stages of building projects, aiding architects, engineers, and designers in creating and sharing information [35]. It offers enormous potential for the construction industry, enabling the complete life cycle management of buildings digitally, from design to maintenance. Despite the clear benefits of BIM in advancing digitization in the industry, some stakeholders remain unconvinced [21,27,28,36,37]. This enables editing, sharing, and visualization of 3D underground models that are available to all stakeholders within the project team [38].

Industry and research are looking at new technology developments like big data, the Internet of Things (IoT), and Construction 4.0 to further improve BIM capabilities with data-driven applications [39]. These technological developments are intended to eventually create an integrated digital twin universe, where real-time physical data will be recorded, analysed, and exchanged with the virtual environment throughout the product lifecycle using a digital twin model [40,41]. Many of these will be inter- and multi-disciplinary connections in the future [37,42].

2.2. Difficulties in implementing the digital tools

In Malaysian construction projects, fragmented projects perform rather poorly, are less productive, and are less likely to adopt novel ideas. One could contend that companies are less likely to change their goals to adopt cutting-edge technology [11]. This industry adopts new technologies at a very slow rate, which lowers project efficiency and labour productivity. The least digitized industry, the construction industry has carried on as usual for a long time [28]. Other than that, when it comes to data collection and analysis, progress management techniques that are frequently utilized on construction sites are inaccurate and time-consuming. A lot of manual labour is required; hence it is also labour-intensive [43]. The construction industry faces an immediate global crisis. Lack of productivity, constant material waste, and safety risks are among the most common construction site problems that have a significant impact on society [5,22].

The widespread practice of digital transformation also requires leaders to focus on the organizational side of change by putting plans into action. The lack of organization will affect the process of making plans work. The organization's ability to influence its business must be taken into consideration if it is planning for long-term success [8,11,14,28,44–47]. Financial management becomes a crucial part where they need to allocate an amount of money to implement digitalization. There is no specific standard for digitalization implementation cost estimation. The construction industry's adoption of I4.0 makes it risky for the majority to invest in new technology [11,21,22,28,31].

Initiatives are being introduced to spread awareness of the Global Accredited Cybersecurity Education (ACE) Certification Scheme to enhance Malaysia's cyber security capabilities. Due to a lack of safety management, the program emphasizes that certified individuals must possess fundamental knowledge and abilities in the fields of organization and management, principles and concepts, legal framework, techniques, operations, and architecture [11,12,28,42]. There is a lack of labour and staff involvement, where there is an insufficient understanding to guide digitization and workers who are willing to learn new skills rather than perform their regular duties. Digitalization encourages collaboration and knowledge sharing within an organization while requiring less expertise and money [8,11,14,28,46,48].

2.3. The critical success of industry revolution (IR) 4.0

The effects of utilizing digital technology will result in Industry 4.0 having more professionalism and expertise. Also, opens up job opportunities to anyone who is interested in the fields of construction, architecture, or management and is eager to learn and gain knowledge. The pros of digitization can be applied to create new jobs in technology [24,26]. Completing a construction project quickly usually means less overall spending and a faster return on investment. BIM can help designers and builders speed up the process by providing efficient workflows and essential information for successful completion on time [20,22,26,38].

Another advantage of BIM is a visual risk analysis for safety evaluations. These in-depth reports describe the conditions on the site, which is a terrific way for new construction employees to adjust to the work environment. Because of the fine details associated with specific tasks, construction managers can eliminate risks before the construction process even begins. The construction process can be easily followed by safety professionals by viewing real-time updates on inspections and maintenance [20,38].

3. Methodology

Initially, the literature on the concept of digitalization and the technologies employed in the construction industry was reviewed. The literature helps identify the aspects that contribute to the questionnaire's development. The survey was administered online to construction industry professionals who have experience with digitalization. The questions were intended to gather information about the present status of digitalization in the construction sector, as well as the challenges and opportunities that come with it. The final version of the questionnaire was given to a greater number of participants. After the survey responses were received, the data was analysed using the Statistical Packages for Social Sciences (SPSS) software. The questionnaire survey gives useful insights into the existing status of digitalization in the construction sector, as well as aids in the development of a framework for possibilities and digitalization implementation. Fig. 1 shows the research flow.

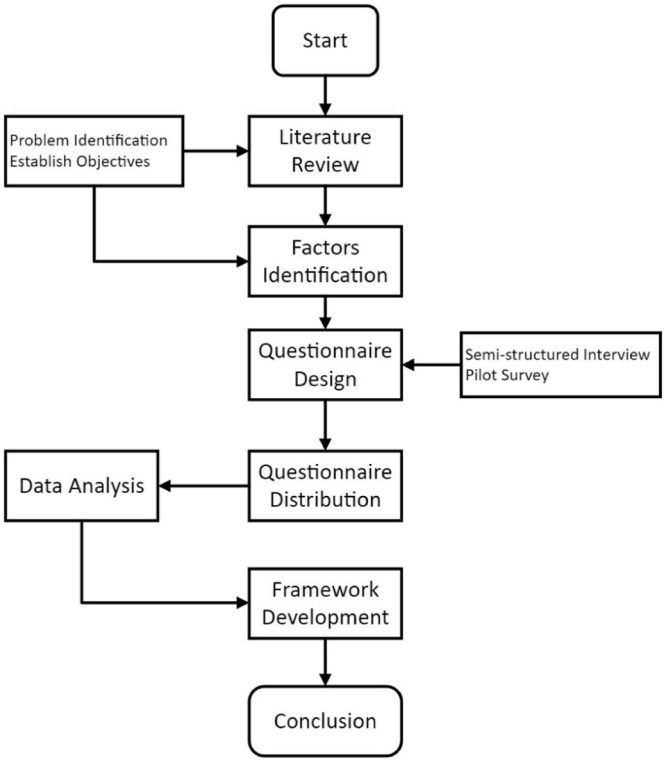

Fig. 1. Research Flowchart.

3.1. Development of the questionnaire

Initially, the factors were identified from the literature that was gathered from well-known Databases and Search engine, i.e., Web of Science, Scopus and Google Scholar. Before moving towards the full-scale distribution, semi-structured interviews from the field experts and a pilot survey was conducted to adapt the factors as per the Malaysian construction environment. The process was useful which helped to refine the content and make a final questionnaire for further distribution and analysis. The questionnaire was split into two sections; the first section seeks the respondent's profile. The second section, which consists of Likert-scale questions, aims to determine the degree of "Awareness", "Challenges" and "Opportunities" of digitalization in the Malaysian construction industry. These three major groups were further subcategorized to foresee the information in a better manner.

3.2. Target population, sample size and Respondents Profile

The target audience is any employee who worked for a company that has worked with digitalization or another digital system at their place of employment, whether they were in course engineering, site engineering, surveying, or architecture. For the population to be large, using the sample size makes it easier to calculate and know the accuracy of the whole population. To determine the necessary sample size for a study on the role of digitalization in the construction industry, Slovin's formula was utilized as mentioned in Equation (1).

$$\frac{N}{(1+N\,e^2)} \tag{1}$$

The target population consisted of 1.38 million individuals within the engineering field and a margin of error of e = 0.05 with a confidence level of 95% (alpha level of 0.05) was selected for improved accuracy. Plugging these values into the formula, a total sample size of 399.8 was calculated. Thus, it was decided to distribute 400 surveys to potential respondents [49]. Ultimately, a total of 161 individuals responded to the survey, resulting in a response rate of 40%. The sample size of this study exceeded the recommended minimum of 30%, which indicates a satisfactory level of representativeness [50]. However, it is important to note that while Slovin's formula provided a useful estimation for sample size, other factors could influence the accuracy and representativeness of the sample. These factors include the sampling method, survey design, and potential response bias, which should be considered when interpreting the results.

Fig. 2 shows the general information of the respondents in terms of Education Level, Position, Organization Type and Working Experience. It can be observed that the majority of the respondents hold a Bachelor's Degree and a high rate of responses was attained from Site Engineers. Moreover, in Organization Type most of the respondents were Contractors. It was also observed that the maximum number of respondents in Working Experience were in the 6–10 years range.

3.3. Reliability and correlation test

Reliability refers to the consistency or precision of measurement [51], which improves as the obtained value increases. In statistics, the internal consistency coefficient is also known as Cronbach's alpha or a reliability test. It is commonly used to assess the validity and reliability of psychometric tests for a group of examiners and to provide an estimate of their reliability for test subjects. Besides, the correlation was performed as it shows the statistical technique that measures the strength and direction of association between two ranked variables.

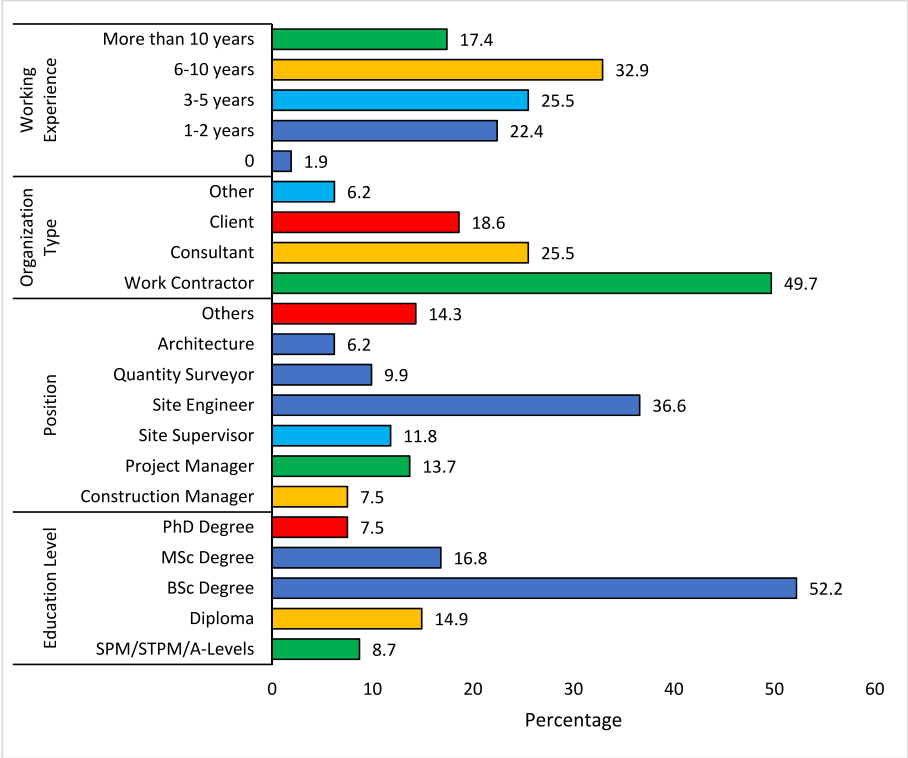

Fig. 2. Respondents profile.

3.4. Relative important index (RII) method

The RII is a qualitative estimate of the importance of several factors in a decision. It is determined as the sum of weighted components, where each element has a weight that indicates its relative importance, as indicated in Equation (2). The RII value can then be used to identify the most and least important factors in a decision by comparing it to the range defined for the RII metric.

$$RII = \Sigma W / (AxN) \quad (2)$$

Where, W = Weight of each factor, A = Highest weight, N = Total Respondents.

4. Result and discussion

A Google Form survey was distributed among professionals in the engineering field. The survey consisted of a few sections that covered general information, awareness of digitalization in construction, and challenges and opportunities to implement digital transformation in the construction industry. The findings provide insights into the respondents' demographics, familiarity with digital technologies, challenges faced in adopting these technologies, and potential benefits.

4.1. Reliability analysis

The obtained Cronbach's Alpha value is 0.969 which shows that the data is highly reliable for further processing. As seen in the Cases category, the responses are 100% valid with the number of items 57 with the number of respondents 161, hence 0% were excluded. The overall analysis can be seen in Table 1.

Table 1
Reliability analysis.

Case Processing Summary			
		N	%
Cases	Valid	161	100.0
	Excluded	0	0.0
	Total	161	100.0
Reliability Statistics			
Cronbach's Alpha		0.969	
N of Items		57	

4.2. Validity and correlation analysis

The data validity and correlation coefficient analysis can be seen in Table 2, which were found to be significant with a P-value of <0.001, meeting the acceptance criteria for the hypothesis test with a significance level of 0.05. The results indicate that the data collected for assessing the level of awareness, challenges, and opportunities related to digitalization in the construction industry of Malaysia are reliable and valid. These findings validate the overall data collected for the study and support the credibility of the research findings.

4.3. Correlation between categories

The correlation between Awareness and Challenges is 0.649, which shows a moderate positive relationship. This means that as awareness increases, perceived challenges also tend to increase. The correlation coefficient between awareness and opportunities is 0.586, which also shows a moderate positive relationship. This means that as awareness increases, perceived opportunities also tend to increase. The correlation coefficient between challenges and opportunities is 0.849, which indicates a strong positive relationship. the detailed outcome can be seen in Table 3.

4.4. Ranking of the factors

The concept of the RII was utilized to assess the level of awareness of

Table 2
Correlation Coefficient and P-value data.

Code	Factor	Correlation Coefficient	P - value
B1	familiar with Construction Industry's Digitalization	0.566	<0.001
B20	Building Information Modelling (BIM)	0.604	<0.001
B21	Augmented Reality (AR)	0.578	<0.001
B22	Virtual Reality (VR)	0.616	<0.001
B23	Internet of Things (IoT)	0.622	<0.001
B24	Digital Twin	0.568	<0.001
B25	3D Printing	0.693	<0.001
B26	Cloud computing	0.661	<0.001
B27	Blockchain	0.564	<0.001
B28	Industrialized Building System (IBS)	0.627	<0.001
B29	Geospatial Data	0.516	<0.001
B3	Joined any training in Digitalization	0.460	<0.001
B4	The company organizes any Digitalization training	0.429	<0.001
B5	Had implemented Digitalization in construction project	0.373	<0.001
B6	Experience in Digitalization implementation	0.365	<0.001
B7	Digitalization can improve the deliverables of any project.	0.298	<0.001
B71	Improve project quality	0.590	<0.001
B72	Standardized organization	0.607	<0.001
B73	Reduce cost and time	0.545	<0.001
B74	Increase safety issue	0.568	<0.001
B75	Reduce environmental pollution	0.556	<0.001
B76	Increase productivity	0.592	<0.001
C1	Organizational costs are among the high initial costs of implementing technologies, standards, and specifications	0.624	<0.001
C2	The construction industry has traditionally lacked commitment to investment	0.673	<0.001
C3	Insufficient budget for hiring the digitalize professional	0.604	<0.001
C4	Low demand from the market since the building lacks new features, especially for smaller companies	0.643	<0.001
C5	The failure of timely release of funding	0.652	<0.001
D1	International contractors are becoming more concerned about project management capabilities for digitization and risk exposure	0.652	<0.001
D2	Integration of risk management and innovative management strategies is still in its early stages	0.685	<0.001
D3	The fear that technology will replace the labour force in construction causes companies to discourage the adoption of technology	0.601	<0.001
D4	Poor research and development in digitalization fields	0.664	<0.001
D5	Non-existent standardized tools and procedures	0.573	<0.001
E1	Shortage of experienced digitization users	0.642	<0.001
E2	A limited number of professionals to guide the use of the digital application	0.674	<0.001
E3	Lack of training in the Digitization field	0.683	<0.001
E4	High cost of training personnel involved, system reform, software/hardware update etc	0.698	<0.001
E5	Lack of awareness in learning new courses in digitalization	0.662	<0.001
F1	Lack of demand from the contractors and sub-contractors that requires the use of digitalization in the project	0.638	<0.001
F2	The lack of awareness among the construction workers	0.659	<0.001
F3	Shortage of experience in digitalization	0.616	<0.001
F4	Industry's lack of BIM such as the files are not updated on work progress by the contractor during the construction phase	0.640	<0.001
F5	The employees are not interested because they need to learn from the start	0.603	<0.001
G1	The application of digitalization is a major challenge for the small company	0.579	<0.001
G2	Lack of security management, data protection and cyber security	0.583	<0.001
G3	Implementation of BIM most in large companies than in small companies	0.590	<0.001
G4	Software limitations contribute to challenges in digitalization	0.595	<0.001
G5	The government and the organization itself cannot encourage construction stakeholders to adopt IoT in the construction industry	0.635	<0.001
H1	Increased productivity and efficiency in processes	0.681	<0.001
H2	Procedures better planned and monitored	0.676	<0.001
H3	Produce more expert workers in digitalization field	0.607	<0.001
H4	Improved the lifecycle construction with better handling	0.684	<0.001
H5	Technologies utilization in the different types of buildings project	0.555	<0.001
I1	Reduce the number of incidents at the construction site and improve the risk safety	0.638	<0.001
I2	Smoothed the ways of construction and maintenance	0.609	<0.001
I3	Reduces the time and cost of construction	0.618	<0.001
I4	Reduce environmental pollution from the site project	0.697	<0.001
I5	Improved the quality and consistency of the project	0.605	<0.001

Table 3
Pearson correlation analysis.

Correlations				
		Awareness	Challenges	Opportunities
Awareness	Pearson Correlation	1	0.649[a]	0.586[a]
	Sig. (2-tailed)		<0.001	<0.001
	N	161	161	161
Challenges	Pearson Correlation	0.649[a]	1	0.849[a]
	Sig. (2-tailed)	<0.001		<0.001
	N	161	161	161
Opportunities	Pearson Correlation	0.586[a]	0.849[a]	1
	Sig. (2-tailed)	<0.001	<0.001	
	N	161	161	161

[a] Correlation is significant at the 0.01 level (2-tailed).

digitalization in the construction industry through a series of questions. The RII provides a quantitative measure of the level of familiarity or not familiarity of the respondents with the questions posed, the findings are discussed below.

4.4.1. Technology applied in construction industry

Table 4 presents the ranking of various technologies applied in the construction industry. The outcome indicate that the Industrialized Building System (IBS) received the highest rank with an RII score of 0.75031. IBS is widely recognized and used in the Malaysian construction industry to represent prefabrication and industrialization terminologies. It is a popular and widely adopted technology among practitioners, researchers, and the government in the country for advancing construction industrialization. Followed by Building Information Modelling (BIM) with an RII score of 0.734161 and a ranking of 2. 3D Printing, Virtual Reality (VR), Cloud computing and Augmented Reality (AR) are also important technologies in the construction industry, with RII scores ranging from 0.696894 to 0.691925 and rankings from 3 to 6. The less important technologies are ranked lower, with

Table 4
Technology applied in construction industry.

Code	Factor	RII	Rank
Technology Applied in Construction Industry			
B20	Building Information Modelling (BIM)	0.734161	2
B21	Augmented Reality (AR)	0.691925	6
B22	Virtual Reality (VR)	0.710559	4
B23	Internet of Things (IoT)	0.679503	7
B24	Digital Twin	0.640994	8
B25	3D Printing	0.724224	3
B26	Cloud computing	0.696894	5
B27	Blockchain	0.632298	10
B28	Industrialized Building System (IBS)	0.750311	1
B29	Geospatial Data	0.636025	9

Geospatial Data, Blockchain, Digital Twin, and Internet of Things (IoT) having RII scores ranging from 0.632298 to 0.679503 and rankings from 7 to 10. The lower-ranked technologies, such as Blockchain and Geospatial Data, may not be as well-known or understood due to their more specialized and technical nature. Overall, the study suggests that there is a growing awareness of digitalization in the construction industry, with companies adopting and utilizing various technologies to improve efficiency, productivity, and collaboration. The results are acceptable based on Kamar et al. [34] study.

4.4.2. Project Delivery by digitalization

From Table 5, it is evident that project deliveries by digitalization play a crucial role in the construction industry. The highest-ranking factor was the standardization of organization (B72), with an RII of 0.735404, closely followed by the improvement of project quality (B71) with an RII of 0.731677. In third place was the reduction of cost and time(B73), while the fourth place was occupied by the issue of safety (B74). The fifth-ranked factor was the reduction of environmental pollution (B75) with an RII of 0.685714. The lowest-ranking factor was the increase in productivity (B76) with an RII of 0.680745. The result of the top rank for project deliveries is aligned with the literature [11,52].

4.4.3. Challenges of implementation of digital technologies in construction

This section was categorized into five main questions regarding the challenges to the implementation of digital technologies. Each main question contains five factors, resulting in a total of 25 questions related to the challenges of implementing digital technologies in the construction industry. Table 6 presents the overall results of the challenges, where the Cost Management category had the highest RII for factor C1, which was related to the high initial costs of implementing digital technologies, standards, and specifications [22]. Additionally, the most critical challenge identified was the "Lack of awareness in learning new courses in digitalization" (E5), ranked second with an RII of 0.781366. Another significant challenge was the "Lack of demand from contractors and sub-contractors requiring the use of digitalization in projects" (F1), which ranked third with an RII of 0.775155. These results were also supported by the study of Salvatore Gerbino [53] and Demirkesen and Tezel [8]. Overall, the results provide insight into the challenges faced by the construction industry in implementing digitalization and understanding these challenges can help stakeholders in the construction industry address them and take steps towards successful digitalization.

Table 5
Project Delivery by digitalization.

Code	Factor	RII	Rank
Project Delivery by Digitalization			
B71	Improve project quality	0.731677	2
B72	Standardized organization	0.735404	1
B73	Reduce cost and time	0.724224	3
B74	Increase safety issue	0.710559	4
B75	Reduce environmental pollution	0.685714	5
B76	Increase productivity	0.680745	6

Table 6
The challenge to Digitalization implementation.

Code	Factor	Rank	RII
Cost Management			
C1	Organizational costs are among the high initial costs of implementing technologies, standards, and specifications	1	0.792547
C2	The construction industry has traditionally lacked commitment to investment	11	0.76646
C3	Insufficient budget for hiring the digitalize professional	13	0.762733
C4	Low demand from the market since the building lacks new features, especially for smaller companies	17	0.759006
C5	The failure of timely release of funding	24	0.746584
Risk Management			
D1	International contractors are becoming more concerned about project management capabilities for digitization and risk exposure	18	0.757764
D2	Integration of risk management and innovative management strategies is still in its early stages	23	0.750311
D3	The fear that technology will replace the labour force in construction causes companies to discourage the adoption of technology	25	0.734161
D4	Poor research and development in digitalization fields	5	0.773913
D5	Non-existent standardized tools and procedures	19	0.757764
Professional/Trainee			
E1	Shortage of experienced digitization users	7	0.770186
E2	A limited number of professionals to guide the use of the digital application	12	0.76646
E3	Lack of training in the Digitization field	6	0.770186
E4	High cost of training personnel involved, system reform, software/hardware update etc	10	0.768944
E5	Lack of awareness in learning new courses in digitalization	2	0.781366
Worker/Staff			
F1	Lack of demand from the contractors and sub-contractors that requires the use of digitalization in the project	3	0.775155
F2	The lack of awareness among the construction workers	8	0.770186
F3	Shortage of experience in digitalization	16	0.761491
F4	Industry's lack of BIM such as the files are not updated on work progress by the contractor during the construction phase	21	0.75528
F5	The employees are not interested because they need to learn from the start	22	0.754037
Application Digitalization			
G1	The application of digitalization is a major challenge for the small company	9	0.770186
G2	Lack of security management, data protection and cyber security	14	0.762733
G3	Implementation of BIM most in large companies than in small companies	4	0.775155
G4	Software limitations contribute to challenges in digitalization	15	0.762733
G5	The government and the organization itself cannot encourage construction stakeholders to adopt IoT in the construction industry	20	0.756522

4.4.4. Opportunities of digital transformation in construction industry

Table 7 presents data related to the role of digitalization in the construction industry, with a focus on the opportunities associated with its implementation. In this case, the factors are divided into two categories: company management and construction site. The top five factors that received the highest rank include: "Procedures better planned and monitored" with RII 0.793789, second rank includes "Technologies utilization in the different types of buildings project" with RII 0.780124, while "Increased productivity and efficiency in processes", "Improved the lifecycle construction with better handling" and "Reduce the number of incidents at the construction site and improve the risk safety" ranked third, fourth and fifth. Overall, the data presented in the table highlights the significance of planning, monitoring, and utilizing technology in the

Table 7
Opportunities for implementation the digitalization.

Code	Factor	RII	Rank
Company Management			
H1	Increased productivity and efficiency in processes	0.776398	4
H2	Procedures better planned and monitored	0.793789	1
H3	Produce more expert workers in the digitalization field	0.770186	7
H4	Improved the lifecycle construction with better handling	0.772671	6
H5	Technologies utilization in the different types of buildings project	0.780124	2
Construction Site			
I1	Reduce the number of incidents at the construction site and improve the risk safety	0.773913	5
I2	Smoothed the ways of construction and maintenance	0.77764	3
I3	Reduces the time and cost of construction	0.767702	8
I4	Reduce environmental pollution from the site project	0.765217	9
I5	Improved the quality and consistency of the project	0.760248	10

construction industry to increase productivity, reduce costs, and improve safety and quality. It also shows that a focus on construction site processes, such as smoothing the ways of construction and maintenance, reducing incidents and environmental pollution, and improving project quality, is crucial for the success of digitalization in the construction industry.

4.5. Conceptual framework for digitalization

By addressing the challenges and embracing the opportunities, the construction industry in Malaysia can fully realize the potential of digitalization. Based on the findings, a conceptual framework for digitalization in the construction sector was developed, as seen in Fig. 3. One of the major issues that the construction sector faces is cost management. The integration of digital technologies into the construction process requires significant investment, and many companies are reluctant to incur additional costs. Another significant challenge is risk management, as there are concerns about the cybersecurity of digital systems and the potential for system failures. Furthermore, the lack of trained professionals or trainees to manage the digitalization process is another major challenge. The industry also faces challenges with worker or staff acceptance and adoption of digital technologies, as they may be resistant to change or lack the necessary skills to operate digital systems effectively. Finally, the application of digitalization itself is another challenge, as companies may struggle to identify the most appropriate digital technologies to implement and how to integrate them into existing systems. Despite these challenges, there are numerous opportunities for digital transformation in the construction industry. Digitalization can significantly improve company management procedures, making planning and monitoring more effective. It can also be used to streamline various types of building projects, making management and execution much more efficient. Additionally, digitalization can improve progress on construction sites, enabling smoother and faster work processes and making maintenance and upkeep more manageable. The objective of understanding the challenges and opportunities of digitalization in the construction industry is to upgrade the standards of digitalization in Malaysia. By identifying these challenges and opportunities, companies can be more confident in investing in digital technologies and enhancing their processes to keep pace with IR 4.0. Digitalization is the future of the construction industry, and by embracing it, Malaysia can take a significant step forward in its progress towards IR 4.0. This framework will also help in the better adoption of digitalization not only in the Malaysian construction industry but also in other developing construction industries having similar challenges and opportunities.

5. Conclusion

This research delves into the crucial topic of the role of digitalization in the construction industry, specifically in Malaysia. This research sheds light on the impact of digitalization on the industry and helps to guide companies towards investing in and upgrading their digitalization processes. A questionnaire-based study was utilized to get feedback from the construction industry stakeholders about the awareness, challenges and opportunities of digitalization in the construction industry. The findings show that the implementation of digital technologies in the construction industry of Malaysia faces several challenges. One significant challenge is the lack of awareness and understanding of the benefits and potential of digitalization among industry stakeholders. There is also a shortage of skilled labour and a lack of training opportunities for

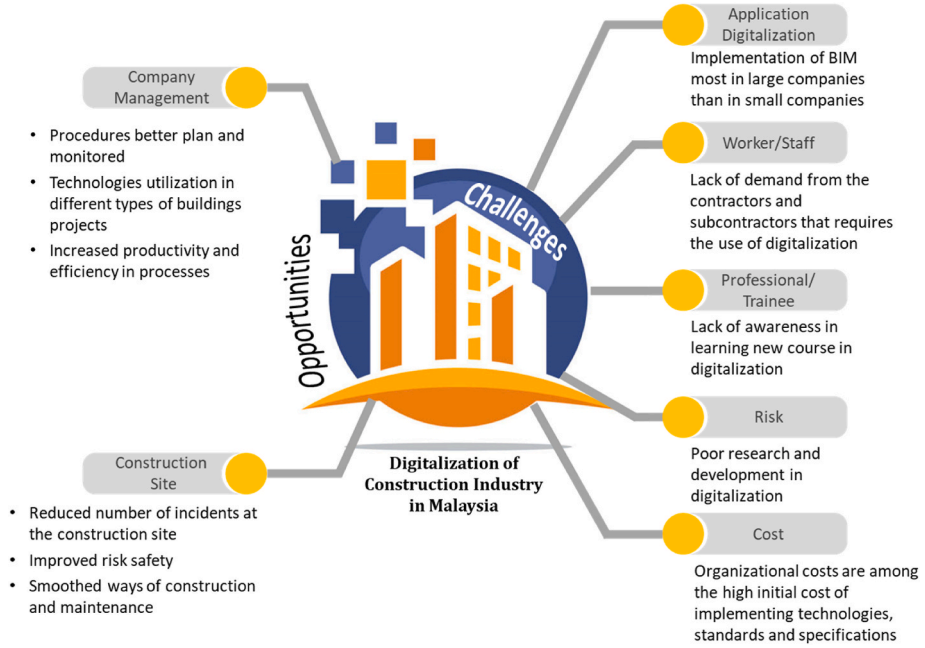

Fig. 3. Conceptual framework for digitalization in the construction industry.

workers to acquire the necessary digital skills. Furthermore, the high initial investment required for the implementation of digital technologies may discourage companies from adopting these tools. The results of the survey were also analysed to develop a framework that guides the exploration of digitalization in the construction industry of Malaysia, specifically in terms of the challenges and opportunities it presents. This framework can also be adapted to other developing countries' construction industries with similar characteristics.

6. Limitations and future direction

The study on the role of digitalization in Malaysia's construction industry sheds light on the industry's difficulties and potential in the era of IR 4.0. This study has some constraints, which influenced the suggested future direction:

One subject for future research is to take a deeper look at the obstacles that Malaysia's construction industry has while using digital technology. This might involve a more in-depth evaluation of topics such as cost management, risk management, and employee training. By better understanding these issues, researchers and industry leaders may devise methods to overcome them and improve the effective deployment of digital technology in the construction industry.

Another subject for future research is an analysis of the prospects created by digitization in Malaysia's construction industry. This might involve looking at how digital technology can be utilized to boost production, minimise waste, and improve safety in construction sites. Identifying these possibilities allows researchers and industry leaders to prioritise the introduction of digital technologies in areas where they will have the biggest influence on the construction industry.

A third topic of future research is examining the influence of digitization on Malaysia's construction supply chain. This might involve looking at how digital technologies are being adopted by constructing material and equipment suppliers, manufacturers, and distributors. Understanding these consequences allows researchers and industry leaders to work together to guarantee that the advantages of digitalization are diffused across the construction industry, from project design to project completion.

A fourth topic for future study is to investigate the potential for digitization to improve the quality of construction projects in Malaysia. This might include the use of modern design software and quality control technologies to guarantee that construction projects meet the highest standards. Digitalization can assist in raising the safety, lifespan, and value of buildings and infrastructure by enhancing the quality of their construction.

Overall, future studies on digitalization in the construction industry should focus on these areas to better understand the difficulties and potential presented by IR 4.0. By doing so, researchers may assist companies and governments in effectively implementing digital technologies, ensuring that Malaysia's construction industry stays competitive and sustainable in the digital era.

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Muhammad Ali Musarat: Writing – original draft, Validation, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Wesam Salah Alaloul:** Writing – review & editing, Visualization, Supervision, Resources, Methodology, Investigation, Funding acquisition, Data curation, Conceptualization. **Siti Mariam Binti Zainuddin:** Writing – original draft, Software, Methodology, Investigation, Formal analysis. **Abdul Hannan Qureshi:** Writing – review & editing, Visualization, Methodology, Data curation, Conceptualization. **Ahsen Maqsoom:** Data curation, Methodology, Visualization, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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