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Implementation of The Fourth Industrial Revolution (IR 4.0) For Controlling Workers' Safety at Construction Site

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Abstract: The adoption of technology associated with the Fourth Industrial Revolution (IR 4.0) is seen as a main factor in the construction industry's increased reliance on intimate human-machine interaction and associated hazards. Due to the complex management techniques utilized on construction sites, potential workplace hazards cannot be eliminated. Despite, there were increasingly more accidents and fatalities. Therefore, this research was carried out to discover solutions by implementation of IR 4.0 for controlling workers' safety at construction site. The purpose of this study was to identify the key problems, key factors, and promoting methods implementation of IR 4.0 for controlling workers' safety at construction site. Questionnaires were used as the tool for data collection in this research to accomplish the goals. In Selangor, 341 G7 contractors contributed to the distribution questionnaire for this study, and 138 of those respondents reported receiving their questionnaire results. The data were analyzed through SPSS to determine the mean, standard deviation and the pie charts, frequency, and percentage values for the respondents' backgrounds. The findings indicated that the key problems with IR 4.0 were high setup and post-processing costs, as well as high costs of IR 4.0 technology developers' employment. Enhancing real-time data capture for workers' safety was one of the key factors of IR 4.0 implementation and promoting methods of IR 4.0 was promoted IR 4.0 technology by regularly controlling workers' safety. In conclusion,

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the research offered a wealth of information for effectively regulating employees' safety with the adoption of IR 4.0 at the construction site.

Keywords: Construction site, Controlling workers' safety, G7 contractors, IR 4.0

1. Introduction

The implementation of IR 4.0 produces a setting where every mechanised automation will be linked through technology developments to operate and transmit information with less risk to workers, boosting worker safety and effectiveness. Since its inception, the advantages have been obvious due to its enhanced operational performance, increased health, and safety, shortened time to market, and enhanced product quality (You and Feng, 2020). According to Adepoju (2022), various safety technologies, including Radio Frequency Identification (RFID), Augmented Reality (AR), Virtual Reality (VR), Building Information Modelling (BIM), smart sensor and wireless technology, online databases, robotics, and automation, have significantly improved the efficiency of health and safety management on construction sites. New technologies can be used to create a safe workplace by separating employees from risky working circumstances (Min *et al.*, 2019). For instance, real-time monitoring of dangerous leaks or staff mishaps is conceivable when using surveillance cameras with a deep-learning system that can recognise patterns in human behaviour. When a potentially hazardous situation is immediately reported to the operator, safety officer, or pertinent department, an accident can be avoided (Chen, 2012).

Construction has been listed as one of the industries that potentially benefit from the Fourth Industrial Revolution (IR 4.0) in the "Made Smarter UK" study (Maier, 2017). According to Turner et al. (2020), data analytics, sometimes referred to as data warehouses, will supply the fuel required to power data analytics and artificial intelligence systems by recording data on worker activities and onsite conditions at construction sites. Then, using planning and optimization tools, fresh approaches might be created to deal with any possible risks to workers' safety that might arise during an on-site construction project. According to Zhang *et al.* (2015), automating the detection and avoidance of construction worker fall hazards on the job site suggests using drones and virtual reality. In their research, they used an automated rule-checking technique to locate boundaries and safe working spaces in a building. Technology such as Augmented Reality (AR) provides a unique visualisation solution that allows worker safety, monitoring worksite activities, and marking up vital information for a digital twin to intelligently carry out offline hypothesis generation and analysis. The working environment of the construction site might also be marked with digital markups and important messages, like how natural ants increase efficiency (Turner *et al.*, 2020). Thus, this study attempts to identify the implementation of the Fourth Industrial Revolution (IR 4.0) for controlling workers at the construction site to address the above-mentioned issues.

According to a study by Roelofs *et al.* (2011) on the perspectives of construction workers on the factors that impact construction site safety and risk, many workers believe that training is valuable, however, none of them will allocate 30 to 60 minutes for it because they are busy focusing on finishing the job quickly. They felt that training was not important because their main objective was to perform their duties and be paid. This exposes the workers' disregard for safety and health norms. Therefore, another concern for the safety of construction workers is accidents that result from construction-related activities and cause difficulties with physical, mental, or finances. They utilise hammers, cutting machines, sickles, spades, huge axes, chisels, and other sharp objects hastily and carelessly. When such equipment is handled carelessly, it might injuries such as slashed fingers or cause significant pain, wounds, and blood loss. As a result, many workers, including carpenters, welders, painters, lumber, and helpers, get accidents and have a lot of issues (Ponnaian & Iyappan, 2016). Additionally, it would be crucial to protect the privacy of workers' data safety, and poor planning would make it easier for opportunistic people to interfere with construction operations (Sony, 2020). According to Flatt *et al.*

(2016), there are a few cyber-security safety, such as the shutting down of cyberattacks, data workers' security, as well as other sensitive data. As a result, the safety and security of the workers' personal data on the construction site may be compromised. Therefore, this study seeks to identify key problems, factors, and methods to promote the implementation of IR 4.0 for controlling workers at the construction site.

2. Literature Review

2.1 Industrial Revolution 4.0 Technology

In addition to being a natural outcome of digitalization and new technology, the implementation of Industry 4.0 is linked to the fact that several previously explored prospects for increasing profit in industrial manufacturing have been essentially exhausted and new chances must be identified (Rojko, 2017). According to Schwab (2016), IR 4.0 is differentiated by a few characteristics of new technologies such as physical, digital, and biological worlds. The development strategies of economies, companies, and governments are all being significantly impacted by technological advancement. Thus, Schwab demonstrated the importance of IR 4.0 as one of the key ideas in the development of international trade and the global economy.

2.2 Controlling Workers' Safety at Construction Site

The social and behavioural sciences have made significant contributions to improving workers' awareness of occupational safety through the ideas of an organizational safety environment (Mohammed*et al.,* 2017). For instance, in Malaysia where the government has recognised the value of increasing construction workers' awareness of safety management systems, the Construction Industry Development Board (CIDB) and the National Institute of Occupational Safety and Health (NIOSH) have been putting on the Green Card program, a safety and health induction program (CIDB, 2011). This program is an integrated safety and health training program including all construction employees and personnel, according to the Construction Industry Development Board (CIDB). Similarly to that, the program's objectives are to ensure that construction workers comprehend the importance of a safe and healthy workplace, to provide them with a basic understanding of safetyand health at construction sites, and also to inform them of the relevant laws related to safety and health (CIDB, 2011).

2.3 Problems of IR 4.0 Technology Implementation for Controlling Workers' Safety

(a) Negative impact of data sharing

There are two concerns in a competitive setting, data sharing of workers' safety has a negative influence. First is the high level of transparency, there may be risks including high-risk computer security of data workers' safety, industrial spying of data workers' safety, as well as other related issues. Second is the organisations that establish limiting platform requirement for controlling workers' safety when the implementation of IR 4.0 occur (Zhou *et al.,* 2017). Among the examples of limiting platform requirements is the limitation of data coverage to control worker safety and the limitation of time and location of image acquisition to control worker safety such as the use of drones (Rodríguez-Ardura & Meseguer-Artola, 2010).

(b) IR 4.0's socio-technical implications

The social economic theoretical approach should be incorporated into every phase of the designed system for Industry 4.0 (Davies *et al.,* 2017). Some of the social issues that will arise as a result the implementation of IR 4.0 (Avis, 2018) include workers who work with or near robots may sustain injuries due to conflict in the job specification issues including loose connections between parts or mistakes in programming and external devices interface (Frey *et al.,* 2016). Furthermore, increasing regulatory capture on workers' safety can lead to the deregulation of the actions of the purportedly regulated parties themselves while keeping regulations that benefit them, including entry restrictions, subsidies, and bailout assurances from the taxpayer which can impact the workers' data safety at the construction site (Rainie & Anderson, 2017).

(c) High initial costs

To adopt IR 4.0, money must be raised because capital expenses are expensive as well as to monitor workers' safety. Long-term profitability will arise from the expenditure, but the up-front cost of implementing IR 4.0 is high (Rojko, 2017). In an Additive Manufacturing facility, which would be regarded as one of the IR 4.0 enablers for controlling workers' safety, setting up machines and post-processing equipment, for example, is quite expensive. The development of the work environment andthe demand for highly qualified developers, while initially expensive, are only necessary at the beginning. Following that, the contractors need enough money for implementing IR 4.0 technology for controlling workers' safety (Lasi *et al.*, 2014).

(d) Reduce inter-human contact

Workers' safety is probably going to be significantly impacted by IR 4.0 technology (Bonekamp & Sure, 2015). It is certain that encouraging workers to accept IR 4.0 technology was difficult for them. This is because it can reduce inter-human contact between employees and managers as well aswith their coworkers, which could affect the work environment by increasing stress linked to one's job as well as have long-term detrimental effects on one's health (Leso *et al.,* 2018). The increased accessibility, adaptability, and mobility of machines could also enable them to work anywhere at any time, thus impairing everyone's ability to keep a healthy work-life balance (Celik & Öztürk, 2017). Stress related to workplace change, work overtime, and interfering with the workers' quality timebecause of the use of IR 4.0 technology such as robotics in place of humans might all be seen (Murashov *et al.,* 2016).

Table 1: Problems of IR 4.0 technology

No	Problems of IR 4.0 Technology	Author
1	Negative impact of data sharing	• Zhou *et al.* (2017) • Rodríguez (2014)
2	IR 4.0's socio-technical implications	• Davies *et al.* (2017) • Avis (2018) • Frey *et al.* (2016) • Rainie & Anderson (2017)
3	High initial costs	• Rojko (2017) • Lasi *et al.* (2014)
4	Reduce inter-human contact	• Bonekamp & Sure (2015) • Leso *et al.* (2018) • Celik & Öztürk, (2017) • Murashov *et al.* (2016)

2.4 Factors of IR 4.0 Technology Implementation for Controlling Workers' Safety

(a) Efficiency and effectiveness in the workplace

Implementing IR 4.0 technology can control the efficient workers' safety at construction site (Argenti, 2018). Workplace hazards can cause injuries, illnesses, and incidents. Effective controls can reduce or eliminate these risks to a worker's safety and health. Additionally, it can assist organisations in offering secure and healthy working environments to employees. Indirectly, adoption of IR 4.0 for controlling workers' safety can boost an organization's innovativeness. It can manage, prevent accidents, and guarantee a regular flow of work, which helps to raise morale and productivity.

Additionally, it encourages teamwork and a sense of community among the workers (Roy & Khastagir, 2016).

(*b*) *Enhanced operations*

IR 4.0 implementation can enhance real-time data capture for workers' safety. situational awareness was made available to security executives at a crucial time due to real-time data capture for workers' safety. The top management has integrated their communication protocols because of the growth of remote communications technologies, such as the Internet of Things (IoT), which can manage remote workers and use multiple security teams on-site. They have also gained actionable insights and visibility into their daily operations (Oettmeier & Hofmann, 2017). At the same time, IR 4.0 technology also can enhance quality of controlling workers' safety by regularly meeting such as going over safety guidelines and talking with the workers about preventative to keep workplace safety (Rudtsch *et al.*, 2014).

(c) Monitoring of employees' well being

Real-time alarm systems for managing worker safety at construction sites can be enhanced by implementing IR 4.0 (Lichtblau et al. 2015). It warns people about potential threats and gives them the knowledge they need to stay safe. As an illustration, consider a real-time location-based construction labour safety management system that monitors and visualises workers' where in real-time and notifies those who are at risk (Sony & Naik, 2019). At the same time, this can improve workers' performance on safety consent at construction site (Ennis *et al.*, 2018).

(d) Product quality and safety improvement

By implementing IR 4.0 technology, it can avoid repetitive accidents by controlling workers' safety at construction site such as safety protocols, provide safety trainings and warning signs (Li & Lau, 2017). Furthermore, the prevention of accidents can assist construction sites to avoid lost productivity, legal problems, personnel injuries, and building damage. Workers are less likely to be distracted from their work when they feel appreciated and protected (Li & Lau, 2017). Artificial intelligence can be used to monitor self-control among workers and test the quality of products at various stages of the manufacturing process (Radziwill, 2018).

Table 2: Factors of IR 4.0 technology

No	Factors of IR 4.0 Technology	Author
1	Efficiency and effectiveness in the workplace	• Argenti (2018) • Roy & Khastagir (2016)
2	Enhanced operations	• Oettmeier & Hofmann (2017) • Rudtsch *et al.* (2014)
3	Competitive advantages	• Lichtblau *et al.* (2015) • Sony & Naik (2019) • Ennis *et al.* (2018)
4	Product quality and safety improvement	• Chen & Hua (2017) • Li & Lau (2017) • Radziwill (2018)

2.5 Promoting Methods of IR 4.0 Technology Implementation for Controlling Workers' Safety

(a) Internationalisation transformation

Construction companies must innovate and internationalise at the same time to keep up with the growing competition in the global market with implement IR 4.0 (Sima *et al.*, 2020). By integrating IT resources, top management can promote IR 4.0 technology by regularly controlling workers' safety at construction sites. Integration of IT resources can improve the firm's ability to manage international relations more effectively through shared control, interfirm coordination, and hybrid centralization. For example, wearable sensors can increase safety for frontline employees who are frequently exposed to risky situations by monitoring employee activity, health risks, and environmental dangers. Top management can further reduce the toll that accidents or work-related illnesses impose on their workforce by alerting connected workers regularly when they need a break or when their health is in danger (Zhao & Priporas, 2017).

(b) Reconfigurations of products

Providing advanced digitalization by IR 4.0 implementation can control workers' safety at construction site. This also can reconfiguration of products in the construction industry which smart products will acquire new competitive advantages in the market. The intelligent product develops into a complicated system that can also control the workers' safety that includes a range of sensors, storage systems, software, and communication (Porter & Heppelmann, 2020). The Internet of Things, which will have a significant impact on worker behaviour safety, will also have an impact on the decision-making at various stages of the purchasing process (Abashidze *et al.,* 2016).

(c) Cloud systems (CS)

The term "cloud" is utilised for applications by implementing IR 4.0 such as private services, colour management, and performance benchmarking applications. The cloud implements significantly more rapid distribution than stand-in systems, as well as quick upgrades in workers' safety (Bauernhansl & Jäger, 2014). According to Ghadge *et al.* (2020), cloud technology is the most main online service that allows operational comfort with web-based apps that do not require any installation. It enhances data protection by controlling workers' data safety.

(d) Strengthening sustainability

The priority of new energy sources and social communication technology characterises the "post-economy of artificial intelligence". New complex forms emerge in the artificial intelligence economy, putting new pressures on market institutions such as competition, innovation, and commercialization (Ripoll *et al.,* 2019). The adoption of Industry 4.0 by SMEs brings with it economic, ecological, technical, and social risks, the latter of which is primarily comprised of job losses. Technical hazards are mostly concerned with IT security and political issues. All these risks necessitate a new type of management, one that is intelligent, synergistic, and predictive, capable of anticipating and managing all threats (Birkel *et al.,* 2019).

Table 3: Promoting methods of IR 4.0 technology

No	Promoting Methods of IR 4.0 Technology	Author
1	Internationalisation transformation	• Sima *et al.* (2020) • Zhao & Priporas (2017)
2	Reconfigurations of products	• Porter & Heppelmann (2020) • Abashidze *et al.* (2016)
3	Cloud systems	• Bauernhansl & Jäger (2014) • Ghadge *et al.* (2020)
4	Strengthening sustainability	• Ripoll *et al.* (2019) • Birkel *et al.* (2019)

3. Research Methodology

3.1 Research Design

In this study, the quantitative method is suitable to be adopted because it highlights objectivity and isespecially useful when collecting quantifiable measures of variables and presumptions from population samples. On the other hand, quantitative research makes use of formal tools and standardised procedures to collect data in an objective and methodical manner. Moreover, statistical approaches are used to analyse numerical data, and software including SPSS is frequently used (Queirós *et al.*, 2017). There are 5 phases in the research process each of that will describe the full technique and activities from start to finish. Figure 1 represents a preliminary research, literature reviewprocess, data collection, data analysis, and conclusion and recommendations.

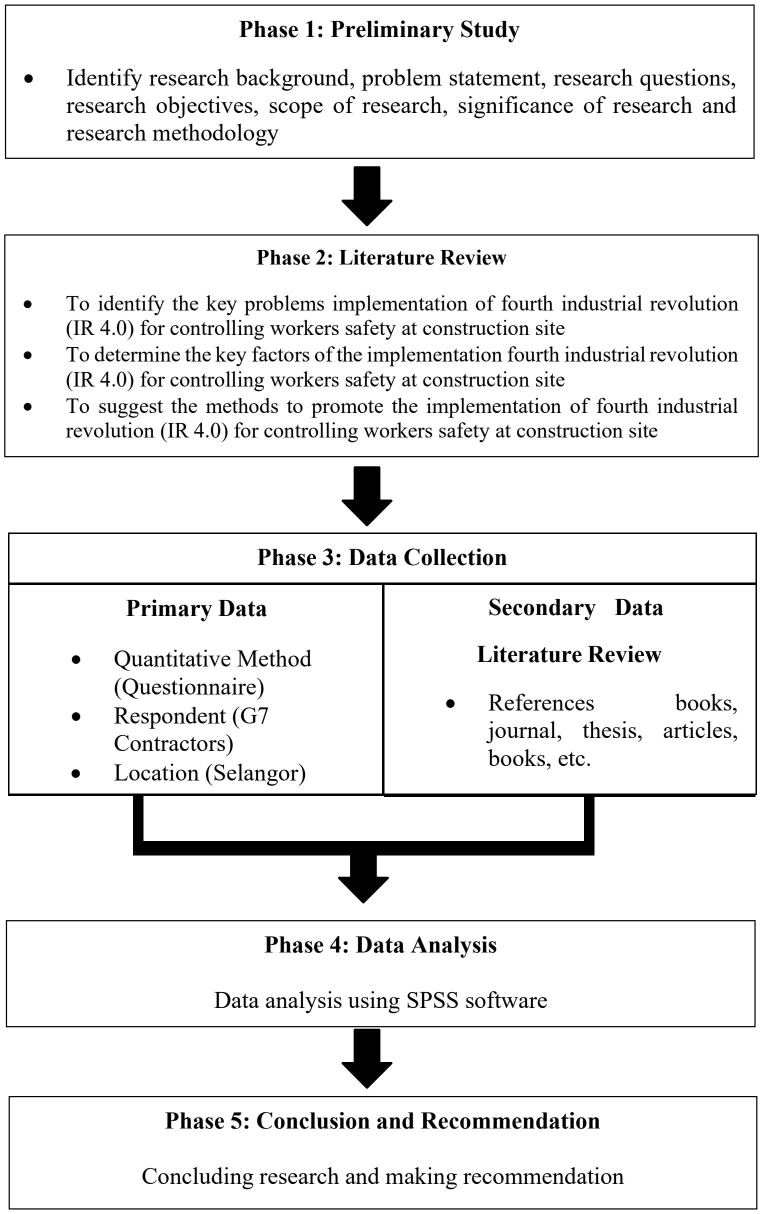

Figure 1: The research methodology flowchart

3.2 Data Collection

There were two sorts of data in this study which are primary data and secondary data. All the data were gathered from primary and secondary data. As a result, the methods of data collection were thoroughly explained. Data from primary data sources were complete and accurate because it is collected directly from the source and according to specific content guidelines (Khuc & Tran, 2021).

Experiments, surveys, observations, and questionnaires are all sources of primary data (Kabir, 2016). For this study, fundamental data were collected by quantitative methods, which is by the distributed questionnaires to obtain information from respondents. The questions in the surveys were centered on the study's goals. Secondary data was information gathered from a source that has previously been published in a certain manner. According to Ajayi (2017), books, Internet articles, and journal articles from previous researchers were used as secondary data sources in order to gather all relevant information for this study.

In this research, the target population was focused on the construction sites located in Selangor. Around 3027 G7 construction contractors in Selangor have reached the highest number (CIDB, 2022). The sampling size for this research was determined using the Krejcie and Morgan sampling table approach in this study as shown in Table 6. As a result, the sample size was set at 341G7 contractors. The questionnaire is designed such that each question has multiple response options such as Likert Scale and frequency. It is divided into three sections which are described in Table 5.

Table 5: Questionnaire content

Section	Measured Construct	Measurement Technique
A	The question will ask the respondents about the demographic, which. consists of race, age, working experience, education level and occupational.	Frequency
B	The questions regarding the desire to achieve the first objective of identifying the problems implementation of Fourth Industrial Revolution (IR 4.0) for controlling workers' safety at construction site.	Likert Scale and Mean Score
C	This section it toward obtaining the data to achieve the second objective, which are the key factors of the implementation Fourth Industrial Revolution (IR 4.0) for controlling workers' safety at construction site.	Likert Scale and Mean Score
D	This section refers to the desire to achieve the third objective which is the methods to promote the implementation of Fourth Industrial Revolution (IR 4.0) for controlling workers' safety at construction site.	

Table 6: Sampling size (Krejcie & Morgan, 1970)

N	*S*	*N*	*S*	*N*	*S*
10	10	220	140	1200	291
15	14	230	144	1300	297
20	19	240	148	1400	302
25	24	250	152	1500	306
30	28	260	155	1600	310
35	32	270	159	1700	313
40	36	280	162	1800	317
45	40	290	165	1900	320
50	44	300	169	2000	322
55	48	320	175	2200	327
60	52	340	181	2400	331
65	56	360	186	2600	335
70	59	380	191	2800	338
75	63	400	196	3000	341
80	66	420	201	3500	346
85	70	440	205	4000	351
90	73	460	210	4500	354
95	76	480	214	5000	357
100	80	500	217	6000	361
110	86	550	226	7000	364
120	92	600	234	8000	367
130	97	650	242	9000	368
140	103	700	248	10000	370
150	108	750	254	15000	375
160	113	800	260	20000	377
170	118	850	265	30000	379
180	123	900	269	40000	380
190	127	950	274	50000	381
200	132	1000	278	75000	382
210	136	1100	285	1000000	384

Note.—*N* is population size. *S* is sample size.

Source: Krejcie & Morgan, 1970

3.3 Data Analysis

Data analysis is a technique for addressing a research topic by using data and statistics. It is vitalto get the answers to related studies (Ashirwadam, 2014). Data analysis is therefore the process of doing certain calculations and analyses to extract relevant information from the data (Ibrahim, 2015).The SPSS software were used to generate the results. The information acquired throughout the questionnaire delivery procedure can be analysed using the SPSS programme. The collected data were analysed before being submitted like an outcome of the study to obtain accurate and genuine replies. The analysis is finished to get the frequency and mean score values that would appear in tables, and diagrams in the future chapter.

4. Results and Discussion

4.1 Response Rate & Reliability Test

There were 341 respondents were chosen as the sample size for this research based on the Krejie and Morgan Sampling Method, 1970, out of 3027 G7 contractors in Selangor who responded to the survey. Survey distribution to respondents began on November 6, 2022. On December 10, 2022, over a month after they were originally distributed, 40.5% of the questionnaires that had been sent had been returned (refer Table 7). Evaluation of the quality of the questionnaire's data is a goal of reliability measurement, which also aims to generate accurate results. According to Taber (2020), asserts that researchers typically utilize the statistic known as Cronbach's Alpha coefficient to show the applicability of tests and scales they had adopted for a particular study topic. Table 8, which summarizes the findings of the reliability test on 138 questionnaires, the dependability is 0.895 which very good. This is because the Cronbach's Alpha coefficient is between 0.8 and 0.9 based on Table Shamsuddin

(2015). The background of the respondents and the main objectives of the study are covered in this summary.

Table 7: Response Rate of Questionnaire

Questionnaire	N	Response Rate (%)
Questionnaire Distributed	341	100%
Questionnaire Received	138	40.5%
Questionnaire Not Received	203	59.5%

Table 8: Reliability Statistics

Cronbach's Alpha	Number of Item (N)
0.895	41

4.2 Respondent's Background

Since most of respondents were mature and easy to work with, Table 9 shows that 52.9% of them were between the ages of 26 and 30. Since the research topic indicated that the bachelor's degree was highly participatory, most respondents which 77.5% had it as their highest academic qualification. Additionally, since site supervisors were most of the target responders, the position with the highest employment rate which 35.5% was those of them. Hence most respondents had more than five years of work experience in the area and spent longer in the construction business, most of respondents, or 50.7%, had work experience between six and ten years. Prefabrication and modular building, including IBS and Precast Building Systems, represented the majority of respondents which 39.1%, indicating that IR 4.0 technology was widely implemented in Selangor's construction industry.

Table 9: Respondent's background

Item		Frequency	Percentage (%)
Age	22-25 years	27	19.6
	26-30 years	73	52.9
	31-40 years	36	26.1
	41 years and above	2	1.4
Highest Academic Qualification	Diploma	36	22.6
	Bachelor Degree	107	77.5
	Master	5	3.6
	PhD	0	0
Working Position	Project Manager	8	5.8
	Site Supervisor	49	35.5
	Site Manager	41	29.7
	Project Engineer	21	15.2

	Engineer	19	13.8
Working Experience	1-5 years	51	37
	6-10 years	70	50.7
	11-15 years	17	12.3
	16 years and above	0	0
Usage of IR 4.0 Technology	Building Information Modelling (etc. Revit, BIM Cloud)	50	36.2
	Internet of Things (etc. RFID, GPS Tracker)	2	1.4
	Prefabrication and Modular Construction (etc. IBS, Precast Building System)	54	39.1
	Autonomous (etc. Robotics)	0	0
	3D Scanning and Photogrammetry (etc. Drone, Laser Scanning)	3	2.2
	3D Printing and Additive Manufacturing (etc. 3D Printing Technology)	0	0
	Big Data and Predictive Analysis (etc. Cloud, Database)	0	0
	Advanced Building Material (etc. Lightweight Concrete)	2	1.4
	Augmented Building Material (etc. Lightweight Concrete)	0	0
	Blockchain (etc. Smart Contract, IoT)	0	0
	Cloud and Realtime Collaboration (etc. Serves, Databases)	0	0
	Artificial Intelligence (etc. Robotics, Smart Devices)	0	0
	None	27	19.6

4.3 Key Problems of IR 4.0 for Controlling Workers' Safety

Table 10 illustrated the key problems implementation of IR 4.0 for controlling workers' safety atconstruction site. There were two highest means of the key problems implementation of IR 4.0 whichwere *"High cost of setting up and post-processing of IR 4.0 technology"* (4.167) and "*High cost of IR 4.0 technology developers' employment* " (4.167) within 138 respondents. These results align with previous study from Rojko (2017) and Lasi *et al.* (2014) state that setting up machines and post- processing equipment, for example, is very expensive in an Additive Manufacturing facility, which would be regarded one of the IR 4.0 enablers for controlling workers' safety. While the developmentof the workplace environment and the requirement of highly qualified developers is initially costly. Following that, the contractors need enough money for implement IR 4.0 technology for controlling workers' safety. The lowest means of the key problems implementation of IR 4.0 was 3.413 in ranking10 which was "*Disturbing workers' work-life balance*" and the standard deviation was 0.550. This result concurrent with previous research such as Rainie & Anderson (2017) state that by implement IR 4.0 technology, it can disturb workers' wok life balance such as work overtime and interfere the workers' quality time. Therefore, the average mean for key problems of IR 4.0 was moderate with 3.783 which can be proven based on Table Freeman (2018).

Table 10: Key problems of IR 4.0

No.	Item	N	Mean	Standard Deviation	Ranking
1	High cost of setting up and post-processing of IR 4.0technology	138	4.167	0.507	1
2	High cost of IR 4.0 technology developers' employment	138	4.167	0.477	1
3	High cost of repairing IR 4.0 technology	138	4.130	0.538	3
4	High risk stress among employees with IR 4.0implementation	138	3.840	0.487	4
5	High level of monitoring for controlling workers' safety	138	3.840	0.472	4
6	Less communication between employees	138	3.783	0.537	5
7	Conflict in the job specification	138	3.732	0.548	6
8	High risk of computer security	138	3.681	0.540	7
9	Unemployment technical workers	138	3.616	0.596	8
10	Increase regulatory capture on workers' safety	138	3.515	0.697	9
11	Limiting platform requirements for controlling workers' safety	138	3.515	0.557	9
12	Disturbing workers' work-life balance	138	3.413	0.550	10
	Total Average Mean		3.783		

4.4 Key Factors of IR 4.0 for Controlling Workers' Safety

Based on Table 11, the highest mean of key factors for IR 4.0 implementation was "*Enhance real-time data capture for workers' safety*" with 3.942 and the standard deviation was 0.464. This result agreeing with the previous research from Oettmeier & Hofmann (2017) state that situational awareness was made available to security executives at a crucial time due to real-time data capture for workers' safety. Top management have integrated their communication protocols as a result of the growth of remote communications technologies, such as the Internet of Things (IoT), which can manage remote workers and use multiple security teams on-site. They have also gained actionable insights and visibility into their daily operations. The lowest mean was "*Avoid repetitive accidents*" which was 3.268 and the standard deviation was 0.574 as shown obviously below Table 11. This result aligns with the previous study such as Li & Lau (2017) state that by implement IR 4.0 technology, it can avoid repetitive accidents for controlling workers' safety at construction site such as safety protocols, provide safety trainings and warning signs. Thus, the total average mean in Table 11 was moderate which 3.739 and this can be proven through Table Freeman (2018).

Table 11: Key factors of IR 4.0

No.	Item	N	Mean	Standard Deviation	Ranking
1	Enhance real-time data capture for workers' safety	138	3.942	0.464	1
2	Enhance self-control among workers for improving safety	138	3.935	0.471	2
3	Enhance quality of controlling workers' safety	138	3.935	0.439	2
4	Improve workers' performance on safety consent	138	3.906	0.434	3
5	Avoid accidents and injuries with IR 4.0 technology	138	3.862	0.515	4
6	Enhance the safety systems for improving workers'	138	3.862	0.456	4

	safety				
7	Efficient workers' safety control with IR 4.0implementation	138	3.819	0.502	5
8	Increase organization innovativeness	138	3.674	0.543	6
9	Reduce late modification of IR 4.0 technology for controlling workers' safety	138	3.630	0.528	7
10	Enhance real-time alerts systems for controlling workers' safety	138	3.565	0.553	8
11	Competitive advantage for the organization	138	3.471	0.556	9
12	Avoid repetitive accidents	138	3.268	0.574	10
	Total Average Mean		3.739		

4.5 Promoting Methods of IR 4.0 for Controlling Workers' Safety

According to the Table 12, the highest mean of promoting methods for IR 4.0 implementation was "*Promote IR 4.0 technology on regular controlling workers' safety*" with 3.862 and the standard deviation was 0.386. By integration of IT resources, top management can promote IR 4.0 technology on regularly controlling workers' safety at construction site (Zhao & Priporas, 2017). The lowest mean was "*Provide sustainable controlling workers' safety system by IR 4.0 technology implementation*" which was 3.725 and the standard deviation was 0.551 as shown obviously below Table 12. It is possible to monitor workers' safety system required for sustainable behaviour by utilising IR 4.0 technologies implementation (Deaconu *et al.,* 2018). Thus, the total average mean in Table 12 was moderate which 3.798 and this can be proven based on Table Freeman (2018).

Table 12: Promoting methods of IR 4.0

No.	Item	N	Mean	Standard Deviation	Ranking
1	Promote IR 4.0 technology on regular controlling workers' safety	138	3.862	0.386	1
2	Increasing data security of controlling workers' data safety	138	3.848	0.434	2
3	Provide quality controlling workers' safety system by IR 4.0 implementation	138	3.841	0.437	3
4	Improvise data protection of controlling workers' data safety	138	3.841	0.437	3
5	Increase security protection in controlling workers' safety by IR 4.0technology implementation	138	3.833	0.477	4
6	Provide advanced digitalization technology by IR 4.0implementationof controlling workers' safety	138	3.819	0.456	5
7	Increase the digitalization system in controlling workers' safety by IR 4.0 technology implementation	138	3.812	0.492	6
8	Improve IR 4.0 technology capabilities for controlling workers' safety	138	3.783	0.464	7
9	Promote sophisticated IR 4.0 technology implementation for controlling workers' safety	138	3.754	0.481	8
10	Reducing the costs of controlling workers' data safety	138	3.732	0.586	9

11	IR 4.0 implementation for improving the system of controlling workers' safety	138	3.732	0.534	9
12	Provide sustainable controlling workers' safety system by IR 4.0 technology implementation	138	3.725	0.551	10
	Total Average Mean		3.798		

5. Conclusion

Overall, the literature review is carried out on specific studies to uncover the problems, factors and promoting methods of implementation Industrial Revolution (IR 4.0) for controlling workers' safety at construction site. According to the data analysis on the research, the key problems of IR 4.0 implementation is recorded as the highest average value in Table 10 were 4.167, which are "high cost of setting up and post-processing of IR 4.0 technology" and "high cost of IR 4.0 technology developers' employment". Therefore, the majority of respondents believe that the main issues with IR

4.0 require high cost of setup, post-processing, and hiring of IR 4.0 technology developers to control workers' safety at construction sites. The key factors of IR 4.0 implementation were recorded as the highest average value in Table 11 was 3.942, which are "enhance real-time data capture for workers' safety". Most of the respondents agreed that IR 4.0 implementation requires more real-time data capture for their workers' safety at construction site. The promoting methods of IR 4.0 implementation was recorded as the highest average value in Table 12 was 3.862, which are "promote IR 4.0 technology on regular controlling workers' safety". Most of the respondents agreed that IR 4.0 implementation requires to promote more IR 4.0 technology on regular controlling for their workers' safety at construction site.

While conducting this study, the researchers faced several problems and limitations which the first limitation is the difficulty of contacting the respondent. Since some respondents were ignored and some questionnaire questions were unanswered, getting data was tough. This is because the respondent, who was unable to take part in the survey, was backed up in rush hour and had no time to finish the questionnaire. The next limitation was over an extended period of time for getting data from respondents. This is since some respondents are unmotivated to complete the questionnaire because they will need some time to respond to the question. Therefore, only 138 out of 341 respondents' cumulative data were gathered by the researchers.

The Fourth Industrial Revolution (IR 4.0), which requires expensive setup and post-processing of the technologies, can be better comprehended, and implemented by contractors as a result of this research study's contribution to the construction industry. With enough funding, the contractor can deploy IR 4.0 technology to monitor worker safety on the job site. Construction site accidents and worker injuries can be prevented with the use of IR 4.0 technology. The primary issues of the construction industry's lack of awareness of IR 4.0 technology can be resolved by the contractor's senior management promoting IR 4.0 technology. Moreover, this research also contributed knowledge input to the academic reference of the key problems, key factors and promoting methods of IR 4.0 implementation for controlling workers' safety.

The combination of "internet of things" (IoT) and RFID-based labor tracking systems as a real-time safety early detection system to avoid accidents and control employees' safety at construction sites is advised for the construction industry. BIM, IoT, and IBS technology together can better direct worker activities on the construction site. This safety barrier alert system assists workers in altering their dangerous behaviours and preventing accidents on construction sites that are continually changing. Future researchers will be able to mix the two research methods that are quantitative and capable of offering a qualitative approach to conduct research in this field of study. In doing so, the substance of the results report would be clearer.

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