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IMPACT OF PERFORMANCE AND BARRIERS TOWARDS INDUSTRIAL REVOLUTION 4.0 IMPLEMENTATION IN MALAYSIAN CONSTRUCTION PROJECTS

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ABSTRACT

Malaysian construction industry is still lagging in new technology adoption, while the world is moving towards Industrial Revolution 4.0 (IR 4.0). This study aims to identify the critical barriers of hindering the implementation of IR 4.0 among stakeholders in construction industry by using a set of questionnaires. The impacts of IR 4.0 to construction industry were also studied. The quantitative data were analysed using Relative Importance Index. The data revealed that the top barriers were related to technology deficiency and financial issue, while the greatest impacts of IR 4.0 implementation on project performance were safety, project success and time performance. The future of construction industry moving towards a fully digitalization is promising, although a longer time is required to achieve the desired status.

Keywords: *Barriers, construction projects, Industrial Revolution 4.0, performances*

INTRODUCTION

The construction industry is a crucial economic sector that contributes to the country's Gross Domestic Product (GDP). However, the growth in construction industry has remained nearly flat for almost 50 years (Alaloul et. al., 2018). The perplexity of construction projects these days has remarkably increased as a consequence through the engagement of different disciplines parties, and a construction project itself consists of complex information. Most of the processes in a construction project is carried out manually and this may contribute to a high possibility of human error which could lead to undependable decisions and delays. The construction industry worldwide has encountered consequential delays and cost overrun (Ishak et al., 2019; Smith, 2014; Tahir et al., 2018). For instance, approximately 17.3% of contract projects from the Malaysian government in 2005 experienced delay and some were abandoned (Tahir et al., 2018).

Today, the Fourth Industrial Revolution (Industrial Revolution 4.0), which was originated from the German government in 2011, is to link human and technology together. Industrial Revolution 4.0 was first developed in the advanced manufacturing known as Smart Manufacturing. According to Osunsanmi et al. (2018a), the construction sector has been considered as latecomer to the advantages offered by the application of information technology compared to other industries for instance, banking and manufacturing, which have already established the implementation of digitization and information technology. The idea of IR 4.0 has remarkably enhanced the quality and productivity in the manufacturing industry and such implementation is also believed to have similar impacts in the construction industry. Nevertheless, stakeholders in the construction industry are unaware of the necessities and importance to implement this concept. Previous research has shown that there is very little existing knowledge regarding the implementation of IR 4.0 in Malaysian construction projects, hence, there is inadequate guidelines for them to move forward in this transition journey. As such, the study aims to explore the implication of IR 4.0 in construction projects. This study embraced the following objectives:

- to determine the critical barriers of the implementation of IR 4.0 in construction projects in Malaysia; and
- to identify the impact of IR 4.0 on different aspects of performances in construction projects.

Current Status of IR 4.0 in Malaysia

Research by Newman et al. (2020) discovered that published papers related to IR 4.0 were expanded from two (2) papers in year 2013 to 111 papers in year 2018 despite a reduction in the amount with 75 papers in year 2019. Out of all these papers, 21% of them are from Asian institutions and this reflects that IR 4.0-related topics have gained attentions globally. Also, it is worth mentioning that out of all the countries listed in the study, Malaysia is known as the only developing country, while the others are all developed countries.

In the year of 2019, the Ministry of International Trade and Industry (MITI) had announced the Industry4WRD policy that was to only appoint the manufacturing industry. However, Datuk Seri Mustapa Mohamed, Minister in the Economy Department of the Prime Minister, revealed that the government would establish and launch the Digital Economy Masterplan in October 2020 as an encouragement to involve all sectors inclusive of the non-manufacturing sector in Malaysia. This policy indicates the emergence change of technology and smart system development in non-manufacturing sector such as the construction industry. As attested by the government newsletter, in the Industry4WRD policy, RM210 million had been allocated in the Budget 2019 to empower the entire country to move towards IR 4.0 in the year 2019 to 2021 (Nordin, 2020). In view of the initiatives from the Malaysian government, it is worth to gauge more information from the construction stakeholders on the potential implications of IR 4.0 implementation in the construction industry in terms of the barriers and potential impacts on construction projects performance.

LITERATURE REVIEW

Majority of the past studies on IR 4.0 focus on other industries for instance, manufacturing (Castelo-Branco et al., 2019; Dachs et al., 2019; Hamzeh et al., 2018; Raj et al., 2020; Varela et al., 2019) and automotive industries. There is limited IR 4.0 literature in the construction sector. Table 1 indicates a summary of few selected past studies in the construction industry. Numerous past studies were also found to be carried out in other countries. For example, Daribay et al. (2019) focused on the status, opportunities, and challenges of implementing IR 4.0 in the region of Kazakhstan. This study discovered that the region would improve on its productivity and competitiveness if the implementation of IR 4.0 focused on global standard and global community. Osunsanmi et al. (2018a) focused on awareness and readiness of construction stakeholders on full digitalization in South Africa, while, Dallasega et al. (2018) proposed a general framework of how Industry 4.0 affect 4 different types of proximity enablers, namely, technological, organizational, geographical and cognitive.

There is limited relevant past studies in Malaysia. One of the most recent literature was Alaloul et al. (2020) studied on the challenges hindering the implementation of IR 4.0 in Malaysian construction industry. However, this study focused on construction sector in general which leaves a research gap for future study to explore critical barriers in construction projects to provide construction stakeholders with a better understanding and a clearer direction on this digital transition. This study found that social and technical were the most critical barriers, while political factor was found to be the least critical barrier in the construction sector.

Besides, Aripin et al. (2019) reviewed on the barriers and benefits of IR 4.0 as well as current digital technologies in Malaysian construction industry. Five potential barriers have been identified, namely, implementation cost, technology acceptance, higher requirements on equipment and process, lack of knowledge and individual hesitance. The researchers have also identified benefits of adopting digital technologies on five different aspects: cost, time, quality, safety, and industry image. They concluded that IR 4.0 implementation is far reaching in the construction sector and recommended further exploration using qualitative or quantitative survey to understand that the perspectives of stakeholders in Malaysia is essential to ensure a more reliable result.

Studies were also focused on the specific type of digital technologies related to the concept of IR 4.0 such as Building Information Modelling (BIM). For instance, Jamal et al. (2019) conducted a survey to investigate opinions from architects on BIM and this leaves a gap for further study to be conducted in obtaining opinions from other stakeholders. This study found that lack of skilled and experience workforce and high implementation cost were the key barriers of adopting BIM in the construction sector. On the other hand, Jabbour et al. (2018) carried out a study based on the theoretical suggestions by focusing on the IR 4.0 and environmentally sustainable manufacturing which leaves gap for future study by using a more reliable survey approach. However, this research did not identify and assess the important level of each successful factor in construction projects.

Based on the results from the literature review, few studies focused on the Asian countries, namely, Alaloul et al. (2018), Alaloul et al. (2020), Aripin et al. (2019), Li and Yang (2017) and Rastogi (2017). Among these Asian-based studies, Alaloul et al. (2020) and Aripin et al. (2019) reported that past studies of this subject matter in the Malaysia region was limited). Besides, research-based of existing studies focused on construction industry were not adequate, (Alaloul et al., 2020; Osunsanmi et al., 2018a; Rastogi, 2017). The concept of IR 4.0 in the construction industry is quite new, as such most of the existing literature was conducted in the form of desktop study (e.g. Dallasega et al., 2018; Wu et al., 2016) instead of research-based study. Because of this, it is essential to carry out more surveys in order to acquire a more reliable data and result.

A concluding remark by reviewing the past studies revealed that there is very little information on the implementation of IR 4.0 in Malaysian construction projects as majority of the past studies were conducted in other regions, especially the developed countries, or in other sectors such as manufacturing sector. Thus, this highlights that future studies in Malaysian construction industry are necessary to provide construction stakeholders sufficient information on the challenges that could be faced in the transition journey of IR 4.0.

Table 1. Summary of Selected Main Past Studies

Nos.	References	Regions of the study	Type of research	Area of study
1.	Daribay et al. (2019)	Kazakhstan	Review paper	Current state of IR 4.0 as well as opportunities and challenges
2.	Alaloul et al. (2018)	-	Review paper	Challenges and opportunities
3.	Alaloul et al. (2020)	Malaysia	Research paper	Challenges and opportunities

4.	Aripin et al. (2019)	Malaysia	Review paper	Current digital technologies practice, barriers and benefits of IR 4.0
5.	Dallasega et al. (2018)	-	Review paper	Challenges and benefits of supply chain in construction
6.	Li and Yang (2017)	China	Review paper	Mechanism and development paths of BIM
7.	Osunsanmi et al. (2018a)	South Africa	Research paper	Awareness and readiness of stakeholders
8.	Rastogi (2017)	India	Research paper	Lean digital thinking
9.	Wu et al. (2016)	-	Review paper	Challenges and future of 3-D printing

Source: Author

RESEARCH METHODOLOGY

A quantitative approach was adopted in this study as compared to qualitative approaches as data can be collected in a shorter period of time and covers a larger area (Marosi & Bauer, 2017). A questionnaire survey was adopted as the research method in this study. The questionnaire was designed into three main sections and adopted from Wee (2020). The questionnaire adopted a 5-point Likert scale (1 = not important, 2 = slightly important, 3 = moderately important, 4 = very important, and 5 = extremely important) to analyze the collected data statistically (Marosi & Bauer, 2017). A 5-point Likert scale was used in this study as it is the most common scale type used by past studies such as Alaloul et al. (2020). In addition, according to Dawes (2008), the 5-point scale can increase the reliability and validity of the scales. To assure content validity of the research findings, factors were extracted from literature search of relevant past studies.

This survey targeted different types of construction organizations, namely, consultants, contractors, and developers in Malaysian construction industry. The sampling method of this study was convenience and simple random sampling. It focused on the point of view and experience of experts from different professional disciplines in construction projects, namely, civil engineering, electrical engineering, project management, and architecture. The sampling frame of this study was based on the open access databases from relevant professional bodies such as Board of Engineers Malaysia (BEM) and the Construction Industry Development Board (CIDB) in

Malaysia. The questionnaire was sent to approximately 200 construction-related organizations. Responses from participants with at least 10 years of working experience were considered in this study to increase the reliability of the research findings. In view of the time and funding constraints as well as geographical location limitation, random and convenience sampling was adopted in this study.

RESULTS AND DISCUSSIONS

A total of 200 copies of questionnaire were delivered to industry professionals through mail and drop and pick methods. Only 30 responses were obtained in this study. The low response rate was due to the current Covid-19 pandemic in Malaysia where many companies are under arduous situation. In this study, 26 responses were considered valid. Although the response rate was low, all the respondents have more than 10 years of working experiences in the construction industry, as such, the findings were deemed as more reliable, as they have good technical and practical knowledge in construction projects and they are well-aware of the current condition in construction sector.

Demographic Information

The background of respondents is summarized and shown in Table 2. Majority of the respondents are from the discipline of civil engineering (28.6%), followed by structural engineering (17.9%) and project management (14.3%). It can be seen that 67.8% of them are working as engineers of various disciplines. In addition, majority of the respondents are working in the consultancy companies (70%), followed by 23.3% of respondents involve in contractor companies. Majority of the respondents have 10 – 20 years of working experience (73.1%), followed by 21 – 30 years (15.4%) and 30 years and above (11.5%).

Table 2. Background of Respondents

Category	Percentage (%)
Professional Discipline:	
Architecture	14.3
Electrical Engineering	7.1
Geotechnical Engineering	7.1
Structural Engineering	17.9
Civil Engineering	28.6
Mechanical Engineering	7.1
Project Management	14.3
Land Surveying	3.6
Type of Organization:	
Consultant	70.0
Contractor	23.3
Client/Developer	6.7
Working Experience:	
10 - 20 years	73.1
21 - 30 years	15.4
31 years and above	11.5

Source: Author

Main Barriers Hindering Implementation of IR 4.0

Table 3 shows the mean score and RII of the top 10 most critical barriers in the implementation of IR 4.0 in construction projects. The results of this study indicated that the four (4) most important barriers with the highest RII are ‘additional time/task is required (e.g. model checking, information entering etc.)’ (RII=0.800), ‘staff is lack of technical skill and knowledge’ (RII=0.800), ‘lack of financial resources’ (RII=0.777) and ‘lack of manpower’ (RII=0.777). ‘Compatibility issues of the current software with new technology’ and ‘difficulty in authorizing and monitoring of the quality and progress of construction’ have RII of 0.769, while barriers with the least RII is ‘worry that human and machine (e.g. Robot) cannot work together’ (RII=0.600), followed by ‘ageing workforce’ (RII=0.636). The six critical barriers with the highest RII are further discussed in the following sub-sections.

Table 3. Mean, RII and Ranking of the Barriers

Barriers	References	Mean	RII	Ranking
Additional time/task is required (e.g. model checking, information entering etc.)	[7], [11]	4.000	0.800	1
Staff are lack of technical skill and knowledge	[4], [7], [11], [12], [14], [16], [18], [19], [20]	4.000	0.800	1
Lack of financial resources	[4]	3.885	0.777	2
Lack of manpower	[12]	3.885	0.777	2
Compatibility issues of the current software with new technology	[10], [11], [15], [16]	3.846	0.769	3
Difficulty in authorizing and monitoring of the quality and progress of construction	[11]	3.846	0.769	3
Fear of long payback period	[4]	3.808	0.762	4
Impractical planning, inefficient project construction & business processes	[19]	3.808	0.762	4
Lack of continuous training	[7]	3.808	0.762	4
Lack of support from top management	[4], [11], [12], [17], [20]	3.808	0.762	4
Complex nature of construction projects	[3], [7], [18]	3.769	0.754	5
Complexity and higher requirement of new technology	[8], [10], [14], [18]	3.769	0.754	5
Lack of awareness of the benefits of IR 4.0	[1], [4], [10], [11], [12], [13], [14], [16]	3.769	0.754	5
Lack of market demand	[1], [4]	3.769	0.754	5
Lack of standard and references in implementation	[3], [6], [10], [11]	3.769	0.754	5
Difficulty in control and maintenance if exposed the technology on the site	[14]	3.731	0.746	6

Source: adapted from Wee, (2020)

Table 3. Mean, RII and Ranking of the Barriers (continued)

Barriers	References	Mean	RII	Ranking
High/uncertain life cycle cost	[4]	3.731	0.746	6
Lack of relevant industrial clusters where they could learn	[12]	3.731	0.746	6
High cost in training/attending seminars	[1], [14], [18]	3.692	0.738	7

High investment cost	[1], [2], [4], [7], [8], [11], [12], [14], [16], [19], [20]	3.692	0.738	7
High maintenance cost	[18]	3.692	0.738	7
Lack of government legislation compliance	[1], [4], [8], [16], [17], [19]	3.692	0.738	7
Lack of professional trainer	[1]	3.692	0.738	7
Little knowledge about the IR 4.0	[12], [13]	3.692	0.738	7
Organizational and process changes	[2], [3], [8], [10], [16]	3.692	0.738	7
Uncertainty of return of investment	[1], [3], [4], [18], [20]	3.692	0.738	7
High risk industry	[7]	3.654	0.731	8
Lack of proper technology	From the authors	3.654	0.731	8
Lack of support from the government	[3], [4]	3.654	0.731	8
Need for continuous & consistent training	[8], [14], [16]	3.654	0.731	8
Resistance to change/adopt new technology by top management/ employers	[1], [3], [4], [6], [7], [8],[14]	3.654	0.731	8
Restriction/incomplete of current form of contract	[3], [7], [11], [19]	3.654	0.731	8
Technical challenges in connecting with existing devices	[2], [3]	3.654	0.731	8

Source: adapted from Wee, (2020)

Table 3. Mean, RII and Ranking of the Barriers (continued)

Barriers	References	Mean	RII	Ranking
Short term mission focused by the organizations	[3]	3.615	0.723	9
Employees unwilling and not interested in learning new technology	[8], [11]	3.577	0.715	10
High cost in data security and protection	[18]	3.577	0.715	10
Lack of dispute resolution system	[3], [6], [10], [11]	3.577	0.715	10
Poor technological readiness and maturity	[10], [16], [20]	3.577	0.715	10
Resistance to change by employee	[15], [18]	3.577	0.715	10
Worry of job security	[7], [9], [18]	3.577	0.715	10
Insufficient research and development in new technology	[7], [13], [17], [18]	3.538	0.708	11

Lack of awareness of government initiatives	[3], [4]	3.538	0.708	11
Not all project parties are technology oriented	[7], [15], [19], [20]	3.538	0.708	11
Perception of how the technology can replace or do work better than human	[10], [11], [14]	3.538	0.708	11
Increase project complexities and uncertainties	[19]	3.500	0.700	12
Poor information exchange system	[7], [12]	3.500	0.700	12
Require support from the external environment to be implemented successfully	[10]	3.500	0.700	12
Uncertainty nature of construction projects	From the authors	3.500	0.700	12

Source: adapted from Wee, (2020)

Table 3. Mean, RII and Ranking of the Barriers (continued)

Barriers	References	Mean	RII	Ranking
Change in working culture	[14]	3.462	0.692	13
Cybersecurity issue	[2], [3], [5], [8], [12], [16]	3.462	0.692	13
Intellectual property right issue	[12]	3.462	0.692	13
Low educational level	[3], [6], [10], [11]	3.423	0.685	14
Low return	[7], [19]	3.423	0.685	14
Difference culture between nation and regions	[15]	3.385	0.677	15
Fragmented characteristic of construction industry	[3], [7]	3.385	0.677	15
Size of company	[10], [18]	3.346	0.669	16
Ageing workforce	[7]	3.182	0.636	17
Worry that human and machine (e.g. Robot) cannot work together	[7], [10], [14]	2.923	0.585	18

Source: adapted from Wee, (2020)

Note:

[1]=Abubakar et al. (2014); [2]=Alaloul et al. (2018); [3]=Alaloul et al. (2020); [4]=Ametepey et al. (2015); [5]= Corallo et al. (2020); [6]=Daribay et al. (2019); [7]=Delgado et al. (2019); [8]=Klinc & Turk (2019); [9]=Kurt (2019); [10]=Masood & Egger (2019); [11]=Mehran (2016); [12]=Mogos et al. (2019); [13]=Osunsanmi et al. (2018a); [14]=Aripin et al. (2019); [15]=Jabbour et al. (2018); [16]=Kamble et al. (2018); [17]=Li & Yang (2017); [18]=Osunsanmi et al. (2018b); [19]=Rastogi (2017); [20]=Ślusarczyk (2018)

Additional time/task is required (e.g. model checking, information entering etc.)

The result of this questionnaire survey reflected that this barrier was the most crucial barrier in hindering the transition journey of IR 4.0 in construction projects. The professionals appear to be unenthusiastic about sacrificing additional time and effort to take up this adoption. The reason could be the implementation of IR 4.0 would help in alleviating the time pressure or increase the burden of their existing tasks. For instance, it was revealed that there is no automatic recording of the amendments made on the building models in the Building Information Model (BIM), which induce a missed-on notifications or overlook issues for the groups involved (Dallasega et al., 2020). In this case, more time and tasks would be required to perform model checking. A concern on whether the implantation of IR 4.0 would affect the work-life balance of employees has been raised as well (Newman et al., 2020). People are concern about the strategies of IR 4.0 would increase stress and burden to employees as the construction industry has already been considered an over-worked environment.

Lacking in technical skill and knowledge among staff

It can be seen from the survey that IR 4.0 is still not common and acknowledged in Malaysian construction projects. The construction professionals have limited information about this new implementation in construction projects and hence, leads to insufficient knowledge with regards to this transition journey. Consistent to previous studies, namely, Ametepey et al. (2015), Aripin et al. (2019), Delgado et al. (2019), Mehran (2016), Mogos et al. (2019), Osunsanmi et al. (2018a), Rastogi (2017) and Ślusarczyk (2018), informed the lack of skilled workforce has been rated as a critical barrier.

Lack of financial resources

This study found that most of the companies seem to have an issue in procuring sufficient financial resource to engage and keep up with the latest IR 4.0 technology. This study was supported by Kiel et al. (2017), the implementation of IR 4.0 in construction requires a huge investment with unknown rate of profitability. Thus, this makes clients hesitated to invest vastly on new systems, which they are unfamiliar with such as

Industrial Internet of Things related products and services. Past studies namely, Abubakar et al. (2014), Aripin et al. (2019) and Ametepey et al. (2015) confirmed that keeping up with new technology involves a certain amount of funding as most of the equipment or machineries are still not well-established and the possible profit returned is unknown. Additionally, offering relevant technical training for staff to be acquainted with the latest technology also involves a massive amount of funding (Abubakar et al., 2014).

Lack of manpower

IR 4.0-related technology is new in Malaysia, and it entails a particular team of professionals to allocate time and put in extra effort to explore and research in order to master the skill and knowledge. These professionals team may be required to hold back on their original positions and work so as to put in more time on the implementation of IR 4.0. This creates problems to the firm in the aspect of manpower allocation in various ongoing construction projects. This concern is further proven by the results of the survey where the lack of manpower is placed in the third ranking order. Finding of this study confirmed the assertion made by Mogos et al. (2019) on the lack of resources such as manpower has always been the main concern in transforming to the digital era. According to Newman et al. (2020), implementation of technologies, products or services related to IR 4.0 requires a team of people to oversee and monitor the entire process.

Compatibility issues of the current software with new technology

The findings of this study showed that construction firms are worried that IR 4.0 transformation in construction projects would complicate the systems and the use of flawed technology might leave the systems unreliable and affect the product functional safety because of the interoperability and compatibility issue of the systems (Kiel et al., 2017). To support this, Mehran (2016) highlighted that compatibility is a critical factor in determining BIM adoption in the construction sector. Issues such as uniform integration and interoperability of systems may also develop when upgrading and launching the equipment, machineries and network systems which are currently in used in order to align with the new IR 4.0-related software so as to construct a cyber-physical framework of the Internet of Things (IOT) environment (Kamble et al., 2018). For example, the augmented reality (AR) technology is required to be connected with the IT infrastructure, as such, it is crucial to ensure the compatibility with the current IT system (Masood and Egger, 2019).

Difficulty in authorizing and monitoring the quality and progress of construction

Results also found that there is a consequential difficulty in authorizing and monitoring the quality and progress of construction as IR 4.0-based technologies demand close supervision and inevitable implementation processes due to the advanced technology of the products and services. Specific skills are essential in supervising the operation of these technologies to reduce negative impacts on the work quality especially in the construction projects with an unpropitious and complicated environment, which causes difficulties in monitoring and authorizing the progress. Besides, Mehran (2016) reported that the authorizing and monitoring of quality and progress is one of the main factors affecting BIM adoption in construction.

Impact IR 4.0 Implementation in Performances of Construction Projects

Table 4 indicates the results on the impact of IR 4.0 on different aspects of performances in construction projects. The most critical performance factors of the implementation of IR 4.0 are safety (RII=0.0.900), followed by project success (RII=0.885), and time performance (RII=0.877).

Table 4. Mean, RII and Ranking of All Performances

Performances	Mean	RII	Ranking
Safety	4.500	0.900	1
Project success	4.423	0.885	2
Time performance	4.385	0.877	3
Cost performance	4.308	0.862	4
Scope performance	4.269	0.854	5
Quality performance	4.231	0.846	6
Client satisfaction	4.192	0.838	7
Design quality	4.115	0.823	8
Productivity	4.115	0.823	8
Environmental quality	3.885	0.777	10

Source: adopted from Wee, (2020)

Safety

The results show that safety as the top priority in the construction works, could be enhanced through the implementation of IR 4.0. The finding of this study substantiated Forcina and Falcone's (2021) findings in which technologies related to IR 4.0 can improve safety management such as products safety, storage areas and transports. Ainul et al. (2018) reported that the railway accidents occurred in 2010-2017 involved severe-to-minor bodily injuries, and equipment damages. Any on-site injuries of employees would possibly delay the work progress which indirectly would result in cost overrun. Based on a press released by the CIDB, the chief executive Datuk Ir Ahmad 'Asri Abdul Hamid, the Construction Industry Transformation Plan 2016-2020 (CITP) has established a goal of reduction in construction site deaths, but reflecting from the records, there is an exceptional increase of job-related death cases in the past few years (New Straits Times, 2019).

Funds and time allocation on the implementation of IR 4.0-related technology might bring positive results in improving the safety of workers and reduce the rate of job-related injuries in construction projects. In addition, enhancement of employees' safety at site could also attract more younger generations to involve in this industry and create better chances of IR 4.0 development in Malaysia, which perchance an opportunity to transform into a developed country as construction industry is one of the vital contributors of the country's GDP.

Project success

The denotation of a project success can be very complex, personal, and impressionistic depending on the point of view of the individuals, but study showed that determining whether a project is a success or not is mainly based on three aspects, namely, time, cost and quality of work (Jatarona et al., 2016). Findings of this study reflected that IR 4.0 is believed to create greater project success in construction projects as it is ranked second amongother performance-related factors. Taking one of the IR 4.0-related technology, Industrialized Building System (IBS) as an example. This enables the building structural elements to be fabricated off-site and then, be assembled on-site with simpler construction process, which helps to guarantee superior quality of construction works with shorter time and minimalize material and labour cost (Aripin et al., 2019). This could increase the chances of a project success.

Time performance

The respondents of this study strongly believed that by bringing in IR 4.0-related technologies, construction projects can be assured to be accomplished on time or the project duration can even be vastly shortened as time performance has been ranked third place. This finding was further confirmed by existing studies, namely, Aripin et al. (2019), Jabbour et al. (2018) and Li and Yang (2017). In addition, Osunsanmi et al. (2018a) addressed that IR 4.0 will not merely improve time performance in the construction sector, but it will have a positive impact on cost saving and sustainable aspects too.

CONCLUSION

Based on the literature review, the past studies on the theme of IR 4.0 were mostly carried out in other countries or other industries. There is limited information in construction projects in Malaysia. The implications of IR 4.0 in construction projects in terms of barriers and impact have been identified and supported by some existing literature. The findings of this study showed that the main barriers that hindered the transition of IR 4.0 in construction projects were 'additional time or task required', 'staff lack of technical skill and knowledge', 'lack of financial resources', 'lack of manpower', 'compatibility issues of current software and new technology' and 'difficulty in authorizing and monitoring of the quality and progress of construction'. It can be concluded from the results that these main barriers hold up the construction stakeholders in the adoption of IR 4.0 in construction projects and they are correlated to technology deficiency and financial issue.

Moreover, according to the point of view of the stakeholders, it is also discovered that the implementation of IR 4.0 in construction project is believed to have significant impact on three (3) performance aspects, namely, safety, project success and time performance. By identifying the impacts of IR 4.0 in different performance aspects, the stakeholders should establish a rigid idea on the benefits of incorporating IR 4.0 transformation into organizational strategy.

In short, it is certain that the future of this transition journey towards a fully digitalized construction projects could be very enthusiastic and propitious with the cooperation and support from different parties.

Limitation of research and recommendation

This study was carried out during the pandemic of COVID-19 and therefore, many restrictions and limitations were to be considered. The low response rate of this study was mainly due to the delay on courier services and restricted operation of construction organizations during the pandemic period. Hence, drop and pick method was adopted to increase the response rate. This leaves a gap for future research to reach more stakeholders in the construction industry after the pandemic.

Future research can further be explored on the potential strategies to mitigate the impacts of the critical barriers to boost the development of IR 4.0 in construction projects. More studies on how government and construction firms can collaborate in funding IR 4.0-related technologies can also be carried out as financial resource is one of the major concerns of construction stakeholders.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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