READINESS OF DIGITAL TRANSFORMATION IN MALAYSIAN CONSTRUCTION INDUSTRY

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A project report submitted in partial fulfilment of the requirements for the award of Bachelor of Science (Hons.) Quantity Surveying

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DECLARATION

I hereby declare that this project report is based on my original work except for citations and quotations which have been duly acknowledged. I also declare that it has not been previously and concurrently submitted for any other degree or award at UTAR or other institutions.

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APPROVAL FOR SUBMISSION

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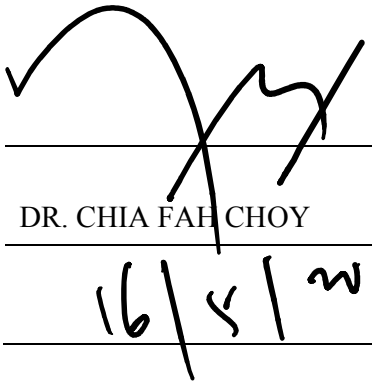
Signature : 

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ABSTRACT

The Fourth Industrial Revolution has brought digital disruption to our daily life and workplace. The rapid increase in the advancement of artificial intelligence, big data and connectivity empowered all industrial sectors to change the ways it operates. The construction industry is not an exception. Will the digital transformation improve the efficiency in delivering and operating of the built environment? Are Malaysian construction players able to cope with the disruption from digital transformation? These are the research questions that this study intended to answer. The research objectives of this study included reviewing the essential elements of digital construction in construction industry; exploring the awareness of digital construction and analysing the readiness of the practitioners in the Malaysian construction industry. Quantitative analysis is adopted in this research. Literature related to the application, maturity level and lesson learnt in digitalisation in the construction industry has been consulted in order to develop a theoretical framework. The theoretical framework is subsequently used as a blueprint to develop the questionnaire for the field survey. The targeted respondents were the Malaysian construction industry practitioners. Data collected from 104 respondents are analysed and presented descriptively for plain data interpretation and inferentially for generalisation. This research will broaden the knowledge of digital application in the construction industry. It is expected to beneficial to the Malaysian construction industry so that practitioners are able to embrace the emerging changes of the industry revolutionary, resiliently and robustly.

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Q	Value of Chi-square
f_i	Observed frequencies
e_i	Expected frequencies
CLT	Central Limit Theorem

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CHAPTER 1

INTRODUCTION

1.1 Background

The digital economy has changed how the industrial sectors work. Regardless of whether the industry players are aware or not, it is disrupting every sector significantly. The changes to all industrial sectors are unavoidable, including construction industry. It is noticeable that the artificial intelligence presents in every aspect around our life. One of the agendas of 2019 G20 Ministerial Meeting (Crowley, 2019) on Trade and Digital Economy, the ministers involved agreed on the guiding principles for using artificial intelligence (Koizumi, 2019).

The analysis carried out by McKinsey & Company shows that appropriate adoption of digital tools in construction industry will reduce the cost by 45 percent (Koutsogiannis, 2019). It is noticeable that digital transformation is altering how the construction industry works. Many construction industries from the developed countries has adapted themselves to the disruption from the digital era. The next five years are critical if the construction industry desires to unlock the full potential via digital transformation (Radley, 2019).

The construction industry is playing an important role in Malaysia. It contributed 5.9% to the GDP in Malaysia in 2017 (Akob, 2018). The Construction Industry Development Board (CIDB) is in the final stages of drafting the Industry 4.0 roadmap for construction industry to offer a distinct path for the construction parties and streamline future plan regarding Industry 4.0 (Ahmad, 2019, Sze, n.d.).

In order to stay competitive locally and internationally, The Malaysian construction industry needs to focus on advanced skills such as Building Information Modelling (BIM) (Ikhsan, 2019). The adoption of Building Information Modelling and digital Industrialise Building System can assist the Malaysian government to fulfil the demand of affordable house within ten years (Mohamad, 2019). Sharifuddin (2019) suggests application of BIM might be made compulsory for all developers in future by the local authority because of its benefits in time and cost reduction (Sharifuddin, 2019).

1.2 Problem Statement

The readiness of digital transformation in construction industry is still in its infancy (Lee, 2018). Based on the McKinsey Global Institute industry digitization index, construction industry is ranked second to last as compared to other sectors (Manyika, et al., 2015). According to the statistic, the construction industry around the world has poorer performance over the past few decades in terms of labour productivity as compared to other sector, which only grown by 1% per year (Sridhar & Tonby, 2017). The productivity in the construction industry does not change significantly due to it is one of the industries that is slow in adapting the technology changes (McKinsey, 2017). Despite the construction industry is one of the industries that produce huge data, study found that only three percent from the industry in which the data is being stored in a Common Data Environment (CDE) (Koutsogiannis, 2019).This indicates that the digitalisation of construction industry in terms of technologies adoption is still low (Koutsogiannis, 2019).

Some of the parties and organizations have propagated the ideas of digital transformation in construction industry. The Digital Construction Week is held in UK regularly to raise the awareness of digital construction in the industry. In the education aspect, there are only few tertiary education institution are offering the digital construction programme or courses. For example, University of Salford, Digital Construction Academy, University of Westminster, University of New South Wales Sydney, National University of Singapore, Universiti Tunku Abdul Rahman Sungai Long, etc. However, most of the tertiary education institutions only focus on the area of Building Information Modelling (BIM) in their Digital Construction course. Recently, University Tunku Abdul Rahman have offered a new elective subject called Digital Construction. The topics covered include majority digital technology described in the Industry 4.0 such as BIM, big data, Internet of Things, artificial intelligence, blockchain technology, digital built environment, etc. (Chia, 2019).

Besides, there are few researches related to the digital construction in Malaysia. For example, Yusuf, et al., (2017) studied on the readiness of Building Information Modelling (BIM) for academic in Malaysian higher education institution. Besides, Yaakob, et al., (2016) studied the critical success factors of implementing Building Information Modelling (BIM) In Malaysian

Construction Industry. In addition, Latiffi, et al., (2016) researched on transformation of Malaysian construction industry with Building Information Modelling (BIM). Most of the studies only cover on the aspect of BIM. Although BIM is central to digitalisation of construction industry, but it cannot represent the whole of it (European Construction Industry Federation, 2019).

Table 1.1: Summary of Published Journal Paper Related to the Digital Construction in Malaysia.

Research Title	Summary
1) Academic readiness for building information modelling (BIM) integration to Higher Education Institutions (HEIs) in Malaysia	Although some HEIs include BIM to their program, there are challenges such as: low awareness level among educators, low competent knowledge on BIM, procurement of hard and soft wares and the need of training and educating of students across all academic disciplines of the industry (Yusuf, et al., 2017).
2) Identifying Critical Success Factors (CSFs) of Implementing Building Information Modelling (BIM) In Malaysian Construction Industry	Several critical success factors such as technology, organisation, process and legal in implementation of BIM is identified (Yaakob, et al., 2016).
3) Transformation of Malaysian Construction Industry with Building Information Modelling (BIM)	Malaysian construction industry is aware of the importance of BIM. However, better strategies is required to highlight and embrace the BIM adoption (Latiffi, et al., 2016).

Malaysian construction industry faces challenges to move towards Industry 4.0 (Wong, 2020). The adoption of Building Information Modelling is still low at 17 percent as compared to developed countries such as United State, which is 71 percent (Ikhsan, 2019). Besides, most of the construction

practitioners have misperception that the adoption of new technologies will have cost implications. However, its benefits will enhance and add value to the construction projects (Wong, 2020).

The present research is to study the readiness of digital transformation in Malaysian construction industry. The word "readiness" is defined as the state of being fully prepared for something (Cambridge Dictionary, 2020). The readiness of digital transformation in construction industry is the preparation state of construction industry in embracing digital transformation. Do the practitioners in Malaysian construction industry ready for the digital transformation? Is the industry ready for the disruption? This research intended to answer these questions.

1.3 Research Aim

This research intends to examine how ready Malaysian construction industry in the digital transformation is.

1.4 Research Objectives

The following research objectives are set up in order to achieve the research aim as mentioned above:

1) To review the essential elements of digital construction in construction industry.
2) To explore the awareness of digital construction in Malaysian construction industry.
3) To analyse the readiness of the practitioners in the Malaysian construction industry.

1.5 Research Method

The primary data for this study is obtained by using questionnaire. The descriptive and inferential analysis are used to analyse the primary data collected in order to obtain the generalisable knowledge. The research approaches conducted to realise the objectives of research is summarised as follow:

Table 1.2: Summary of Research Approaches.

Phase 1:	**Phase 2:**	
Literature Review	**Questionnaire Survey and Data Analysis**	
Objective 1:	Objective 2:	Objective 3:
To review the essential elements of digital construction in construction industry	To explore the awareness of digital construction in Malaysian construction industry	To analyse the readiness of the practitioners in the Malaysian construction industry

1.6 Research Scope and Limitation of the Study

The data are collected from construction practitioners from different business activities, professions, working experience, education level and age group to analyse any significant differences in answering the questionnaire among the respondents. This research may not covered the latest digital aspects or approaches as digital business trend is changing too fast to be keeping up-to-date.

1.7 Structure of the Report

The Chapter 1 is the introductory part of the entire research report. It discusses the background of the digital construction and the current issues on the readiness of digital construction in the industry. This chapter also outline the aim, objective, research methods, scope and limitations of this study.

Chapter 2 provides a summary of relevant information on digital construction which collected from published sources such as websites, journal articles, etc. This chapter highlights the fourth industrial revolution, digital construction and its application, importance and challenges in construction industry. The theoretical framework is established at the last section of this chapter to shows the relationship between the variables discussed in this research.

Chapter 3 shows how the research was conducted. The research type and design used are explained. Furthermore, it shows how the collection of data was done. The questionnaire proposed is in accordance with the theoretical

framework established. Besides, it also reviews the sampling size and target respondents. The last part of chapter 3 shows the data analysis methods adopted.

Chapter 4 summarised the findings and evaluate the readiness and critical success factors of digital transformation in Malaysian construction industry from the data collected. The data collected are analysed and the findings are generalised by using statistically significant tests. It also discusses the descriptive and inferential statistic utilised. The findings outcome is used to compare with the literature review.

The final chapter (Chapter 5) of this research summaries the findings of this research. It concludes the entire research and the current conditions of the readiness of digital transformation in Malaysian construction industry. Besides, the implication of this research is discussed. This chapter also provides the limitations and recommendations to enhance the quality of future study.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

It is undeniable that digital age is reshaping the society and business. It is the result of the fourth industrial revolution. The next section follows will elaborate what Fourth Industrial Revolution is. The digital construction and its essential elements, application, maturity and challenges will be discussed subsequently. The last part of this chapter proposes the theoretical framework of the readiness of digital transformation in construction industry.

2.2 Fourth Industrial Revolution

Digital transformation is the major transformation in activities, processes, competencies and models of business or organisation which fully leverage the digital technologies mix shifts and opportunities. It also fully leverages accelerating stimulation on society (I-Scoop, 2019). The computerization of Third Industrial Revolution is optimised by the Fourth Industrial Revolution (Marr, 2018). The automation in manufacturing process is enhanced to a higher level due to customised and flexible mass production technologies (Martin, 2017). The adoption of self-optimization, self-cognition and self-customization allows the machines to run by collaborating with humans or independently. It gathers the data to analyse and advice upon it. The Internet of Things (IoT) and Internet of People (IoP) allows the machines to communicate with each other (Martin, 2017).

The fourth industrial revolution is not only limited to smart and connected machines & systems. Occurring simultaneously are waves of further breakthroughs in scopes from gene sequencing to nanotechnology, from renewables to quantum computing. The mix of these technologies and their interaction on the domain of physical, digital and biological has make the difference of fourth industrial revolution from previous revolutions. As compared to the previous revolutions, the emerging technologies and broad-based innovation of fourth industrial revolution are diffusing in a faster phase. According to statistics, around 17% of the population in the world has yet to

fully experience the second industrial revolution. Meanwhile for the third industrial revolution, more than half of the population are unable access the internet. As compared to the hallmark of the first industrial revolution, spindle which took almost 120 years to spread outside of Europe, the internet has spread to the world rapidly in less than a decade (Schwab, 2016).

One of the issues on Fourth Industrial Revolution is low in required leadership levels and understanding of the changes underway, across all sectors when compared with the need to rethink the economic, social and political systems to respond to the fourth industrial revolution. Thus, the necessary institutional framework to control the innovation spread and reduce the disruption is insufficient. The next issue is lack of a constant, positive and common narrative that outlines the fourth industrial revolution's opportunity and problems (Schwab, 2016).

2.2.1 Consequences of the Fourth Industrial Revolution

Generally, the fourth industrial revolution benefits the consumer the most. However, it burdens the supply side the most. It affects developed and fast-growing economies countries such as China. The labour share of China as a GDP percentage decrease significantly. This is because the relative price of investment goods decrease due to the innovation progress that substitutes the labours for capital. On the other hand, the fourth industrial revolution increases the gap between peoples who own capital and peoples that rely on labours. It benefits the intellectual and physical capital providers (innovators, investors, shareholders) (Schwab, 2016). Construction industry is an important industries that provides essential foundations of a powerful economy (Mayur, 2017). The Malaysian construction industry cannot ignore the disruption from technologies of building that are being deployed in the industry (Ikhsan, 2019).

2.3 Digital Construction

Digital construction is the adoption of digital tools to enhance the process of delivering and operating the built environment. It can also be defined as creating safer, efficient and collaborative built environment in terms of delivery, operation and renewal process (Mills, 2016). The trend is unavoidable and we are difficult to stay away from it regardless of whether we wished (Castagnino,

et al., 2018). It alter how the construction industry works and brings it to next level (GenieBelt, 2019). Although prefabrication construction has many advantages, but there are still some restrictions on it. This has drove the engineers to taking the advanced technology on-site. The CEO of Newtecnic, Andrew Watts claimed that this will be the digital construction new era, where the drones and robots will turn into ordinary things in construction. Digitalisation has impacted engineering and designing side significantly, but not in physical construction. The idea of the Newtecnic's Construction Labs is to solve this problem, combining modular building with on-site construction to produce ideal finishes on public buildings (Wade, 2018).

There is not a definite definition for digital construction. It is confusing as it may refers as the entire process of lifecycle instead of the process of construction solely. Different people will have different views in defining this term (Radley, 2019). The term Construction 4.0 is also used to refer as digitalisation of the construction industry (Osunsanmi, et al., 2018). In UK, Digital Construction Week which dedicated to digital construction, design, engineering, manufacturing and operation is held frequently. Their goal is to assist the industry explore its potential and realise how to utilise and employ these technologies, processes and tools to increase efficiency & profitability and produce a diverse industry.

2.3.1 Essential Digital Elements and Operations in Construction Industry

There are a lot of forms that could be took by the digital construction. For instance, it includes common tools such as messaging tools which allow for easier communication and decrease the travel need. Moreover, the form could be the enhancement or automation of the process of manufacturing, improvement in plant or materials cloud-based computing and filing system, or software applications for use in delivery or operation management. Furthermore, the form could be some advances tools such as Unmanned Aerial Vehicle (drones) for site inspection, 3D & 4D printing, robotic, artificial intelligence (AI), etc. (Mills, 2016). Chia, et al (2019) proposed a model, D = A + B + C which represents digital construction (D) embraces artificial intelligence (A), big data (B) and connectivity (C). In short, all these forms can be categorised

into 4 main elements that are interrelated, which are artificial intelligence, big data, and connectivity and digital applications.

a) Big Data (B)

Big data can be defined as great volume of structured, semi-structured and unstructured data which are hard to process by conventional software and database techniques (Beal, 2019, Rouse, 2018). The effective data gathering and the methods it is shared is one of the most significant topics in digital transformation (Radley, 2019). Based on the report done by McKinsey, the real time evaluation of data can enhance the productivity greatly (Rao, 2019). The construction sites are getting denser due to the number of individual involved, large amount of equipment and tasks taking place at the same time. Besides, the big data also assume an essential role in the change and performance assessment measures within organisation supply chain (Johnson, 2019). However, most of them did not capture these data (Agarwal, et al., 2016). 5G network allows for faster deliver transfer speed which improve the data conveying (Lundblad, 2018). The data has close relationship with connectivity and work together with the digital tools and digital concept such as artificial intelligence.

Big data can also be equal to huge amount of data gathered from individual location and sales, internet, and information of equipment such as performance, maintenance, hours run, etc. (Johnson, 2019). For example, a concept machine that depending big data is revealed by the Volvo to remove the manpower, reduce the emissions of carbon and cost in aggregate and quarry industry. However, the protection and privacy of data has discouraged the resources sharing and costs reduction (Johnson, 2019).

b) Connectivity (C)

5G network enhances the connectivity of every sectors significantly and helps in developing autonomous machine (Lundblad, 2018). It has faster speed of transfer and thus increase the speed of data transferring. This will improve the performance of self-driving machines because more accurate map and signals can be achieved. Another example of connectivity is Bluebeam Revu which is adopted to track the labours (Matthews, 2017). Besides, it also improve the

communication to enhance the safety and efficiency (Lundblad, 2018). 5G network also enhance the drone's performance by providing ultra-high definition video. Mobile technology such as smart phone is utilised in construction works. The labours could record down the information by using smartphone and share to others through internet connection. The photos captured also helps in inspection of distant site (Matthews, 2017). In addition, some GPS fleet tracking such as 'Fleetmatics Reveal' allows for better fuel consumptions and transportation time.

i. Internet of Things

Internet of things means connecting all the everyday objects to the internet (McClelland, 2019). In construction aspect, the Internet of Things able to provide materials, equipment, machinery, structures, etc. to connect to the central data platform to determine performances. Advanced technologies such as sensors, nearfield-communication (NFC) are able control the assets and staffs productivity. For example, inventory management can be adopted to predict and notify the person in charge whenever the materials are out of stock. Besides, equipment monitoring can be achieved by using sensors that communicate and discover needs of maintenance and notify the user to avoid maintenance. In addition, the quality of the structure can be examined by using vibration sensors to discover defects. The safety of the labours can be enhanced by using wearable devices that will notify the users if the vehicle is not operating. The NFC usage is getting advanced. One of the example of NFC is RFID. It is getting cheaper and able to provide more information such as defects, specifications, etc. (Agarwal, et al., 2016).

ii. Cloud Storage

Cloud storage is a cloud computing model that kept, administrate, back up the data remotely and everyone is able to access with network (Rouse, 2016). This will enhance the communication between the construction parties without spending a lot of money. They could access to various documents such as safety plans and drawings through the network connection (GenieBelt, 2017). Besides, the cloud storage in construction can enhance the real time collaboration. Everyone with network connection could update their problem or message and share within the whole construction team members. Moreover, the

adoption of cloud storage in construction field can improve the security by avoiding data loss and physical theft. It also allows the construction profession to do plans comparison or measurement at anywhere with the present of internet network and devices.

c) Artificial Intelligence (A)

Artificial intelligence is the machine that imitate the human intelligence to carry out works (Rouse, 2018, Copeland, 2019); while machine learning is the subset of artificial intelligence that gather data and study itself (M, 2018). The Artificial Intelligence programs may gather the current project information so that it can provides design alternatives, analyses problems and provides solution in the future (Culbert, 2019). It gathers a huge number of data to learn and improve themselves nonstop. These data can be produced through drones, mobile devices and BIM that capture pictures. For instance, the Artificial Neural Networks that depending conditions such as type of contract and size of project can be adopted to forecast the cost overruns of a project (Rao, 2019). In addition, an algorithm is exploited to determine safety such as the labours are not wearing the PPE. Furthermore, the artificial intelligence also can be adopted in the post construction phase to control issues and provide solutions to prevent issues (Rao, 2019). The BIM 360 Project IQ developed by the Autodesk which is in pilot currently is able to obtain data from the job site in video & audio form and documents of construction management. The data collected is connected and the machine learning will then forecast high risk problem (Bharadwaj, 2019). In addition, SMARTCONSTRUCTION is launched by Komatsu to gather data from the objects and labours at site to enhance safety (Bharadwaj, 2019).

One of the applications that rely on artificial intelligence is generative design. The generative design is able to produce high performing alternatives of design rapidly. It is a concept for the process of design exploration by adopting artificial intelligence cloud compute power (Akella, 2019). The design outcomes may never to be imagined by human mind (Galjaard, 2018). This means the design process no longer limited to human experience and imaginations. For instance, the design requirements such as cost, quality, material types and manufacturing method are inserted into the generative design software (Akella, 2019). The software will then examine every probable

solution permutations and produce the design alternative rapidly without clashing the paths for mechanical, electrical and plumbing with the building architecture (Rao, 2019). It will studies and examines every iteration. Thus, the designers are able to choose from the various alternatives that meet their requirements.

d) Digital Applications

i. 5D Building Information Modelling

The software used by the construction parties for all construction stages are different from each other's. This has caused the single source that provides a real time view and integrated of design, schedule and cost unachievable (Agarwal, et al., 2016). 5D Building Information Modelling is able to consider the 3D parameter of standard spatial design incorporating with schedule and cost of the project at the same time. It provides faster quantities automatic generation and greater accuracy (GenieBelt, 2019). Besides, it also comprises specifications, acoustic, geometry, aesthetic and thermal attributes. It also permits the construction users to analyse, determine the consequences of changes schedule and cost of project. This allows the construction parties to evaluate the risks earlier to decide the best solutions (Agarwal, et al., 2016). 5D BIM also enhance the process of management regarding to cost since various construction parties able to collaborate feedback (GenieBelt, 2019). Building Information Modelling also incorporates virtual reality and augmented reality to design and build with better sustainability and efficiency (Radley, 2019). During the construction process, the site managers are able to visualise the cables or pipes placements by using virtual reality headset to prevent obstacle (Culbert, 2019). Augmented reality apps enable the 2D plan drawings to be transformed to an as-built model. On the other hand, the sequential animation in virtual reality can be shown when a 4D scheduling modelling is incorporated with the augmented reality and thus allowing for better decision making (Trivedi, 2018).

ii. Preassembly

In-factory assembly can be used for modular building such as condominium. The work site is able to change into a manufacturing system by integrating off

site capabilities by prefabricated, prefinished volumetric construction (PPVC). This will enhance the efficiency, safety and reduce wastage at the same time.

iii. Unmanned-Aerial-Vehicle (UAV) & Drone

Drones plays two important roles at construction site, which are to enhance safety and provide oversight. By using drones, the manager could obtain an entire new view of construction site conditions (Bharadwaj, 2019). The bird's eye view feature of the drone is able to provide a fuller image of the land and the progress being made and assist to reduce human mistake. Besides, drones also play the role as communication tool, keeping person in charge in the loop although they are absent on the site. It also adopted to enhance the survey data. In respect of safety, the drones can monitor the whole site conditions and work process (Radley, 2019). Besides, it assists to decrease vandalism and theft. The drone can enhance the safety by activating the alarm when there are threats to the worker's safety, which cannot be observe easily on the ground. This can rescue anyone from injury (Michael Page, 2018).

iv. Light-detection-and-ranging (lidar)

Difference between actual ground conditions and early survey will causes the cost of the project to increase. By using new technique such as integrate high-definition photography, geographic information system and 3D laser scanning allowed by drone and unmanned-aerial-vehicle technology improvements able to increase the speed and accuracy. For instance, light-detection- and-ranging (lidar) is used together with other tools to provide good quality of underground and aboveground 3D images which will cause minimum disturbance. Besides, the costs of these high tech survey have decreased significantly (Agarwal, et al., 2016).

v. 3D Printing

3D print a house is possible in the construction industry. A Russian company, Apis Cor is researching the large-scale 3D printers which is able perform unbelievable things. One of their printers is able to construct a 400 square foot cement structure in one day. However, the structure printed was not ready immediately. It requires the labours to carry out some installation (Culbert, 2019). By using 3D printer, the duration and cost of the construction can be decreased significantly (Patel, 2019). Furthermore, the printer is able to produce

various types of building materials, such as from concrete to mortar. These materials are being developed to fulfil the building codes. Although the industry is still some time away from the 3D printing being the norm, however that day is approaching quickly (Michael Page, 2018).

vi. Robots

It is common to see large machinery such as cranes and bulldozers at the construction site. However, the North American construction industry is looking for more robots that are able to perform demolishing, levelling, digging, etc. more effectively and lesser human energy. Creating these machines autonomous may do wonders for projects in various ways. It allows for safer sites and more efficient work by controlling the progress and ensuring the labours free from harm. Besides, it also enhance the productivity of the work (Jones, 2018). In terms of safety, the robots also can replace some of the more risky and rigorous works at the construction site (Michael Page, 2018).

vii. Digital Collaboration

Digitisation indicates avoiding the use of paper which has caused low productivity and shift to online. The adoption of paper causes the data cannot be analyse easily. Not only it is time wasting, but dispute often occurred among the clients and contractors due to mismanagement of paperwork. Digital collaboration promotes real time information sharing that enhance collaboration, promptly progress, quality monitor and trustworthy result (Agarwal, et al., 2016). It means that everyone is working in a shared online space, called 'common data environment'. It can store every information of project such as schedules and drawings (Mills, 2018). Before digitisation, the clients and contractors are unable to work from same reality version.

2.3.2 Digital Maturity

There are only few E & C firm that are capable to implement the artificial intelligence technology despite it is proven to have high return on investment to them (Blanco, et al., 2018). Although the adoption of drones are getting more common in construction industry, this technology is consider as far from cutting edge (Radley, 2019). In Malaysia, the adoption level of Building Information Modelling is 17%; while 38% in UK, 65% in Singapore and 71% in US

(Bernama, 2019). According to "Bauma Industry Barometer", only 4% of the organisation perceived that they are digitalisation leader (Bauma, 2019). Besides, this survey also revealed that 25% of the organisations perceived that their digitisation has begun, rather be a latecomer.

The McKinsey Global Survey shows that more than 8 over 10 of the companies are taking effort to capture the benefits of digital trend. However, they perceived the success in their effort is elusive (Boutetière, et al., 2018). EY digital survey revealed that only 25% of respondents perceived that they have clear digital strategy (Buisman, 2018). This survey also showed that 98% of respondents perceived that digital solutions are critical in future. Most of the respondents agreed that digital innovation are very likely to be transformative to their business. Moreover, most of the respondents perceived that the competitors' digital effort would be some threat to their business.

LetsBuild has offered a survey, "Construction Digital Maturity Ladder" (CDML) which assess the digital maturity of construction firms globally (Heiskanen, 2019). The level of digital maturity is divided into several extent, which are business as usual, present & active, formalised, strategic, converged, innovative & adaptive and guiding star. In the end of the survey, the respondents are able to figure out how digitally mature is their company. Based on the survey, majority of the respondents report updates from site to office weekly. Only 22% of the respondents report updates from site to office every day. On the other hand, only 13% of the respondents report updates from site to office in a real-time basics (Koutsogiannis, 2019). Common data environment (CDE) is important in order to achieve digital collaboration (Mills, 2018). However, the CDML found out only 3% of the respondents are working in a CDE despite construction industry is one of the sectors that produced most data. Most of the respondents store their data in searchable format or images and PDF, but in each of the relevant platform or setup. This will prevent the construction industry to enjoy the insights together. However, almost half of the respondents indicated that building information modelling and 30 percent of the respondent indicated that CDE will have significant impact in construction industry over the next three years. In addition, half of the respondents claimed that the programmes infrequently reflect the reality. Some of them even uncovered that the programmes never reflect the reality. Poor communication can be solved by

adopting mobile devices. However, only 31 percent of the respondent claimed that their company has provided smartphones for them. Based on the survey, the technology that most of the respondents are using or testing is modular or prefabrication construction. The rank is followed by big data and virtual reality & augmented reality. Moreover, only not more than 15 percent of companies has invested in developing digital skills from three percent or more from the earnings (Koutsogiannis, 2019).

2.3.3 Challenges in Adopting Digital Construction

The following five years are critical for the construction industry to unleash the whole potential through digital transformation (Radley, 2019). Although construction industry is said to be faster to recognize its potential as compared to other sides, but having to a degree missed out on the industry 3.0 of IT, it cannot be overconfident on how fast or far construction digitalisation will solve the problems encountered. Some of the organization had contributed many resources and time in examining the capability of construction digitalisation (Radley, 2019). Besides, it is one of the most resistant industrial sector in employing new technology due to the tight margins of their work (Culbert, 2019) . Albeit numerous organization wish to adopt new technology, most of the tech adopted is a long way from cutting edge such as drones. Currently, the most significant basic of digital transformation is gathering of data itself and methods in which it is shared effectively. This has caused some problems such as the protection and ownership of data (Lee, 2018). There are some barriers that avoid the organizations completely grasping new tech. One of the barriers is obviously cost. All these high tech items such as 3D printers, robots, etc. are high in cost. However, numerous organizations are facing the problems such as insufficient capital investment and low profit margin even though it is cost effective for long term. Despite certain organisation able to invest in these technologies, they may not have people with ability required to exploit it. Besides, the training expenses for labours will be very high (Radley, 2019). Despite digital transformation has commenced on majority of the industries, the progress in construction industry is slow (Ismail, 2019). According to McKinsey survey, only 16% of respondents perceived that digital transformation of their organisation had delivered improvements in sustainable performance. This is

due to few characteristics of construction industry which caused the digitalisation in construction industry more challenging. These characteristics include fragmentation, lack of replication, transience and decentralisation in construction industry (Koeleman, et al., 2019).

2.4 Proposed Theoretical Framework for Digital Construction

To sum up, the literature review can be summarised into theoretical framework as shown in Figure 2.1. It is assumed that the readiness of digital transformation in construction is depends on the digital visions, strategies, operations and actions of the construction organisations and practitioners. Whereas the moderating variables "challenges" have contingent effect to the readiness of digital transformation in construction industry.

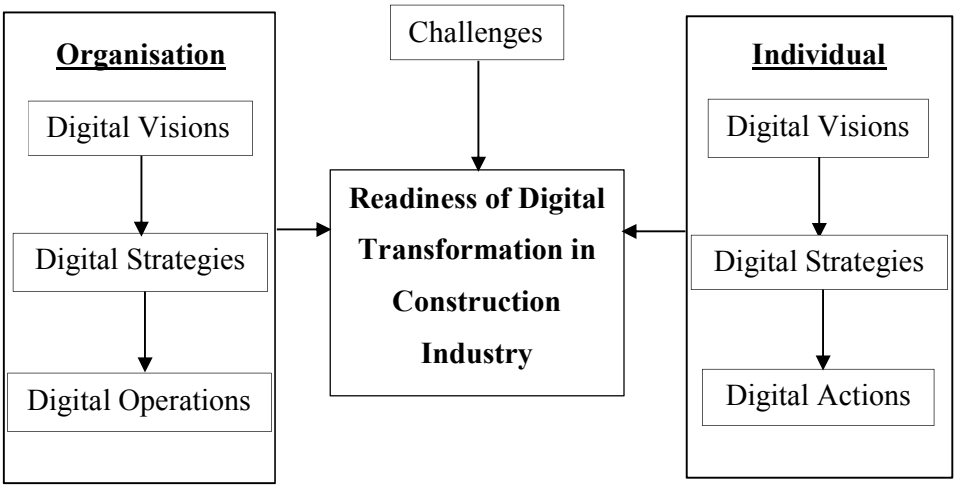

Figure 2.1: Theoretical Framework for Digital Construction.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

The current situations and studies of the digital transformation in construction industry were reviewed in the previous chapter. This chapter report the research methodology executed. The design of questionnaire and its relationship with the literature reviewed is explained in Section 3.3. In addition, the sampling size and data analysis are outlined in Section 3.4 and 3.5 respectively.

3.2 Exploratory Study

This exploratory study aims to examine how ready Malaysian construction industry in the digital transformation is. The exploratory study is applied in the research to clarify or investigate vague issues in a specific circumstance (Kumar, et al., 2012). Generally, it is executed to better understand the essence of the issue because only little researches have been carried out in that field (Sekaran, 2002). Most of the researches carried were focus only on Building Information Modelling aspect as shown in Table 1.1.

3.3 Research Instrument

In this research, quantitative research method is used to explore how ready Malaysian construction industry in digital transformation is. The questionnaire survey is adopted to gather data and produce statistic from a huge number of respondents (Kumar, et al., 2012). There is a correlative relationship between quantitative approach and deductive approach to testing theory. The questionnaire designed for this study is based on 5 digital approaches, which are digital visions, strategies, operations, actions and challenges. All these approaches will be used to analyse the readiness of practitioners in digital transformation. The researcher is not taking part in the survey nor is influencing what being researched (Kumar, et al., 2012). The design of the questionnaire and its relationships with the literature reviewed will be discussed in the following sections.

3.3.1 Questionnaire Design

The sample of questionnaire is available in the Appendix A. The questionnaire for this research is structured into four sections. The questionnaire designed shown in Figure 3.1 is developed from the theoretical framework proposed in Chapter 2 (Figure 2.1).

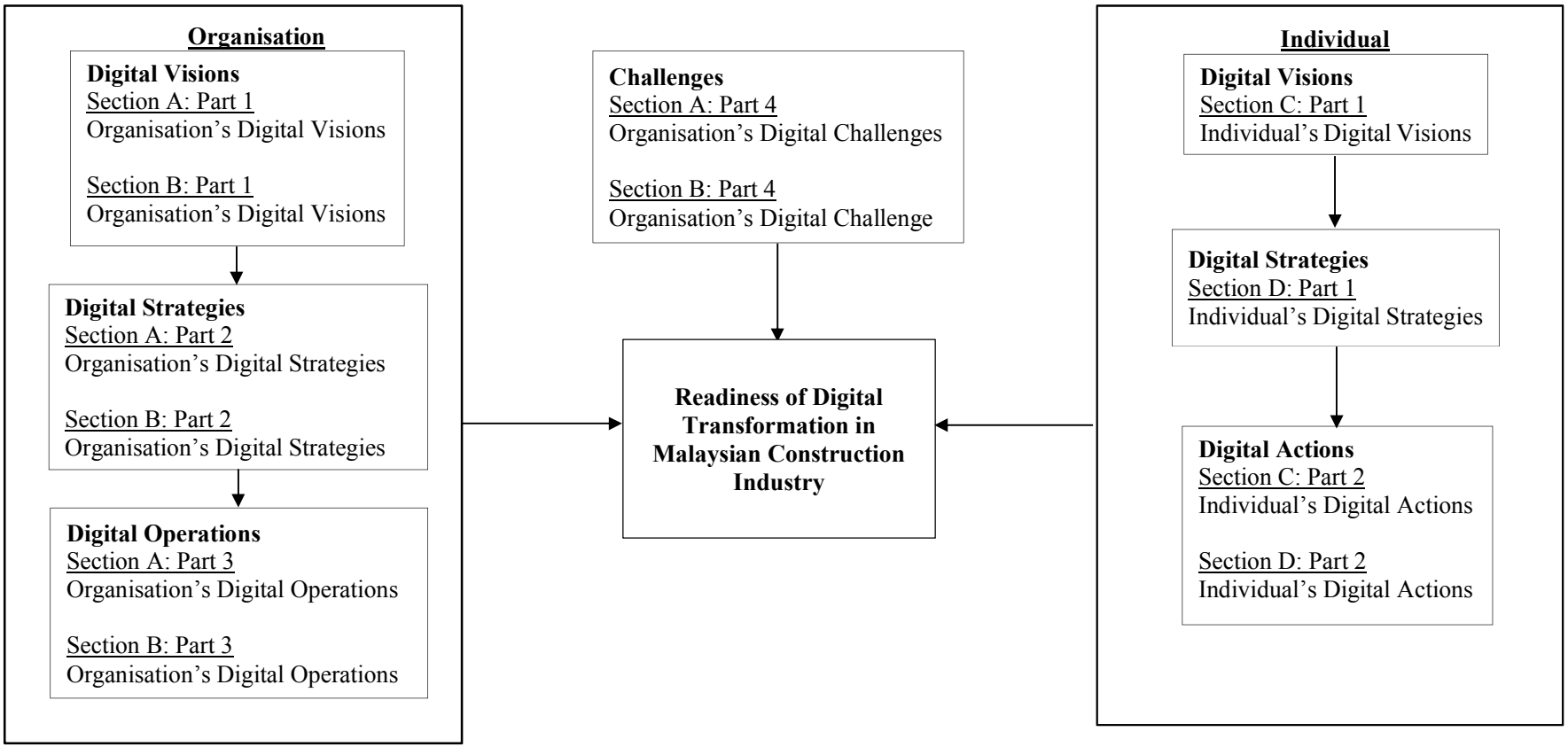

Figure 3.1: Theoretical Framework for Questionnaire.

The questionnaire consists of four main sections to evaluate the readiness of digital transformation in Malaysian construction industry. Each main section is sub-divided into multiple sub sections, which are digital visions, strategies, operations, actions and challenges. Section A and B will focus in organisational practice while Section C and D will focus on individual perception. Seven points Likert scale is adopted in the questionnaire to obtain the views of respondents on the digitalisation of construction. It consists of the options of 'don't know/not sure', 'strongly disagree', 'mostly disagree', 'slightly disagree', 'slightly agree', 'mostly agree' and 'strongly agree' to a given questions. The respondent will answer the questions based on their perspectives and knowledges. The Table 3.1 shows the statements coverage on each section.

Table 3.1: Statements Coverage.

Main Sections	**Sub Sections/ Statements**			
Organisation	**Visions**	**Strategies**	**Operations**	**Challenges**
Section A	Statements 1-2	Statements 3-8	Statements 9-22	Statements 23
Section B	Statements 1-3	Statements 4-8	Statements 9-12	Statements 13

Individual	**Visions**	**Strategies**	**Actions**	**Challenges**
Section C	Statements 1-4	-	Statements 5	-
Section D	-	Statements 1	Statements 2	-

Section E will focus the respondents' background in order to analyse the respondent's attributes towards organisations and individuals' digital approaches. The data to be obtained are listed in Table 3.2.

Table 3.2: Data to be collected in Section E.

No	Respondent's Attributes
1	Organisation's Industry
2	Profession
3	Role in Organisation
4	Working Experience
5	Highest Qualification
6	Age

3.4 Sampling Size

3.4.1 Central Limit Theorem

The sample size determination is based on the Central limit theorem (CLT). CLT is reasonably accurate if number of samples equal or greater than 30 (Chihara & Hesterberg, 2011). CLT explains that if there are sufficient large of samples, the distribution of the samples is approximately standard normal.

3.4.2 Target Respondents

The target respondents for this research are the individuals working in Malaysian construction firms from different business activities, professions, working experience, education level and age group to analyse any significant differences between the categories of respondent.

3.5 Data Analysis

In order to ensure the construct of the questionnaire for each section is internally consistent, Cronbach's Alpha Reliability tests is adopted. The descriptive and inferential statistic are adopted to analyse the findings. Descriptive statistics are used for plain interpretation and presentation of data while the inferential statistics are used to generalise the findings.

3.5.1 Reliability Test

Reliability Analysis is conducted for every matrix question to questionnaire construction. The alpha coefficient value is range from 0 to 1. It measures the test or scale internal consistency. Internal consistency shows to what degree are

every item measures the same concept (Tavakol & Dennick, 2011). Any alpha coefficient value that more than 0.7 shows the data is reliable.

3.5.2 Descriptive Analysis

The descriptive analysis is one of the simplest methods of analysis that offers an overview of the outcomes. The frequency distribution is useful in classification of huge number of raw data quantity into specific category (Naoum, 2013). Thus, frequency distribution was adopted to analyse the data gathered.

3.5.3 Inferential Statistic

a) Chi-Square Goodness-of-Fit Test

The Chi-square goodness-of-fit test is used to disclose the significant difference by comparing the observed sample distribution with expected probability distribution. The formula of Chi-square goodness-of-fit test is shown below (Pearson, 1900):

$$Q = \sum_{i=1}^{k} (f_i - e_i)^2 / e_i$$

Where,

$Q =$ Value of Chi-Square

$f_i =$ Observed frequencies

$e_i =$ Expected frequencies

Section 4.4, 4.5, 4.6 and 4.7 are interpreted by the percentage of "highly digitised". The Table 3.3 shows the meaning of "highly digitised" for each section.

Table 3.3: The Meaning of "Highly Digitised".

Section	Meaning of Highly Digitised
4.4 & 4.7	Aggregate of "mostly agree" and "strongly agree"
4.5	Aggregate of "mostly important" and "very important"
4.6	Aggregate of "expect to use in 3 years" and "using now"

b) Extension of Median Test

Extension of median test is adopted to test whether two or more independent groups have been drawn from a population with the same or different median (Gibbons & Chakraborti, 2010). It is extended version from Mood's Median Test in order to analyse two or more independent groups (Daniel, 1990). To determine the rejected null hypothesis, the value of significance must be less than or equal to 0.05. The rejected null hypotheses show the groups which are statistically significant with 95% of confidence level and worth to be discussed.

The result of hypothesis testing on the pairwise comparison across respondent's attributes towards few sections are shown in Table 4.4, 4.6, 4.8 and 4.10. Only the statements successful in rejection of the relevant null hypotheses of the Extension of Median Tests are shown with their respective statistically significance ($p<0.05$). The Table 3.4 shows the pairwise comparison across respondent's attributes in each section.

Table 3.4: Sections Used for Pairwise Comparison across Respondent's Attributes

Table	Sections used for pairwise comparison across respondent's attributes
4.4	Section 4.4: Extent of Agreements toward Statements Related to Organisation's Digital Approaches
4.6	Section 4.5: Perception towards the Importance of Technology to Organisation
4.8	Section 4.6: Knowledge on Digital Technology Practiced by Organisation
4.10	Section 4.7: Expectations and Experiences of Individual Encountered in the Workplace

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

This chapter reports the result of the field survey. The results gathered are used to analysed and inferred for generalisation. The respondents' background are discussed in section 4.2. Section 4.3 outlines the results of reliability analysis. Section 4.4 to 4.7 reports the results of data obtained. Lastly, the Section 4.8 summarises the findings and compares these findings with the literature reviewed.

4.2 Respondents' Background

A total 104 sets of questionnaires are received through social media including LinkedIn, Facebook, WhatsApp and email. The details of the respondents' attribute are summarised in Table 4.1. More than half of the respondents are from consultancy firms (51.9%). The number of respondents who are working as a quantity surveyor are the highest (32.7%); while the number of respondents who are working as an engineer and an architect are the same (28.8%). The length of working experience of respondents are almost the same, i.e. 'less than 2 years' (31.7%), '2 to 5 years' (33.7%) and 'more than 5 years' (34.6%). Almost two-thirds of the respondents are below 30 years old.

Table 4.1: Respondents' Attributes (N=104).

General Information	Categories	Frequency	Percentage (%)
Organisation Business Activities	Others	5	4.8
	Building materials merchant	2	1.9
	Consultancy	54	51.9
	Construction business	35	33.7
	Development	8	7.7

Table 4.1 (Continued)

Profession	Others	8	7.8
	Charter Builder	2	1.9
	Quantity Surveyor	34	32.7
	Engineer	30	28.8
	Architect	30	28.8
Working Experience	Less than 2 years	33	31.7
	2 to 5 years	35	33.7
	More than 5 years	36	34.6
Age	Less than 25 years old	27	26.0
	25-30 years old	39	37.5
	Above 30 years old	38	36.5

N= Total number of respondents

4.3 Reliability Analysis

Table 4.2 shows the result of reliability test on the four sections of the questionnaire. All the Cronbach Alpha value of the four sections are greater than 0.7, which indicate that the construct of these sections is internally consistent.

Table 4.2: Cronbach Alpha Value of Reliability Test.

Sections	Cronbach alpha value
Section A: Extent of agreement related to organisation's digital approaches	0.94
Section B (No. 9): Perception towards the Importance of Technology to Organisation	0.836
Section B (No. 11): Knowledge on Digital Technology Practiced by Organisation	0.852
Section C: Expectations and Experiences of Individual Encountered in the Workplace	0.742

4.4 Extent of Agreements toward Statements Related to Organisation's Digital Approaches

Table 4.3 shows the results of extent of agreement towards statements related to organisation's digital approaches. All the results obtained from Chi-Square tests are statistically significant. The table also shows the frequency of "highly digitised" (i.e. aggregate of "mostly agree" and "strongly agree") of each statement.

Table 4.3: Results of Extent of Agreement towards Statements Related to Organisation's Digital Approaches.

Statements	1	2	3	4	5	6	7	Highly Digitised (≥6)	(%)	Chi-square	Sig.
Our leaders have the vision necessary to lead our digital business efforts.	2	2	1	3	36	50	10	60	57.7%	159.442[a]	0.000
Digital reporting is always available and used strategically across team in our organisation.	2	2	10	11	23	46	10	56	53.8%	96.173[a]	0.000
My organisation encourages new ideas to be shared and tested at all levels of the organisation.	1	1	5	19	24	37	17	54	51.9%	72.481[a]	0.000
Funding digital initiatives is a significant challenge that affects my organization's digital efforts.	4	3	1	10	36	36	14	50	48.1%	92.135[a]	0.000
My organisation encourages feedback and interaction to learn how to work in new ways.	0	3	3	18	34	28	18	46	44.2%	46.346[b]	0.000
My organization's management structure and practice (e.g. reporting relationships and decision-making processes) interfere with its ability to engage in digital business successfully.	4	3	3	12	36	37	9	46	44.2%	92.808[a]	0.000

Table 4.3 (Continued)

Digital transformation is a top management priority at my organisation.	0	2	6	13	38	31	14	45	43.3%	58.115[b]	0.000
My organisation is using digital technology essentially to do business in fundamentally new or different ways.	2	3	1	14	39	35	10	45	43.3%	59.423[a]	0.000
Our organisation has a clear and coherent digital business strategy.	5	3	1	10	40	36	9	45	43.3%	105.462[a]	0.000
My organisation effectively utilises the digital knowledge, skills, interest, and experience held by our employees.	3	3	4	7	42	37	8	45	43.3%	116.769[a]	0.000
My organisation is using digital technology essentially to do what we have always done, but faster and cheaper.	3	2	6	17	32	29	15	44	42.3%	101.692[a]	0.000
Our organisation is increasingly organised around cross-functional project teams, not necessary functions and divisions, to implement digital business priorities.	3	4	5	14	34	35	9	44	42.3%	78.269[a]	0.000
My department or team uses technology to get work done more effectively than our organisation does as a whole.	3	1	2	25	32	30	11	41	39.4%	76.654[a]	0.000

Table 4.3 (Continued)

My organization scales successful initiative to drive digital transformation across the organisation.	2	1	3	13	44	32	9	41	39.4%	113.000[a]	0.000
My department or team is working or starting to work with advanced collaborative tools instead of email to facilitate better communication.	2	3	11	17	33	27	11	38	36.5%	54.981[a]	0.000
My organisation is actively seeking to use new data analytics (e.g. sociometric tools, artificial intelligence) to help employees and leadership improve employee performance.	2	4	3	19	38	27	11	38	36.5%	76.654[a]	0.000
My organisation is effectively developing the types of leaders who have the capabilities necessary to lead the organisation in a digital environment.	3	4	2	16	42	27	10	37	35.6%	89.712[a]	0.000
Our organisation has up-to-date digital technology to connect everyone in the organisation.	2	1	4	21	39	29	8	37	35.6%	90.385[a]	0.000
My organisation has sufficient talent to support our organization's digital business strategy.	3	2	4	21	37	35	2	37	35.6%	102.500[a]	0.000

Table 4.3 (Continued)

My organisation provides its employees with the resources and/or opportunities to develop skills and opportunities to thrive in a digital business environment.	2	1	3	17	45	24	12	36	34.6%	101.154[a]	0.000
Our organisation always use real time data across of the organisation in day to day management and planning.	5	3	2	20	38	27	9	36	34.6%	77.192[a]	0.000
My organisation needs to find the new leaders in order for the organization to succeed in the digital age.	3	1	13	18	35	26	8	34	32.7%	62.115[a]	0.000
We embedded advanced digital approaches across all communications.	4	1	8	17	41	23	10	33	31.7%	76.385[a]	0.000

Remark: 1: Don't know/ not sure 2: Strongly Disagree, 3: Mostly Disagree, 4: Slightly Disagree, 5: Slightly Agree, 6: Mostly Agree, 7: Strongly Agree

Based on Table 4.3, more than half of the respondents (57.7%) highly agreed on "Our leaders have the vision necessary to lead our digital business efforts". Besides, around half of the respondents highly agreed on "My organisation encourages new ideas to be shared and tested at all levels of the organisation". Moreover, more than half of the respondents (53.8%) highly agreed on "Digital reporting is always available and used strategically across team in our organisation". However, only 34.6% of respondents highly agreed on "Our organisation always use real time data across of the organisation in day to day management and planning".

The result of hypothesis testing on the pairwise comparison across respondent's attributes in "extent of agreement with the statements related to organisation's digital approaches" are reported in Table 4.4. Only those statements successful in rejection of the relevant null hypotheses of the Extension of Median Tests are shown in table 4.4 with their respective statistically significance ($p<0.05$).

Table 4.4: Rejected Null Hypothesis Extent of Agreement towards Statements Related to Organisation's Digital Approaches and Pairwise Comparison across Respondents' Attributes as Indicated.

Rejected Null Hypothesis	Sig.
The medians of "Our organisation has a clear and coherent digital business strategy." are the same between	
a) Role categories of	
i. Head of business units/Department-Manager/Senior Executive	0.024
The medians of "My organization scales successful initiative to drive digital transformation across the organisation." are the same between	

Table 4.4 (Continued)

a) Profession categories of		
i.	Architect-Engineer	0.000
ii.	Architect-Landscape architect	0.038
The medians of "My organization's management structure and practice (e.g. reporting relationships and decision-making processes) interfere with its ability to engage in digital business successfully." are the same between		
a) Profession categories of		
i.	Architect-Engineer	0.001
ii.	Charter Builder-Engineer	0.042
b) Role categories of		
i.	Head of business units/Department-Executive	0.013
ii.	Head of business units/Department-Manager/Senior Executive	0.001
iii.	Head of business units/Department-Board members/Directors/General Managers	0.022
c) Working experience categories of		
i.	Less than 2 years-2 to 5 years	0.013
The medians of "Our organisation is increasingly organised around cross-functional project teams, not necessary functions and divisions, to implement digital business priorities." are the same between		
a) Role categories of		
i.	Manager/Senior Executive-Head of business units/Department	0.002

Table 4.4 (Continued)

The medians of "My organisation is using digital technology essentially to do business in fundamentally new or different ways." are the same between		
a) Age group categories of		
i.	Less than 25 years old-25-30 years old	0.008
The medians of "My organisation encourages new ideas to be shared and tested at all levels of the organisation." are the same between		
a) Working experience categories of		
i.	More than 5 years-Less than 2 years	0.048
ii.	Less than 2 years-2 to 5 years	0.023
The medians of "My organisation effectively utilises the digital knowledge, skills, interest, and experience held by our employees." are the same between		
a) Age group categories of		
i.	Less than 25 years old-Above 30 years old	0.038
ii.	Less than 25 years old-25-30 years old	0.010

The results of Median Test and pairwise comparison of "extent of agreement on statements related to organisation's digital approached" reported in Table 4.4 are summarise below.

a) Our organisation has a clear and coherent digital business strategy

i. The respondents who are working as manager/ senior executive were more agreed (Median = 6.00) on *"Our organisation has a clear and coherent digital business strategy"* than the respondents who are working as a head of business units/ department (Median = 4.00).

b) My organization scales successful initiative to drive digital transformation across the organisation

i. The respondents who are working as an engineer were more agreed (Median = 6.00) on *"My organization scales successful initiative to drive digital transformation across the organisation"* than the respondents who are working as an architect and a landscape architect (Median = 5.00).

c) *My organization's management structure and practice (e.g. reporting relationships and decision-making processes) interfere with its ability to engage in digital business successfully*

i. The respondents who are working as an engineer and a charter builder were more agreed (Median = 6.00) on *"My organization's management structure and practice (e.g. reporting relationships and decision-making processes) interfere with its ability to engage in digital business successfully"* than the respondents who are working as an architect (Median = 5.00).

ii. The respondents who are working as board members/directors/general managers and manager/ senior executive were mostly agreed (Median = 6.00) on *"My organization's management structure and practice (e.g. reporting relationships and decision-making processes) interfere with its ability to engage in digital business successfully".* Besides, the respondents who are working as an executive were more agreed (Median = 5.00) on this statement than the respondents who are working as a head of business units/department (Median = 4.50).

iii. The respondents with 2 to 5 years of working experience were more agreed (Median = 6.00) on *"My organization's management structure and practice (e.g. reporting relationships and decision-making processes) interfere with its ability to engage in digital business successfully"* than the respondents with less 2 years of working experience (Median = 5.00).

d) *Our organisation is increasingly organised around cross-functional project teams, not necessary functions and divisions, to implement digital business priorities".*

   i. The respondents who are working as a head of business units/ department were more agreed (Median = 6.00) on *"Our organisation is increasingly organised around cross-functional project teams, not necessary functions and divisions, to implement digital business priorities"* than the respondents who are working as a manager/ senior executive (Median = 5.00).

e) *My organisation is using digital technology essentially to do business in fundamentally new or different ways*

   i. The respondents aged from 25 to 30 years old were more agreed (Median = 6.00) on *"My organisation is using digital technology essentially to do business in fundamentally new or different ways"* than the respondents aged below 25 years old (Median = 5.00).

f) *My organisation encourages new ideas to be shared and tested at all levels of the organisation*

   i. The respondents with less than 2 years and 2 to 5 years of working experience were more agreed (Median = 6.00) on "*My organisation encourages new ideas to be shared and tested at all levels of the organisation"* than the respondents with more than 5 years of working experience (Median = 5.00).

g) *My organisation effectively utilises the digital knowledge, skills, interest, and experience held by our employees.*

   i. The respondents aged from 25 to 30 years old were more agreed (Median = 6.00) on *"My organisation effectively utilises the digital knowledge, skills, interest, and experience held by our employees"* than the respondent aged below 25 and above 30 years old (Median = 5.00).

4.5 Perception towards the Importance of Technology to Organisation

Table 4.5 shows the results of perception towards the Importance of Technology to Organisation All the results obtained from Chi-Square tests are statistically significant. The results of “highly digitised” are the sum of “mostly important” and “very important”.

Table 4.5: Results of Perception towards the Importance of Technology to Organisation.

Statements	1	2	3	4	5	6	7	Highly Digitised (≥6)	(%)	Chi-square	Sig.
How importance is the following technology to your organization? [Internet of things (IoT)]	1	3	5	8	13	34	40	74	71.2%	99.538a	0.000
How importance is the following technology to your organization? [Mobile]	0	1	5	7	20	37	34	71	68.3%	69.077b	0.000
How importance is the following technology to your organization? [Analytics]	1	4	1	7	26	42	23	65	62.5%	100.346a	0.000
How importance is the following technology to your organization? [Social media]	1	5	3	9	25	33	28	61	58.7%	71.942a	0.000
How importance is the following technology to your organization? [Virtual reality]	1	10	6	11	21	39	16	55	52.9%	62.654a	0.000
How importance is the following technology to your organization? [Cognitive technology/Artificial Intelligence]	0	8	6	8	27	29	26	55	52.9%	35.038b	0.000

Table 4.5 (Continued)

How importance is the following technology to your organization? [Manufacturing/ warehouse robots]	3	19	7	13	16	33	13	46	44.2%	37.481a	0.000
7. How importance is the following technology to your organization? [Robotic process automation]	3	14	6	15	25	29	12	41	39.4%	35.731a	0.000
7. How importance is the following technology to your organization? [Additive manufacturing]	5	13	11	12	23	29	11	40	38.5%	27.250a	0.000

Remark: 1: I don't know what it is 2: Not Important, 3: Mostly Not Important, 4: Slightly Not Important, 5: Slightly Important, 6: Mostly Important, 7: Very Important

Based on Table 4.5, Majority of the respondents (71.2%) perceived that Internet of Things (IoT) is highly important to their organisation. The second highest (68.3%) technology that respondents perceived that it is highly important to their organisation is mobile technology. Moreover, around half of the respondents (52.9%) perceived that virtual reality and cognitive technology/ artificial intelligence are highly important to their organisation. The robotic process automation (39.4%) and additive manufacturing (38.5%) are least important to the practitioners.

The result of hypothesis testing on the pairwise comparison across respondent's attributes in "perception towards the importance of technology to organisation" are reported in Table 4.6. Only those statements successful in rejection of the relevant null hypotheses of the Extension of Median Tests are shown in table 4.6 with their respective statistically significance ($p<0.05$).

Table 4.6: Rejected Null Hypothesis Perception towards the Importance of Technology to Organisation and Pairwise Comparison across Respondents' Attributes as Indicated.

Rejected Null Hypothesis		Sig.
The medians of "How importance is the following technology to your organization? [Analytics]" are the same between		
a) Profession categories of		
i.	Quantity Surveyor- Landscape architect	0.042
ii.	Quantity Surveyor-Draughtsperson	0.042
iii.	Architect-Landscape architect	0.038
iv.	Architect-Draughtsperson	0.038
The medians of "How importance is the following technology to your organization? [Social media]" are the same between		
a) Organisation industry categories of		
i.	Consultancy-Construction business	0.003
ii.	Construction business-Development	0.004

Table 4.6 (Continued)

b) Profession categories of		
i.	Engineer-Architect	0.000
ii.	Quantity Surveyor-Architect	0.013
The medians of "How importance is the following technology to your organization? [Mobile]" are the same between		
a) Highest qualification categories of		
i.	Diploma-High school (e.g. A-Level, STPM, other post SPM certificate)	0.014
ii.	Bachelor degree/Advanced Diploma-High school (e.g. A-Level, STPM, other post SPM certificate)	0.017
iii.	Postgraduate (e.g. Master, PhD)-High school (e.g. A-Level, STPM, other post SPM certificate)	0.014
The medians of "How importance is the following technology to your organization? [Additive manufacturing]" are the same between		
a) Organisation industry categories of		
i.	Consultancy-Construction business	0.008
ii.	Consultancy-Development	0.025
The medians of "How importance is the following technology to your organization? [Virtual reality]" are the same between		
a) Working experience categories of		
i.	Less than 2 years-More than 5 years	0.047
ii.	2 to 5 years-More than 5 years	0.036

The results of Median Test and pairwise comparison of "Perception towards the Importance of Technology to Organisation" reported in Table 4.6 are summarise below.

a) How importance is the following technology to your organization? [Analytics]

i. The respondents who are working as a landscape architect and a draughtsperson perceived that analytics technology is more important to their organisation (Median = 7.00) than the respondents who are working as an architect and a quantity surveyor (Median = 6.00).

b) How importance is the following technology to your organization? [Social media]
   i. The respondents who are working in development firm perceived that social media is more important (Median = 6.50) than the respondents who are working in consultancy and construction firm (Median = 6.00).
   ii. The respondents who are working as an architect perceived that social media is very important to their organisation (Median = 6.50). On the other hand, the respondents who are working as a quantity surveyor perceived that social media is important (Median 6.00) than the respondents who are working as an engineer (Median = 5.00).

c) How importance is the following technology to your organization? [Mobile]
   i. The respondents which have highest qualification of high school perceived that mobile technology is very important (Median = 7.00) to their organisation. Moreover, the respondents which have the highest qualification of bachelor degree/ advanced diploma and postgraduate perceived that mobile technology is more important (Median = 6.00) than those who have highest qualification of diploma (Median = 5.00).

d) How importance is the following technology to your organization? [Additive manufacturing]
   i. The respondents who are working in development firm and construction firm perceived that additive manufacturing were

more important (Median = 6.00) than the respondents who are working in a consultancy firm (Median = 4.00).

e) How importance is the following technology to your organization? [Virtual reality]
   i. The respondents with 2 to 5 and more than 5 years of working experience perceived that virtual reality is more important (Median = 6.00) than the respondents with less than 2 years of working experience (Median = 5.00).

4.6 Knowledge on Digital Technology Practiced by Organisation

Table 4.6 shows the knowledge on technology implemented by organisation. All the results obtained from Chi-Square tests are statistically significant. The results of "highly digitised" are the sum of "using now" and "expect to use in 3 years".

Table 4.7: Results of Knowledge on Digital Technology Practiced by Organisation.

Statements	1	2	3	4	5	Highly Digitised (≥4)	(%)	Chi-square	Sig.
What technology has your company implemented to improve digital efficiency within teams across projects? [Using file-sharing tools (e.g. Dropbox, Google Drive, One Drive) to share and access drawings.]	0	5	2	5	92	97	93.3%	223.615[a]	0.000
What technology has your company implemented to improve digital efficiency within teams across projects? [Scheduling software]	5	5	7	14	73	87	83.7%	166.385[b]	0.000
What technology has your company implemented to improve digital efficiency within teams across projects? [Estimation software]	9	4	8	23	60	83	79.8%	102.250[b]	0.000

Table 4.7 (Continued)

What technology has your company implemented to improve digital efficiency within teams across projects? [BIM technology for 3D modelling]	4	5	13	16	66	82	78.8%	127.827[b]	0.000
What technology has your company implemented to improve digital efficiency within teams across projects? [Web conferencing for meetings]	10	9	18	23	44	67	64.4%	38.788[b]	0.000
What technology has your company implemented to improve digital efficiency within teams across projects? [VR/AR/MR]	15	16	15	40	18	58	55.8%	22.442[b]	0.000
What technology has your company implemented to improve digital efficiency within teams across projects? [Collision detection software]	15	13	19	28	29	57	54.8%	10.423[b]	0.034

Table 4.7 (Continued)

What technology has your company implemented to improve digital efficiency within teams across projects? [SaaS Construction software to manage the full process]	20	15	21	34	14	48	46.2%	12.250[b]	0.016
What technology has your company implemented to improve digital efficiency within teams across projects? [Drone technology]	11	22	25	22	24	46	44.2%	6.096[b]	0.192

Remark: 1: Do not know 2: No plan to use, 3: Expect to use in 5 years, 4: Expect to use in 3 years, 5: Using now

Based on the Table 4.7, majority of the respondents (93.3%) are using or expect to use file-sharing tools (e.g. Dropbox, Google Drive, One Drive) to share and access drawings in their organisation. Moreover, more than half of the respondents are using or expect to use VR/AR/MR (55.8%) and Collision detection software (54.8%) in 3 years. In addition, there are 20 number of respondents who don't know what SaaS Construction software is and only 46.2% of them are using or expect to use it in 3 years. Besides, there are only 44.2% of respondents are using or expect to use drone technology in 3 years.

The result of hypothesis testing on the pairwise comparison across respondent's attributes in "knowledge on digital technology practiced by organisation" are reported in Table 4.8. Only those statements successful in rejection of the relevant null hypotheses of the Extension of Median Tests are shown in table 4.8 with their respective statistically significance ($p<0.05$).

Table 4.8: Rejected Null Hypothesis Perception towards the Knowledge on Technology Implemented by Organisation and Pairwise Comparison across Respondents' Attributes as Indicated.

Rejected Null Hypothesis	Sig.
The medians of "What technology has your company implemented to improve digital efficiency within teams across projects? [Collision detection software]" are the same between	
a) Highest qualification categories of	
i. Postgraduate (e.g. Master, PhD)-Diploma	0.007
ii. Bachelor degree/Advanced Diploma-Diploma	0.006
b) Organisation industry categories of	
i. Consultancy-Construction business	0.001
ii. Development-Construction business	0.008
The medians of "What technology has your company implemented to improve digital efficiency within teams across projects? [Web conferencing for meetings]" are the same between	

Table 4.8 (Continued)

a) Role categories of		
i.	Executive-Head of business units/Department	0.024
ii.	Head of business units/Department-Manager/Senior Executive	0.001
The medians of "What technology has your company implemented to improve digital efficiency within teams across projects? [SaaS Construction software to manage the full process]" are the same between		
a) Profession categories of		
i.	Architect-Charter Builder	0.044
ii.	Architect-Engineer	0.002
The medians of "What technology has your company implemented to improve digital efficiency within teams across projects? [Drone technology]" are the same between		
a) Role categories of		
i.	Executive-Head of business units/Department	0.024
ii.	Head of business units/Department-Manager/Senior Executive	0.001
The medians of "What technology has your company implemented to improve digital efficiency within teams across projects? [VR/AR/MR]" are the same between		
a) Profession categories of		
i.	Quantity Surveyor-Engineer	0.001
ii.	Quantity Surveyor-Architect	0.014
iii.	Quantity Surveyor-Charter Builder	0.040
i.	Architect-Charter Builder	0.001
ii.	Engineer-Architect	0.028

The results of Median Test and pairwise comparison of "Knowledge on Technology Implemented by Organisation" reported in Table 4.8 are summarise below.

a) What technology has your company implemented to improve digital efficiency within teams across projects? [Collision detection software]
    i. Respondents who have highest qualification of diploma are most likely (Median = 5.00) to use collision detection software in the organisation; while the respondents who have highest qualification of postgraduate (Median = 3.50) and bachelor degree/ advanced diploma (Median = 4.00) are likely to use collision detection software in future.
    ii. Respondents who are working in a construction firm are most likely to use collision detection software (Median = 5.00). Moreover, the respondents who are working in development and consultancy firm are likely to use collision detection software in future (Median = 3.00).

b) What technology has your company implemented to improve digital efficiency within teams across projects? [Web conferencing for meetings]
    i. The respondents who are working as a manager are likely (Median = 4.00) to use web conferencing for meetings; while the respondents who are working as an executive and head of business units/ department are likely to use web conferencing for meetings in future (Median = 3.00).

c) What technology has your company implemented to improve digital efficiency within teams across projects? [SaaS Construction software to manage the full process]
    i. The respondents who are working as a charter builder are most likely (Median = 4.50) to use SaaS Construction software to manage the full process; while the respondents who are working as an architect (Median = 3.00) and engineer (Median = 4.00) are

likely to use SaaS Construction software to manage the full process in future.

d) What technology has your company implemented to improve digital efficiency within teams across projects? [VR/AR/MR]

i. The respondent who are working as a charter builder were likely to use VR/ AR/ MR now (Median = 5.00); while the respondents who are working as an architect and an engineer were likely to use VR/ AR/ MR in future (Median = 4.00). Moreover, the respondents who are working as a quantity surveyor were not likely (Median = 2.50) to use this technology in future.

4.7 Expectations and Experiences of Individual Encountered in the Workplace

Table 4.9 shows the results of extent of agreement towards statements related to organisation's digital approaches. All the results obtained from Chi-Square tests are statistically significant. The results of "highly digitised" are the sum of "mostly agree" and "strongly agree" the statement.

Table 4.9: Result of Expectations and Experiences of Individual Encountered in the Workplace.

Statements	1	2	3	4	5	6	7	Highly Digitised (≥6)	(%)	Chi-square	Sig.
I am interested in the opportunity to use new data analytics (e.g. artificial intelligence) to help me improve my performance.	2	2	9	12	27	26	26	52	50.0%	51.750[a]	0.000
I expect my job to change considerably over the next 3 to 5 years as a result of digital business trends.	3	1	3	13	32	34	18	52	50.0%	77.192[a]	0.000
It is important to me personally to work for an organisation that is a digital business leader.	2	1	14	9	26	34	18	52	50.0%	60.096 [a]	0.000
I am satisfied with how my organisation is helping me prepare for the changes necessary for working in a digital environment.	2	3	3	11	45	28	12	40	38.5%	104.385[a]	0.000

Table 4.9 (Continued)

I use digital technologies that are not provided or not supported by my organization to get my job done.	4	6	13	16	35	24	6	30	28.8%	51.75[a]	0.000

Remark: 1: Don't know/ not sure 2: Strongly Disagree, 3: Mostly Disagree, 4: Slightly Disagree, 5: Slightly Agree, 6: Mostly Agree, 7: Strongly Agree

The result of hypothesis testing on the pairwise comparison across respondent's attributes on "expectations and experiences of individual encountered in the workplace" are reported in Table 4.10. Only those statements successful in rejection of the relevant null hypotheses of the Extension of Median Tests are shown in table 4.10 with their respective statistically significance ($p<0.05$).

Table 4.10: Rejected Null Hypothesis Extent of Agreement towards Statements Related to Individual's Digital Approaches and Pairwise Comparison across Respondents' Attributes as Indicated.

Rejected Null Hypothesis	Sig.
The medians of "I am satisfied with how my organisation is helping me prepare for the changes necessary for working in a digital environment." are the same between	
a) Working experience categories of	
i. Less than 2 years-2 to 5 years	0.033
ii. Less than 2 years-More than 5 years	0.023
b) Age group categories of	
i. Less than 25 years old-25-30 years old	0.012
ii. Less than 25 years old-Above 30 years old	0.045
The medians of "I am interested in the opportunity to use new data analytics (e.g. artificial intelligence) to help me improve my performance." are the same between	
a) Working experience categories of	
i. More than 5 years-Less than 2 years	0.023
ii. More than 5 years-2 to 5 years	0.044
The medians of "I use digital technologies that are not provided or not supported by my organization to get my job done." are the same between	
a) Profession categories of	
i. Engineer-Architect	0.000

Table 4.10 (Continued)

ii.	Quantity Surveyor-Architect	0.000
b) Role categories of		
i.	Executive-Head of business units/Department	0.002
ii.	Manager/Senior Executive-Head of business units/Department	0.001
The medians of "I expect my job to change considerably over the next 3 to 5 years as a result of digital business trends." are the same between		
a) Working experience categories of		
i.	More than 5 years-Less than 2 years	0.006
ii.	More than 5 years-2 to 5 years	0.003
The medians of "It is important to me personally to work for an organisation that is a digital business leader." are the same between		
a) Working experience categories of		
i.	More than 5 years-Less than 2 years	0.003
ii.	More than 5 years-2 to 5 years	0.006

The results of Median Test and pairwise comparison of "extent of agreement on statements related to individual's digital approached" reported in Table 4.10 are summarise below.

a) *I am satisfied with how my organisation is helping me prepare for the changes necessary for working in a digital environment.*
   - *i.* The respondents with less than 2, 2 to 5 and more than 5 years of working experience were mostly agreed (Median = 5.00) on *"I am satisfied with how my organisation is helping me prepare for the changes necessary for working in a digital environment"*.
   - *ii.* The respondents aged below 25, 25 to 30 and above 30 years old were mostly agreed (Median = 5.00) on *"I am satisfied with how*

my organisation is helping me prepare for the changes necessary for working in a digital environment".

b) *I am interested in the opportunity to use new data analytics (e.g. artificial intelligence) to help me improve my performance.*

   i. The respondents with less than 2 and 2 to 5 years of working experience were more agreed (Median = 6.00) on *"I am interested in the opportunity to use new data analytics (e.g. artificial intelligence) to help me improve my performance"* than the respondents with more than 5 years of working experience (Median = 5.00).

c) *I use digital technologies that are not provided or not supported by my organization to get my job done.*

   i. The respondents who are working as an architect were more agreed (Median = 6.00) on *"I use digital technologies that are not provided or not supported by my organization to get my job done"* than the respondents who are working as an engineer (Median = 4.00); while the respondents who are working as a quantity surveyor were slightly agreed (Median = 5.00) on this statement.

   ii. The respondents who are working as head of business units/ department were more agreed (Median = 6.00) on *"I use digital technologies that are not provided or not supported by my organization to get my job done"* than the respondents who are working as an executive and a manager/ senior executive (Median = 5.00).

d) *I expect my job to change considerably over the next 3 to 5 years as a result of digital business trends.*

   i. The respondents with less than 2 and 2 to 5 years of working experiences were more agreed (Median = 6.00) on *"I expect my*

job to change considerably over the next 3 to 5 years as a result of digital business trends" than the respondents with more than 5 years of working experiences (Median = 5.00)

e) *It is important to me personally to work for an organisation that is a digital business leader*

i. The respondents with less than 2 and 2 to 5 years of working experience were more agreed (Median = 6.00) on *"It is important to me personally to work for an organisation that is a digital business leader"* than the respondents with more than 5 years of working experience (Median = 5.00).

4.8 Discussion

The following discussion is based on the findings reported in the previous sections. The findings are compared with the literature reviewed in Chapter 2 whenever relevant. The discussion is structured with three main themes, which include organisation's digital approaches, individual's digital approaches and readiness of digital transformation in Malaysian construction industry.

4.8.1 Organisation's Digital Approaches

a) Organisation's Digital Strategy

Less than half of the respondents were highly agreed that their organisation has clear and coherent digital business strategy (Table 4.3). This finding is concurred with the EY digital survey, which stated that only one out of four of the respondents perceived that they have clear digital strategy (Buisman, 2018). Besides, it has connection with the McKinsey Survey, which stated that most of the respondents perceived that the digital strategy in their organisation had not delivered improvement in sustainable performance (Koeleman, et al., 2019). This implied that most of the organisations do not have effective digital strategy. However the results shows that the 'manager/ senior executive' were more agreed that their organisation have clear and coherent digital business strategy as compared to their superior, i.e. head of business units/ department as referring

to Section 4.4(a)(i). It may due to misunderstand of the meaning of 'clear and coherent digital businesses strategy' by the 'manager/ senor executive'.

Moreover, only 39.4% of the respondents highly agreed that their organisation scales successful initiative to drive digital transformation (Table 4.3). This is concurred with the "Bauma Industry Barometer", which stated that only very few organisation consider themselves as digitalisation leader (Bauma, 2019). The engineers appeared to be more agreed than the architect on *"My organization scales successful initiative to drive digital transformation across the organisation"* (Section 4.4(b)(i)).

Nearly half of the respondents agreed that their organisation is increasingly organised around cross-functional project teams, not necessary functions and divisions, to implement digital business priorities. This is concurred with the "Bauma Industry Barometer", which mentioned that some organisation has begun their digitisation effort and rather be a latecomer (Bauma, 2019). However, the McKinsey Global Survey also mentioned that the success these effort is elusive (Boutetière, et al., 2018), which is identical to the analysis result. Based on Section 4.4(d)(i), the respondents who are working as a head of business units/ department tend to more agreed on "*our organisation is increasingly organised around cross-functional project teams, not necessary functions and divisions, to implement digital business priorities"*, while a manager/ senior executive were slightly agreed on this. It shows that a head of business units/ department (superior) perceived that their organisation is increasingly strengthen the digital strategy as compared to their subordinate. Unlike mentioned in the previous paragraph, the word 'strategy' may have been misunderstood by the subordinate as they tend to be more agreed that their organisation has clear and coherent digital business strategy as compared to their superior. This implies that the subordinate may not fully understand their organisation strategy, and thus they may not be able to see how far their superiors are seeing. In short, the superior perceived that the digital business strategy is unclear and uncoherent, but their organisation is increasingly improve their strategy to implement digital business priorities.

Furthermore, half of the respondents were highly agreed that their organisation encourages new ideas to be shared and tested at all levels of the organisation (Table 4.3). Although it has only half of the respondents agreed on

this, this strategy is considered highly implemented by organisation as compared to other strategies (Table 4.3). The respondents with less than 2 and 2 to 5 years of working experience were mostly agreed on this; while respondents with more than 5 years of working experience were slightly agreed on this (Section 4.4(f)(i)). It shows that there is a greater approval regarding their organisation encouraging new ideas to be shared and tested at all levels in younger generation.

b) Organisation's Digital Operation

Only 34.6% of the respondents were highly agreed that their organisation always use real time data across of the organisation in day to day management and planning (Table 4.3). This is concurred with the "LetsBuild's Construction Digital Maturity Ladder" (CDML) survey, whereby only minority of the practitioner report updates from site to office in a real time basic (Heiskanen, 2019).

Besides, less than half of the respondents were highly agreed that their organisation effectively utilises the digital knowledge, skills, interest, and experience held by their employees. The respondents aged from 25 to 30 years old were mostly agreed on this; while the respondent aged below 25 and above 30 years old were slightly agreed on this (Section 4.4(g)(i)).

Moreover, 44.2 % of the respondents highly agreed that their organization's management structure and practice (e.g. reporting relationships and decision-making processes) interfere with its ability to engage in digital business successfully. The engineer and charter builder were mostly agreed on this; while the architect slightly agreed on this. The board members/directors/general managers and manager/ senior executive were mostly agreed on this, while the respondents who are working as an executive were slightly agreed on this and the respondents who are working as a head of business units/department were slightly disagreed on this (Section 4.4(c)(i)). It shows there is a greater approval in respondents with 2 to 5 years of working experience towards this being implemented by their organisation as compared to respondents with less than 2 years of working experience.

Furthermore, less than half of the respondents highly agreed that their organisation is using digital technology essentially to do business in fundamentally new or different ways. The age group of "25 to 30 years old" was more agreed on this as compared to the age group of "below 25 years old" (Section 4.4(e)(i)). Only few of the organisations are adopting drone technology. This is opposed to the literature reviewed, which stated that drones are getting more common in construction industry (Radley, 2019). Besides, more than half of the respondents perceived that social media is highly important to their organization (Table 4.5). Section 4.5(b)(i) also reveals that the social media is more important for development firm as compared to consultancy and construction firms. This may due to the requirement of their works since development firm needs social media for their advertising strategy.

Moreover, around half of the respondents perceived that virtual reality is highly important to their organisation. The construction practitioners with 2 to 5 and more than 5 years of working experience perceived that virtual reality were more important than those practitioners with less than 2 years of working experience (Section 4.5(e)(i)). Another case can also be observed in discussion above, which mentioned that practitioners with 2 to 5 years working experience were more agreed on *"My organisation is using digital technology essentially to do business in fundamentally new or different ways".* This is because the age group of "25 to 30 years old" may have more working experience than the age group of "below 25 years old" and thus they are more familiar with the digital operation in their organisation.

Around half of the respondents are using or expect to use the collision detection software in the near future (Table 4.7). Section 4.6(a)(ii) shows that construction firms were more likely to have adopted this technology as compared to development and consultancy firm. Another case that shows the adoption of digital technology in construction firm is higher than others can be observed from Section 4.6(c)(i). It reveals that the charter builder are adopting or expect to adopt SaaS Construction Software in near future to manage the full process.

4.8.2 Individual's Digital Approaches

a) Individual's Digital Vision

The respondents with less than 2 and 2 to 5 years working experience have stronger digital vision as compared to the respondents with more than 5 years of working experience (Section 4.9). The younger generation are more interested in the opportunity to use new data analytics (e.g. artificial intelligence) to improve their performance. However, only few Malaysian construction organisation are actively seeking to use artificial intelligence. They expect their job to change considerably over the next 3 to 5 years as a result of digital business trends regardless of their organisation's current digital practices. This is concurred with the McKinsey survey, which stated that only few E & C firm are capable of implementing the artificial intelligence technology despite its benefits is proven (Blanco, et al., 2018). Moreover, the younger generation also perceived that it is important to work for an organisation that is a digital business leader.

b) Individual's Digital Action

Only 28.8% of the respondents were highly agreed that they are using digital technologies that are not provided or not supported by my organization to get their job done (Table 4.9). Section 4.7(c)(i) reveals that architect were more likely to use digital technologies that are not provided or not supported by their organisation to get their job done as compared to engineer and quantity surveyor. This shows that the architect is adopting digital technologies regardless of whether there is a strong digital approach in their organisation. Moreover, the 'head of business units/ department were more likely to use digital technologies that are not provided or not supported by their organisation to get their job done as compared to their subordinate.

4.8.3 Readiness of Digital Transformation in Organisation Practice and Individual perception in Malaysian Construction Industry

Overall, Section 4.4 (Organisational practice) and 4.7 (Individual perception) concludes that the Malaysian construction industry have stronger digital visions as compared to digital strategies, operations and actions. This implied that they

are aware of the digital disruption in their organisation. This is concurred with the EV digital survey, which mentioned that most of the respondents perceived that digital solutions are critical in future and likely to be transformative to their business (Buisman, 2018). They are agree that their leaders have the vision necessary to lead their digital business efforts (Section 4.4). They perceived that they don't need to find the new leaders in order for the organization to succeed in the digital age. However, this doesn't implies that Malaysian construction industry are ready for the digital transformation by having only digital vision solely. The other approaches such as digital strategies, operations and actions should not be overlooked. This may due to the challenges such as cost and few characteristics of construction industry that caused the digitalisation in construction industry more challenging (Culbert, 2019, Radley, 2019, Koeleman, et al., 2019).

The Section 4.7 (Individual perception) shows the similar situation as Section 4.4 (Organisational practice), whereby the digital vision are stronger than other approaches. They are interested to use new data analytics (e.g. artificial intelligence) and expect their job to change considerably over the next 3 to 5 years as a result of digital business trends. They also perceived that it is important to work for an organisation that is a digital business leader. In short, Malaysian construction practitioners are aware of the digital trend in industry. However, they are currently not ready in terms of digital strategies, operations and actions due to challenges faced.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

The accomplishment of research objectives is outlined in the following Section 5.2. The contribution of this research is presented as research implications in Section 5.3. The reflection of research limitations is outlined in Section 5.4 and further studies are recommended in Section 5.5.

5.2 Accomplishment of Research Objectives

The brief account of digital transformation, its essential elements, digital maturity and challenges encountered in construction industry are synthesised from publish literature and world-well-known research institution such as McKinsey Global Institute, The B1M, BIM Plus, LetsBuild, etc. A theoretical framework of digital transformation in construction industry was developed from the literature reviewed as summarised in Figure 2.1. It has identified a total of four number of essential elements of digital construction, which are artificial intelligence, big data, connectivity and digital applications. This is the attainment of the first research objective.

The research findings revealed that the organisation and individual levels in the Malaysian construction industry are aware of digital transformation, which is what the second objective of this research plan to establish. Most of the organisation are satisfied with the leaders and perceived that their leaders have strong digital vision necessary to lead the digital business efforts. Moreover, most of the organisation are planning to invest in digital business initiatives in future. The practitioners with lesser working experience tend to expect their work to change considerably as a result of digital business trends. Besides, the younger generation is more interested in novel digital technology. They expect their organisation to provide opportunities to develop new skills through on-the-job learning and training. However, most of the age group of respondents are only slightly satisfied with how organisation is helping them prepare for the changes necessary. Moreover, the head of business units

department perceived that their organisation does not have clear and coherent digital business strategy

In answering to the third research objectives of this study, the deeper analysis of this research revealed that younger generation tend to be more agreed that their organisation is using digital technology essentially and encouraging new ideas to be shared to do business in fundamentally new or different ways. The younger generation also tend to be more appreciated with the opportunity in using new data analytics (e.g. artificial intelligence) to improve their work. Although only less than one-third of organisations provide its employees with the resources or opportunities to develop skills at the moment, but the younger generation are optimistically to expect their job will change considerably over the next 3 to 5 years as a result of digital business trends. Besides, this generation thinks that it is important for them to work for an organisation that is a digital business leader. However, the findings show that most of the organisation is not effectively developing the types of leaders who have the capabilities necessary to lead the organisation in a digital environment. The findings also discovered that the engineers perceived that their organisation have scaled successful initiative to drive the digital transformation across their organisation. Moreover, the engineers and practitioners with two to five years working experience also perceived that their organisation's management structure and practice (e.g. reporting relationships and decision-making processes) interfere with its ability to engage in digital business successfully. The findings also revealed that the architects are using the digital technologies that are not provided or not supported by their organization to get the job done. This may implies that their organisations do not have sufficient up-to-date digital technologies.

In conclusion, the younger generation in the Malaysian construction industry is ready for the digital transformation; while the older generation is not. Both organisation and individual levels are aware towards digital transformation, especially within the younger age practitioners. They are aware of the disruption caused by the digital transformation and expect to change to cope with digital business trends. Most of the organisations have scaled digital initiatives, but there is still room for improvement. Among all the professions, the engineer is ahead of others in implementing digital initiatives. Besides, most of the organisations do not have sufficient up-to-date digital skills or technologies in

day to day operations. One of the reasons that caused this situation is the organisation is yet to investing in digital technology. Most of the organisations have not budgeted for their digital transformation and which indicates that digital initiatives are yet to be a core part of the business strategy. However, most of the organisations are expecting to implement the digital technologies such as drone, virtual reality and augmented reality in the near future. The Figure 5.1 summarises the key findings of this research.

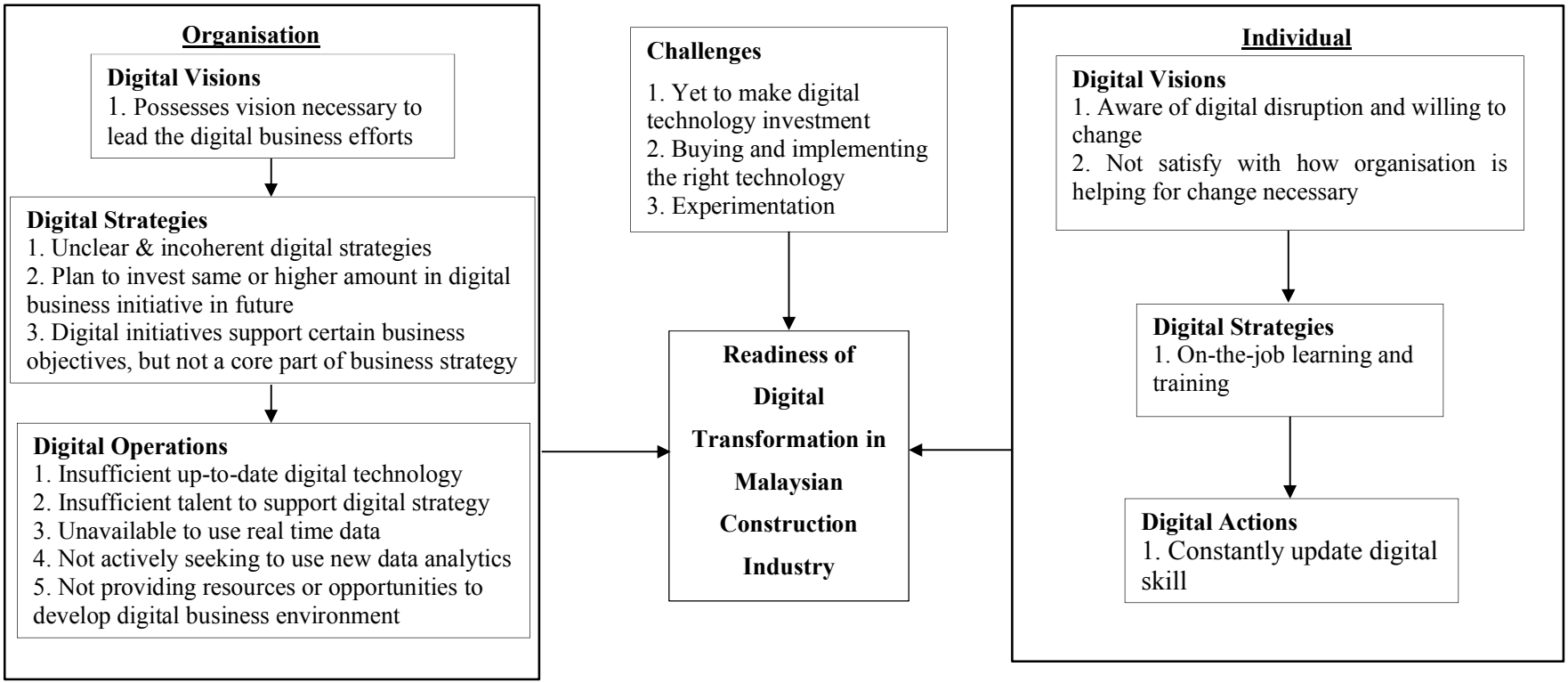

Figure 5.1: Summary of Key Findings.

5.3 Research Implications

This study provides an empirical account on the digital transformation in the Malaysian construction industry. From the overall findings, at the moment, Malaysian construction industry is yet to transform into highly or fully digital business environment although the awareness of need to change is there. The findings show that younger generation tends to more aware of the digital disruption and expect to cope with the change. Among all the professions, the engineer is ahead of others in digital practice across their organisation. Hopefully, this finding will alert the other professions in Malaysia such as architect, quantity surveyor and charter builder to wake up and be prepare to cope with the digital business trend. Construction industry involves with multi-discipline professions and multi-stakeholders supply chain. It needs the change in all parties concerned for new digital business model. The finding also shows that some architects are using the digital technologies that are not provided by their organization to get their job done. It shows the lack of investment in the digital technology.

The progress of digital transformation in construction industry is slow as compares to other industries (Ismail, 2019). Based on the findings, most of the construction practitioners are aware of the digital business trend and willing to change to cope with the disruption. However, they are yet to make digital technology investment. The policymakers need to understand the issues faced by the industry practitioners, to remove the hindrance and provide incentive to enable the digital transformation of the industry. The professional institute such as RICS, CIDB, PAM, IEM and BQSM to draft strategies on how to have the long term digital plan for their respective professions.

The overview of the current status of the readiness on digital transformation in Malaysian construction industry provided thresholds for the researchers to conduct research by focusing on more precise scope such as big data, block chain, artificial intelligence and machine learning in the industry.

5.4 Research Limitation

One of the potential issues in this study may arise from the misunderstanding of the respondents on what digital construction is. Therefore, some of the construction practitioners approached were not confident to take part in the

study because of concern that Digital Construction is a novel knowledge and hence caused the poor participation rate of the survey. The sample size determination is based on the Central limit theorem (CLT), whereby the data obtained is reasonably accurate if number of samples equal or greater than 30 as stated in Chapter 3. However, the distribution of the respondents may not reflect the actual profile of the population in the industry. Those groups with less than 30 respondents such as 'charter builder' and 'others' in profession categories are not sufficient to represent their respective group for testing of difference between the different groups. Moreover, the digital business is developed at the speed of difficult to be keeping up to date. Therefore, the questionnaire designed may not cover the latest digital aspects and approaches.

5.5 Research Recommendations

A qualitative research may be conducted to analyse the readiness of digital transformation in Malaysian construction industry in future to overcome the shortcoming of the quantitative research. There may be some undetected factors regarding the digital trend which was not included when designing the questionnaire can be obtained through interview. Besides, a narrower scope of research may be defined such as specific digital technology or operation in construction site or indoor working office to obtain more specific information. This will help the researcher to focus on more specific topics in future research. Meanwhile, more rich contents can be obtained from the qualitative interviews.

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APPENDICES

APPENDIX A: Survey Questionnaire

Readiness of Digital Transformation in the Malaysian Construction Industry

Dear Sir/ Madam,

I am a final year undergraduate student pursuing Bachelor of Science (Hons.) Quantity Surveying in University Tunku Abdul Rahman (UTAR). I am currently conducting a research on "Readiness of Digital Transformation in the Malaysian Construction Industry". It would be appreciated if you could spare 15-30 minutes to answer the following questionnaire survey. You are being assured that all the information collected are treated as private and confidential and will be strictly used for this research only. Should you have any further queries, please do not hesitate to contact me at leekebin97@gmail.com.

Thank you.

Yours faithfully,
Lee Ke Bin

1. Email address

Section A1: Organisation's Digital Vision

Please indicate the degree to which you agree or disagree with the following statements:

1. Our leaders have the vision necessary to lead our digital business efforts.

- ◯ Strongly Agree
- ◯ Mostly Agree
- ◯ Slightly Agree
- ◯ Slightly Disagree

- Mostly Disagree
- Strongly Disagree
- Don’t know/not sure

2. My organisation needs to find the new leaders in order for the organization to succeed in the digital age.

- Strongly Agree
- Mostly Agree
- Slightly Agree
- Slightly Disagree
- Mostly Disagree
- Strongly Disagree
- Don’t know/not sure

Section A2: Organisation's Digital Strategy

3. Our organisation has a clear and coherent digital business strategy.

- Strongly Agree
- Mostly Agree
- Slightly Agree
- Slightly Disagree
- Mostly Disagree
- Strongly Disagree
- Don’t know/not sure

4. Digital transformation is a top management priority at my organisation.

- Strongly Agree
- Mostly Agree
- Slightly Agree
- Slightly Disagree
- Mostly Disagree
- Strongly Disagree
- Don’t know/not sure

5. My organization scales successful initiative to drive digital transformation across the organisation.

- Strongly Agree
- Mostly Agree
- Slightly Agree
- Slightly Disagree
- Mostly Disagree
- Strongly Disagree
- Don’t know/not sure

6. Our organisation is increasingly organised around cross-functional project teams, not necessary functions and divisions, to implement digital business priorities.

- Strongly Agree
- Mostly Agree
- Slightly Agree
- Slightly Disagree
- Mostly Disagree
- Strongly Disagree
- Don’t know/not sure

7. My organisation encourages new ideas to be shared and tested at all levels of the organisation.

- Strongly Agree
- Mostly Agree
- Slightly Agree
- Slightly Disagree
- Mostly Disagree
- Strongly Disagree
- Don’t know/not sure

8. My organisation encourages feedback and interaction to learn how to work in new ways.

- Strongly Agree

- Mostly Agree
- Slightly Agree
- Slightly Disagree
- Mostly Disagree
- Strongly Disagree
- Don’t know/not sure

Section A3: Organisation's Digital Operations

9. My organization’s management structure and practice (e.g. reporting relationships and decision-making processes) interfere with its ability to engage in digital business successfully.

- Strongly Agree
- Mostly Agree
- Slightly Agree
- Slightly Disagree
- Mostly Disagree
- Strongly Disagree
- Don’t know/not sure

10. My organisation is using digital technology essentially to do what we have always done, but faster and cheaper.

- Strongly Agree
- Mostly Agree
- Slightly Agree
- Slightly Disagree
- Mostly Disagree
- Strongly Disagree
- Don’t know/not sure

11. Our organisation has up-to-date digital technology to connect everyone in the organisation.

- Strongly Agree
- Mostly Agree
- Slightly Agree

- Slightly Disagree
- Mostly Disagree
- Strongly Disagree
- Don’t know/not sure

12. My organisation is using digital technology essentially to do business in fundamentally new or different ways.

- Strongly Agree
- Mostly Agree
- Slightly Agree
- Slightly Disagree
- Mostly Disagree
- Strongly Disagree
- Don’t know/not sure

13. My organisation has sufficient talent to support our organization’s digital business strategy.

- Strongly Agree
- Mostly Agree
- Slightly Agree
- Slightly Disagree
- Mostly Disagree
- Strongly Disagree
- Don’t know/not sure

14.My organisation effectively utilises the digital knowledge, skills, interest, and experience held by our employees.

- Strongly Agree
- Mostly Agree
- Slightly Agree
- Slightly Disagree
- Mostly Disagree
- Strongly Disagree
- Don’t know/not sure

15. My department or team is working or starting to work with advanced collaborative tools instead of email to facilitate better communication.

- Strongly Agree
- Mostly Agree
- Slightly Agree
- Slightly Disagree
- Mostly Disagree
- Strongly Disagree
- Don't know/not sure

16. We embedded advanced digital approaches across all communications.

- Strongly Agree
- Mostly Agree
- Slightly Agree
- Slightly Disagree
- Mostly Disagree
- Strongly Disagree
- Don't know/not sure

17. My department or team uses technology to get work done more effectively than our organisation does as a whole.

- Strongly Agree
- Mostly Agree
- Slightly Agree
- Slightly Disagree
- Mostly Disagree
- Strongly Disagree
- Don't know/not sure

18. Our organisation always use real time data across of the organisation in day to day management and planning.

- Strongly Agree
- Mostly Agree
- Slightly Agree

- Slightly Disagree
- Mostly Disagree
- Strongly Disagree
- Don't know/not sure

19. Digital reporting is always available and used strategically across team in our organisation.

- Strongly Agree
- Mostly Agree
- Slightly Agree
- Slightly Disagree
- Mostly Disagree
- Strongly Disagree
- Don't know/not sure

20. My organisation is effectively developing the types of leaders who have the capabilities necessary to lead the organisation in a digital environment.

- Strongly Agree
- Mostly Agree
- Slightly Agree
- Slightly Disagree
- Mostly Disagree
- Strongly Disagree
- Don't know/not sure

21. My organisation is actively seeking to use new data analytics (e.g. sociometric tools, artificial intelligence) to help employees and leadership improve employee performance.

- Strongly Agree
- Mostly Agree
- Slightly Agree
- Slightly Disagree
- Mostly Disagree
- Strongly Disagree

- Don’t know/not sure

22. My organisation provides its employees with the resources and/or opportunities to develop skills and opportunities to thrive in a digital business environment.

- Strongly Agree
- Mostly Agree
- Slightly Agree
- Slightly Disagree
- Mostly Disagree
- Strongly Disagree
- Don’t know/not sure

Section A4: Organisation's Digital Challenges

23. Funding digital initiatives is a significant challenge that affects my organization’s digital efforts.

- Strongly Agree
- Mostly Agree
- Slightly Agree
- Slightly Disagree
- Mostly Disagree
- Strongly Disagree
- Don’t know/not sure

Section B1: Organisation's Digital Vision

To the best of your knowledge which of the following statements best described the digital involvement of your current company.

1. How would you characterise your organisation’s efforts to develop as a digital business?

- Don’t know/not sure
- Non-participant
- Laggard
- Slow Adopter

- ◯ Mainstream
- ◯ Fast follower
- ◯ Leader

2. How would you characterise the outcome of digital business initiatives in your organisation to date?

- ◯ Don't know/not sure
- ◯ Very unsuccessful
- ◯ Unsuccessful
- ◯ Neither successful nor unsuccessful
- ◯ Successful
- ◯ Very successful

3. When do you expect your organisation will get the most value out of its digital initiatives?

- ◯ Don't know/not sure
- ◯ My organization currently has no digital initiative underway
- ◯ In more than 5 years
- ◯ In 3-5 years
- ◯ In the next 1-2 years
- ◯ We already are realizing/ have realised the value of our digital initiatives.

Section B2: Organisation's Digital Strategy

4. Is your organisation planning to invest a higher/lower amount in digital business initiatives in the next 1-2 years?

- ◯ Significantly increasing
- ◯ Increasing
- ◯ About the same
- ◯ Decreasing
- ◯ Significantly decreasing
- ◯ Don't know/ not sure

5. The purpose of my organisation's digital initiatives is to

◯ Mainly exploit existing organisational competencies

◯ Exploit existing competencies more than explore new ways of doing business

◯ Exploit existing competencies and explore new ways of doing business equally

◯ Explore new ways of doing business more than exploit existing competencies

◯ Mainly explore new ways of doing business

◯ Don't know/not sure

6. When my organisation implements digital business initiative, they tend to start as:

◯ Mostly small experiments

◯ Mostly big enterprise wide efforts

◯ Both small experiments and big enterprise-wide efforts

◯ Not applicable /my organisation is not implanting digital business

◯ Don't know/not sure

7. How would you best characterize the primary role of digital business within your organisation?

◯ Digital initiatives are a core part of our organisation's business strategy

◯ Digital initiatives support certain business objectives, but they are not a core part of our business strategy

◯ Digital initiatives are used in our organization, but the business objectives aren't always clear

◯ We talk about digital business more than actually doing anything about it

◯ Our organisation does not pay much attention to digital business

◯ Don't know/ not sure

8. My organisation primarily drives digital business adoption and engagement internally through:

◯ Cultivating a strong digital business culture that strives for risk taking, collaboration, agility, and continuous learning

- ◯ Expecting employees to be motivated to embrace digital business opportunities
- ◯ Mandating from management
- ◯ Providing career advancement opportunities for those who participate
- ◯ Including in performance review
- ◯ Recognition
- ◯ Providing financial incentives
- ◯ My organization doesn't encourage digital adoption and engagement
- ◯ Other:

Section B3: Organisation's Digital Operations

9. How importance is the following technology to your organization?

	Very important	Mostly Important	Slightly Important	Slightly Not Important	Mostly Not Important	Not important	I don't know what it is
Analytics							
Social media Mobile							
Internet of things (IoT)							
Cognitive technology/Artificial Intelligence							
Robotic process automation							
Additive manufacturing							
Virtual reality							

Manufacturing/ warehouse robots							

10. How frequent collaboration is done through these channels in your organization?

	Always	Mostly	Sometimes	Rarely	Very Rare	Not at All	I don't know what it is
Email							
Scheduled, in-person local meetings							
Conference calls							
Video conferences							
Non-scheduled, in person local meetings							

Travel for in-person meetings							
Social media platform							

11. What technology has your company implemented to improve digital efficiency within teams across projects?

	Using now.	Expect to use in 3 years.	Expect to use in 5 years.	No plan to use.	Do not know
Using file-sharing tools (e.g. Dropbox, Google Drive, One Drive) to share and access drawings.					
Scheduling software					
Estimation software					
BIM technology for 3D modelling					

Collision detection software					
Web conferencing for meetings					
SaaS Construction software to manage the full process					
Drone technology					
VR/AR/MR					

12. Imagine an idea organisation in the Digital Age will utilise digital technologies and capabilities to improve its operations, engage talent across the organisation, interacting others in the industries, and drive new ways of doing business. How close is your organisation to that idea?

	1	2	3	4	5	6	7	8	9	10	
Not at All	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	Very Close

Section B4: Organisation's Digital Challenges

13. What is the biggest challenge impacting your organisation's ability to compete more effectively in a digital environment?

◯ Experimentation (getting people to take risks and work in a more agile way)
◯ Ambiguity and constant change
◯ Buying and implementing the right technology
◯ Distributed decision-making
◯ Transparency and democratization of information
◯ Fluidity in organizational structures
◯ Multigenerational workforce issues
◯ Transient and rapidly changing team structures
◯ Workforce augmentation (e.g. robotics, automation, artificial intelligence)
◯ Segmentation of customer bases
◯ Other:

Section C1: Individual's Digital Vision

Please indicate the degree to which you agree or disagree with the following statements:

1. I am interested in the opportunity to use new data analytics (e.g. artificial intelligence) to help me improve my performance.

◯ Strongly agree
◯ Mostly agree
◯ Slightly agree
◯ Slightly disagree
◯ Mostly disagree

- ◯ Strongly disagree
- ◯ Don’t know/not sure

2. I expect my job to change considerably over the next 3 to 5 years as a result of digital business trends.

- ◯ Strongly agree
- ◯ Mostly agree
- ◯ Slightly agree
- ◯ Slightly disagree
- ◯ Mostly disagree
- ◯ Strongly disagree
- ◯ Don’t know/not sure

3. It is important to me personally to work for an organisation that is a digital business leader.

- ◯ Strongly agree
- ◯ Mostly agree
- ◯ Slightly agree
- ◯ Slightly disagree
- ◯ Mostly disagree
- ◯ Strongly disagree
- ◯ Don’t know/not sure

4. I am satisfied with how my organisation is helping me prepare for the changes necessary for working in a digital environment.

- ◯ Strongly agree
- ◯ Mostly agree
- ◯ Slightly agree
- ◯ Slightly disagree
- ◯ Mostly disagree
- ◯ Strongly disagree
- ◯ Don’t know/not sure

Section C2: Individual's Digital Action

5. I use digital technologies that are not provided or not supported by my organization to get my job done.

- ◯ Strongly agree
- ◯ Mostly agree
- ◯ Slightly agree
- ◯ Slightly disagree
- ◯ Mostly disagree
- ◯ Strongly disagree
- ◯ Don’t know/not sure

Section D1: Individual's Digital Strategies

Please select which of the following statements best described about yourself.

1. Please describe the most important opportunities your organisation provides you to develop new skills for a digital environment.

- ◯ Training
- ◯ On-the-job learning
- ◯ Continuing education
- ◯ Workplace environment
- ◯ Ecosystem and networks
- ◯ Limited/none
- ◯ Other:

Section D2: Individual's Digital Action

2. How often do you need to update your skills to do your job effectively in a digital environment?

- ◯ Continually Once every 1-3 months
- ◯ Once every 6 months
- ◯ Once every year
- ◯ Once every few years
- ◯ I don’t need to update my skills to do my job well
- ◯ Don’t know /not sure
- ◯

Section E: Respondent's Profile

1. Which best describes your organisation's industry?

- ◯ Development
- ◯ Construction business
- ◯ Consultancy
- ◯ Building materials merchants
- ◯ Machinery renting, hiring and selling
- ◯ Other:

2. Which of the following best describes your profession?

- ◯ Architect
- ◯ Engineer
- ◯ Quantity Surveyor
- ◯ Charter Builder
- ◯ Other:

3. Which of the following best describes your role?

- ◯ CEO/President/Managing Director
- ◯ Board members/Directors/General Managers
- ◯ Head of business units/Department
- ◯ Manager/Senior Executive
- ◯ Executive
- ◯ Other:

4. How long is your working experience in construction industry?

- ◯ Less than 2 years.
- ◯ 2 to 5 years.
- ◯ 5 to 10 years.
- ◯ 10 to 20 years.
- ◯ More than 20 years.

5. What is your highest qualification?

- ◯ Postgraduate (e.g. Master, PhD)
- ◯ Bachelor degree/Advanced Diploma

- ◯ Diploma
- ◯ High school (e.g. A-Level, STPM, other post SPM certificate)
- ◯ Other:

6. Which of the following age groups you belong to?

- ◯ Less than 25 years old.
- ◯ 25-30 years old.
- ◯ 30-35 years old.
- ◯ 35-40 years old.
- ◯ 40-50 years old.
- ◯ More than 50 years old.