Association of Researcher of Skills and Vocational Training, Malaysia

ANP-JSSH
ISSN: 2773-482X, e-ISSN 2785-8863
DOI: https://doi.org/10.53797/anp.jssh.v3i1.4.2022

Readiness of Construction Organizations Towards Industrial Revolution 4.0 (IR 4.0)

Yusof, Yusmarwati[1*], Morbe, Ida Farhana Muhainy[2], Fatahol-Qarib, Muhammad Faris[3], Roddin, Rohayu[4] & Marina, Ibrahim Mukhtar[5]

[1,2,3,4,5]Faculty of Technical and Vocational Education, Universiti Tun Hussein Onn Malaysia, 86400 Batu Pahat, Johor, MALAYSIA

*Corresponding author email: marwati@uthm.edu.my

Received: 7 February 2022; Revised: 21 February 2022; Accepted: 24 February 2022; Available Online: 7 March 2022

Abstract: Readiness of construction organization towards Industrial revolution 4.0 (IR4.0) is important to help the country achieve progress in the use of latest technology. However, lack of knowledge and readiness of the organization can make an organization to be left behind and will be left out of the arena that has highly competitive rivals. Therefore, this research aims to identify the readiness of construction organizations for the IR 4.0 in Malaysia and identify the challenges of construction organizations in heading towards the IR 4.0. This research was conducted using a survey design. Research data were analyzed descriptively on a sample representing the entire study population. The sampling technique chosen in this study is a simple random sampling. Questionnaires were used as a major instrument to collect the data. This study involved a total of 51 workers from construction organization comprising government agencies, developers, consultants, surveyors and contractors from few states in Malaysia. All data from the questionnaire were analyzed to obtain frequency, percentages, mean scores, and standard deviations. The findings of this research found that readiness of construction organizations for the IR 4.0 was excellent. More than half of the workers understand and well aware about IR 4.0. Nonetheless, it is found that the main challenge of construction organizations is the difficulty of using the latest technology, besides the high cost of the equipment and software. Therefore, this study is expected to provide useful input to construction organizations and in turn can increase the readiness and overcome the challenges faced by organizations to realization of IR 4.0 in Malaysia.

Keywords: Revolution industry 4.0, construction organization, readiness of IR4.0, challenge of IR4.0

1. Introduction

The construction industry is one of the main contributors to the country's economic growth as the construction sector is growing every year in Malaysia. The Construction Industry Development Board (CIDB), expects an increasing in the construction sector to eight (8) percent through the growth of mega construction projects such as Mass Rapid Transit (MRT3), Gemas-Johor Double Track Project, JB-Woodlands Rapid Transit System, Railway Klang Valley Twin Towers (Phase 1), Pan Borneo Highway, East Coast Rail Line and Light Rail Transit 3 (LRT3). As such, the use of latest technologies are expected could help to progress the construction works rapidly (Ardiny et al., 2015).

The industrial revolution introduced by Arnold Toynbee (1889-1975), is the development and change of an industry to ensure that the industry is at an advanced level. The industrial revolution is also an important element to boost the progress of a country development (Schwab & Davis, 2018). Therefore, the industry has undergone changes starting with industry revolution 1.0 with the steam-based industry, and now the world has entered the industry revolution 4.0 which is industry based on digital automation (Phoon et al., 2021). The IR 4.0 is happening globally and has become a hot topic nowadays. The world is now moving towards a new revolution in the field of industry, and construction industries cannot deny this change and have to moving parallel with the currents of technological change if they want to survive in the industry (Ismail, 2018).

Therefore, the construction industry needs to emphasize the application of the IR 4.0 because in the future the construction sector becomes increasingly complex and complicated. If there is no use of technology that can facilitate the work process in the construction industry, it is very likely that the construction industry will lag far behind other

*Corresponding author email: *marwati@uthm.edu.my*
https://www.arsvot.org/ All right reserved.

industries. In the construction industry, some technologies have been used, among them such us the use of prefabrication and modular construction systems to increase productivity maintenance works. Besides that, the Building Information Modelling (BIM) is used for design and the use of drones to monitor safety and risky aspect in construction areas and so on. However, the number of the use still at the low level. As such, the construction industry cannot deny these changes and withstand the currents of technology change if they want to move further in this arena that are very competitive.

1.1 Problem Background

According to Stiles et al. (2021) the low use of technology in construction industries due to the lack of skills in the use of technology. Therefore, our country focuses on technical and vocational fields to produce a highly skilled and knowledgeable organization in order to help the country to achieve the fourth industrial revolution (IR4.0) and to overcome the problem on dependence too much on energy resources that will significantly change the future of construction industries.

Additionally, according to Ismail (2018), construction organizations face problems in adopting new technologies to settle down their task. Furthermore, the COVID-19 pandemic that has hit the world which indirectly effected construction organizations due to non-critical work sectors and construction being temporarily stop and all less important construction-related industries have to be shut down. As a result, organization who involved in this industry, such as developers, contractors, suppliers, consultants and construction workers, are going through a difficult time to carry out their duties and commitments through online or work from home (Saraswati & Ahmad Puad, 2020). This is due to lack of skill in using technology such as use the online applications, not skilled in using the latest software, besides the low internet coverage have also further delay the work progress (Sabri & Yahya, 2020).

Therefore, all organizations need to learn a variety skills to prepare with the drastic change in the use of technology because every change that takes place requires preparation from the organization as it is a key of element in facing all the changes and needs to master the required skills to ensure they can survive in this industry (Sudirman et al., 2020).

1.2 Problem Statement

Based on the issues mentioned above, in general, the construction industries is one of the important sectors that contributed to the country's economic transformation. However, the level of readiness of construction organizations in terms of technology in leading the industrial revolution 4.0 (IR4.0) is very worrying. If no action is taken to improvise the system and technology, it is likely that the country will lag behind in terms of the use of technology in the construction industry.

It is found that construction organizations face difficulties in adopting new technologies in their jobs. This is because, most employees do not have knowledge or exposure to the use of technology especially IR4.0 technology. This is due to the lack of knowledge and skills from the organization causing them to have limited competency and knowledge on the use of technology. The age factor of workers also affects job productivity due to the lower ability to use technology compared to the younger group. As a result, they prefer to do work in traditional way, using manual system than the use of technology. Accordingly, this research is important to identify the readiness of the construction workers towards IR4.0 and explore the challenges that hold them from the change.

2. Literature Review

A developing country such as Malaysia, the construction industry has an important role in helping the country's development process. The vast and good development will increase demand for construction projects and promote economic growth (Maskuriy et al., 2019). In each construction project, construction methods can be selected from any possible technologies as long as they complied with a number of factors such as cost, resources and building laws and regulation. The ability to use simple technology in most projects will make the construction industry easier to venture with lower investment. To increase the use of technology, Prasetyo & Trisyanti (2018) suggested that developing countries should provide opportunities for the local construction industry to handle large projects so that construction can be carried out by local construction organizations so that they are exposed to high -tech construction. The use of technology in construction will further accelerate the construction process.

The Construction Strategic Plan 4.0 is a long -term plan designed to enhance the capacity of the construction industry in the revolution industry 4.0 (CIDB, 2020). This strategic plan was developed in line with the Wawasan Kemakmuran Bersama (Shared Prosperity Vision -WKB) and the Industry 4.0 National Policy (Industry 4WRD). CIDB has also identified technologies that will change the landscape of the construction industry in Malaysia in the future, such as Building Information Modeling (BIM), 3D Scanning and Photogrammetry, Autonomous Construction and Advanced building materials. According to Schönbeck et al. (2020), the use of technology in an organization can save about 15 to 20 percent of planning and design time, depending on the design and construction works of the project. Therefore, the importance of the fourth industrial revolution (IR 4.0) in the construction industry to accelerate the construction process and be able to respond to the government's need to realize the IR 4.0 in Malaysia.

In the government's efforts to transform Malaysia to an IR 4.0 country, technology is a very important asset to be explored to face the various possibilities that will occur in the future. Malaysia needs to be prepared for the technological

changes we are facing now which are integration and innovation in the lives of the community today (Pereira et al., 2017). The construction sectors also underwent major changes due to IR 4.0. This situation also has an impact on the readiness of construction organizations to face of these changes. Therefore, the readiness of construction organizations to the emergence of IR4.0 is important because it will influence and impact the construction industries in the use of industry technology in Malaysia (Ismail, 2018). Hence, construction industries need to ready to change and development to the IR4.0 needs to ensure that they could meet the standards required to remain relevant in the industry.

2.1 Concept of the Industrial Industry 4.0 (IR4.0)

The industrial revolution 4.0 or better known by the term IR 4.0 is being introduced as a popular term to describe the trends towards the use of information technology and automation that are being used and known in almost all industrial sectors in the world (Oesterreich & Teuteberg, 2016). According to Tariq & Rahim (2016), IR 4.0 indicates the emergence of systems involving new capabilities. Physical cyber systems are a key technology on intelligent manufacturing components as well as new production (Steiner & Jornitz, 2017). This industry drives increased productivity in the industry and is driven by technological advancement. Currently, the world is on wave 4.0 in technological development. Therefore, the goal of this revolution is to achieve better levels of productivity and operational efficiency.

To realize the IR4.0, there are nine main pillars in developing technology towards more sophisticated and intelligent technological innovation. Figure 1 shows nine cores developed as benchmarks for realizing IR 4.0. These nine cores of IR 4.0 will dominate the economy today (Muhammad et al., 2018)

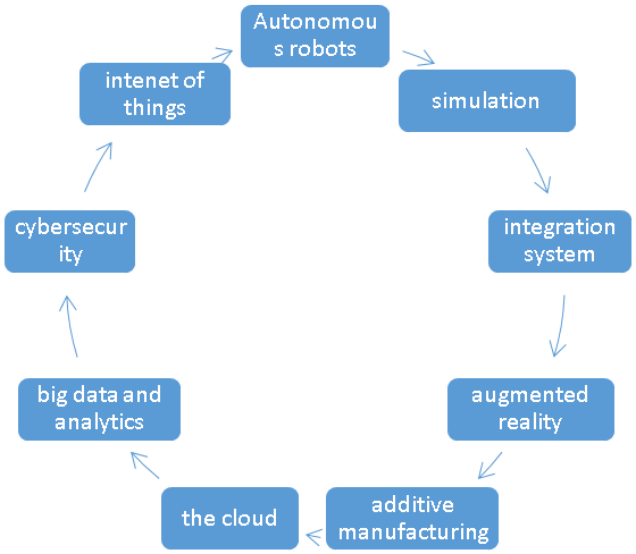


Fig. 1: Nine pillars of IR 4.0 (Muhammad et al., 2018)

The growing wave of technology has resulted in new innovations that are also transforming the construction sector. Technology can help the construction industry to visualize new buildings or structures that cannot be realistically designed. In recent years, many technologies have been used in the construction industry such as architecture, interior design, and construction (Bai et al., 2020). Therefore, these nine pillars need to be known and applied in the construction industries to help them to realize the IR4.0. The use of this technology is very important for the construction industries because it can save costs, energy and can increase the understanding of something that cannot be imagined. This technology can also facilitate problem solving for a specific job. Therefore, the CIDB has designed a program to ensure that each organization has the knowledge and skills in using this application.

2.2 The Important of IR4.0 in the Construction Industry

The contribution of the construction industries to the economy and development of the country is enormous. Apart from that, the results of the construction of a country can also reflect the image and technology owned by a country. Each country has a variety of technologies to be used and applied in construction ranging from simple construction that is traditional construction to complex construction methods and require the use of high technology. In each project, construction methods can be selected from a variety of technologies. The ability to use simple technology in most projects will make the construction industry easier to venture into with lower investment and guarantee high profits. This can directly guarantee the speed of a construction project while increasing productivity.

In addition, in the construction industries productivity can be increased by using new technologies generated from digitalization, the latest construction methods, and innovation. The use of tools such as three-dimensional (3D) scanning,

Building Information Modelling (BIM), drones, and augmented reality should be used to produce quality construction since other developed countries have begun to apply the nine cores of the IR4.0 in their construction industries. As the use of technologies in construction grows, construction organisation can increase productivity levels, safety, quality, and improve project management. Therefore, the importance of the IR4.0 in driving rapid development and making Malaysia a country that is par with the current of modernization that is increasingly used of technology.

However, in the post-industrial era has shown that not only the industrial sector is the main focus in increasing economic growth of a country, but other sectors, especially the construction sector also strive to increase the growth rate of Malaysia's construction industry with various high-tech projects. Therefore, the industrial revolution is able to increase economic growth in the construction industries if all parties, together ensure that the construction industries is ready with the use of technology to ensure that the construction produced is more efficient and technology savvy.

3. Methodology

The research employed a survey design method with a quantitative approach using a questionnaire. In the research survey design, a questionnaire form was used as a tool to gather the required information. This research emphasizes on objective and controlled phenomena through data collection and analysis using a quantitative approach. It was conducted on the sample of a study identified to obtain the necessary data.

Data is gathered through the distribution of the questionnaire to the workers who is work at various construction organizations. The workers included government agencies, developers, consultants, surveyors and contractors from Johor, Pahang and Terengganu. A total of 51 construction workers have been randomly selected through non purposive sampling. The selection of the sample is based on the feedback given to the questionnaire that has been distributed through email and WhatsApp to the identified workers who is known by the researchers. And the identified workers help to circulate the information into their known organizations, which eventually provided a sufficient number of samples for this research. Roscoe Jr et al. (1975) stated that a sample of between 30 to 500 people is appropriate in a study. Therefore, researchers take into account all respondents who have given feedback as a sample of this study.

Research instrument is the process of forming, testing and using tools or materials for the process of obtaining data. This study used the form of a questionnaire as the main instrument where the items are constructed modestly from previous studies. The questionnaire consisted of three sections, Section A, B, and C. Section A was the demographic data of the respondents. Whilst Part B, and C used a likert scale that asked in the aspect of readiness of construction organization and challenges towards IR4.0. The likert scale ratings from 1(strongly disagree) to 5 (strongly agree). The items are constructed in a Google form for ease of distribution and accesses to the data by any respondent.

According to Lee et al. (2015), a reliable measuring instrument is not necessarily valid but a measuring instrument that has good validity is necessarily reliable. Therefore, the questionnaire has been validated and piloted for its reliability before distributing to the sample. Three experts consisting of two senior lecturers at the Faculty of Civil Engineering & Built Environment at the Universiti Tun Hussein Onn Malaysia and a representative from the contractor were selected to validate the questionnaire. Meanwhile, a total of 15 workers from various construction organizations (who are not involved in the actual study) were involved in the pilot test. The value of Cronbach's Alpha score for all items is 0.964 which indicates that the items in the questionnaire for this study are very good and as a whole, the items that have been developed are appropriate and can be used for the actual study.

Statistical Package for Social Science (SPSS) version 25.0 is used to analyze the data. This software is used to facilitate the work of data analysis to carry out and translate the data into a more detailed and structured form of information. The data were analyzed descriptively for frequency, percentage, mean and standard deviation. Furthermore, this software is very helpful especially when it involves collecting a lot of data so that it can be analyzed quickly and the results of the analysis can be presented in the form of pie charts, graphs, tables and so on that are easy for readers to understand.

4. Results and Discussion

The sample involved in this study consists of construction organizations comprising government agencies, developers, consultants, surveyors and contractors. Descriptive data analysis was performed on demographic information, readiness and challenge of construction organization towards IR4.0.

Respondents involved in this study were randomly selected among the construction organizations from various companies that run construction work. The details of the respondents is presented in Table 1.

4.1 Analysis of Respondents' Demographic Data

Table 1: Respondents' demographics detail

Demographic Information		Frequency	Percentage
Gender	Male	29	56.9
	Female	22	43.1
Age	21 – 30	41	80.4
	31 – 40	4	7.8
	41 – 50	6	11.8
	Above 50	0	0
Race	Malay	43	84.3
	Chinese	7	13.7
	Indian	1	2.0
	Others	0	0
Experience	Below 1 year	9	17.6
	1 – 5 years	29	56.9
	6 – 10 years	7	13.7
	Above 10 years	6	11.8
Organization	Contractor	35	68.6
	Consultant	3	5.9
	Quantity surveyor	4	7.8
	Surveyor	2	3.9
	Architecture	1	3.0
	Others	6	11.8

From the table it can be seen that the number of male workers is more than the female workers. There are 29 male workers (56.9%), meanwhile, female workers are 22 (43.1%). There is no big different between both genders, however it is clearly indicated that more male workers are working at construction organizations due to its nature of work that are more risky and tough work, which is more suitable for the man.

The majority of workers are between the ages of 21-30 which is a total of 41 workers (80.4%). The rest of them aged between 31-40 years, which is 4 workers (7.8%) and aged 41-50 years are 6 workers (11.8%). However, there are no workers who aged more than 50 years that involved in this study. The result shows that many workers are at a younger age which suggested that is easy for them to adapt for any changes in the working environment.

Nonetheless, many of them are new in this field. Many of them have working experience between 1-5 years who is 29 workers (56.9%). There are also nine workers (17.6%) who have worked less than one year. Only six workers (11.8%) who have more than 10 years. The rest of them who have 6-10 years of experience are seven workers (13.7%). Even they are many young workers, however with the limited experience might limit their knowledge and skill as well.

Majority respondent are Malay who is 43 workers (84.3%). Chinese respondents were seven (113.7%), and only one (2.0%) Indian respondent, but there are no respondents from others races. This might due to the reason that more than 50% of the workers (68.9%) are from contractors companies, where contractors is commonly related to Bumiputra Holders. The rest of the workers are consultant (5.9%), quantity surveyor (7.8%) and others companies with 11.8% respondents. The least workers come from survey company (3.9%) and architect, only 1respondent (3%).

4.2 Workers' knowledge of IR4.0

This question has been asked to evaluate workers' knowledge about nine pillars that are the major elements of the IR 4.0. The Fig. 2 presents the finding of this aspect.

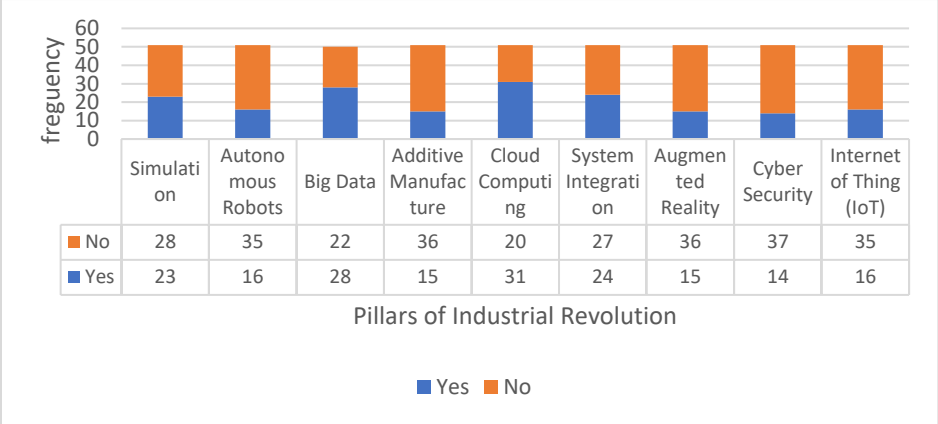


Fig. 2: The pillars of the IR4.0 known by respondents

As can be seen from the figure, majority respondent are well aware about IR 4.0 and have a basic information about the elements of IR4.0. 31 of them knows about cloud computing and follow by respondents who know about big data which is 28 workers. Many workers also know about integration system as well as simulation, with 24 and 23 workers, respectively. Internet of Thing and autonomous robots have same number among of respondents which is 16 workers. The less familiar elements of IR4.0 are a cyber security which is 14 workers only. Additive manufacture and augmented reality also provide the similar respond where only 15 workers who know about this pillars. In general, these data indicate that workers have basic information related to the Industrial Revolution (IR4.0).

4.3 Analysis of The Readiness of Construction Organization Towards IR 4.0

A total of 20 items have been developed in Section B of the questionnaire to identify the readiness of workers in construction organizations towards IR4.0. Table 2 displays finding for this analysis.

Table 2: Readiness of Construction Organization towards IR 4.0

No	Item	Min Score	Standard Deviation	Interpretation
B1	I know about IR 4.0 technology used in construction.	4.03	0.958	High
B2	I am always looking for IR 4.0 related information to improve my knowledge	3.90	1.005	High
B3	I was able to learn on my own and adapt in the IR4.0 environment	3.88	0.840	High
B4	I know how to use certain online applications in building designs.	3.73	0.918	High
B5	I know how to store data/information using certain online applications	4.08	0.845	High
B6	I always make sure my device/gadget is up to date	4.35	0.770	High
B7	I always share related information about IR4.0 to my organization	3.90	0.973	High
B8	I was able to implement my work using IR 4.0 technology applications	3.92	0.913	High
B9	I am ready to learn about the IR4.0 element	4.37	0.720	High
B10	I am ready to be mentor for other employees (teach the skills required in the IR4.0 element)	4.10	0.878	High
B11	I am good of using software such as BIM, Revit and other construction related software	3.83	1.053	High
B12	I am able to operate software that is able to perform integration between a system or software	3.70	1.035	High
B13	I have skills and knowledge in using simulation elements for work	3.90	0.878	High

B14	I have skills and knowledge in handling 'Big Data' for biggest amount of data related to project	3.84	1.084	High
B15	I have skills and knowledge in operating 'Cloud Computing'	3.84	1.007	High
B16	I have skills and knowledge to use 'Augmented Reality' to facilitate construction work.	3.64	1.036	Moderate
B17	I have skills and knowledge in handling cyber security for the confidential data.	3.55	1.024	Moderate
B18	I have skills in estimating initial costs, utilization costs and disposal costs for the purpose of implementing IR4.0 elements	3..82	0.953	High
B19	I have skills and knowledge in operating 'Robot Automation' in construction sites	3.47	1.120	Moderate
B20	I have skills and knowledge in handling 'Additive Manufacturing'	3.67	1.013	High
	Average Mean Score	**3.88**	**0.951**	**High**

With reference to the Table 2, the highest mean value is for item B9 which is related to ready to learn about the IR4.0 element with a mean value of 4.37 and the standard deviation is 0.720. While item B10 has the second highest mean value 4.10 and the standard deviation is 0.878 that related to readiness to be mentor for other employees. From the Table 2 it can also be seen that the rest items has high mean score which indicated that most workers possess required skills and knowledge towards IR4.0. Only three items are at a moderate level. The lowest mean value is for item B19 related to the skills and knowledge in operating robot automation with a mean value 3.47 and standard deviation 1.120. Although, there are a few items has a moderate level, nonetheless, the average of mean score is 3.88 (SD 0.951) which is at the high level. This findings suggested that workers in the construction industries have a sufficient knowledge and skill and are ready to inculcate the IR 4.0 into their job descriptions.

4.4 Analysis of The Challenge of Construction Organization in Industrial Revolution 4.0

To identify the challenge, a total of 12 items have been developed in Section C to identify the challenge of construction organization in industrial revolution 4.0. Table 3 presents the statistical analysis of the findings.

Table 3: Challenge of construction organization in IR 4.0

No	Item	Min Score	Standard Deviation	Valuation
B1	Lack of skilled manpower	4.35	0.770	High
B2	Difficult to obtain IR4.0 information related to the construction field.	4.13	0.825	High
B3	Difficult to use the latest software related to construction performing task	3.96	1.019	High
B4	Difficult to implement a skill with the advancement of IR4.0 technology	4.04	0.871	High
B5	Difficult to motivate organization to adopt a new technology.	4.08	0.891	High
B6	Difficult to adapt employee in the use of new technology	4.04	1.020	High
B7	Difficult to used technology related to IR4.0 in performing tasks.	4.10	0.900	High
B8	Need fast and efficient internet access	4.50	0.758	High
B9	Expose to the violations and abuses of privacy.	4.16	0.946	High
B10	Higher cost for education and training	4.25	0.796	High
B11	Higher tools and software cost	4.40	0.802	High
B12	Didn't get incentive support from the government	4.20	0.849	High
	Average Mean Score	**4.20**	**0.871**	**High**

As been shown in the table, overall average mean score is 4.20, SD 0.871, that generally indicate a high challenge of workers in construction industry towards IR4.0. The highest mean score was 4.50, with a standard deviation value of 0.758 for item B8 related to need fast and efficient internet access. This indicates that this item is categorized as a major challenge among organizations. This is follow by B11 with a mean score value of 4.40 with a standard deviation value of 0.802. This item related to the higher tools and software cost. Meanwhile, the lowest mean is recorded by items B3 that related to difficulty in using the latest software with mean score values of 3.96, standard deviation value is 1.019. However, this item still at a high level that shows part of challenges to be faced by the workers.

5. Discussion and Conclusion

Based on the analysis that has been done, the respondents age between 41-50 with more working experience are more aware to technological changes that related to IR4.0. According to Dharmawati (2016), one's knowledge is influenced by one's education, age, and work experience. According to him, experience is an event that a person has experienced, the longer the working period then the knowledge will increase.

Furthermore, the result of analysis of respondents' readiness towards IR4.0 found that the majority of respondents were aware and ready to face IR 4.0. This proves that construction organizations are aware of the importance of IR4.0 even though their skills in applying IR4.0 are still lacking. Companies or employers, need to work together such as held a seminar or provide instructors to improve their skills and knowledge among organizations related to the IR4.0. Its could help to increase their skills and knowledge toward IR4.0 elements in their scope of work.

On the other hand, in the aspect of challenge of construction organization in IR4.0, workers need a good and efficient internet, which is one of major challenges faced by most workers in the construction industries. Some workers need to work from home and fast internet access is important to complete their task. Furthermore, nowadays internet access become one of important tools since many tasks needed for internet access. Even they have high challenge to realization of IR4.0, nonetheless, majority workers in the organizations are ready to face the IR4.0 to bring about good and positive technology use changes towards sustainability in the construction industry. In conclusion, the readiness of construction organization towards IR4.0 is important to ensure construction industry does not lagging behind any others technology changing. In addition, every challenge faced by organization need to be taken seriously and the organization should overcome every challenge that existed. Therefore, organization cooperation is necessary to ensure that IR4.0 can be realized and organizations are always ready to face challenges and technological changes in the construction industry in Malaysia. Hence, they can help to accelerate the construction process and be able to respond to the government's need to realize the IR 4.0 in Malaysia and meets requirement by National Industry 4.0 Policy (Industry4WRD).

Acknowledgement

The authors would like to thank fellow authors and organizations whose intellectual properties were utilized for this study.

Conflict of Interest

The authors declare no conflicts of interest.

References

Ardiny, H., Witwicki, S., & Mondada, F. (2015, October). Construction automation with autonomous mobile robots: A review. In *2015 3rd RSI International Conference on Robotics and Mechatronics (ICROM)* (pp. 418-424). IEEE. https://doi.org/10.1109/ICRoM.2015.7367821.

Bai, C., Dallasega, P., Orzes, G., & Sarkis, J. (2020). Industry 4.0 technologies assessment: A sustainability perspective. *International journal of production economics*, *229*, 107776. https://doi.org/10.1016/j.ijpe.2020.107776.

CIDB, (2020). IR 4.0 Dalam Pembinaan. Retrieved October 13, 2020, from https://www.cidb.gov.my/index.php/ms/maklumat-pembinaan/teknologi/ir40.

Dharmawati, I. G. A. A. (2016). Hubungan tingkat pendidikan, umur, dan masa kerja dengan tingkat pengetahuan kesehatan gigi dan mulut pada guru penjaskes sd di Kecamatan Tampak Siring Gianyar. *Jurnal Kesehatan Gigi (Dental Health Journal)*, *4*(1), 1-5.

Ismail, Z. Z (2018). Cabaran Industri Pembinaan Di Malaysia Terhadap Revolusi Industri 4.0. *Universiti Teknologi Malaysia.*

Lee, L., Chen, D. T., Li, J. Y., & Lin, T. B. (2015). Understanding new media literacy: The development of a measuring instrument. *Computers & Education*, *85*, 84-93. https://doi.org/10.1016/j.compedu.2015.02.006.

Muhammad, B., Kumar, A., Cianca, E., & Lindgren, P. (2018, November). Improving port operations through the application of robotics and automation within the framework of shipping 4.0. In *2018 21st International Symposium on Wireless Personal Multimedia Communications (WPMC)* (pp. 387-392). IEEE.

Maskuriy, R., Selamat, A., Ali, K. N., Maresova, P., & Krejcar, O. (2019). Industry 4.0 for the construction industry—How ready is the industry?. *Applied Sciences*, *9*(14), 2819.

Oesterreich, T. D., & Teuteberg, F. (2016). Understanding the implications of digitisation and automation in the context of Industry 4.0: A triangulation approach and elements of a research agenda for the construction industry. *Computers in industry*, *83*, 121-139. https://doi.org/10.1016/j.compind.2016.09.006.

Pereira, T., Barreto, L., & Amaral, A. (2017). Network and information security challenges within Industry 4.0 paradigm. *Procedia manufacturing*, *13*, 1253-1260. https://doi.org/10.1016/j.promfg.2017.09.047.

Phoon, G. C., Idris, M. Z., & Nugrahani, R. (2021). Virtual Reality (VR) in 21st. Century Education: The Opportunities and Challenges of Digital Learning in Classroom. *Asian Pendidikan*, *1*(2), 105-110. https://doi.org/10.53797/aspen.v1i2.15.2021.

Prasetyo, B., & Trisyanti, U. (2018). Revolusi industri 4.0 dan tantangan perubahan sosial. *IPTEK Journal of Proceedings Series*, (5), 22-27. http://dx.doi.org/10.12962%2Fj23546026.y2018i5.4417.

Roscoe Jr, A. M., Sheth, J. N., & Howel, W. (1975). Intertechnique Cross-Validation. *New Marketing for Social and Economic Progress and Marketing's Contributions to the Firm and to the Society: 1974 Combined Proceedings*, *8*(36), 145.

Sabri, S., & Yahya, M. Y. (2020). Penggunaan Internet of Things (IoT) dalam Industri Pembinaan di Malaysia. *Research in Management of Technology and Business*, *1*(1), 482-498.

Saraswati, P., & Ahmad Puad, F. N. (2020). Development of touristic village and creative industry in improving social welfare at Wukirsari Village, Imogiri, Bantul District. *Asian Journal of Assessment in Teaching and Learning*, *10*(1), 87-97. https://doi.org/10.37134/ajatel.vol10.1.10.2020.

Schwab, K., & Davis, N. (2018). *Shaping the future of the fourth industrial revolution*. Currency. United Kingdom: Penguin UK.

Schönbeck, P., Löfsjögård, M., & Ansell, A. (2020). Quantitative review of construction 4.0 technology presence in construction project research. *Buildings*, *10*(10), 173.

Steiner, R., & Jornitz, M. (2017). Continuous processing in the pharmaceutical industry: status and perspective. *Continuous Manufacturing of Pharmaceuticals*, 369-403.

Stiles, S., Golightly, D., & Ryan, B. (2021). Impact of COVID-19 on health and safety in the construction sector. *Human Factors and Ergonomics in Manufacturing & Service Industries*, *31*(4), 425-437.

Sudirman, A., Muttaqin, M., Purba, R. A., Wirapraja, A., Abdillah, L. A., Fajrillah, F., ... & Simarmata, J. (2020). *Sistem Informasi Manajemen*. Yayasan Kita Menulis.

Tariq, B., & Rahim, R. A. (2016). The environmental effects of intra-industry trade in the SAARC region. *International Journal of Business and Society*, *17*(1).