Challenges of industrial revolution 4.0: quantity surveying students' perspectives

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Abstract

Purpose – The industrial revolution 4.0 (IR4.0) signifies technological advancements and digitalization. The fragmented and labour-intensive nature of the construction industry inherently possesses difficulties for IR4.0 adoption compared to other industries. This paper aims to investigate the perspectives of quantity surveying students on the challenges of IR4.0 implementation in the construction industry.

Design/methodology/approach – A questionnaire survey were distributed to a population of 191 quantity surveying students, with 96 valid responses returned. Descriptive statistics and factor analysis were employed to analyse the collected data.

Findings – Factor analysis revealed eight components as the key challenges for IR4.0 implementation, which revolved around resistance to change, data security issues, etc.

Practical implications – The findings could provide a guideline to higher education institutions on certain IR4.0-related areas to be incorporated into the syllabus, in ensuring that the students are equipped with such skills and knowledge, in meeting market demands. The construction stakeholders' could look into the identified challenges for strategizing the organizations in moving towards IR4.0 adoption.

Originality/value – To the best of the authors' knowledge, this is the first study to investigate quantity surveying students' perspectives on the challenges of IR4.0 implementation in the construction industry by employing factor analysis method. The findings contribute to the body of knowledge in relation to the opinions of a younger generation who has more exposure towards technology on the hindrance of IR4.0 adoption.

Keywords Challenges, Construction industry, Industrial revolution 4.0, Quantity surveying, Students, University

Paper type Research paper

1. Introduction

The construction industry contributes considerably to a country's gross domestic product (GDP), with 5% in Germany and 7% in Australia, which undoubtedly boosts the employment rate with increased household income (Burda and Severgnini, 2018; Ramasundara *et al.*, 2018). However, the emergence of the fourth industrial revolution (IR4.0) signifies an evolution from mass production to innovative and digitalization production (Schmidt *et al.*, 2015; Zhou *et al.*, 2015), worrying unemployment rate due to the automated operations and replacement of labour force with technologies and/or machines (Birkel *et al.*, 2019; Oesterreich and Teuteberg, 2016). Studies had shown that the evolvement of IR4.0 in the manufacturing sector with the advancement of technologies leads to massive technologies involvement, including the Internet of Things (IoT), augmented reality and big data (Mohamad *et al.*, 2021; Raj *et al.*, 2020). The manufacturing industry had shown a growth of 6.7% in labour productivity per person while only 2.3% for the construction industry (May and Fersht, 2014). This seems to indicate that the late adoption of IR4.0 in the construction industry affecting its productivity. It is undeniable that IR4.0 assists the industry's productivity and overall performance but the associated costs shall not be overlooked (Schmidt *et al.*, 2015; Zhou *et al.*, 2015).

To transform the Malaysian construction industry into a sustainable environment with relevant technologies and high-skilled labour, Strategic Plan 4.0 (2021–2025) was launched by the Construction Industry Development Board (CIDB, 2020). However, this initiative could be considered a laggard if compared to the manufacturing industry as the Ministry of

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International Trade and Industry (MITI) initiated IR4.0 adoption in 2018, and such initiative gained USD47.6 million (i.e. RM210 million) financial support from the Malaysia government from the year 2019 to 2021 (Ministry of International Trade and Industry, 2018). This seems to indicate the failure of construction stakeholders in identifying the benefits of IR4.0 at the earliest stage, contributing to its late adoption. The management-related stakeholders in the construction industry identified that technologies in IR4.0 assist the growth of the construction industry (Maskuriy *et al.*, 2019). Studies had shown limited research on IR4.0 from construction stakeholders' perspectives.

Multiple stakeholders are involved in the construction industry, and quantity surveyor (QS) could be considered as one of the stakeholders who regularly provides sound advice and actionable feedback to the other stakeholders. As QS involves in construction projects for estimating construction costs prior to the start of the project and monitoring construction expenditures during the construction of a project, QS has to action promptly and timely to avoid time and cost overrun issues (CIDB, 2020). IR4.0 undoubtedly could assist with the efficiency and productivity of construction stakeholders (Dallasega *et al.*, 2018). Hence, identifying the challenges of IR4.0 technologies specifically suited to the construction industry is of utmost importance (Hossain and Nadeem, 2019). With a profound understanding of IR4.0 evolution and implementation, it seems crucial for higher education to introduce IR4.0 at the early stage of quantity surveying education, as this could allow higher institutions to position themselves and prepare future QS that would be able to meet the industrial demand (Tan *et al.*, 2017). Current studies had investigated the drivers of implementing IR4.0 (Demirkesen and Tezel, 2021), challenges faced by the industrial stakeholders (Alaloul *et al.*, 2020; Kasim and Razali, 2021) and the impact of IR4.0 adoptions (Kozlovska *et al.*, 2021), with only one study by Jima'ain *et al.* (2020) that conducted with students on the challenges from the skill aspects (e.g. communication and networking skill) from four public higher education institutions in West Malaysia.

It is undeniable that higher education plays a pivotal role in educating and shaping the values and areas of expertise of the future generation. Arguably, construction graduates seem not to be fully equipped with construction-related software (Olatunji, 2019). The perspectives of students are essential to assess and measure the existing challenges on IR4.0 implementation in the construction industry as they will be involved in the construction industry in the future. An early identification of the potential challenges perceived by students could allow sufficient knowledge sharing with employers, for better transitioning into the digitalized environment of the construction industry. Therefore, this research aims to investigate the perspective of quantity surveying students on the challenges of IR4.0 implementation.

2. Literature review

The construction industry is labour-intensive and some countries may rely on immigrants for construction activities (Lau *et al.*, 2019b). The classification of construction as one of the riskiest industries (Zid *et al.*, 2020) may alert the stakeholders to a more efficient and safe environment. For example, in 2018, the Malaysian construction industry contributed to 45.5% of the country's fatality rate (Azmi *et al.*, 2020). IR4.0 seems like an opportunity to reduce such a rate with a higher level of technological advancements and involvement, through stakeholders' collaboration in fostering the effectiveness of the construction industry and reducing project completion time (Chen *et al.*, 2018). However, the transition of the construction industry from labour-intensive to technological advancement involves complex issues as stakeholders require financial, skill and time investments and adoptions (de Lange *et al.*, 2017; Lau *et al.*, 2019a). Lau *et al.* (2019a) accentuated the importance to identify the readiness of construction stakeholders towards transitioning into IR4.0.

Studies had been conducted in different countries on the challenges and strategies of IR4.0 implementation. Osunsanmi *et al.* (2018) indicated that the financial aspect of new technology investment is the key hindrance to implementation in South Africa despite the potential for time and cost savings. As such, a framework proposed by Dallasega *et al.* (2018) stressed the influence of IR4.0 on the technological, geographical, organizational and cognitive proximity enablers. Daribay *et al.* (2019) explored that the globalized standards and community could foster IR4.0 implementation and its competitiveness in Kazakhstan. The UK seems to have sufficient capacity to invest in IR4.0 but is limited by the organizational management system (Newman *et al.*, 2020).

In Malaysia, studies had been conducted mostly in the manufacturing sectors. Lee *et al.* (2019) found that flexibility is the key challenge of IR4.0 implementation based on experts with more than nine years of experiences. There seems to have a flaw in the Malaysia National Policy on IR4.0 adoption in the manufacturing industry in terms of the scalability manufacturing sector (Ling *et al.*, 2020). Therefore, foreign sectors involvement is essential for knowledge diffusion and awareness towards IR4.0 rules and regulations in ensuring advanced technologies and productivity (Mohamad *et al.*, 2021). To ensure competitiveness, Backhaus and Nadarajah (2019) proposed a conceptual framework to identify the relationship between the productivity of the manufacturing sector and IR4.0. In the construction industry, Aripin *et al.* (2019) identified implementation cost as the key challenge and cost benefits as the most essential driver for IR4.0 adoption. Alaloul *et al.* (2020) investigated construction stakeholders' opinions and identified that technical and social factors were the most critical factors. Wee *et al.* (2022) supported technology deficiency as the most critical challenge. Table 1 showed the challenges identified from the literature review.

As previous research was mostly conducted from the viewpoint of construction stakeholders with limited touch-up on the quantity surveying students' perspective, this study is going to provide empirical data in bridging the knowledge gap. It is vital to study the quantity surveying students as students could have a better grasp on the technology for digitalization evolution. QS, one of the key construction stakeholders, exercises contract practice, project management, construction technologies, cost estimating, project finance and procurement, which required sufficient competencies as indicated by the RICS (2022). Despite the knowledge and skills, RICS emphasizes that QS shall possess good ethical conduct in their practices. This seems to imply that the internationally recognized body affirmed the vital role of QS in the construction industry. Arguably, digitalization in the construction industry shall not diminish QS role and value as errors exist in the digital model and QS shall re-invent and involve in the digital evolution (Olatunji and Akanmu, 2015).

Low *et al.* (2021) accentuated that educational, government and industry sectors shall collaborate towards IR4.0 evolution. However, the current quantity surveying program offered by the higher education institution faced challenges such as poor Internet connectivity and a lack of skilled lecturers, in assisting students in moving towards digitalization (Babatunde and Ekundayo, 2019). Strategies shall be worked out to solve the problems and ensure students' exposure to digital devices. Therefore, it is important to look into students' perspectives, on the potential challenges of IR4.0 implementation, to enlighten the construction stakeholders on the key aspect to focus on, as well as the educational institution to potentially collaborate with the industry in solving the discovered challenges.

3. Research methodology

This research adopted a quantitative method to investigate the insight of quantity surveying students from a private technical university funded by the state government in Malaysia, on the challenges of IR4.0 implementation in the construction industry. The technical vision and nature of this university are in line with IR4.0 development. This university was chosen as it is located within an economic development corridor established by the Malaysian Government for stimulating investment into the areas and recorded an employment rate of

No	Topics	Details	References 1	2	3	4	5	6	7	8	9	10	11
1	Intellectual property right issue	Uncertainties on the ownership of information generated							√	√			
2	Lack of dispute resolution system	Incomprehensive resolution system for the additional potential disputes arose				√		√					√
3	Legal and contractual uncertainty	Uncertainty on the security guideline and responsibilities in shifting information online		√					√		√		
4	Regulatory compliance	Difficulties to decide on the level of accessibility and type of data on cloud that is complied with laws and policies						√	√	√	√		
5	Lack of a clear digital operations vision	Absent of managerial long-term vision in investing in IR4.0 technologies							√	√		√	
6	Inefficient regulatory framework	Lack of mandatory and voluntary framework for organization in adopting IR4.0							√			√	
7	Lack of national IR4.0 long-term strategy	Absent of strategies to enhance IR4.0 in construction industry by Malaysian government					√		√				√
8	Low investment in research and development (R&D)	Restricted spending in R&D due to low profit margin			√	√		√					√
9	Lack of government support	Lack of government assistance such as emphasizes on the networking organizations creation and introduction of technologies		√			√		√	√		√	
10	Hesitation to adopt	Uncertainties on the return of capital investment hesitated the organizations							√		√		
11	Threat of new business model	Hostility of new model for big data integration into the project system	√	√				√					
12	Unclear benefits and gains	Unknown advantages		√		√			√	√			

(*continued*)

Table 1. Challenges identified from literature review

No	Topics	Details	References 1	2	3	4	5	6	7	8	9	10	11
13	Lack of access to loan/finance	Low rate of loans approval for purchasing intellectual technologies										√	√
14	Organizational and process change	Requirement for re-evaluation of organization structure and business processes		√				√			√	√	
15	High implementation cost	High cost of capital investment	√	√	√	√	√	√	√	√	√	√	√
16	Lack of standardization	Lack of standard operating procedures for the transitions of organizations from traditional operations towards digitalization		√	√	√		√		√	√	√	√
17	Job security issue	Job loss due to shifting towards digitalization						√	√	√	√		√
18	Lack of professional trainer	Lack of qualified trainer to train existing workers for required skills	√					√		√		√	
19	Threat of new competitors	Digitalization reduces entry requirement of new competitors	√					√					
20	Lack of labour force	Shortage of labour forces in deploying digital technologies				√						√	
21	Low rate of collaboration between the academy and industry	Lack of joined collaboration for hypothesis testing and practices							√			√	
22	Resistance to change	Conservative nature of construction stakeholders	√	√	√	√	√	√	√		√	√	
23	Lack of readiness	Un-readiness of organizations due to the uncertain risks							√	√			
24	Lack of awareness	Limited awareness on the benefits							√			√	√
25	Lack of knowledge	Lack of knowledge of organizations on the project operation			√		√		√		√	√	
26	Need for enhanced skills	Additional training required for IoT skill enhancement	√	√			√		√	√	√		
27	Threat of new technology	Adoption of new technologies creates distrust among construction stakeholders	√					√					

Table 1. (*continued*)

No	Topics	Details	References 1	2	3	4	5	6	7	8	9	10	11
28	Need to improve company infrastructure	Upgrade of Internet and digitalization equipment placing organizations into competitive disadvantages	√										√
29	Lack of technology	Lack of IR4.0-related technologies							√	√			
30	Technology changes over time and has to be updated constantly	Challenge to constantly update the technologies						√	√	√		√	√
31	Enhancement of existing communication networks	Existence of the high-bandwidth network							√		√		
32	Data security and data protection	Concerns on data security	√	√				√	√	√	√		
33	Higher requirement for computing equipment	Concern on the constant protection on computing equipment on site due to dust and extreme weather			√				√	√	√	√	
34	Negative effect on energy use, global warming, and climate change	Increasing usage of technologies leads to an increase in greenhouse gases emissions						√	√				
35	The unknown potential impact on sustainability and the environment	Replacement of old machinery with new technologies leads to disposal of materials						√	√				
36	Increase project complexities and uncertainties	Comprehensive specifications of the technologies add burdens to the existing complex projects			√	√							
37	Fragmented and project-based nature of the industry	Fragmented nature creates difficulties for construction stakeholders to adopt IR4.0 at the similar timing			√	√							

Source(s): 1 = Contador *et al.* (2020), 2 = Alaloul *et al.* (2020), 3 = Osunsanmi *et al.* (2018), 4 = Demirkesen and Tezel (2021), 5 = Newman *et al.* (2020), 6 = Birkel *et al.* (2019), 7 = Lau *et al.* (2019b), 8 = Lau *et al.* (2019a), 9 = Oesterreich and Teuteberg (2016), 10 = Gamil and Rahman (2019), 11 = Kumar *et al.* (2020)

Table 1.

99.1% for the graduates which assured employability. This seems to assure that the students could share knowledge gained from the university in the workplace to improve industry productivity and efficiency. The university's programme has closely aligned with meeting industrial needs and is accredited by various professional bodies, namely, Board of Quantity Surveyors Malaysia and Pacific Association of Quantity Surveyors.

This research employed a questionnaire survey, as conducted by previous similar studies, such as Alaloul *et al.* (2020), Contador *et al.* (2020) and Kumar *et al.* (2020). Such quantitative research method through a questionnaire survey allows the data to be gathered efficiently, and the quantitative information could be tabulated and quantified in numerical format, for objective representation (Queirós *et al.*, 2017). The questionnaire survey consisted of two parts. Part A seeks for the demographic details of respondents, such as study year, gender and working experiences. Part B intends to collect the opinions of the respondents towards the perceived challenges of IR4.0 implementation in the construction industry, with the adoption of five-point Likert scale of 1 (strongly disagree), 2 (disagree), 3 (neutral), 4 (agree) and 5 (strongly agree).

The questionnaire was designed and distributed to three academicians, three professional QSs and two final-year students for checking the content prior to distributing it to the respondents. The first step of verification occurred with the academicians and QSs who have substantial knowledge of IR4.0 to ensure overall coverage of the challenges and that the wordings used were unambiguous. The second step of verification involved two students to ensure that the students could understand the wording used in the questionnaire. The respondents reported no changes to the questions but some examples were being added at the end of certain terms (Part B) so that the targeted respondents are able to understand the content and answer validly.

An online questionnaire survey was then distributed to a population of 191 Year 1 to Year 4 quantity surveying students, from September to October 2021, through Email and an instant messaging platform (i.e. WhatsApp Messenger). The respondents were followed-up fortnightly. To increase the response rate, the lecturers of this university were approached by the researchers to share the online questionnaire link with their students. The students were invited to participate voluntarily and not coerced. The returned questionnaires were checked to ensure that all questions had been answered without missing data. Responses that were submitted in duplicate had been checked and omitted. This leads to 96 valid responses, representing a response rate of 50.26%.

Descriptive statistics could assess the data collected through quantitative representation (Queirós *et al.*, 2017), while factor analysis could create new concepts and reduce the variables (Cattell, 1988; Malhotra, 2010). Hence, descriptive statistics was adopted for Part A's analysis, representing the background of respondents with percentage, while factor analysis was adopted for Part B's analysis, to generate the most critical challenges from the 37 challenges available, with the assistance of Statistical Package for the Social Sciences (SPSS). This research accepts the challenges with a loading value of more than 0.4 as recommended by Izquierdo Alfaro *et al.* (2014). Moreover, Varimax rotation was applied to ensure that an equal distribution of variances (Malhotra, 2010).

4. Results and discussions

4.1 Demographic details

Table 2 showed the demographic details of the 96 respondents, with 56.3% of female and 43.8% of male respondents. Majority (74%) of the respondents fall under the age group of 21–25 years old, while only 5.2% of respondents are aged between 26 and 30. This seems to indicate that the respondents are ranging from late Generation Y to earlier/mid-Generation Z. This group of respondents could potentially have the exposure to digital devices since their childhood (Ebbeck *et al.*, 2016), and hence may be considered as the group that may easier in accepting technology changes.

There seems to have an equal spread of respondents in different years of the quantity surveying degree studies with 56.3% of the respondents in the Year 3 and Year 4 studies. This may provide good coverage of the knowledge and perceived uptake of different categories of studies on IR4.0. A majority (69.8%) of the respondents have construction industry working experience and this may indicate that the respondents understand the demands and/or operations of the construction industry.

Categories	Aspects	Percentage (%)
Gender	Male	43.8
	Female	56.3
Age (years old)	≤20	20.8
	21–25	74.0
	26–30	5.2
Year of study	Year 1	21.9
	Year 2	21.9
	Year 3	27.1
	Year 4	29.2
Working experience	Yes	69.8
	No	30.2

Table 2. Demographic details of respondents

4.2 Challenges of IR4.0

To ensure that the data obtained are suitable for the factor analysis method, Kaiser–Meyer–Olkin (KMO) and Bartlett's test was conducted. The results showed that the KMO value was 0.748, exceeding the benchmark value of 0.6 (Kaiser, 1974). The Barlett's test of Sphericity achieved 1729.799 chi-square with a statistical significance value of 0.000 met the benchmark of less than 0.05 (Bartlett, 1951). These indicated that the correlation matrix was not an identity matrix and that the collected data was suitable for factor analysis. The factor analysis result showed that 35 of the identified challenges had been loaded into 11 components with Eigenvalue of more than 1, as suggested by Kaiser (1974) and Malhotra (2010). Two identified challenges (V9 and V34) had been eliminated due to the loading factor of less than 0.4. Varimax rotation was conducted on the 35 challenges for equalizing the relative importance of the 11 components, which accounted for 70.191% of the total variance, exceeding the recommended threshold of 60% variance (Malhotra, 2010). Out of the 11 components, three components were removed from analysis due to unrelated challenges or only one challenge being identified (refer to Table 3), which leads to only 8 components with 31 challenges being discussed as follows.

Component 1 consisted of seven underlying challenges and all of the challenges are closely related to the resistance to change caused by the lack of knowledge, company infrastructure and technological concerns, high cost and requirements of skill enhancement. This component accounted for 10.754% variance, which is the largest portion of variance if compared to the other components. The IR4.0-related technologies seem to be uncommon in Malaysia, a developing country, with careful consideration for budget allocations. Demirkesen and Texal (2021) suggested that the reluctance to technology and innovation acceptance contributes towards organizations' resistance to change. The respondents could foresee the resistance to change but younger people could be better at dealing with such challenges and stymie IR4.0 adoption (Czarnitzki and Delanote, 2013). However, organizations may be reluctant to adopt such technologies due to a lack of knowledge on the new technology which demoralizes productivity and original work structure (Newman *et al.*, 2020). Inadequate infrastructure such as high-speed Internet disadvantaged the organization in technology adoption (Raj *et al.*, 2020). The situation is worsened by the high implementation cost and the associated risk (Alaloul *et al.*, 2020). Birkel *et al.* (2019) supported that the technology introduction in the manufacturing industry is challenged by the scepticism of different parties due to risk uncertainty. Additional costs incurred from providing training for skill enhancement in dealing with both technical and non-technical fundamental knowledge of IR4.0 as well as the external consultancy fee (Ryan and Watson, 2017; Smith, 2014). Anuar and Abidin (2015) further supported that some contractors had limited technology for IR4.0 adoption which resisted them from technological adoption.

Code	Challenges	Loading	Eigenvalue	Variance (%)	Cumulative variance (%)
Component 1 Challenges of resistance to change which caused by the lack of knowledge, company infrastructure and technological concerns, high cost, and requirements of skill enhancement					
V25	Lack of knowledge	0.749	9.734	10.754	10.754
V22	Resistance to change	0.681			
V28	Need to improve company infrastructure	0.614			
V15	High implementation cost	0.512			
V27	Threat of new technology	0.506			
V29	Lack of technology	0.477			
V26	Need for enhanced skills	0.463			
Component 2 Challenges caused by data security due to the fragmentation of construction industry and project complexities					
V37	Fragmented and project-based nature of the industry	0.786	2.731	7.459	18.214
V36	Increase project complexities and uncertainties	0.720			
V32	Data security and data protection	0.550			
Component 3 Challenges on the lack of standardization created issues on job security, regulatory compliance and low collaboration					
V16	Lack of standardization	0.767	2.068	7.427	25.641
V17	Job security issue	0.735			
V4	Regulatory compliance	0.505			
V21	Low rate of collaboration between the academy and industry	0.447			
Component 4 Legislative uncertainty and improper dispute resolution system, hesitated organizations to invest in research and development					
V3	Legal and contractual uncertainty	0.698	1.910	6.865	32.506
V8	Low investment in research and development	0.627			
V10	Hesitation to adopt	0.621			
V2	Lack of dispute resolution system	0.584			
Component 5 Challenges caused by the lack of strategic plan and technologies adoption					
V7	Lack of national IR4.0 long-term strategy	0.745	1.730	6.652	39.159
V33	Higher requirement for computing equipment	0.704			
V30	Technology changes over time and has to be updated constantly	0.683			
Component 6 Issues of intellectual property rights, unclear vision of digitalization and potential impact on sustainable environment, created unreadiness					
V1	Intellectual property right issue	0.689	1.651	6.361	45.519
V5	Lack of a clear digital operations vision	0.673			
V35	The unknown potential impact on sustainability and the environment	0.558			
V23	Lack of readiness	0.453			
Component 7 Challenges due to lack of awareness and labour force, and threat of new competitors					
V19	Threat of new competitors	0.749	1.420	5.475	50.994
V20	Lack of labour force	0.668			
V24	Lack of awareness	0.509			

(*continued*)

Table 3.
Factor analysis of the challenges of IR4.0

Code	Challenges	Loading	Eigenvalue	Variance (%)	Cumulative variance (%)
Component 8 (excluded due to two unrelated challenges)					
V31	Enhancement of existing communication networks	0.676	1.359	5.273	56.267
V14	Organizational and process change	0.658			
Component 9 (excluded as only one challenge being loaded)					
V13	Lack of access to loan/finance	0.753	1.222	4.721	60.988
Component 10 Threat of new business model due to the lack of professional trainer and unclear benefits and gains					
V11	Threat of new business model	0.818	1.106	4.686	65.674
V18	Lack of professional trainer	0.499			
V12	Unclear benefits and gains	0.468			
Component 11 (excluded as only one challenge being loaded)					
V6	Inefficient regulatory framework	0.726	1.043	4.517	70.191

Table 3.

Component 2 is related to the challenges caused by data security due to the fragmentation in the construction industry and project complexities, which accounted for 7.459% variance. As the respondents consisted of Generations Y and Z with earlier exposure to technologies, they could potentially be concerned about the effectiveness of data protection and the project information due to the flaws in technologies and complexities of the project. Technological advancement of IR4.0 undoubtedly required a large amount of data flows and this raised concerns about data security (Hecklau *et al.*, 2016). Cyberattacks such as unauthorized files assess prone construction industry towards financial and legal risks (Mantha and de Soto, 2019; Patel and Patel, 2020). Moreover, the fragmented nature of the construction industry and dynamic nature of construction projects created complexity for logical technology adoption, limited knowledge sharing, impeded the effectiveness of communication and hindered innovation (Demirkesen and Tezel, 2021; Lavikka *et al.*, 2018; Yap *et al.*, 2019). Such situation is worsened by the dynamic nature of construction projects which creates uncertainties and complexities for a conducive environment for data sharing (Shen *et al.*, 2010).

Component 3 comprised 7.427% variance, with four key challenges that are closely related to the lack of standardization, and hence this component is named as "lack of standardization created issues on job security, regulatory compliance and low collaboration". The lack of standardization in the process of information exchange and handling IR4.0 among organizations impeded its adoption among construction stakeholders (Demirkesen and Tezal, 2021). It is undeniable that the adoption of new technology and information sharing needs to comply with the regulations for fairness and legality. However, organizations faced difficulties to comply with the regulations, law and policies while adopting IR4.0 technology (Yu *et al.*, 2017). For instance, Radio-Frequency Identification (RFID) optimizes construction project schedules by digitalizing labour and equipment management and faced issues in complying with the German data protection law for outsourcing data outside European countries (Oesterriech and Teuteberg, 2016). Similar cases could be applicable in Malaysia for organizations to comply with the Personal Data Protection Act (Department of Personal Data Protection, 2010). This appears to indicate the essentiality of collaboration between the academy and industry in fostering comprehensive standard operating procedures for organizations. The management team of the organizations shall comprehend the continuous learning and changes in standardizing organizations towards IR4.0 (Contador *et al.*, 2020). Arguably, the automated process of IR4.0 technologies may create a sense of job insecurity as the employees could perceive employers to reduce the labour force for cost savings measures (Yu *et al.*, 2017; Birkel *et al.*, 2019). Therefore, uniformity and standardization for the standard operating procedure within organizations are essential for transitioning towards digitalization operations (Demirkesen and Tezal, 2021).

Component 4 included four challenges by revealing a phenomenon that legislative uncertainty and improper dispute resolution system could hesitate organizations to invest in the R&D of IR4.0, with 6.865% variance. The students may be exposed to dispute resolution and the changes in legislation throughout their quantity surveying degree and hence could have a better understanding of these terms. Dispute resolution such as the legal court system and alternative dispute resolution aretime-consuming and the new technologies create uncertainties due to the lack of standardized laws and regulations (Li and Yang, 2017). Demirkesen and Tezel (2021) stressed the importance of R&D for the prevailing technological adoption in the construction field, but the investment cost of R&D and its return are questionable. Studies had supported that lack of government mandatory command on the usage of technologies hesitated organizations to adopt appropriate innovations for digitalization (Smith, 2014). This seems to indicate that the certainty in law and regulation and a proper dispute resolution systemcould possibly increase the confidence in stakeholders' involvement with R&D for IR4.0 technologies.

Component 5 consisted of three challenges: "lack of national IR4.0 long-term strategy", "higher requirement for computing equipment" and "technology changes over time and requires constant updates", which accounted for 6.652% variance. All these challenges could be summarized as a lack of strategic plan and technology adoption. The national strategic plan is essential to ensure that all stakeholders are aware of the specific IR4.0 objectives of a country as well as the amount of incentives and supports provided by the government. This could help construction companies to plan ahead, investing to upgrade their computing systems and flexibility to update the constant changes of technology. For instance, the French government initiated the cross-cutting "Industrie du Future" to foster digitalization collaboration among organizations for technology implementation and production modernization (Won, 2017; Yang and Gu, 2021). Aripin *et al.* (2019) accentuated that maintaining technologies on construction sites are inherently difficult due to the dusty and dangerous environment. Hence, a lack of a strategic plan hindered the technological adoption in the construction industry and the additional costs incurred for the continual updates and upgrades of the technologies hesitate the construction stakeholders (de Lange *et al.*, 2017). Therefore, on a fair ground, capturing of the upgrading of technologies associated with appropriate care and environment comes with costs and requires a proper national plan to levy the financial obligations and planning of an organization.

Component 6 detailed issues of intellectual property rights, an unclear vision of digitalization and potential impact on a sustainable environment could lead to a lack of readiness. This component accounted for 6.361% variance. The respondents apprehended that the organization and legislative aspects of the safeguard of intellectual property affect the readiness of stakeholders in adopting IR4.0 (Birkel *et al.*, 2019). The possibility of data being known by the competitors affected organizations' competitive advantage. Moreover, Erol *et al.* (2016) supported that failure of performing the vision of IR4.0 into practicality affected the supply chain stakeholders' viewpoint on the sustainability of such investment and transformation. Technology involvement such as higher requirements on the computing system and Internet may generate additional waste for machinery or equipment replacement (Birkel *et al.*, 2019) and hence contradicted with the national sustainable development goals.

Component 7 is related to social challenges from the aspects of lack of awareness and labour force, and the threat of new competitors, which accounted for 5.475% variance. The lack of awareness and skilled workers challenged the IR4.0 adoption as the management of organizations may be concerned about its functionality and practicability (Demirkesen and Tezal, 2021).

Awareness of the benefits of relevant technologies could reduce cybersecurity attacks and assist employees to support management's decisions in shifting towards digitalization (Cugno *et al.*, 2021; Kumar *et al.*, 2020). However, IR4.0 vanishes the geographical borders that increase competitors from other regions which could affect existing construction organizations' revenue (Birkel *et al.*, 2019; Contador *et al.*, 2020). Muller *et al.* (2018) confirmed that competitors could offer new platforms and threaten the market share of existing organizations. As such, Anuar and Abidin (2015) supported that an in-depth understanding of IR4.0 is essential for the organizations' adoption yet able to maintain their competitive advantage.

Component 10 revealed that the threat of a new business model may cause by the lack of professional trainers and unclear benefits and gains. This component accounted for 4.686% variance. Birkel *et al.* (2019) stressed on the organizations' hostility towards a new business model for integrating big data into the platform. However, the existence of a professional trainer could assist with big data integration and troubleshooting. Lack of such trainers affects the organizations' economic confidence in the possible benefits associated with the high-cost investment (Umar, 2021; Arayici and Coates, 2012). Lee and Lee (2015) supported that the unclear benefits and gains hesitated organizations' investment in new technologies. Moreover, construction projects' uncertainties created complexity for the construction stakeholders in estimating the benefits (Lechler *et al.*, 2012), which probably require a professional consultant (e.g. QS) to advise on the associated cost (Olatunji and Akanmu, 2015). Demirkesen and Tezel (2021) added that a complete assessment of the potential benefits was hindered by the fragmented nature of the construction industry, which creates doubt towards the management of organizations for investing in the new business model. It is undeniable that the existing business model seems unable to cater for the digitalization trend (Birkel *et al.*, 2019). Hence, a new business model is essential for organizations to cater the future needs by generating sufficient value from the data, with the assistance of professional trainers.

5. Conclusions

IR4.0 focuses on innovative production and digitalization for improving the efficiency and productivity of the construction industry, but lacking tremendously if compared to other industries. QS who serves as the consultant could potentially advice the construction stakeholders on risk management and mitigation strategies for the technological adoption. Quantity surveying students, the future influencer in the construction industry, could implement the technological usage in the organizations and be the potential earlier trainers to implement IR4.0 technology as they could easily master the technology-related skills. As such, examining the perspective of quantity surveying students on the challenges of IR4.0 adoption could bridge the gap between the expectations of students and the construction stakeholders' expectations.

A questionnaire survey with 37 challenges identified through a comprehensive literature review were distributed to quantity surveying students. The factor analysis results revealed the statistical significance of 31 challenges under 8 components which could offer new insight into bridging the gap between theory and practice. Key issues underlined under the eight components were "resistance to change", "data security issue", "lack of standardization", "legal uncertainty", "lack of strategic plan and technologies adoption", "ownership of the intellectual property rights", "lack of awareness and labour force, and threat of new competitors" and "threat of new business model". These could possibly be the key focus of construction stakeholders for digitalization transformation by scrutinizing standards for organizations with specific legislative guidance.

These identified challenges could enlighten higher education institutions on the key concerns of students that could possibly be incorporated into the syllabus, to equip their theoretical and practical skills that are necessitates for the IR4.0 technological adoptions. This is one of the first research that gathered the opinions of quantity surveying students and hence could improve the theoretical contribution towards literature. Lecturers could highlight the identified challenges to students for them to have a better transition into labour force in the future. This research not only alert students but industry stakeholders on the emergence and the associated challenges of IR4.0, which could possibly be the pivotal focus for smooth adoption in developing countries. By classifying the challenges, the respective stakeholders could be informed of the underlying challenges of IR4.0 that need to be addressed concurrently. As such, the assessment of the challenges could be conducted for a fruitful IR4.0 adoption and transformation.

Research limitations were identified as the respondents involved only from one university and one programme, which leads to a small sample size. As such, future studies are recommended to employ a wider range of respondents from various higher education institutions for cross-country comparison. Future research could employ qualitative research such as construction industry-based case studies for verifying the identified challenges and developing a comprehensive framework for the collaboration between higher education institutions and construction companies to enhance IR4.0 adoptions.

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