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Conference Paper in AIP Conference Proceedings · November 2022

DOI: 10.1063/5.0111461

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Cite as: AIP Conference Proceedings **2644**, 030002 (2022); https://doi.org/10.1063/5.0111461
Published Online: 07 November 2022

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Barriers in Implementing Artificial Intelligence (AI) and Internet of Things (IoTs) among Malaysian Construction Industry

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Abstract. Artificial Intelligent (AI) and Internet of Thing (IoT) becoming more broadly discussed by the researcher as well as their construction players includes Malaysians' construction players too. By having this implementation, the transmission of the data relating to the construction project can be successfully transfer and all the relevant parties who involves in the project can access it together at one time. However, there are a few barriers faces by the Malaysian construction players to adopt, practices and implementing these two concepts. The objective of this study is to investigate the barriers in implementing AI and IoT among Malaysian construction players. There are 384 numbers of questionnaires has been sent out and 167 respondents responded. The methodology use for this study is quantitative method where the questionnaire drives from systematic review of literature review. The data further analysed by using PLS-SEM. The findings show from 39 constructs, 31 constructs are fall under very true statement. The findings discuss may further overcoming the barriers faced by Malaysian construction industry turn to fully understanding on how this implementation should drives to.

INTRODUCTION

Artificial intelligence is becoming more and more common in our daily, social and professional lives. The construction industry also welcomes new technologies in artificial intelligence. In the construction industry, artificial intelligence plays a greater role in improving worker efficiency, sustainability, and safety [1]. As the years go by, more and more advanced technologies are entering our workplace, thus providing a lot of efficiency and information immediately. Artificial Intelligence (AI) is characterised as a division of computer science dealing with smart behaviour simulation based on computers [2]. It may also be defined as an area of science and engineering dealing with the machine comprehension of what is generally referred to as intelligent behaviour and the creation of objects that reflect such behaviour [2]. It is a robot that imitates the processes of cognition that humans apply to other human minds, such as reasoning and solving problems.

In order to ensure the efficient transmitting of information, the rapid growth of the construction industry has allowed the construction industry to create a full network communication infrastructure. One of today's most common representations of virtual networking is the Internet platform. Other businesses are rising quickly using these advanced technologies. The use of this IoTs technology should be emphasized by the construction industry, as the building industry in the future will become more and more complicated. The building industry would be left behind by the

10th International Conference on Applied Science and Technology
AIP Conf. Proc. 2644, 030002-1–030002-13; https://doi.org/10.1063/5.0111461
Published by AIP Publishing. 978-0-7354-4241-2/$30.00

growth of other sectors if there is no application that will encourage related work [1]. The construction industry is one of the major contributors to the national economy as the building sector is rising in Malaysia every year. Malaysia's Construction Industry Development Board (CIDB) expects the construction sector to develop by eight percent in 2018 and further developed by 10 percent in year 2019. Under the 11th Malaysia Plan (RMK-11), which promises an optimistic and rapid economic growth in the construction industry, this is expected to lead the growth of other sectors by 11% [1].

During the forecast period, things are expected to become more advanced with more focus on telematics and operating parameters for construction vehicles, including fluid temperature and pressure gages in construction machinery. In terms of tracking performance level and increased connectivity, IoTs with wearables smart is expected to change the construction industry. Wearable devices in the construction industry could provide seamless communication in emergency situations and could improve end-user safety. It is expected that the construction industry will witness more developments with building equipment receiving sensors that could monitor issues such as temperature fluctuations remotely. Workers are alerted when any problem is detected, and it is fixed as soon as possible avoiding any vital equipment failure. This could be considered as one of the predictive maintenance instances used in construction projects to prevent unnecessary delays.

AI in construction refers to the integration of technologies focused on Artificial Intelligence in the construction industry. In different organizations, production time, working environments and labor-intensive operations, the building industry is one of the determining sectors with its distinctive characteristics [19]. The strong artificial intelligence technology can automate building work and can boost performance, protection and other aspects of business success. Building information modelling (BIM) and 3D printing are two of the technologies contributing to dramatic improvements in the construction industry in Malaysia at the moment.

According to [25], the barriers to implementing it’s on inability to connect, gather and understand the data. The programme of IoT adaptation are still immatures and the root problem remains though, the industry to date has not embraced digital transformation with the same enthusiasm as other industries as according to [23]. This may further lead to highlight the objective of this paper to identify the barriers in implementing artificial intelligence (AI) and internet of things (IoTs) among Malaysian construction industry, which the finding may further been used to benchmark and minimize the barriers to make fully implementation of AI and IoT.

BACKGROUND OF STUDY

The use of Internet of Things and Artificial Intelligence in building technologies in Malaysia is still relatively recent compared to countries such as Japan and America [14]. Implementing AI is a fairly unexplored topic, in particular within the construction industry. AI can automate several operations and make building processes more efficient [28]. The Malaysian government implemented implementation on BIM and 3D printing to ensure that construction players such as designers, engineers and contractors were aware of and concerned with the implementation of BIM and 3D printing in construction projects, due to the problems in construction works that have slowed down the efficiency and quality of the construction industry. Artificial intelligence plays a larger role in improving productivity, quality and safety at the job site in the construction industries.

IoT is a vast concept encompassing too many sensors, actuators, data storage and data processing capabilities interconnected by the Internet. Thus, any IoT enabled device can sense its surroundings, transmit, store and process the data gathered and act accordingly. The last step of acting accordingly is entirely dependent on the processing step. The true smartness of an IoT service is determined by the level of processing or acting that it can perform. A non-smart IoT system will have limited capability and will be unable to evolve with the data. However, a smarter IoT system will have artificial intelligence and may serve the actual goal of automation and adaptation [14].

The value of construction or infrastructural production for economic growth and the infamous inefficiency of the transition of capital to goods in the industries include the need to increase building productivity [16]. Using cutting-edge innovative design, new developments in the building industry are aimed at minimizing the inefficiencies of construction operations. Innovative technology such as the Internet of Things (IoT), big data, and cyber-physical networks are changing traditional way of planning and executing construction projects [35]. The concepts of Architecture for Production and Assembly and Industry 4.0 have transformed building to be seen as a manufacturing process with immense potential to use Big Data to optimize processes and make better choices at different levels in an attempt to improve overall efficiency and market value in the construction industry [16]. The IoTs ecosystem is able to produce and convert data across its interconnected layer of hardware, software and internet networking with the growing market of low-cost sensors and developments in artificial intelligence to improve different stages of building [35].

In addition, CIDB and PWD formed a group of committees to improve the construction project process by drawing up the BIM roadmap and guidelines as a structure for BIM to be applied to their construction projects safety [1]. The committee developed the BIM standard manual checklist as a guide for team building. The introduction of BIM and 3D Printing, however, remains slow and less interested by building participants, while the Malaysian government has made efforts to enhance the use of these two artificial intelligence technologies in the construction industry [5].

Work on the application of artificial intelligence to managing construction industry projects started in the 1980s [16]. In certain cases, these methods were compared to conventional simulation and predictive regression approaches to test changes in the areas of labour efficiency, litigation, demand forecasting, cost estimates, optimization of construction site layout, estimation of cash flow and bidding in construction projects [5]. The advantages of artificial intelligence techniques over mathematical and statistical models in situations where the mechanism to be modelled is complex and where conventional models lack the capacity to learn on their own, produce solutions and react appropriately to highly correlated, incomplete or previously unknown data. The complexity and applicability of smart device solutions clearly shows that this field can and has solved a multitude of organizational problems with the help of a wide range of techniques and methods.

Application of Artificial Intelligence and Internet of Things (IoTs) in Construction Industry

AI can provide extra insights into data that a construction team cannot or will take longer to process due to human errors and could be processed with less accuracy. Construction robots may perform repetitive tasks performed by construction workers, such as the bricklaying job for a masonry project [21]. The use of robotics in the construction industry can be useful if the job is to be done more efficiently without the need for a break during the work or going on holidays that greatly improve productivity and efficiency. These robots improve quality, accuracy and safety whilst also reducing waste. Construction projects are special in nature, and complicated. Meanwhile, the construction industry is struggling with shortages of skilled workers, and the emergence of new technologies provides tremendous benefits for enhancing construction productivity and bridging gaps and helps the construction team with their tasks. AI functions well with automation and, unlike workers, does not get tired or make mistakes [3].

Most importantly, AI helps to record projects progress from initial stage to the completion. In the past, all the construction team used paper records to save project data or used a blackboard to record information, keep notes, or create to-do lists during a meeting. With all of this existing information, keeping track of information properly and staying on the same page with other collaborators was still difficult. Using the data collected in combination with AI via mobile devices makes the information available, reliable, accessible and consistent [41]. It helps the project team to access the information and see trends that are not otherwise apparent in the data. The following examples explore different ways in which AI can help develop with automation by accessing resources such as data [20].

As the years go by, more and more advanced types of technology are joining the construction industry, offering at a blink of an eye a wealth of productivity and information. Machines can now show their own intelligence by storing, analyzing and determining information on the basis of that data [21]. Such a process is invaluable for construction, as it allows for a degree of prediction based on the information the artificial intelligence provides. The major applications for AI in construction and building can be classify into categories of planning and design, monitoring and maintenance, and safety.

In advanced technology countries such as America and Japan, autonomous vehicles and AI robotics are already being used to boost the conditions of the works at construction site [26]. Automated bulldozers, cranes and other equipment are used to facilitate consistent and consistently efficient work. In addition, autonomous site machinery also enables the driver to stay outside the vehicle as it works at dangerous heights. Using sensors and GPS, the vehicle can calculate the safest route [20]. Moreover, AI is revolutionizing a number of conventional construction methods. For example, there are already many companies producing robotic bricklayers [26]. In the future, these robots may build structures in extreme or inhospitable environments and reduce human participation in hazardous tasks on site.

Currently, the Malaysian government introduced the implementation of artificial intelligence technologies in construction industry is only focused on the software technologies like BIM and 3D Printing [19]. In fact, there are lots of artificial intelligence technologies, ranging from software to autonomous and robotics, are available in the construction market which are yet to be introduce to the construction industry in Malaysia. As for this research, the literature review will only cover on RFID, 3D Printing, BIM and drone.

Barriers in Implementing Artificial Intelligence (AI) and Internet of Things (IoTs)

Artificial intelligence (AI) and Internet of Things technology is changing the way companies operate in the construction industry. Several studies have shown that innovations can improve efficiency, safety and other key elements of business success [34]. However, there are a range of obstacles that hold back the widespread acceptance that must first be resolved before progress with artificial intelligence technologies is found.

Prejudice against the Adoption of AI Technologies

At the top of the issue lies that all the time, people are scared of a new thing. Many people are dissatisfied with certain modern technical developments that are unknown [29]. Looking back to history, during the Industrial Revolution, this was also the case. Before trying out new technologies, many individuals tend to have unfavorable opinions or feelings [13]. In accordance with [26], one of the key barriers to the implementation of emerging technology is human reluctance. Initially, modern tools are seen as inadequate because they cause problems and difficulties for new users, such as application errors and inconsistent access. New users do not know how to use them and complain about how poor the new tools are, in comparison to the older ones, at the first issue or event. Zero breakdowns are unrealistic, however, even with the most current tool or programmer. Typical examples of resistance to change and reluctance towards new tools are that users appear to have reservations about the need to switch to a new system, users are uncertain about the advantages of new technology towards work, users are confident using current tools or technology to hesitate to switch a new one [6]. Besides that, the busy work schedule is another common reason for people to fail to learn about the use of new technology. People would be less interested in allocating time to learn how to use new stuff because of heavy workload or task time pressure, because they put job achievement in the first place. There is a systemic resistance in the construction industry to new technical developments which need to be solved, building on the principle of fear. The culture of the construction industry is not known for swift change [30]. The construction industry is much less active than many other major industries in creating and implementing emerging technologies. The construction industry is more conservative in contrast to industries such as high tech and telecommunications, the automobile industry and the financial services industry [15]. In the construction industry, people are particularly cautious about disruptive large-scale changes that clash with conventional approaches, since technologies are often applied in key market environments and vital infrastructures [30].

Furthermore, in his study [16] found that many individuals were still concerned about the possible implications of technology. Employees were afraid that technology would take away their employment because cautioned that AI might pose an existential threat to humanity [22]. Fear has also led to strong negative employee reactions to the possibility of applying AI technology to the company.

Lack of Executive and Government Support

It is very costly to introduce a technological transition in an organization in terms of the high cost of the technology itself and the time taken to get used to the new ways of working. Therefore, there is no question that employers or governments, as paymasters and initiators, play the most important role in the adoption of emerging technologies. [17].

Insufficient management support is an obstacle to adopting AI, according to [11], and if there is a lack of support from the top management team, it is difficult for a company to resolve improvements and holistically accept AI technology. The literature describes the top management team as the group of the most significant managers, such as the Chief Executive Officer (CEO), the Chief Operating Officer (COO) and the Chief Financial Officer (CFO), who have overall responsibility for the company [11]. There is clear evidence, according to [11] and [5], top management support contributes to successful product innovation, as well as successful implementation and assimilation of information systems.

The lack of understanding of these emerging technologies was one of the reasons why organizational leaders declined to accept the implementation of AI technologies. Research has shown that many construction players refuse the use of modern technology because they do not discover its advantages for construction works [5]. This happened often when the company had more seniors at the management level. As compared to young managers, senior managers have fewer exposure to emerging technology due to the distinct era of birth and the distinct education earned. It is also more difficult to persuade them to switch from conventional construction methods to AI technologies.

In addition, data also shown that enterprises deploying AI technology experienced challenges with stakeholder buy-in and supporting by [37]. The promise of emerging technologies is understood by many stakeholders, but they also refuse to gamble multi-billion- dollar ventures on apps they deem to be unproven. For large-scale consumer penetration of AI technology, resource limitations may be a significant issue. Efforts to incorporate AI solutions that require a range of expenditures, such as legacy systems or technology overhaul, cost of deployment and administration, recruitment, re-skilling, and upskilling of workers. In the lack of financial or infrastructure funding from partners, it is often difficult to practise the implementation of emerging innovations in the enterprise.

Another important challenge is the lack of government funding that slows the widespread introduction of AI in the construction industry. A lack of AI system funding is an obstacle for the industry to promote the implementation of AI. The Government of Malaysia has not granted subsidies to architecture, engineering and construction (AEC) firms to use the AI system or to provide investment in research and development (R&D) in construction. This is why most local construction firms, especially medium-sized and small-sized construction firms, prefer to adopt the conventional method to manage construction projects [4][27].

Government also did not give the building organisation operational pressure to practise the use of AI technologies for construction projects [18]. The use of Building Information Modelling (BIM) in the construction industry for example, is currently not common and no government mandates have been given to use BIM in projects of any note [32]. The role of governments in driving the adoption of BIM is not yet as critical as in other countries such as the USA and the UK, government have not made effective use of their ability to facilitate BIM adoption in the areas of economy, finance, education and training [36].

Lack of Security

Another major concern about the implementation of AI from an IT perspective is security. People are concerned about issues of ownership and risk management with regard to the use of the AI system [18]. The primary challenges facing big data are data security and privacy problems. At present research and implementations are not especially advanced in the field of industrial big data, and all sectors need to be further improved, from hardware to software [38]. There are many problems to be solved in terms of 'how to maintain network security' and 'how to deal with cyber espionage to prevent hackers and other cybercrimes' caused by the infringement [37].

In addition, the government is not actually adopting appropriate protocols and legislative policies to resolve security concerns [27]. For this case a good example is the legal risk involved with possession of BIM details. If owners pay for the architectural design of building projects, they may claim possession of the design papers. Licensing concerns that occur when BIM-integrated knowledge is given by stakeholders other than owners and architects [31]. Another concern is how to decide who can control access to information and be liable for inaccuracies, and this factor may pose a major danger [24]. In the BIM model, stakeholders expect sensitive data privacy, but a variety of legal and security concerns have been reported in relation to the management of development projects in the technological environment [31].

High Implementation Cost

Supported by studies on the complexities of the deployment of construction robotics technology in Malaysia, the high cost of implementation of AI technology adoption in construction works has been one of the challenges to widespread adoption in the construction industry [23]. Based on the research results, deployment costs are higher than other barriers for the implementation of new technology in Malaysia's construction industry.

Firstly, it can be very difficult for a construction industry to own a new invention or equipment [6]. Compared to other industries, there is a poor availability of new technology in the building sector due to a lack of innovation. Research and Development (R&D) is the lifeblood of any company. Nevertheless, the advantages of R&D are long-term, whereas in the present the costs occur. This disparity is inappropriate for the project-driven business in which the construction industry operates, so less attention was given to R&D here than to other industries.

Secondly, it is expensive for AI technology to upgrade and sustain. The cost of software or system control or repair is expensive since it needs special technicians to perform maintenance or update work [23]. AI technologies also need to be operated with certain level of skills. Therefore, organization will need to allocate certain budget in providing employees training courses since most of the construction workers at site are low skilled labors. Sometimes company will also need to employ specialist such as technical consultant to aid the use of AI technology during construction project period.

In conclusion, both of these add-up costs for new technology are an obstacle to the widespread acceptance of AI technologies in the building industry. Only major building companies with good financial support can make these investments because of the high cost of adopting the implementation of emerging technology. Though small building businesses are often reluctant to take a high gamble on risky developments in new technologies.

Lack of Specialists' IT Infrastructure

Implementing AI technology in a large company and industry would entail a considerable build-up of skills, in particular adequate training for staff and substantial updating of information technology (IT). For architectural, engineering and construction (AEC) firms, the lack of skills or qualified staff is a big obstacle in expanding their use of AI [6]. Many AI experts are required to move AI programmes from development to implementation as AI becomes a general-purpose technology, and many qualified employees are required to run AI-based machinery or computer programming [33].

The lack of availability for AI experts is attributed to the fact that academic and educational programmes are unable to keep up with the speed of innovation and new AI discoveries. Other than official preparation, AI practitioners will require on-the-job experience. Therefore, there are not sufficiently seasoned AI practitioners who are just beginning to implement AI techniques in their operations to move into the leadership positions expected by the industry.

Moreover, many IT leaders are still worried about the lack of IT infrastructure as an obstacle to AI in the construction industry [22]. Models of design and training require enormous amounts of data and very fast devices. Since high-performance computing systems are very costly, the costs of implementing AI are increased. Most managers are not willing to invest in technology because of the expensive cost (Izabela Hager, 2016). The reasoning for this unwillingness to invest in IT may derive from a lack of perceived return on investment in IT spending and a project emphasis aimed at gaining maximum return on process investment from single projects [1].

METHODOLOGY

Quantitative research is defined as the systematic study of phenomena by gathering quantifiable data and performing empirical, mathematical or computational techniques [10]. Sampling methods are used for quantitative research to gather data from participants and submit online surveys, online polling, questionnaires, etc. whose results can be presented in numerical form. These quantitative data are used to identify large-scale patterns and to use statistical operations to define casual and correlative relationships between variables [12]. This study is fully used quantitative method where the questionnaire is derived from systematic review of literature review. A structured questionnaire has been sent out to 384 numbers of respondents in construction industry which consists of Quantity Surveyor, Construction Director, Project Manager, Site Supervisor, Site Coordinator, Assistant Supervisor, Project Executive and Clerk of Work across Malaysia. There are only 167 responded received which according to [40], the 50% respond received just appropriate to make this study undergo to the next process. Items in the questionnaire have been developed based on the input gathered through rigorous literature review, thus they are in-line with the listed objectives of this study.

Likert scale is a psychometric scale commonly used in research that adopts questionnaires survey. The psychometric scale means that the respondents specify their level of agreement on a symmetric agree-disagree scale for a series of statements while responding to a particular Likert questionnaire item. The range of Likert scale captures the concentration of their approaches for a given item [7]. This study uses five-point Likert scales of agreement and importance, which are commonly used for scales (Likert, 1932). For this questionnaire survey sampling design used a purposive sample, where non-probability sample is selected based on characteristics of a population and the research objectives of this study.

The method analysis to be use are factors analysis for categorising the barriers in implementing Artificial Intelligence (AI) and Internet of Things (IoTs). All the data gathered from the questionnaire survey is analysed via the Rasch model using WINSTEPS version 3.69.1.16 software. There are five analysis in the Rasch model, which are reliability and validity analysis, organisation misfit analysis, unidimensionality analysis, item misfit analysis and Person-Item distribution map analysis. Rasch model analysis is used because it changes the concept of reliability from creating a fit of the data into constructing a reliable measurement instrument [39]. [8] states one of the advantages of the Rasch model is that it builds a hypothetical unidimensional line along which items and persons identified according to their difficulty and ability measures are shown in the Person Item Distribution Map (PIDM). As [9] mentioned, the Rasch model is a prescriptive model in which how the data fit the model is investigated instead of the more classical statistical problem of how the model fits the data. [42] further explained that the data are required to fit the model, and when they do not, items that show misfits discarded until a satisfactory fit obtained.

Thus, the Rasch model analysis is done in this study following [9], who explain that the Rasch model's logit value is the unit of measurement at an interval level instead of the ordinary number. In the Rasch model analysis, this study adopts summary statistics, item characteristic curve scalogram, PIDM, and person and item measure order used. The analysis shows both person and item measures to indicate that the respondent is completing the survey. At the same time, the respondent understands the questions given, while the item in the survey is understood and answered.

DATA ANALYSIS AND FINDING

There are 384 questionnaires has been sent out to the respondents and 167 respondents responded back to the questionnaire. Figure 1 shows the output of the respondents' demographic details. From Figure 1 shows that most of the respondents are having between 6 years experienced to 15 years of experienced. Which this makes this research output unbiases in communicating the findings. There are 67 and 65 respondents are having experienced in handling residential and commercial types of projects. There are 8 work position captured: clerk of work, assistant supervisor, project executive, site coordinator, site supervisor, project manager, construction director and quantity surveyor. From Figure 1 shows that quantity surveyor are 45 respondents follow by clerk of work, project executive and site supervisor are 23 each of respondents contributing to the findings.

The input for research objective is with 39 constructs measured. Table 2 shows 39 constructs (non-extreme) are reporting the value of person reliability β = .99 with 0.20 Standard Error (SE), suggesting that the respondents were competent to answer the questionnaire survey [8]. This indicates that the 39 constructs in investigating the barriers in implementing Artificial Intelligence (AI) and Internet of Things (IoTs) in Malaysia have an excellent range of difficulties in measuring the organisation ability. Organisation fit statistics investigation on outfit on Mean Square (OMNSQ) and z-score (OZSTD) show that the OMNSQ is 0.00 and OZSTD is -5.71, which is near to expectation 1 and 0. This reveals that 25 constructs are targeting the right type of respondents in measuring the latent traits and produced data is at a reasonable prediction level of the responses to the constructs. The maximum organisation ability is βmax = +97.60 logit, and the minimum measure is βmin = -27.47 logit. The organisation mean βmean = 0.00 logit reveals that the majority of the respondents find the important to understand barriers in implementing Artificial Intelligence (AI) and Internet of Things (IoTs) in Malaysia.

The principal component analysis (PCA) shows that the raw variance explained by measures was approximately 99.0 percent lower compared to the expected target of 99.3 percent as shown in Table 2, which shows good quality criteria of variance in data explained by measures as stated by Fisher (2007). In addition, the unexplained variance in the 1 contrast is also in good quality criteria [8] which is 0.0 percent. This can be concluded that the 39 constructs in investigating the barriers in implementing Artificial Intelligence (AI) and Internet of Things (IoTs) in Malaysia have one single overarching dimension.

TABLE 1. Summary of 39 constructs (non-extreme) to investigate the Barriers in Implementing Artificial Intelligence (AI) and Internet of Things (IoTs)

	Total Score	Count	Measure	Model Error	Infit			Outfit
					MNSQ	ZSTD	MNSQ	ZSTD
Mean	349.9	75.0	.00	2.66	.03	-1.08	.00	-5.71
S.D	32.6	.0	29.39	.77	.04	.17	.00	2.74
Max.	370.0	75.0	97.60	3.35	.14	-.73	.01	-2.86
Min.	227.0	75.0	-27.47	1.39	.01	-1.23	.00	-9.90
Real SMSE 2.76		True S.D 28.43		Separation 10.30		Construct Reliability .99		
Model S.E. 2.76		True S.D 28.43		Separation 10.30		Construct Reliability .99		
S. E. of constructs MEAN = 6.93								

TABLE 2. Standardised residual variance (in Eigenvalue units)

		Empirical		Modelled
Total raw variance in observation	459.5	100.0%		100.0%
Raw variance explained by measurer	459.3	99.0%		99.3%
Raw variance explained by persons	132.1	28.8%		28.6%
Raw variance explained by item	327.2	71.2%		70.7%
Raw unexplained variance (total)	1.80	0.0%	100.%	0.7%
Unexplained variance in 1st contrast	0.95	0.0%	53.2%	

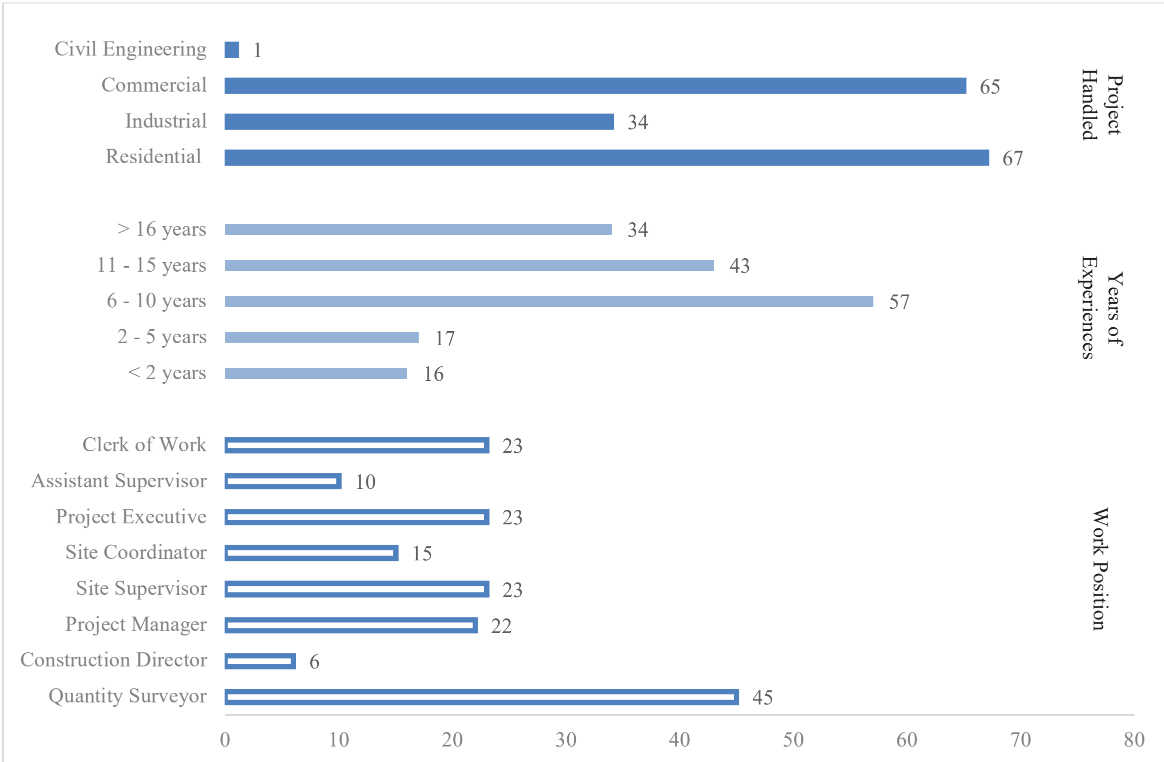

FIGURE 1. Respondents' demographic details

Table 3 shows the standardised residual loadings for construct (sorted by loading) to investigate the barriers in implementing Artificial Intelligence (AI) and Internet of Things (IoTs) in Malaysia. There are nine constructs, which range of measure is from 0.86 *logit* to 0.93 *logit* and eight constructs, which range of measure is from -8.19 *logit* to 0.43 *logit*. The range of Infit MNSQ is within 0.01 *logit* to 0.02 *logit,* while for the Outfit MNSQ is within 0.00 *logit* to 0.01 *logit*, which show that there are no misfit constructs among the 31 constructs. In overall, all 31 constructs are unidimensional with good internal consistency and measure what it should be measured.

TABLE 3. Standardised residual loadings for construct (sorted by loading) to investigate the Barriers in Implementing Artificial Intelligence (AI) and Internet of Things (IoTs)

Contrast		Loading	Measure	MNSQ		Construct
				Infit	Outfit	
1	1	0.93	-8.19	0.02	0.00	A_Prej_01
1	1	0.93	-8.19	0.02	0.00	A_Prej_02
1	1	0.93	-8.19	0.02	0.00	A_Prej_03
1	1	0.93	-8.19	0.02	0.00	A_Prej_04
1	1	0.93	-8.19	0.02	0.00	A_Prej_05
1	1	0.93	-8.19	0.02	0.00	A_Prej_06
1	1	0.93	-8.19	0.02	0.00	A_Prej_07
1	1	0.93	-8.19	0.02	0.00	D_HiCost_02
1	1	0.86	0.43	0.01	0.00	D_HiCost_03
1	1	0.86	0.43	0.01	0.00	D_HiCost_04
1	1	0.86	0.43	0.01	0.00	D_HiCost_05
1	1	0.86	0.43	0.01	0.00	E_SpecIT_04
1	1	0.86	0.43	0.01	0.00	A_Prej_08
1	1	0.86	0.43	0.01	0.00	A_Prej_09
1	1	0.86	0.43	0.01	0.00	B_GovSup_01
1	1	0.86	0.43	0.01	0.00	B_GovSup_02

TABLE 3. Standardised residual loadings for construct (sorted by loading) to investigate the Barriers in Implementing Artificial Intelligence (AI) and Internet of Things (IoTs) (Cont'd)

Contrast		Loading	Measure	MNSQ		Construct
				Infit	Outfit	
1	1	0.86	0.43	0.01	0.00	B_GovSup_03
1	1	0.86	0.43	0.01	0.00	B_GovSup_04
1	1	0.86	0.43	0.01	0.00	B_GovSup_05
1	1	0.86	0.43	0.01	0.00	B_GovSup_06
1	1	0.86	0.43	0.01	0.00	B_GovSup_07
1	1	0.86	0.43	0.01	0.00	B_GovSup_08
1	1	0.86	0.43	0.01	0.00	B_GovSup_09
1	1	0.86	0.43	0.01	0.00	C_Sec_01
1	1	0.86	0.43	0.01	0.00	C_Sec_02
1	1	0.86	0.43	0.01	0.00	C_Sec_03
1	1	0.86	0.43	0.01	0.00	C_Sec_04
1	1	0.86	0.43	0.01	0.00	C_Sec_05
1	1	0.86	0.43	0.01	0.00	C_Sec_06
1	1	0.86	0.43	0.01	0.00	D_HiCost_01
1	1	0.86	0.43	0.01	0.00	D_HiCost_06
1	1	0.86	0.43	0.01	0.00	D_HiCost_07
1	1	0.86	0.43	0.01	0.00	E_SpecIT_01
1	1	0.86	0.43	0.01	0.00	E_SpecIT_02
1	1	0.86	0.43	0.01	0.00	E_SpecIT_03

Indicator:

Code	Construct
Prejudice against the adoption of AI technologies	
A_Prej_01	Satisfaction with modern technical developments
A_Prej_02	Having unfavorable opinions or feelings
A_Prej_03	Resistance to change and reluctance towards new tools
A_Prej_04	Confident using current tools or technology to hesitate to switch a new one
A_Prej_05	The construction industry is much less active than many other major industries in creating and implementing emerging technologies
A_Prej_06	The construction industry is more conservative in contrast to industries such as high tech and telecommunications, the automobile industry and the financial services industry
A_Prej_07	Concern on possible implications of technology
A_Prej_08	AI technologies might pose an existential threat to humanity
A_Prej_09	Unwillingness to invest in IT may derive from a lack of perceived return on investment in IT spending
Lack of executive and government support	
B_GovSup_01	Costly to introduce a technological transition
B_GovSup_02	Insufficient management support
B_GovSup_03	Lack of support from the top management team
B_GovSup_04	Refusal from organisation
B_GovSup_05	Lack of government funding
B_GovSup_06	Lack of subsidies to architecture, engineering and construction (AEC) firms to use the AI system
B_GovSup_07	Lack of investment in research and development (R&D)
B_GovSup_08	No government mandates have been given
B_GovSup_09	Government not critically drive the technologies adoption

Code	Construct
Lack of security	
C_Sec_01	People are concerned about issues of ownership and risk management with regard to the use of the AI system
C_Sec_02	The primary challenges facing big data are data security and privacy problems.
C_Sec_03	Maintaining the network security
C_Sec_04	To deal with cyber espionage/ hackers
C_Sec_05	Lack of appropriate protocol
C_Sec_06	Lack of legal policies
High implementation cost	
D_HiCost_01	High cost of implementation of AI technology adoption
D_HiCost_02	Disparity is inappropriate for the project-driven business
D_HiCost_03	Expensive for AI technology to upgrade and sustain
D_HiCost_04	Cost of software or system control or repair is expensive since it needs special technicians to perform maintenance or update work.
D_HiCost_05	Budget in providing employees training courses
D_HiCost_06	To employ specialist such as technical consultant to aid the use of AI technology
D_HiCost_07	High-performance computing systems are very costly, the costs of implementing AI are increased
Lack of specialists' IT Infrastructure	
E_SpecIT_01	Implementing AI technology in a large company and industry would entail a considerable build-up of skills, in particular adequate training for staff and substantial updating of information technology (IT)
E_SpecIT_02	Lack of skills or qualified staff
E_SpecIT_03	Lack of availability for AI experts is attributed to the fact that academic and educational programmes are unable to keep up with the speed of innovation and new AI discoveries
E_SpecIT_04	Not sufficiently seasoned AI practitioners

Table 4 shows the measure order of 39 constructs in investigating the barriers in implementing Artificial Intelligence (AI) and Internet of Things (IoTs) in Malaysia. The constructs are sorted based on their measured value, which the positive value is less aware constructs while negative value is the aware constructs, based on Construct mean µmean = 0.00 *logit* as the cut-off point.

Table 5 shows the matrix categorisation based on respondents responded to the rating. There are 41.92% score on very true scale follow by 26.95% somewhat true and 25% neither true. The output shows that the respondents responded the most on the construct on the very true scale and its shows that the construct are reliable to relates with the barriers in implementing AI and IoT.

TABLE 4. Measure order of the constructs in investigate the Barriers in Implementing Artificial Intelligence (AI) and Internet of Things (IoTs)

Construct	Measure	Model SE	Remarks
A_Prej_01	10.67	2.35	Somewhat true
A_Prej_02	10.67	2.35	Somewhat true
A_Prej_03	10.67	2.35	Somewhat true
A_Prej_04	10.67	2.35	Somewhat true
A_Prej_05	10.67	2.35	Somewhat true
A_Prej_06	0.43	3.31	Somewhat true
A_Prej_07	0.43	3.31	Somewhat true
D_HiCost_02	0.43	3.31	Somewhat true
D_HiCost_03	0.43	3.31	Somewhat true

TABLE 4. Measure order of the constructs in investigate the Barriers in Implementing Artificial Intelligence (AI) and Internet of Things (IoTs) (Cont'd)

Construct	Measure	Model SE	Remarks
D_HiCost_04	0.43	3.31	Somewhat true
D_HiCost_05	0.43	3.31	Somewhat true
E_SpecIT_04	0.43	3.31	Somewhat true
A_Prej_08	-8.19	2.89	Very true
A_Prej_09	-8.19	2.89	Very true
B_GovSup_01	-8.19	2.89	Very true
B_GovSup_02	-8.19	2.89	Very true
B_GovSup_03	-8.19	2.89	Very true
B_GovSup_04	-8.19	2.89	Very true
B_GovSup_05	-8.19	2.89	Very true
B_GovSup_06	-8.19	2.89	Very true
B_GovSup_07	-8.19	2.89	Very true
B_GovSup_08	-19.48	1.71	Very true
B_GovSup_09	-19.48	1.71	Very true
C_Sec_01	-19.48	1.71	Very true
C_Sec_02	-19.48	1.71	Very true
C_Sec_03	-19.48	1.71	Very true
C_Sec_04	-19.48	1.71	Very true
C_Sec_05	-19.48	1.71	Very true
C_Sec_06	-19.48	1.71	Very true
D_HiCost_01	-19.48	1.71	Very true
D_HiCost_06	-27.47	3.35	Very true
D_HiCost_07	-27.47	3.35	Very true
E_SpecIT_01	-27.47	3.35	Very true
E_SpecIT_02	-27.47	3.35	Very true
E_SpecIT_03	-27.47	3.35	Very true

TABLE 5. Matrix of categorisation to investigate the Barriers in Implementing Artificial Intelligence (AI) and Internet of Things (IoTs)

Categories	Logit	n	%
Very true	0.00 logit to ∞	70	41.92
Somewhat true	-8.19 logit to 0.00 logit	45	26.95
Neither true	∞ to -8.19 logit	25	14.97

CONCLUSION

From the research outputs, there are 31 constructs who contributing to the highest rating which can be categories as very true statements. There are: AI technologies might pose an existential threat to humanity, unwillingness to invest in IT may derive from a lack of perceived return on investment in IT spending, costly to introduce a technological transition, Insufficient management support, lack of support from the top management team, Refusal from organization, Lack of government funding, lack of subsidies to architecture, engineering and construction (AEC) firms to use the AI system, lack of investment in research and development (R&D), no government mandates have been given, government not critically drive the technologies adoption, people are concerned about issues of ownership and risk management with regard to the use of the AI system , the primary challenges facing big data are data security and privacy problems, maintaining the network security, to deal with cyber espionage/ hackers, lack of appropriate protocol, Lack of legal policies, High cost of implementation of AI technology adoption, to employ specialist such as technical consultant to aid the use of AI technology, high-performance computing systems are very costly, the costs of implementing AI are increased, implementing AI technology in a large company and industry would entail a considerable build-up of skills, in particular adequate training for staff and substantial updating of information technology (IT), lack of skills or qualified staff, lack of availability for AI experts is attributed to the fact that academic and educational programmes are unable to keep up with the speed of innovation and new AI discoveries.

The prejudice on the implementation of AI and IoT should be minimize and overcoming by providing the true information to understand the concept as well as the implementation of AI and IoT. An academician and researcher also supporting by the respective ministry comes as a one, the information can be successfully delivering to the construction players especially to the students who going to craft the construction industry in near future.

The support from organisation and respective ministry or government plays crucial roles to ensure the barriers of implementing AI and IoT can be at a minimum score. Where the organisation and respective ministry should encourage the implementation by stating the practices of AI and IoT in each of project drives. The implementation having a cost to be bear, but then, fully controlling from the construction players on the demand to use the tools and the controlling by the ministry, the cost of implementation should fall at reasonable price to be offer to those whom want to practices and purchase the tools.

All the barriers highlighted earlier may overcoming by all the relevant parties comes united as one to ensure Malaysia moving into the right direction with the right practices and implementation. The parties involve especially construction players should make a first move from traditional way of delivering the project to more innovative and advance way to deliver the project without compromising the quality of the delivery.

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