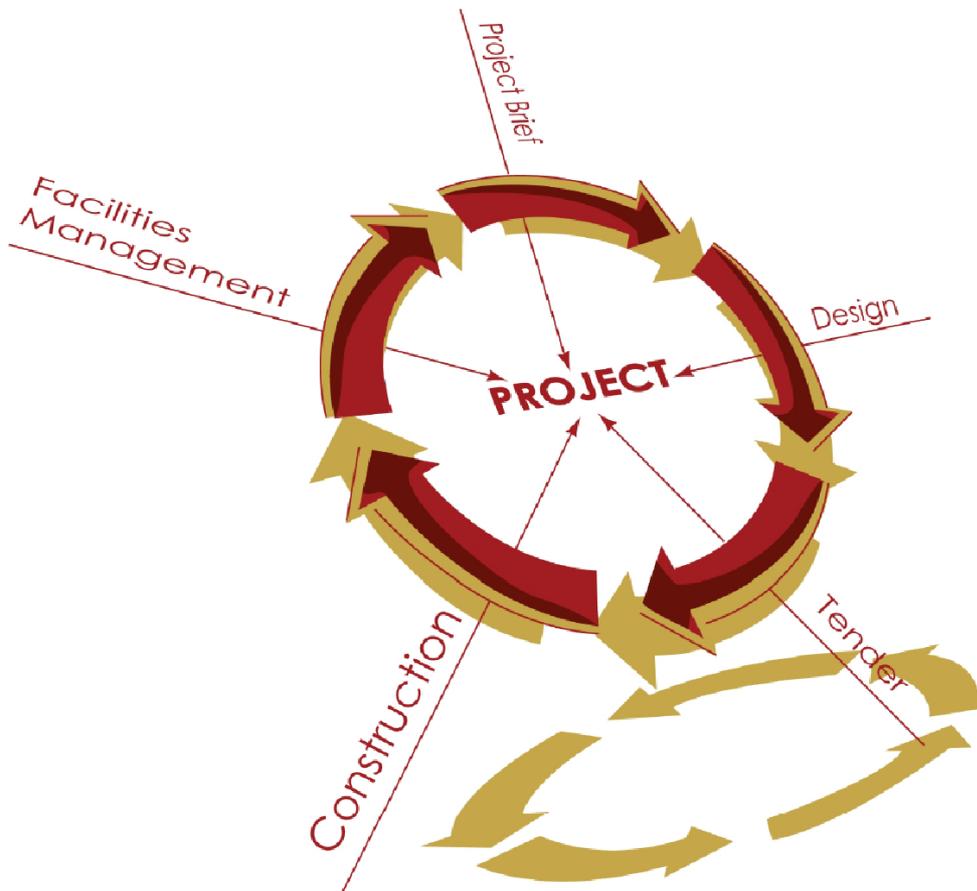


# Malaysian Construction Research Journal

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# **MALAYSIAN CONSTRUCTION RESEARCH JOURNAL (MCRJ)**

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## Introduction

Welcome to the Malaysian Construction Research Journal (MCRJ) special issue in conjunction with the RISM International Research Conference 2021 (RISM-IRC2021). This conference has been jointly organized by the Royal Institution of Surveyors Malaysia (RISM) and University College of Technology Sarawak (UCTS).

The objectives of RISM-IRC2021 are to (i) provide a forum for open dialogue amongst postgraduates and researchers in the region on contemporary surveying and environmental issues and challenges ahead, (ii) provide postgraduates and researchers a networking opportunity with those from other institutions who have common interests and career paths, (iii) generate awareness on current issues and challenges in the construction and property sectors, and (iv) provide an out-reach platform for potential employers to talent-scout potential employees.

The construction industry, as a significant growth driver of the economy, has been very much affected by the outbreak of Covid-19 pandemic. It is vital for the construction industry to maintain its productivity at a reasonable rate in ensuring a sustainable future for its players. In line with this, the organizing committee has decided the theme as “New Norm: Maneuvering Towards Sustainable Future”. The five (5) sub-themes of this conference are Innovation, Technology & Engineering, Green & Sustainability, Quality, Safety & Productivity, Professional Practice & Management, and Education.

Through this conference, much of new findings and solutions on surveying, construction and environmental issues have been produced by the researchers. This special issue has included twenty (20) papers reviewed by the conference scientific committee and international reviewers. It is anticipated that the works included in this special issue will lead to a better understanding of the new norm, thereby, contributing to preparing our built environment towards a sustainable future.

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# Editorial

## Welcome from the Editors

Welcome to the Malaysian Construction Research Journal (MCRJ) special issue in conjunction with the RISM International Research Conference 3.0 (RISM IRC 3.0). We would like to express our sincere gratitude to our contributing authors, reviewers, organizers and readers.

This Special Issues of MCRJ for the RISM IRC 3.0 contains twenty (20) interesting papers covering the theme of “New Norm: Maneuvering Towards Sustainable Future” with five (5) sub-theme: Innovation, Technology and Engineering, Green and Sustainability, Professional, Practice and Management, Quality, Safety and Productivity and Education. It is hoped that the readers would greatly benefit from the scientific content and quality of papers published in this issue:

Brief introduction of each article is given as hereunder:

**Nurshuhada Zainon et al.**, have presented on approach in the production of bioplastic feedstock through a community-driven effort in home-based settings. With this concern, this study aims to identify design criteria of the bioplastic feedstock processing system construction by proposing potential spaces in a residential building that can potentially be utilized. Potential spaces in the residential building were proposed and the consensus on the best approach was agreed between bioplastic scientists and the built environment experts via a focus group platform. The findings revealed that ventilation, aeration, temperature, safety, and pH are the key requirements for construction criteria resulting to spaces that can potentially accommodate the bioplastic processing which includes the backyard area, exterior wall and indoor spaces. This research provides a new academic perspective to explore the new construction project on mixed development of the residential building and light industrial. It also helps in laying a foundation for further research in bioplastic feedstock processing intervention from the built environment perspective.

**Noraziah Wahi et al.**, have explored on crime prevention through environmental design (CPTED) is a prevalent urban planning method to avert crime and extenuate fear of crime through the enhancement of physical surroundings. This paper are to evaluate the level of awareness towards CPTED among the construction stakeholders and to study the benefit of implementing CPTED in construction projects. The outcome of the study had suggested that the construction players were not aware of the CPTED concept due to the lack of exposure from authority, lack of knowledge, and expertise in particular area. Even though the construction players have not recognized the principles of the CPTED, most of them had implemented the concept of CPTED in their previous projects. CPTED should be enforced in the construction industry to decrease the crime rate and fear of crime. Therefore, the research results are meaningful to improve the awareness level towards CPTED among construction players.

**Shazmin Shareena Ab. Azis et al.**, have focused on Green roofs to be one of the solutions in combating environmental issues due to the rapid urbanization such as urban heat island effect and stormwater runoff mitigation. This study aims to align the implementation of green roof and the perceive benefit of green roof among green building architects in Malaysia. The study found that green roof is more suitable to be implement on parking lot roof for social benefit while implementation on other building structure placement is more suitable for economic and environmental benefit. This paper is significant for future references and building owner in determining the most effective placement for green roof.

**David Finnie et al.**, have explored the Two-stage early contractor involvement (2S-ECI) provides a procurement pathway for involving contractors typically after concept design, with pricing based on preliminary and general costs and agreed margins applied to subcontractors. Then parties can work together to develop the design with contractor's buildability input, select subcontractors and agree what is typically a fixed price construction contract. This research explores the challenges and benefits of 2S-ECI in New Zealand through a case study using semi structured interviews with the project team on an airport alteration and seismic strengthening project. The project team consisted of a project manager, engineers, contractor's quantity surveyor and professional quantity surveyor (PQS). Findings build on the body of knowledge to help inform parties considering adopting 2S-ECI on their projects. In particular, the ability to de-risk projects involving continued client operations during the construction stage, and the need for contractual documentation to support 2S-ECI.

**Sylvia Gala Mong et al.**, have presented the preliminary research in developing the standard maintenance management framework. One of the components of the framework is improvement tools that aims to assessing and improving the current maintenance practices which can inform the local authorities of their maintenance performance so that possible actions for improvement could be taken. The methodology adopted is systematic literature review to examine the significant impacts on their management through multiple published research relevant to the use of the maturity model within different industries. Through the comparisons on different industries and maintenance management practices, the maturity model is seen to be beneficial in assessing and improving the organisation's performance and management. In conclusion, it will enable local authorities in creating competencies, cost-savings, and ensure the continuous improvement and sustainable performance of public facilities.

**Habizah Sheikh Ilmi et al.**, have focused to investigate the design and conditions pedestrian's facility in Taylor's Lakeside Campus in relation to the pedestrian's safety and comfort. This study provides background information on the existing pedestrian facility's condition and aims to recommend the most suitable pedestrian facility by using innovative strategies. It integrates quantitative method by collecting data through questionnaires from students and staffs of Taylor's Lakeside Campus. Lack of walkway continuity, poor sidewalk pavement and road, lack of street furniture especially lighting, lack of roof and shades, and safety concerns are some of the commonly identified pedestrian infrastructure problems. This study should be able to provide a clear direction to the university on the problems and the recommendation for the future development by understanding its existing built environment performance on comfort and safety in the occupancy stage of the systems lifecycle.

**Prescilla Palis et al.**, have explored on Work-Family Conflict (WFC) issue that needs to be taken into consideration regardless of countries and cultures all over the world. Therefore, this research paper attempt to identify the underlying factors causing WFC of the respondents working in the Kuching construction industry. This research is statistically descriptive orientated and Statistical Package for the Social Science (SPSS) software was being adopted to analyse the data obtained. The findings revealed that long working hours and inflexible work schedule are the most significant factors that lead to WFC in the Kuching construction industry. Thus, this research paper designed to provide an overview to the organisations and construction professionals in implementing the techniques to minimise the level of WFC so as to achieve balancing between work and family domain.

**Stephanie Stella Dawi et al.**, have presented the need to make improvements for construction project is a part of practical fact. Contracts usually specify when and what time the contractors have to finish the work, yet many construction projects struggle with delay, financial problems and disappointed results due to the inadequate attention paid to determining the variation orders. Moreover, the greater number of variations in design has led to higher cost and lower cost reliability in the construction industry. Therefore, this research paper attempt to examine the impacts of variations on public infrastructure projects in Sarawak. As a result, it was indicated that project cost increase, completion schedule delay and delay in payment are the most important impacts of variation orders on public infrastructure projects. Research results would act to strengthen and simplified existing variation order management practices and take constructive measures to minimize the negative impacts of variation orders.

**Azrina Md Yaakob et al.**, have determined on the gap between the different type of skillsets that students, fresh graduates and employers deems to be necessary for the job. Surveys will be conducted among employers, fresh graduates and Quantity Surveying students to identify the skillsets sought after in the profession. The findings showed that students and fresh graduates were able to identify the skills most prioritized by employers, in terms of the category of skills that were necessary for the traditional roles of a Quantity Surveyor but a mismatch still existed in other less traditional skills. This study also aims to provide students and educational institutions with further insights as to the areas in which current students and graduates are lacking in to increase their employability.

**Azrina Md Yaakob et al.**, have presented on many young couples are struggling in terms of debts and loans due to their lavish lifestyle and with the escalation of property prices, it is very tough to purchase their first property. Due to population growth and urbanization in Selangor as well, developers tend to build more residential properties without catering and taking into consideration the needs and demands of new potential house buyers. The unaffordability housing price decreases the homeownership rate among the younger generations. This study aims to identify the factors that influence the decision making by the first-time buyer of Millennials in purchasing a residential property, to determine the preferred house types among Millennials and to study the factors for the low house ownership among Millennials. The main objectives are achieved positively which shows that financial factor is one of the key concerns for first-time house buyers, followed by locational, neighbourhood and structural factors.

**Wan Lee Yen et al.**, have explored the context of depicting the evolution of women in the construction industry, the objectives of this research paper are: (i) to explore factors encouraging women into the field, (ii) to identify the challenges faced, and (iii) to assess the perceptions towards women working in construction roles. Results from the viewpoints, viz those of professional men and women manifested the advancement of women, particularly within the construction industry, through societal changes and modernization of cultural beliefs gauging the increased of women's participation in the exclusively male-established sector. It was also found that stereotyping and discrimination against women, though subtly, persists to the present day in terms of perceptions and practices which serve as a yardstick to improve the construction industry.

**Chia Kuang Lee et al.**, have explored risks can lead to performance reductions, increased costs, scheduling delays, and even project failure. It is noted that the success of the project depends on identifying the most common risk factors and mitigate them effectively. The purpose of this paper is to identify the critical risk factors and investigate the interrelationship among the risk factors in the construction projects. Decision Making Trial and Evaluation Laboratory (DEMATEL) is employed in the study to prioritize the risks and then analyze the causal relationship among the factors. The findings in this study can provide structural visualization of complex causal relationships among risk factors and also allow construction experts to prioritize the resource allocation to achieve project objectives.

**Tien-Choon Toh et al.**, have investigated on the survival strategies and perceived success of Klang Valley Malaysian small and medium building contractors in the post-COVID-19 era, to uncover the strategies that would ensure the small and medium building contractors' continuous survival. The top five important survival strategies were as follows: (1) effective financial management, (2) upgrading of the skills of employees for productivity improvement, (3) improvement of service quality performance, (4) improvement of problem-solving capabilities, and (5) efficient marketing. The effects of organisational survival on small and medium building contractors' perceived success in terms of business growth, profit growth, and employment growth were also investigated. This study raised awareness and deepened our understanding of the survival strategies used by Klang Valley Malaysian small and medium building contractors, as well as how their organisational survival was perceived.

**Wah-Peng Lee et al.**, have investigated on the survival practices and perceived success of indigenous construction firms to increase the likelihood of firm survival. The top five significant survival practices were (1) upgrading of employee skills to improve productivity, (2) elimination of bad performers, (3) improvements in health and protection at work, (4) promotion of the good image of the company, and (5) practice of quality assurance methods and enhancement of quality. The underlying factors of survival practices were identified using factor analysis, which are as follows: tendering strategy, human resource management, organisational culture, finance management, and marketing. The effects of organisational survival on the perceived success of indigenous construction firms in terms of business growth, profit growth, and employment growth were also investigated. This study raised awareness and deepened our understanding of the survival practices of Malaysian indigenous construction firms in Klang Valley, as well as how their organisational survival was perceived.

**Janelle Angela Cezar et al.**, have presented the implementation of AR as a learning aid which highlights the potential benefits towards tackling the issues students faced in measurements for Quantity Surveying (QS) students. An overview of the findings was formulated from related studies and from perspectives of chosen semester of QS students from a private university using formative usability testing. Therefore, serving as a guide for future researches to consider the usability of AR specifically for measurements. The results show that AR is more than a visualization tool, given a usable programmed interface which fits the function of understanding and interacting in-class or in self-learning of measurements topics, this technology's potential for the module can be optimized. It was observed that AR is beneficial for the module and that further development of an AR interface for the purpose of teaching and learning to enhance the user experience of QS students while tackling construction quantity taking-off notions.

**Nadzirah Zainordin et al.**, have presented the awareness among Private Higher Education Institutions academician towards the element sustainable education criteria in Higher Education Institutions in Malaysia. The research involves a quantitative approach using structured questionnaire survey which was designed based on items obtained from literature review. This study finds that optional course on sustainable development in the curriculum, course on sustainable development for all students and pedagogical approaches used to teach sustainable development issues contributing to favor findings. The findings are able to significantly highlight the specific element for an academician and management at Private Higher Education Institutions to further considering to implementing the sustainable concept in a further better way.

**Richard Frank Fellows** has focused on predicated on the observations that, over human history, people have endeavoured to maintain and repair their possessions but that, today, possessions become obsolete rapidly, are designed against maintenance and repair and so, are discarded and replaced. The means changing behaviour fundamentally, and doing so now, to maintain and repair, re-cycle, conserve and preserve. Innovation and learning are examined as important vehicles to move away from short-term self-centrism in order to foster and promote sustainable survival. Which should reduce reliance on financial techniques and, instead, use direct metrics for evaluating (construction projects), and reverse discounting of the future to enhancing the future. Education and regulation must embrace sustainability requirements – with much greater emphasis in maintenance, repair, and recycling at disposal – such that only proposals that are clearly sustainable will be allowed to be implemented.

**Nadzirah Zainordin et al.**, have presented the critical success factors (CSF) of sustainability implementation in Malaysia Private Higher Education (PHEI) institutions. Through questionnaire survey on 75 and analysis via Rasch Model, 18 attributes on critical success factors on the sustainability implementation assessment for Private Higher Education Institutions in Malaysia have been discussed. From the finding, it is perceived that the successful sustainability implementation assessment should start from the support and direct involvement of the Private Higher Education Institutions' management. The academia should integrate sustainability implementation in teaching and research, and this would further drive to collaboration extension and support within inter-department and vice versa. Further discussion may subsequently enhance the sustainability implementation assessment in the right direction. Eventually, the staff and faculty members may also enhance their level of knowledge towards sustainability implementation assessment.

**Myzatul Aishah Kamarazaly et al.**, have explored the evaluation using performance measurement system on the FM performance in high-rise residential buildings. This study was limited to the opinions and data obtained from property managers and facility managers in high-rise residential buildings in Klang Valley where a qualitative research method was adopted. The findings of this research showed that is still room for improvement for a better implementation of PMS in the Malaysian FM and PM industry particularly high-rise residential buildings in Malaysia. This study sought to fill in the research gap by exploring the current knowledge, extent of utilisation and ways to enhance the adoption of standardised PMS in high-rise residential buildings. The research outcomes can provide a reference for future researchers to further explore the implementation of PMS in other types of buildings namely institutional buildings, offices, hotels etc.

**Sui Lai Khoo et al.**, have focused on a literature review for the critical success factors towards e-tendering implementation in the construction industry. A literature review has been conducted, which about 19 indexed papers fall from year 2013 to 2020 were considered as resources where the elements of CSF further divided into: People (Skill – 2 constructs and staff – 4 constructs), Process (Practice – 14 constructs and Procurers – 7 constructs), Work Environment (Leadership - 10 constructs, management – nine constructs, cultural – 6 constructs and structure – 5 constructs), Technology (System and software – 12 constructs and networking – 4 constructs) and Service Provider (Communication – 4 constructs, market – 5 constructs and technical – 9 constructs). These make a total of five themes, 13 sub-themes and 91 constructs of CSF of eTendering implementation has been identified. Therefore, this study's finding on CSF of eTendering implementation is further beneficial to the construction players to ensure project success. The finding shows the network security concerns of eTendering implementation is a priority in the construction industry.

# A NOVEL APPROACH IN THE CONSTRUCTION OF BIOPLASTIC MICROBIAL FARMING BASE UTILISING POTENTIAL SPACES IN RESIDENTIAL BUILDING

Nurshuhada Zainon<sup>1</sup>, Nik Husni Nik Rusdi<sup>2</sup>, Noor Suzaini Mohamed Zaid<sup>3</sup>, Nik Elyna Myeda<sup>3</sup> and Zafirah Al-Sadat Zyed<sup>4</sup>

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## Abstract

Plastic production causes a serious climate change hazard worldwide, contributing to greenhouse gas emissions at every stage of its life cycle. Bioplastic is currently the best alternative, albeit the cost of the factory-based output is high. To solve this issue, expanding bioplastic production through economies of scale will reduce its costs. Therefore, this paper introduces a novel approach to producing bioplastic biopolymers, known as polyhydroxyalkanoates (PHAs), through a community-driven effort in home-based settings. With this concern, this study aims to identify design criteria for constructing a bioplastic microbial farming base by proposing potential spaces in a residential building that can be utilised. First, exploratory research was conducted to gain insights into bioplastic microbial farming, including its system-induced factors. Based on these findings, the relevant construction requirements were then identified. Subsequently, potential spaces in the residential building were proposed, and the consensus on the best approach was agreed upon between bioplastic scientists and construction industry experts via a focus group platform. The findings revealed that ventilation, aeration, temperature, safety, and pH are the essential requirements for construction criteria resulting in spaces that can accommodate bioplastic microbial farming, which includes the backyard area, exterior wall and indoor spaces. This research provides a new academic perspective to explore the new construction project on mixed development of the residential building and light industrial. It also helps lay a foundation for further research in bioplastic microbial farming intervention from the built environment perspective.

**Keywords:** *Construction design criteria; residential building; bioplastic; microbial farming; and built environment; light industry.*

## INTRODUCTION

Plastics are fantastic materials. Their excellent range of properties and inherent durability contribute to an enormous number of applications, and society has come to rely on them. The conveniences plastics offer, however, led to a throw-away culture that reveals the material's dark side: many of these products, such as plastic bags and food wrappers, have a lifespan of mere minutes to hours, yet they may persist in the environment for hundreds of years (Parker, 2019). Traditional petroleum-based plastics are notorious contributors to plastic pollution, particularly in the oceans. Consequently, it has become one of the most pressing environmental issues, as the rapidly increasing production of disposable plastic products overwhelms the world's ability to deal with them. The global production of plastics has grown exponentially, from 2.3 million tons in 1950 to 448 million tons by 2015 and will be doubling by 2050 (Labreton & Anrady, 2019). The construction sector accounts for almost a quarter

(23%) of this plastic, making it the second-largest contributor in the world (Ray, 2019). These facts strongly suggest the significant role the industry needs to play in mitigating this global issue.

Inefficient or non-existent garbage collection systems are often linked to plastic pollution (Ritchie & Roser, 2018). However, researchers have found that waste management systems solely need more capacity at the global level to dispose of or recycle waste plastic safely (Lau et al., 2020). Recycling can divert waste from landfills and reduce the production of virgin materials, but it simply delays disposal. In this context, biodegradation is considered a solution. Rather than remaining stable for hundreds of years, biodegradable plastics, or bioplastics, can be broken down by microbes and turned into compost (Letcher, 2020).

Bioplastic refers to plastic made from plant or other biological material instead of petroleum. Among other methods, bioplastic can be made from polyhydroxyalkanoates (PHAs), engineered from microorganisms, which scientists believe is best to derive from food waste as it is an ideal strategy for food waste disposal (Ranganathan et al., 2020; Tsang et al., 2019). For example, Malaysia's population bins up to 16,688 tonnes of food daily on average in 2019 (Wei, 2019). Therefore, bioplastic production from food waste could be promising. However, factory-based bioplastic production is growing slower due to the high production cost and low efficiency compared to traditional plastic.

To solve this issue, researchers are looking into alternatives to produce bioplastic from food waste by expanding the scale of its production (Sirajudeen et al., 2020; Tsang et al., 2019). As food waste is readily available to the community, this study introduces an intervention of bioplastic microbial farming in a home-based setting as a new light industry. This proposal will help the industry in two ways: the community, especially in rural areas, can generate income from it, and bioplastic producers can achieve cost advantages when bioplastic biopolymers, or PHAs, can be produced on a large scale.

As a start, this novel approach requires understanding the design criteria to build a bioplastic microbial farming base in potential spaces of a residential building. In doing this, the literature review was conducted to identify the farming process, its system-induced factors and construction requirements. The findings were examined by bioplastic scientists and construction industry experts, which led to proposing potential spaces for microbial farming in a basic home-based setting.

## **METHODOLOGY**

This study introduces a new intervention and hence requires an exploratory research approach. This study began with a literature review of bioplastic and construction disciplines. The literature was collected from multiple secondary data sources, for instance, journal articles, books, conference papers, government portal websites and online independent databases, including Web of Science, SCOPUS, ScienceDirect and Wiley Online Library. The search was set to the English language and restricted to papers published between 2015 to 2020, looking into the last five years of studies. The keywords used were: bioplastic, bioplastic, microbial farming, processing system, requirements, construction, built environment, home-based setting, residential, and community. Through the Google search operator, the exact-match search tool was also used, including "OR", "AND", "\*", and "(").

The review found limited knowledge of the cross-disciplinary perspective on bioplastic microbial farming and built environment studies. Under the bioplastic-related field, there were 79 papers found, which indicates an increasing interest in this topic, with only 18 of them focusing on bioplastic farming in a tropical climate. There was no literature relevant to construction. However, the review successfully outlined system-induced factors that necessitate the development of design requirements for construction. From here, preliminary space design options were developed.

Outcomes from the literature review were presented to and evaluated by bioplastic scientists and construction industry experts employing a focus group discussion. A total of twelve participants were selected using purposive sampling, as shown in Table 1. The questions were in the form of open-ended knowledge and opinion-based, which were divided into two parts. The first part was about bioplastic microbial farming requirements (temperature, growing space required, and precaution required). The second part looked into design criteria and potential spaces for the construction project in fulfilling the farming requirements. During the discussion, the information provided by participants was noted down and audibly recorded to prevent missing out of data and inaccuracy during data analysis and for transcription purposes. The discussion lasted 8 hours.

In the final phase, thematic analysis was conducted, and the themes identified were aimed at figuring out how farming work and how it affects the design criteria of the residential building.

**Table 1. Participants**

Code	Participant	Age (Years Old)	Education Level
001	Bioprocess Technology and Advanced Biomaterial Scientist	43	Ph.D.
002	Bioprocessing Scientist	37	Ph.D.
003	Bioprocessing Scientist	36	Ph.D.
004	Biotechnology Scientist	39	Ph.D.
005	Bioenergy/ Biomass Scientist	37	Ph.D.
006	Bioenergy Analyst	28	Master
007	Quantity Surveyor	37	Ph.D.
008	Sustainability in Climate Change Expert	37	Ph.D.
009	Property Manager	32	Ph.D.
010	Facility Manager	37	Ph.D.
011	Architect	33	Master
012	Quantity Surveyor	26	Undergraduate

## CURRENT DEVELOPMENT OF BIOPLASTIC

Bioplastic is an alternative to conventional petrochemical-based plastic. It has been widely used in the food packaging industry and the daily use of disposable goods, especially in Europe (Iwata, 2015). In the future, bioplastic can be applied in various industries if the production capacity is large enough.

PHAs are one of the most common bio-based plastics. PHAs are produced by bacteria and microorganisms using bio-derived feedstocks. The feedstock used for bioplastic resin production is mainly sugarcane, vegetable oil, and food waste. Tsang et al. (2019) found biorefinery of food waste as an ideal option to reduce the bioplastic production cost compared

to conventional plastic production. It converts food waste into a value-added product, reduces the energy lost, and generates low-cost plastic resin production. Food waste is easily obtainable from household, industrial, and agricultural residue.

Industrial production of bioplastic resin is developed and grown in recent years, but their total market share is still marginal. The slow development is mainly due to inefficient industrial bioplastic production and high production cost (Vermeer et al., 2021). Bioplastic resin production costs are five to ten times higher than the traditional petrochemical-derived resin (Tsang et al., 2019). Many factors contribute to the high factory production cost, such as bioplastic feedstock, electricity, transportation and labour costs. Below is the formula to calculate its production cost based on Changwichan et al. (2018):

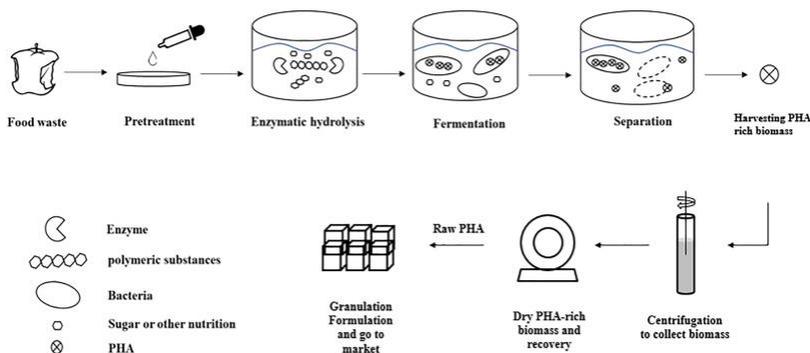
$$Total\ Cost = weight\ of\ plastic\ resin\ per\ functional\ unit\ (kg) \times [resin\ price\ (per\ kg) + electricity\ cost\ (per\ kg) + waste\ management\ cost\ (per\ kg)]$$

**Equation 1.** Production Cost Formula for Bioplastic Microbial Farming

Changwichan et al. (2018) found that around 29% of the total cost was the bioplastic feedstock cost, and 15% was the chemical cost used to isolate or extract bioplastic monomers. Therefore, bioplastic production costs can be reduced by lowering feedstock and chemical costs. On top of that, the location of the biorefinery plant that is close to areas with an abundant supply of bioplastic feedstock, such as rural area, help to reduce the production cost too (Tsang et al., 2019). It also reduces the transportation cost between the supply area to the plant and the labour cost.

### Bioplastic Microbial Farming

Bioplastic polymers, PHAs, are produced through a microbial process, as shown in Figure 1. It includes feedstock cultivation and harvesting, fermentation, resin production and plastic moulding (Changwichan et al., 2018). At first, food waste (the feedstock) must undergo pre-treatment to improve its biological properties (Prajapati et al., 2021). The pre-treatment process is essential to produce a high-quality intermediate product, which is a renewable carbon source. Next, the chosen strains undergo a fermentation process and are subsequently fed with sugar made from a feedstock for better production of PHA. Finally, after a certain period of fermentation, the materials go through a refinery process where PHA are dehydrated and aggregated before being made into long strands of liquid plastic, which dries into solid biodegradable plastic materials.



**Figure 1.** Food Waste to Produce Bioplastic Resin (Tsang et al., 2019)

## Scaled-Down, Home-Based Bioplastic Microbial Farming

Figure 2 illustrates the proposed system for small-scale, home-based microbial farming called the ‘vessel’. Microbial farming is carried out in an uncontrolled environment. It consists of a container with an approximate volume of 70 litres, of which 50 litres is for the medium (feedstock), and the other 20 litres is for air diffusion. It involves an aerobic process; therefore, the vessel needs an opening to allow oxygen in and release carbon dioxide.

Three factors need to be considered during the farming process. Firstly, the heat generated by the microbes during fermentation affects the temperature of the surrounding environment and indoor air quality. Secondly, the pH level, where the mixture drops 2.20 pH value per litre per day. To stabilise the pH, limestones are used to keep the mixture in the most favourable condition. Finally, the feedstock releases the odours; hence charcoal is used to eliminate the unwanted smell.

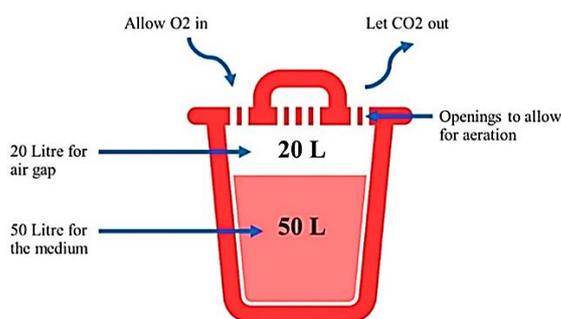


Figure 2. Proposed Scaled-Down, Home-Based Microbial Farming

## CONSTRUCTION REQUIREMENTS FOR THE HOME-BASED BIOPLASTIC MICROBIAL FARMING BASE

In constructing the home-based bioplastic farming base, it is crucial to understand the design requirements. Based on the focus group discussion outcomes, below are the requirements for constructing the microbial farming base.

### Bioplastic Microbial Farming-Induced Factors

During farming, the microenvironment was found to have the most significant influence on PHA production (Mohan & Reddy, 2013). For example, Salehizadeh and Van Loosdrecht (2004) reported that microaerophilic operation produces 62% of PHA compared to 20% with the anaerobic microenvironment. Hence, air diffusion between the medium and environment air is needed to ensure the optimum oxygen level for the operation to be carried out. Besides, pH level affects production. PHA can accumulate higher in neutral pH than in basic (pH 8) and acidic (pH 6) redox conditions; this is because the enzymes involved in the process are active at neutral pH (Mohan & Reddy, 2013; Panda et al., 2006). Temperature is another of the essential parameters for PHA microbial growth. Ocampo-López et al. (2015) suggested that 30°C favours PHA microbial growth. Haba et al. (2007) reported that the highest production rate of PHA in their study was 37°C. Pérez et al. (2019) found that PHA accumulation increased by up to 30% between 30 and 37°C. Last but not least is aeration. A

lower aeration rate promotes greater production than a higher and absent aeration rate - meaning reduced oxygen is suitable for creating a stress condition for growing PHA microbes (Sabapathy et al., 2020). Table 2 summarises the factors required for bioplastic microbial farming.

**Table 2.** Factors and Condition Required for Bioplastic Microbial Farming

Factors	Condition
Temperature	<ul style="list-style-type: none"> <li>• Temperature range: 30° to 37 °C</li> <li>• The temperature depends on the environment, the orientation of the space and the daily temperature changes</li> </ul>
Microenvironment	<ul style="list-style-type: none"> <li>• Microaerophilic condition is better than anaerobic</li> <li>• Depends on the medium growing condition</li> </ul>
Aeration	<ul style="list-style-type: none"> <li>• Low aeration</li> <li>• Depends on the medium growing condition</li> </ul>
pH	<ul style="list-style-type: none"> <li>• Suitable condition is neutral pH (7)</li> <li>• Depends on the medium growing condition</li> </ul>

## Space

The selection of space to build the microbial farming base depends on the environment's aeration. Besides, it also depends on the farming's size and the vessels' arrangement. A larger number of vessels requires a spacious area to accommodate them. Based on the typical residential house in a rural area (Ju & Omar, 2010), the outdoor space range from 1- to 2-metre square and suits a single vessel. For indoor, the base needs at least a 3-metre square to allow better aeration for farming.

## Ventilation

Open spaces and good air circulation are recommended to ensure good air ventilation. This requirement is essential to ventilate heat and odours released by the microbes during farming (Sharma et al., 2020).

## Safety

The vessel contains stagnant water on the surface. It must be covered with a lid to prevent mosquito breeding. A small lid opening allows air diffusion between the medium and the environment to maintain a microaerophilic condition in the vessel. The farming must be based under a shaded to keep the vessel from rain splashing.

## POTENTIAL SPACES FOR THE CONSTRUCTION OF A BIOPLASTIC MICROBIAL FARMING BASE

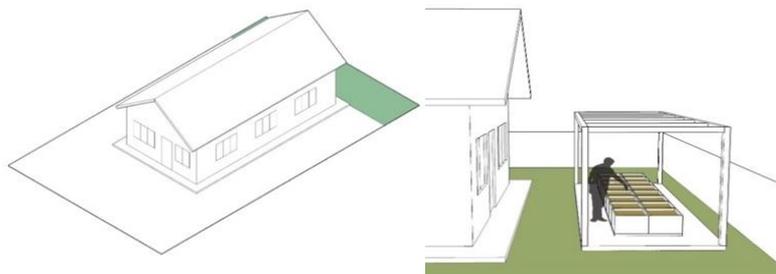
This study focuses on a single-storey detached house, the most common type of residential building in rural areas (Ministry of Housing and Local Government, 2019). Three potential spaces were identified to accommodate bioplastic microbial farming: the backyard, external wall, and indoor area.

## Backyard

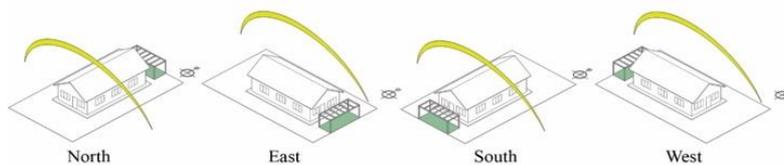
A traditional rural area has a relatively large housing compound. The rear compound or backyard usually relates to kitchen or agriculture farming activities. Implementing a farming unit in the backyard is practical since it does not disturb the existing buildings' structure. In addition, this space allows homeowners to install specific microbial farming features.

However, the variation in outdoor temperature throughout the day might affect farming. Since its favourable condition temperature is 30°C, farming activity can be carried out during the day; hence it can benefit from natural lighting. On top of that, the temperature varies for different spatial orientations due to the solar path and shading. For example, space facing north or south receives constant sunlight throughout the day and is not shaded by the house. In contrast, space-oriented facing east or west only receives the most sunlight during the morning and evening. Thus, a north or south orientation might be the best space orientation for its constant sunlight and temperature.

To prevent splash of rain, roof shelter is provided to protect the medium growing space from unwanted circumstances. Figure 3 and Figure 4 show the proposed spaces in the backyard.



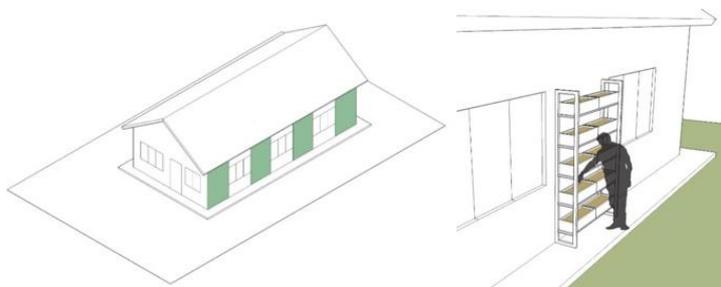
**Figure 3.** Backyard (Source: Author)



**Figure 4.** Space Orientation (Source: Author)

## Exterior Wall

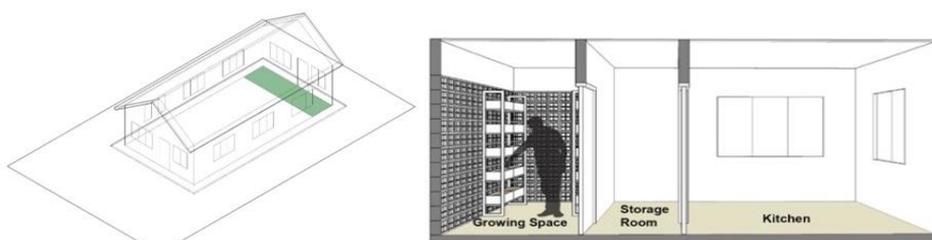
The exterior wall is another potential space for home-based microbial farming. As illustrated in Figure 5, utilising the vertical space to process the feedstock is adequate because it does not compromise spaces for human activities. The vessel can be stacked vertically on the wall without taking up much horizontal space. The only concern is the odour, which can enter the building if the farming base is near the window or door.



**Figure 5.** Exterior Wall (Source: Author)

## Kitchen

The kitchen area can be an excellent potential area to process the bioplastic feedstock, as presented in Figure 6. This design makes the work effective since the feedstock is readily available in the kitchen. A dedicated space with a controlled environment is suggested to be built next to the kitchen area. To maintain good indoor air quality, a buffer zone such as a storage room is suggested between the space for farming and the kitchen to prevent the odour from seeping and causing discomfort to the house occupants. A ventilation block is proposed as a wall material to provide natural air convection for heat release. Besides, it also allows natural lighting during the daytime. However, this proposed design requires renovation of the existing house structure.



**Figure 6.** Kitchen (Source: Author)

## FINDINGS

Participants agreed on the most optimum design for the home-based microbial farming unit. It consists of a 70-litre bucket with 50 litres of the working volume and 20 litres of headspace for air diffusion. The bioplastic feedstock and the microbes are transferred into the bucket for cell growth. Table 3 tabulates the findings under this theme. To establish the design criteria for a residential building to fit with the bioplastic microbial farming unit, conditions during the farming need to be assessed. The conditions are shown in Table 4. The factors include the heat released by the medium and the environment, the increase in temperature, the release of greenhouse gases and the pH value of the medium. The possible bioplastic feedstock sources are waste cooking oil, palm oil mill effluent, food waste, sesame oil and olive oil. Table 5 shows the sources of bioplastic feedstock. The factors that need to be considered during farming include ventilation of space, odour and heat. The potential space to build home-based microbial farming achieved a consensus among the participants to include the backyard area, the exterior wall and the kitchen area with a buffer zone. Table 6 shows the significant factors affecting the design of potential spaces.

**Table 3.** Theme 1: Home-Based Microbial Farming

Content	Codes
The vessel uses a 70-litre garbage bucket. The bucket needs 50 litres of cooking oil or food waste that work as food for the microbe.	The bucket
The bucket should be closed to avoid decreasing volume due to evaporation through aeration is needed.	Lid closing
As the process is aerobic, the air has to be diffused into the bucket.	Air diffusion
The remaining 20 litres of the bucket's headspace allows gas circulation and surface air to diffuse.	Headspace for the vessel
The cell grows at 0.05 per hour in this non-optimised condition, reasonable enough for the microbe through community-based farming.	Cell growth rate

**Table 4.** Theme 2: Bioplastic Microbial Farming Conditions

Content	Codes
Bioplastic microbial farming liberates heat.	Heat
1 gram of microbe generates -17kJ to -18kJ heat.	Heat
A medium chemical used during the processing has a neutral pH level. However, it will be acidic during the process, and the pH level decreases to 2.29 for every litre of medium per day.	pH
Limestone helps restore the pH of the medium chemical. It is cheap too.	pH
About 0.759 grams of carbon is released for every 1 gram of microbe. Therefore, one gram is released for every 1 litre of medium chemical.	Carbon dioxide
The processing increases by 0.02 degrees for every litre per day.	Temperature

**Table 5.** Theme 3: Bioplastic Feedstock

Content	Codes
Palm oil mill effluent; is the most significant advantage as the palm is Malaysia's main crop.	Source of bioplastic feedstock
Cooking oil and food waste.	Source of bioplastic feedstock
Sesame oil, olive oil and palm oil consist of oleic acid (a fatty acid with 18 carbons) as a microbe carbon source.	Source of bioplastic feedstock

**Table 6.** Theme 4: Factors Affecting the Design Criteria

Content	Codes
A buffer zone, such as a storage room, works to avoid odour transmitted in the house.	Odour
Alternatively, charcoal around the tray or bucket can absorb the odour.	Odour
Venting blocks help with circulation and reduce odour.	Ventilation
Open space provides the best aeration for the microbe.	Ventilation
Carbon has to be flown out from space, and air has to be circulated in the vessels.	Ventilation
So far, the best option is still the outside space.	Space

## DISCUSSION

There are a few reasons to propose home-based bioplastic microbial farming. Firstly, bioplastic production in the industry requires a sophisticated system from the upstream to the downstream to produce the final end-user product. The bioplastic production chain is carried out in controlled and well-defined conditions. In industry, the upstream bioplastic production process includes feedstock cultivation, harvesting, and fermentation. This upstream process has occupied around 40% of the total bioplastic production cost. In the feedstock cultivation stage, the industry produces the substrates from feedstock cultivation. The product from this stage is harvested and used as a renewable carbon source in the feedstock fermentation

process. The upstream process is carried out in well-defined conditions, making the final end-user bioplastic product expensive and not economical. Following the data provided by the scientists during the focus group discussion, every 1 kilogramme of bioplastic will cost around USD2 to USD3. Compared to traditional plastic, with around 20 cents per kg of petrochemical-based plastic.

Home-based microbial farming comprises a simple set-up instead of massive machinery in the production chain. The principle adopted in this proposed home-based system is minimum energy usage. As energy consumption directly affects carbon emissions, less machinery used during production can contribute to mitigating global warming. Therefore, home-based microbial farming will potentially overcome the issue in terms of readily available feedstock, increase PHA production, the cheaper operational cost for biorefinery plant based in a rural area, lower labour cost, potentially reduce energy consumption, and, most importantly, add a new light industry for rural communities.

A simple system is made of one fitting vessel. The fitting proposed was a 70-litre bucket. The working volume per vessel is 50 litres, and 20 litres headspace for aeration. The medium in the vessel comprises microbe starting cells, trace components, feedstock and buffer components. Some examples of abundant feedstock that can easily get are food waste and used cooking oil. To avoid the evaporation of the medium in the vessel, it is covered with a lid. An opening on the lid allows oxygen and gas diffusion during fermentation.

There are three main factors affecting the home-based microbial farming base construction design:

1. They are related to microbial farming-induced factors. The selected space must ensure that temperature and pH can be controlled.
2. The odour released from farming. Open space provides better air circulation. In the case of an enclosed area, a buffer zone helps reduce odour from transmitting into the house.
3. The microbes release the heat from carbon dioxide; hence, ventilation is an important design criterion. Natural air convection is the best to utilise minimum energy used.

Considering these factors, three conceptual designs of spaces for the home-based microbial farming base are proposed. First, the backyard area. It provides an isolated space for microbial farming. A small pavilion can be built without affecting the existing building structure and does not interfere with building occupants' activities. Depending on the area, the backyard enables a relatively larger base for microbial farming. Say, with ten units of vessels, the estimated space size of the pavilion is 29.6-meter squares, which is 7.4-meters in length, 4-meters in width, and 0.5-meters span between each vessel. It includes a 1-meter distance between the fittings to the pavilion's edge to prevent rain splash. Vessels can be arranged in two rows, with five units in each row. The pavilion can be built using a steel structure with a metal deck roof and concrete slab.

The second proposal is the kitchen. The kitchen provides the best work efficiency since food waste is readily available. However, the odour is the disadvantage of microbial farming in the kitchen area. A ventilation block is suggested to replace the commonly used brick wall to overcome this problem. It enables air movement between the indoor area and the

surrounding. Hence, natural air convection can remove heat and carbon dioxide. Another drawback is, constructing a microbial farming base in the kitchen affects the existing structure of the residential building. Smaller vessels are required due to space constraints and ventilation issues, proposing a 7-litre bucket with a 5-litre working volume and 2-litre headspace. The vessel size is 220 millimetres lower diameter with 215 millimetres height and 233 millimetres upper diameter. The size of a medium-duty rack proposed is 1.20-meter length, 0.6 meters in depth, and 1.8 meters in height. The medium-duty rack comes in 4-tier level High-Density Fiberboard (HDF) decking with each level maximum of 300 kilogrammes uniform loading capacity. Each deck is designed to accommodate ten vessels. The proposed room area to fit with the fittings is 3.61-meter squares with 1.9-metre length and 1.9-meter width.

Finally, is the exterior wall. This space is suitable when a building has limited backyard and kitchen space. This proposed design does not require alternation on the building's existing structure. The fittings are stacked to save space using four outdoor galvanised shelving units with two decks and 32 20-litre buckets filled with 14-litre medium and 6-litre headspace. The rack size is 1.4 meters high with 0.27-meter depth and 0.6-meter length, while the bucket size is 258 millimetres lower diameter with, 370 millimetres high, and 292 millimetres upper diameter. This base can accommodate two vessels per deck. The estimated space occupied by four shelving units is similar to the base area of the shelving units, which is 0.65-meter squares in total. A metal shelving unit with a water-resistant metal deck with HDF is used. To avoid rainwater splashing into the fittings, the awning roof is suggested to be built above the shelves.

## CONCLUSION

Bioplastic is a promising substitute for conventional plastic due to its biodegradability and biocompatibility characteristics. Furthermore, the production of bioplastic from renewable resources such as food waste reduces environmental problems and makes it more sustainable than existing petrochemical-driven plastic. The home-based production of PHA microbes for bioplastic has a huge potential to be implemented. It has become a part of the light industry to reduce the production cost of bioplastic. This is due to its small-size scale and the wide availability of food and organic waste that can be used as renewable feedstock for PHA production. Potential spaces have been proposed for home-based PHA production with conceptual design strategies in this paper to demonstrate the possibility of this development.

Nevertheless, further research and studies need to be done to develop this research topic. A quantitative research approach will further support the findings of this study. On top of that, future works may also include exploring the life cycle costing and cost-benefit analysis of the construction project and a comparative analysis of the social cost of carbon dioxide between carbon emission of food waste from dumping to landfill and carbon emission of food waste from bioplastic microbial farming.

Theoretically, this research has provided a new knowledge area that fills the gap between the cross-disciplinary of science and the built environment industry. The requirement of home-based microbial farming had been identified to determine the design criteria of the construction project. This research can raise the construction industry's awareness of the plastic waste issue and sustainable development goals and encourage using bioplastic

materials in construction plastic supply. Findings will also help the community set up the microbial farming base in their residential unit as a start-up to this new industry that can be run among community members.

## ACKNOWLEDGEMENT

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# CRIME PREVENTION THROUGH ENVIRONMENTAL DESIGN (CPTED) AWARENESS AMONG CONSTRUCTION STAKEHOLDERS

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## Abstract

Crime prevention through environmental design (CPTED) is a prevalent urban planning method to avert crime and extenuate fear of crime through the enhancement of physical surroundings. Nowadays, CPTED is broadly implemented for neighbourhood's domain that suffers from crime. Hence, the responsibility and cognisance of construction stakeholders such as developers, town planner, architects and quantity surveyors to undertake the precaution during the development of the areas are much needed. The objectives of this paper are to evaluate the level of awareness towards CPTED among the construction stakeholders and to study the benefit of implementing CPTED in construction projects. A structured questionnaire had been used for data collection. Sixty sets of questionnaires had been distributed to construction stakeholders within Sarawak, Malaysia. Data collected had been analysed using Statistical Package for Social Science (SPSS) version 23 software. The outcome of the study had suggested that the construction players were not aware of the CPTED concept due to the lack of exposure from authority, lack of knowledge, and expertise in particular area. Even though the construction players have not recognized the principles of the CPTED, most of them had implemented the concept of CPTED in their previous projects. CPTED should be enforced in the construction industry to decrease the crime rate and fear of crime. Therefore, the research results are meaningful to improve the awareness level towards CPTED among construction players.

**Keywords:** *Crime Prevention Through Environmental Design (CPTED); Sustainable Development; Design.*

## INTRODUCTION

After a few centuries, crime rate has been continuously increasing until it implants fear in society. Nasar and Jonas (1997) mentioned that fear of crime as a major urban stressor and crime problems are social issues that affect thousands of people's lives each year. Littig and Griessler (2005) added that social sustainability is a quality of societies where this can be achieved, provided if work within a society and the related institutional arrangements meeting the needs of human-beings in the long run. Barron and Gauntlett (2002) and Mckenzie (2004) both agreed that one of the most common principles of social sustainability is quality of life and it is crucial for individuals, group, and community level to foster a good quality of life. If this concept is neglected, it would lead to various social problems within the communities and one of it is crime issue (Azmi et al., 2018).

Crime prevention through environmental design (CPTED) is developed on the hypothesis that "the proper design and effective use of the built environment can lead to a reduction in fear and incidence of crime, and an improvement in the quality of life" (Crowe, 2000). CPTED is one important strategy for achieving an improvement in the quality of life and in

order to promote this is by having an effective crime control programs focusing on urban neighborhood (Marzbali et al., 2012). According to Department of Town and Country Planning (2012), CPTED is the design principles that detailed out the effective physical environment that can influence human behaviour from involvement in crime, as well as to reduce the fear of crime. Hence, it can increase the quality of life. Therefore, it is essential for architects, developers, and planners to consider safety features in every project development especially at the initial stages of the design. The combination of the responsibility and awareness of the construction stakeholders to undertake the precaution during the development of the areas is much needed.

The present evidence suggested that quality of life can be better when the feeling of fear of crime decreases and it helps to produce a better development that is more sustainable (Marzbali et al., 2011). Implementing the new concept of crime prevention through environmental design (CPTED) is needed to reduce the crime rate (Ralph and Adele, 1996). Activities such as educational programs and trainings among construction stakeholders may help in promoting CPTED. CPTED must have a place in the curriculum of all professional and academic training programs related to planning, design, and development (Crowe, 2000).

Several principles had been introduced in CPTED namely target hardening, territorial, access control, surveillance, maintenance, and security (Cozen, 2008a). It is essential to practise CPTED principles to prevent crime in residential areas. The principles of CPTED had been translated into physical development to reduce possibilities of the surrounding to be exploited as facilitating and subsistence to this criminal behaviour. Therefore, for a successful CPTED program, the local authorities and construction stakeholders should work hand-in-hand in developing public awareness towards the benefits and acceptance of implementing CPTED to offer the chances of reducing the crime. This paper seeks to evaluate the level of awareness towards CPTED among the construction stakeholders and to study the benefit of implementing CPTED in construction projects.

## **CRIME PREVENTION THROUGH ENVIRONMENTAL DESIGN (CPTED)**

Crime and fear of crime are factors that caused adverse effects to the social development and key factor that influence an individual and the community in settling down in life (Colquhoun, 2004). Marzbali et al. (2011), explained that crime can be influenced by factors such as environmental, economic, social, and governmental factors. A study by Knights et al. (2002) had found that crime is a root of impact on sustainability growth. Cozen (2008) complemented that it is necessary to understand the sustainability that needs to continually develop and change so that the knowledge could be expanded. According to Du Plessis (2000), a city to be called sustainable is a city that has no fear for their safety and livelihood. Thus, a city with a low-quality environment will never be free from crime.

As CPTED is one important strategy for achieving an improvement in the quality of life. Thus, it is at the urban neighbourhood level where effective crime control programs must focus in order to improve the quality of life (Marzbali et al., 2012). Sa'adi and Zainordin (2019) added that the increasing number of the population growth had caused parallel effect in construction developments. Hence, it is necessary for new development to consider the design of a city that could deter any crime activities within the area of development. Governments of Malaysia and other local agencies are trying to overcome these critical issues

by spending a great amount of money to take precautions on crime. For instance, numerous authorities currently adopting the Safe City programme which is the collaboration between urban form, crime and social conditions.

## **Principles of CPTED**

According to Crowe (2000), the implementation of CPTED is profoundly rooted in environmental design and human relationships, which incorporates many principles. The word 'environment' refers to the individuals, physical and social surroundings. CPTED principles attempt to decrease the crime rate and reduce the opportunities for crime by making crime more difficult to be committed (Goharipour et al., 2021). The CPTED was founded in the United Kingdom in the late 1960s, when the federal government became involved in crime reduction in urban housing. Several significant attempts had been made to establish a workable concept for controlling crime through architectural planning and design (Gardner, 1981). Hence, the concept of CPTED was an idea to track and deter the number of crimes such as burglaries, robbery, vandalism, and attack through the design of physical environment. Carmen and Robinson (2000) then explained that CPTED was designed to eliminate the possibility of criminal offenses by reducing the likelihood of criminal offenses and the threat to offenders.

The theory of CPTED is very influential in law enforcement and architectural communities, especially in urban residential development and public housing design and refurbishment. As a place-based crime prevention approach, crime prevention by environmental design (CPTED) had been promoted since its conception (Jeffery, 1971); followed by Newman (1972) on defensible space, and this formally co-founded by Crowe (2000). The evolution of the CPTED definition can be seen from the point of view and the responses of criminologists, designers, architects, researchers, government and companies (Shamsuddin and Hussin, 2013). Shaftoe (2017) added that reducing the possibility of fear of crime was the sole target of regulator in several situations. Over the last two decades, the theory of CPTED had been through the process of refinement by the multiple number of research and studies until the previous approach has been replaced into a new generation of CPTED. The new generation of CPTED deepens for the implementation of physical design which also includes social factors said Cozen (2008). Somehow, this new generation of CPTED is needed to be developed where the need for maintaining friendship and families within neighbours while focusing on personal space and security need said Saville & Cleveland (1998).

CPTED can be proactively implemented at the design stage, and it is based on seven key strategies: territorial reinforcement, surveillance, image, access control, legitimate activity support, and target hardening. The seventh is geographical juxtaposition (surrounding environment). Some practitioners combine these principles in different ways. However, some of these principles are appropriate at certain scales, so the measurement scale plays a significant role in defining these principles (Marzbali et al., 2016). The Table 1 below briefly explained each of the CPTED principles.

**Table 1. CPTED Principles**

No.	CPTED Principles:	Sources
1.	<p><b>Natural Surveillance</b></p> <p>Considered as a form of capable guardianship that can reduce crime since offenders who perceive that they can be observed (even if they are not), are less likely to offend, in the light of the increased potential for intervention, apprehension, and prosecution.</p> <p>Surrounding areas can be designed to be easily observable by modifying physical features to increase visibility and by placing people and activities in configurations that maximize surveillance possibilities.</p>	<p>(Cozens and Love, 2015)</p> <p>(Sohn, 2016)</p>
2.	<p><b>Natural Access Control</b></p> <p>Access control uses doors, shrubs, fences, gates, and other physical design elements to discourage access to an area by all but its intended users.</p> <p>Using vegetation design such as fence, flower bed, hedges, and planting bed.</p>	<p>(Crowe, 2000)</p> <p>(Thani et al., 2016)</p>
3.	<p><b>Territorial Reinforcement</b></p> <p>The design concept of territorial reinforcement seeks to promote notions of proprietary concern and a "sense of ownership" in legitimate users of space, thereby reducing criminal opportunities by discouraging the presence of illegitimate users.</p> <p>It is segregation between public and private spaces.</p>	<p>(Cozens and Love, 2015).</p> <p>(Thani et al., 2016)</p>
4.	<p><b>Image/ Maintenance</b></p> <p>Image/space management seeks to promote a positive image and routine maintenance of the built environment to ensure the continued effective functioning of the physical environment, and this also transmits positive signals to all users.</p>	<p>(Cozens and Love, 2015), (Cozens and Melenhorst, 2014)</p>
5.	<p><b>Target Hardening</b></p> <p>Long-established and traditional crime prevention technique and seeks to improve building security. It focuses on denying or limiting access to a crime target using physical barriers such as fences, gates, security doors and locks.</p>	<p>(Cozens and Melenhorst, 2014)</p>
6.	<p><b>Activity Support</b></p> <p>Activities which involve the community. For example, a basketball court in a public park may provide recreational space for the young while also making strangers more obvious by increasing natural surveillance and a sense of ownership.</p> <p>Key strategies of activity support at the neighbourhood level include putting sidewalks along roads, providing public open space, and supporting public activities in key community areas.</p>	<p>(Cozens, 2002)</p> <p>(Sohn, 2016)</p>

## Implementation of CPTED in Malaysia

Malaysia is one of the most rapidly urbanizing countries in Southeast Asia, and an increase in crime rates is one of the many challenges faced by the nation (Marzbali et al., 2016). Through the National Urban Policy, the Malaysian government had defined a safe city as 'an integrated program to the creation of cities where the population is free from all physical, social and mental threats (Federal Department of Town and Country Planning, 2006). In Malaysia, apart from traditional crime prevention agencies (the Royal Malaysia Police), the Home Affairs Ministry has adopted safe city initiatives. However, CPTED is in its infancy in Malaysia. Meanwhile, the public has taken steps to enhance safety and security through physical measures (Marzbali et al., 2016).

Since the number of crimes in Malaysia has risen dramatically, the Safe City Programme had been implemented in January 2004. The Safe City Program in Malaysia refers to the development a crime-free environment through strategies in the field of physical environment design, target hardening and management, community engagement, and public awareness. The Safe City Program was redefined in December 2009 into three key methods, which consists of 15 steps from 23 initiatives to deter crime in the first edition, which was implemented earlier on in 2004 (Federal Department of Town and Country Planning, 2010). The three main strategies are as follows:

- I. **Strategies 1: Environmental Design Initiatives.**  
The first strategy is recognized as an environmental design initiative. The idea comes out by implementing crime prevention through environmental design, crime information sharing through environmental design, isolating pedestrian walks from motor vehicle lanes by providing walkways, bollards, railings or hedging, and implement a program to the safe city by setting up a monthly meeting with the Council.
- II. **Strategies 2: Target Hardening.**  
The second strategy is introducing the target hardening. The target hardening can be in the form of crime prevention signage, safety mirrors, cleaning and tidying concealed and unkempt areas, safety alarms (panic button), every lane full of houses and shop houses, installation of Closed-Circuit Television (CCTV) in commercial, housing and public places, motorcycle locking facilities, lighting side, allowance for the parking at the side of walkways and pedestrian footpaths and allowance for the small business at the side of the walkways.
- III. **Strategies 3: Social Activities Community and Public Awareness Education.**  
The third strategy is social activities community and public awareness education. This can be done by improving surveillance in housing through the concept of *Rukun Tetangga* and private security firms, more public education in terms of awareness, and setting up safe city status websites at the local authority.

Shamsuddin and Hussin (2013) claimed that Safe City Programme had been in the service for 14 years, and it was updated in 2008 and 2009 to ensure the resource efficiency and effectiveness in the future in terms of the achievement of crime prevention. Then, in July 2010, the first program had been reviewed and the second implementation of the Safe City Programme was introduced. The government, as one of its missions in the National Key Result Area (NKRA) is to ensure that Malaysia's achievement focuses not just on physical growth but also on physiological development, agrees to include crime prevention policies in building development.

Based on the statement made by Dato' Wira Chor Chee Heung (2010) at the opening ceremony of the Safe City Program by the Ministry of Housing and Local Government, Malaysia was the third safest country in Asia after Japan and Singapore and the 26<sup>th</sup> among 144 countries worldwide. As a result, this gives impacts on the positive economic environment and economic growth of the nation. As a result of the positive economic growth, collaborations have been established among various agencies such as Town and Country Planning Department (TPD), Royal Police of Malaysia, Malaysian Crime Prevention Foundation (MCPF), local authorities and other agencies that play roles in achieving the goals (Shamsuddin and Hussin, 2013).

## **Benefit of Implementing the Principles of CPTED**

The CPTED concept offers the possibility of increasing the sense of security in the urban environment. CPTED was successfully accepted as part of the planning process for new buildings or includes all urban districts as mentioned by Matlovičová (2016). This concept of CPTED enables the government to generate new ideas on how to improve the built environment by involving and modifying the design environment. In addition, residents must take responsibility for their space and be aware of it by applying these CPTED principles in order to protect their space. When the areas in which such an environment is missing, and the symbolic boundaries are not set out and there are possibilities a crime will be committed (Matlovičová, 2016).

The aim of CPTED is to alter the physical environment to ensure that the 'normal' users feel safe, but making the 'abnormal' users feel uneasy and apprehensive about engaging in any inappropriate anti-social behaviour (Piroozfar et al., 2019). The purpose of CPTED concept is to have a proper design and to give an effective use of the built environment so that it can help to reduce crime and to overcome the fear of crime (Marzbali, 2016). Marzbali et al. (2019) added, chances to diminish crime in a society would be higher if the understanding and knowledge towards CPTED techniques are expanded. One of the techniques that can be adopted, is by having active communication among each other in a neighbourhood.

Surveillance is a concept which focuses on trying to observe the offender under constant observation. As Schneider (2005) explained, it is important to apply a more natural visual overview whenever new developments are implemented. The benefits of this natural surveillance concept are to help maximization of opportunity against the crimes since it allows the residents to see the offenders earlier than the police. By providing adequate street lighting, adding more doors and windows, and a clear view of landscaping can increase the natural visual overview stated by Cozens et al. (2001).

According to Marzbali et al. (2016), street layouts consisting of cul-de-sac street patterns will reduce opportunities for crime and mitigate the fear of crime. Meanwhile, for other principle of CPTED such as natural access control, this concept offers to reduce the chances of offenders from committing a crime through a particular territory. According to City of Orlando (2007), the benefits of this natural access control is to ensure the limitation of any access to the offender's target and to lower the intention of the offenders from deciding to commit a planned crime. Henrico Police (2011) suggested proper placement of natural elements such as trees and bushes can detect the movement of pedestrians and prevent vandalism.

Furthermore, the tools of territoriality should be involved in design stages that serve as distinguishing public for private property. Pauls et al. (2000) defined that the main purpose of territorial reinforcement is to deliver a sort of message or act as a sign to the offenders that committing a crime in that area is not tolerated. Thus, he also mentioned the advantage of proper design of territorial reinforcement can enhance a sense of responsibility of ownership and identification to that place. Lastly, management and maintenance are also important for the residents to maintain their home which to indicate as a strong place attachment as linked to the crime (Shamsuddin et al., 2013). Besides, according to their research, the management and maintenance had the greatest reflection overall from four main basics of CPTED

principles. It also stated that well – maintained houses and buildings would express more valuable goods worth.

## RESEARCH METHODOLOGY

In general, the research methodology involves several processes where the researchers need to explain, describe and predict the phenomena in the study. This research started by doing extensive review on CPTED. Preliminary data collection was gathered from secondary data that includes resources from journals, books, guidelines, seminars, conferences, newspapers and media socials. The study developed four (4) sections of questionnaires items from the literature reviewed. The research study was conducted within Sarawak, Malaysia. A total of 60 sets questionnaires had been distributed to construction stakeholders within the state by post and conducted in the manner of self-administered survey. All the respondents had been chosen through a snowball sampling. According to Etikan et al. (2016), a snowball sampling method allows the respondents to have a social network connecting to the hidden population. For analysis of quantitative data collection through questionnaires survey, the Statistical Package for Social Science (SPSS) software version 23 software were adopted.

## FINDINGS AND DISCUSSION

### Demographic Background

In this research, sixty (60) copies of questionnaires were distributed to construction stakeholders. A total of forty-nine (49) completed questionnaires were returned and analysed in order to understand the reliability of the questionnaires. The Table 2 below summarised the demographic background of the respondents.

**Table 2.** Demographic Background

No.	Item	Results
1.	Gender	59.2% (Female) 40.8 % (Male)
2.	Job Title	51% (Quantity Surveyors, Civil Engineers) 20.4% (Architects) 18.4% (Developers) 10.2% (Town planners and policy makers)
3.	Years of Working Experience in the Construction Industry	1-5 years (6.1%) 6-10 years (57.1%) 11-15 years (6.1%) More than 15 years (20.4%)
4.	Total Years of Involvement in Sustainable Construction Project	Less than a year (29.1%) 1-5 years (30.2%) 6-10 years (12.8%) 11-15 years (13.2%) More than 15 years (14.7%)

From the results shown in Table 2, there were 59.2% female respondents and 40.8% male respondents had answered the questionnaires. 51.0% of the respondents were quantity surveyors and civil engineers. 20.4% were architects and 18.4% were developers. Meanwhile 10.2% of the respondents were town planners or policy makers. 57.1% of the respondents had 6 to 10 years experienced working in the construction industry. Besides that, 20.4% of respondents had more than 15 years working experience in the relevant industry. This was

followed by 6.1% respondents who have experience from 1 to 5 years and 11 to 15 years, working in the construction industry.

In addition, it is shown in Table 2 that 30.2% of total respondents who had 1 to 5 years' experience in sustainable construction projects. This is followed by 29.7% of respondents who had involved in sustainable projects for less than a year. Next, 14.7% of the respondents had experience above 15 years in sustainable construction projects. 13.2% of the respondents had 11 to 15 years had experience in sustainable projects. Lastly, 12.8% of the respondents had experience for about 6 to 10 years in sustainable construction projects.

### The Level of Awareness Towards CPTED

In this section, the responses to the questionnaire are based on multiple choices questions. The multi-choices questions were applied to identify the respondents' awareness towards CPTED. Table 3 shows the results of the study.

**Table 3.** Respondents' Level of Awareness Towards CPTED

Question	Answer	Percentage
1. Do you aware about CPTED?	I am strongly aware, and I have ever involved in the projects that had adopted CPTED	6.1%
	I am aware but I never involved in the project that adopt CPTED	32.7%
	I am aware but I am not sure about the application of CPTED	20.4%
	I have never heard of CPTED	40.8%
2. Is your organisation aware of the existence of CPTED? (If the answer is 'no' please proceed to question number 3)	Yes (16 respondents)	32.7%
	No (33 respondents)	67.3%
3. What is the reason your organisation is not aware of CPTED? (33 respondents)	Lack of knowledge in crime prevention mechanism	28.6%
	We do not have expertise in the subject matters	14.4%
	Lack of exposure on CPTED from the authority	46.9%
	Foresee no benefit in adopting CPTED	10.1%

From Table 3, only 6.1% of the respondents were strongly aware and had involved in construction projects that had adopted CPTED. 32.7% of the respondents were aware of CPTED but had never been involved in any project that adopts CPTED. This followed by 20.4% of respondents were aware of CPTED but not sure about the application of it. However, 40.8% of the respondents claimed that they never heard of the CPTED. Apart from that, 67.3% respondents declared the organisation that their worked with were not aware of the existence of CPTED. The reason being were due to lack of exposure on CPTED from the authority (46.9%), lack of knowledge in CPTED (28.6%), they do not have expertise in the subject matters (14.4), and they foresee no benefit in adopting CPTED (10.1%). However, only 32.7% organisation that were aware of the existence of CPTED.

### The Awareness of Construction Stakeholders Towards CPTED Principles

This section aims to evaluate the respondents' awareness towards CPTED principles. A five-point Likert scale (1= "Strongly Not Aware", 2= "Not Aware", 3= "Slightly Not Aware",

4= “Aware”, 5= “Strongly Aware”) used to measure respondents’ awareness towards CPTED principles. Higher mean scores indicated higher level awareness of occupants towards the variables asked. Fifteen variables had been listed out in this section.

### *Cronbach’s Alpha Reliability Coefficient Results*

Cronbach’s alpha reliability coefficient normally ranges between 0 and 1. However, there is no lower limit to the coefficient. The closer Cronbach’s alpha coefficient is to 1.0 the greater the internal consistency of the items in the scale. Based upon the formula  $\alpha = \frac{rk}{[1 + (k - 1)r]}$  where k is the number of items considered and r is the mean of the inter-item correlations. The size of alpha is determined by both the number of items in the scale and the mean inter-item correlations (Gliem and Gliem 2003). George and Mallery (2003) provided that if the Cronbach’s alpha reliability coefficient result; > 0.90= Excellent; 0.80 - 0.89 = Good; 0.70 - 0.79 = Acceptable; 0.60 - 0.69 = Questionable; 0.50 - 0.59 = Poor and; < 0.50 =Unacceptable. Table 4.0 reveals the computed summary of the Cronbach’s Alpha analysis for all the item under the construction stakeholders towards CPTED principles. The results (Table 4) shows that Cronbach’s Alpha values is 0.770. As a conclusion, all the items are reliable.

**Table 4.** Summary Of Cronbach’s Alpha Analysis for The Awareness of Construction Stakeholders Towards CPTED Principles

Mean	Variance	Std. Deviation	N of Items	Cronbach’s Alpha
59.3061	35.009	5.91680	15	0.770

### *Data Analysis*

Table 5 shows all the statistical overview of respondents’ awareness towards CPTED principles.

It indicates that most respondents were aware that not enough street lighting would lead to cause of crime (4.735). This followed by the respondents aware that increasing number of crime can create fear of crime among households (4.633), the availability of closed circuit television (CCTV) at the surroundings housing areas would prevent crime (4.632) , crime rates are rising every year (4.327) , by installing security system at the housing project would prevent crimes (4.204) , the availability of CCTV along alleyways would prevent crime (4.082) , abandoned properties would lead to the cause of crime (4.061) , poor building layout design would lead to the cause of crime (3.980) , properties with no fencing and gates would lead to cause of crime (3.939) , the availability of community space would encourage the residents to watch the area (3.796) , a property full of trashes and construction waste would lead to cause of crime (3.776) , a routine environmental maintenance would prevent crime (3.592) , the environmental design concept are connected to criminal behaviour (3.449), the existence of thick trees would make the burglars easy to access the targeted house (3.163) and lastly CPTED concept can help to prevent crimes (2.939).

Based on the results, majority of the construction players were not aware of the concept and existence of the CPTED. Besides that, most of the organisations in the construction industry were not aware of the CPTED due to a lack of exposure from the authority and lack of knowledge in CPTED. As Park (2010) pointed out, the main obstacle in implementing CPTED was because planners, designers and developers have lack of knowledge in crime prevention mechanisms.

**Table 5.** Respondents' Awareness Towards CPTED Principles

No.	Item	Means	Standard Deviation
1.	I am aware that not enough street lighting would lead to cause of crime	4.735	0.446
2.	I am aware that increasing number of crimes can create fear of crime among households	4.633	0.727
3.	I am aware that the availability of closed-circuit television (CCTV) at the surroundings housing areas would prevent crime	4.632	0.566
4.	I am aware that crime rates are rising every year.	4.327	0.718
5.	I am aware that by installing security system at the housing project would prevent crimes	4.204	0.735
6.	I am aware that the availability of CCTV along alleyways would prevent crime	4.082	0.640
7.	I am aware that abandoned properties would lead to cause of crime	4.061	0.899
8.	I am aware that poor building layout design would lead to cause of crime	3.980	1.090
9.	I am aware that properties with no fencing and gates would lead to cause of crime	3.939	0.944
10.	I am aware that the availability of community space would encourage the residents to watch the area	3.796	0.979
11.	I am aware that a property full of trashes and construction waste would lead to cause of crime	3.776	0.685
12.	I am aware that a routine environmental maintenance would prevent crime	3.592	1.019
13.	I am aware that environmental design concept is connected to criminal behaviour	3.449	0.818
14.	I am aware that the existence of thick trees would make the burglars easy to access the targeted house	3.163	0.688
15.	I am aware that CPTED concept can help to prevent crimes	2.939	0.922

Even though majority of the respondents claimed that they never heard about CPTED, most of the respondents were aware of the elements that contributed to the causes of crime and elements that could prevent crime. This result shows that, the stakeholders have knowledge of CPTED without realising it. Therefore, it is very important for the construction stakeholders to have collaboration with each other and with the government as well to ensure the implementation of CPTED in Malaysia could be realised. According to Shamsuddin and Hussin (2013), the implementation of CPTED does not depend solely on local authorities but cooperation and interaction between property developers and consultants are the main success factor for the implementation of CPTED in Malaysia.

### The Benefits of Implementing CPTED

This section construct aims to analyse the benefits of CPTED in the construction industry. A five-point Likert scale (1= "Strongly Not Agree", 2= "Not Agree", 3= "Slightly Not Agree", 4= "Agree", 5= "Strongly Agree") used to measure respondents' level of agreement towards CPTED principles. Seven variables had been listed out in this section.

#### *Cronbach's Alpha Reliability Coefficient Results*

Table 6 represents the computed summary of the Cronbach's Alpha analysis for all the item under the benefits of implementing CPTED in the construction industry. The results shows that Cronbach's Alpha values is 0.802. Therefore, this shows that all the items are reliable.

**Table 6.** Summary of Cronbach's Alpha Analysis for The Benefits of Implementing CPTED

Mean	Variance	Std. Deviation	N of Items	Cronbach's Alpha
28.0612	13.850	3.72160	7	0.802

### Data Analysis

Table 7 below shows the statistical overview of the benefits of implementing CPTED in the construction industry. Below are the results of the survey.

**Table 7.** Statistical Overview of The Benefits of Implementing CPTED in the Construction Industry

No.	Item	Means	Standard Deviation
1.	A proper environmental landscaping layout and design in a housing area can help to reduce crime rate	4.592	0.610
2.	A proper street lighting numbers and design can help to reduce the crime rate	4.490	0.711
3.	A proper natural surveillance design such as windows and doors can help to reduce the crime	4.306	0.822
4.	Unobstructed views of public walkways can help to reduce crime rate	4.225	0.823
5.	The installation of safety alarm can help to reduce the number of crime rate	4.102	0.918
6.	Interaction among residents can help to reduce the number of crime rate	3.857	0.913
7.	Small business activities at vulnerable crime spots can help to reduce crime rates	2.490	0.649

Based on 49 valid responses, the outcomes of the descriptive analysis presented in Table 7. In summary, the highest mean score recorded was 4.592 and the lowest mean score was 2.490. The top three items that had been highlighted by the respondents were, a proper environmental landscaping layout and design in a housing area can help to reduce crime rate (4.592), a proper street lighting numbers and design can help to reduce crime rate (4.490) and a proper natural surveillance design such as windows and doors can help to reduce crime rate (4.306). As highlighted by Welsh and Farrington (2002) and Poyner (1983) by designing a proper natural surveillance such as placing the window and doors, street lightings, and environmental landscaping, it could help the occupants to see offenders earlier than the police.

According to Newman (1972), the impact of the built environment on criminal activity has always been focused on the correlation between physical design characteristics and crime level. Based on the results, majority of the respondents agreed the feature of CPTED should be viewed as part of an initiative to eliminate criminal cases in the housing area. Skjaeveland and Garling (1997) claimed that irrespective of the social character of the community, the physical form of the residence has been shown to have a significant impact on attitude amongst themselves. Abdullah et al. (2013) added, this is related to the ability of the residents to recognize a stranger in the neighbourhood when they have a greater degree of socialization and this allows to reduce crime opportunities. It is therefore proven that most of the respondents understand the concept of the CPTED is quite important in facilitating the interaction of neighbourhoods in order to improve the quality of life. Based on the overall results, majority of the respondents agreed with the positive impacts of implementing the CPTED in a construction project in curbing criminal cases. Thus, the idea of implementing CPTED is very significant in promoting the engagement of communities to enhance the quality of life, to easily recognize a stranger in the neighbourhood when they have a higher degree of socialization, and to reduce the opportunities of crime.

## CONCLUSION

Crime prevention has become a part of the goals for the government to provide a better environment for the public to live safely. This study had concluded that most of the construction players were not aware of CPTED due to the lack of exposure from the authority, lack of knowledge, and expertise in CPTED. The implementation of the CPTED in Malaysia is still new and not comprehensive due to the lack of awareness and understanding of the CPTED from construction players. This has occurred due to the existence of the gap where most of the construction players have no intention to succeed in the implementation of the CPTED. Although the construction players had not recognized the concept of the CPTED, most of them aware the impacts of implementation of design towards crime rates cases. Thus, majority of the respondents agreed that there are many benefits of implementing CPTED in a construction project in order to curb criminal cases. Hence, this study could be used as future references in CPTED to all researchers and construction practitioners. In other words, the implementation of CPTED can be a success when there are cooperation and interaction among the construction players. If the construction players have the intention to understand the concept and strategy of the CPTED, the chances of the implementation can be improved and increased.

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# MOTIVATION IN GREEN ROOF STRUCTURE PLACEMENT FROM MALAYSIAN PROFESSIONAL ARCHITECT PERSPECTIVES

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## **Abstract**

Green roofs are proven to be one of the solutions in combating environmental issues due to the rapid urbanization such as urban heat island effect and stormwater runoff mitigation. Green roofs provide enormous benefit towards building owner in terms of energy efficiency and energy saving. Most studies in Malaysia were conducted solely on the physical components, characteristics, and benefits of green roofs. However, none of the past research conducted to delineate the placement of green roof based on the perceive benefit of green roof from the perspective of green building architects. Henceforth, this study aims to align the implementation of green roof and the perceive benefit of green roof among green building architects in Malaysia. A set of questionnaires were distributed among the expert architects in green building design to develop a framework of green roof structure placement based on significant green benefit. The findings showed that the most rewarding benefit of green roof are boosting thermal performance, increase aesthetic value and extra space for green area. The study found that green roof is more suitable to be implement on parking lot roof for social benefit while implementation on other building structure placement is more suitable for economic and environmental benefit. This paper is significant for future references and building owner in determining the most effective placement for green roof.

**Keywords:** *Green Roof; Benefit; Placement; Green Building.*

## **INTRODUCTION**

Green building is a sustainability practice focuses on increasing the efficiency of resource use energy, water and materials while reducing building impact on human health and the environment during the building's lifecycle (GBI, 2013). This goal is achieved through better siting, design, construction, operation, maintenance, and removal, respectively. The Urban Land Institute (2005) has defined green building as a practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building's lifecycle from siting to design, construction, operation, maintenance, renovation, and deconstruction. Besides, green building is described by Muldavin (2010) as an outcome of building performance determined by green features, strategies, and green certification. Green buildings are capable to reduce the negative effects of real estate development on environment (Aliagha et al., 2013).

Findings from literature studies proves that green components conveyed benefits in terms of energy saving in aspects of cooling, lighting, and heating with annual energy saving nominated as the most prominent benefit conveyed by green component (Cole, 2003). Roof components such as green roof, solar photovoltaic, solar water heating and turbine ventilator proves to gives certain benefits such as satisfying indoor environment, annual energy savings, gives adequate level of daylighting and reduce heat (Ariff et al., 2019; Ismail et al., 2010; Khatib et al., 2013; Hazami et al., 2013; Al-Obaidi et al., 2014; Olivieri et al., 2014; Santamouris, 2013; Ismail et al., 2016). Green infrastructure significantly reduces energy demand while providing green spaces for local community during summertime (Palme et al.,

2020). Grullon-Penkova et al. (2020) proposed green roof as a possible solution for urban stressors heat with certain conditions.

Green roof is described as a contained green space on top of a human made structure and can mitigate climate change and provide effective solutions in preventing environmental problems (Razzaghmanesh et al., 2016). There are two categories of green roofs which are intensive green roofs and extensive green roofs. This category of green roofs is determined based on the depth, maintenance, and components that will be used to implementing the green roofs (Ismail et al., 2018). Moreover, green roof has been widely implemented at other countries such as Germany, Japan, Hong Kong, Singapore, and more.

Building professional such as architects play important roles in the development of green roof. According to Rahman et al. (2013), the benefits of green roof may not be able to be received without the interaction of professional in a built environment industry specifically building architect. Green roof has been proven to provide benefits to the environment, economic and social (Song et al., 2018). Green roofs provide benefits of terms of energy saving, increasing the marketability, storm water mitigation, heat mitigation, high aesthetic value, reduce noise and biodiversity (Ismail et al., 2018; Wong et al., 2003; Vijayaraghavan, 2016; Ismail et al., 2018; Weiler & Scholz-Barth, 2009; Palla et al., 2009; Berardi et al., 2014; Li & Yeung, 2014).

Green roof can also effectively reduce the need for air conditioning in summertime thus contributing to energy saving in buildings (Rumana & Hamdan, 2009). Studies have shown that the integration of green roofs provided approximately 14.7%–49% cooling load reduction per annum (Goerguelue & Ekren, 2013; Treado et al., 1984; Ran & Tang, 2017; Jiang & Tang, 2017; Tian et al., 2017). According to Rahman et al. (2012), green roof is one of the approaches in designing an energy efficient building as it helps to reduce the amount of electricity. According to Zahir et al. (2014), it is crucial to identify the perception of local architects towards benefits of green roofs and their implementation. His study in the perception of local architects registered with the Board of Architects, Malaysia (LAM) perceived those green roofs benefited to the environment in terms of heat reduction and thermal comfort particularly for extensive type of green roofs. Besides, Santamouris et al. (2007) stated that green roof conveyed higher cooling load reduction for unit located at the top floor which positioned precisely under the green roof. This show that unit under green roof get the maximum annual energy saving.

However, according to Ismail et al. (2018) green roof in Malaysia mostly installed on the rooftop of podium, parking area and rooftop residential building, commercial building, or industrial building. This implementation may affect the efficiency of green roof implementation in Malaysia in term of energy saving benefit. Hence, this research is conducted to delineate the placement of green roof to match with the perceive benefit of green roof from the perspective of green building architects. This research aims to align the implementation of green roof and the perceive benefit of green roof among green building architects in Malaysia. There are three objectives outlined in this paper which are; 1) To determine the environmental, economic and social benefit of green roof, 2) To analyse the perceive benefit of green roof structure placement among green building architects, and 3) To develop framework of green roof structure placement based on significant green benefit.

## **GREEN ROOF**

Green roof is one of the components of green buildings. Greening technology in urban areas is important since it provides significant economic, technical, ecological, climatic, and social advantage in both industrial and residential areas (Schrader & Boning, 2006). According to Ismail et al. (2016), green roofs' remarkable development across the world and currently green roof implementation are gradually accepted and acknowledged by the industry. A study conducted by Ismail et al. (2010) found buildings in developed countries have used green roof as one of the solutions to increase green area. Moreover, green roofs are well accepted for European cities with environmental problem and less green space (Carpenter, 2008).

Furthermore, Getter and Rowe (2006) mentioned that the roof area in most urban regions would usually constitute around 21%-26% of the total areas. Thus, the implementation of green roof increases the urban green area. This technology also become common in USA such as Chicago, Portland, Atlanta, and other cities (Ismail et al., 2016). Despite the application of green roofs in the Malaysia is still low, there are few remarkable green roofs applies on buildings in Malaysia as it has slowly becoming a trend in building industry (Saharuddin & Khalil, 2017).

### **Green Roof Concept**

Green roof can be defined as a vegetated layer on top of a roof structure that has certain components and depth (Sajedah et al., 2015). As mentioned by Getter and Rowe (2006), green roof is a vegetated roof system with growing media, supporting layers such as root barrier, roof membrane and drainage to recover the loss of green space. As stated by Vijayaraghavan (2015), this indicates that most of manmade structure with vegetation layers and habitable space beneath the structure can be considered as green roof. Green roof was designed and developed to promote the growth of various forms of vegetation on the top of buildings. It was generally comprised of several component and the role played by each component is well defined in engineered green roof system and type of each green roof component depends on the geographic location (Vijayaraghavan, 2015). Green roof is built upon a roof structure, whether new or existing, which is protected by a higher quality waterproofing and root repellent system, a drainage layer, a filter cloth and root repellent layer, a lightweight growing medium and plants, and finally a mulch layer. There are two types of green roofs which is intensive green roofs and extensive green roofs. Intensive green roofs or also known as roof gardens are heavier and strong enough to support an additional load, where it is suitable for underground garages and heavy buildings. It is generally heavy and the system requires specific support from the building (Rahman et al., 2013). Intensive green roofs required minimum depth of 15 cm for a deeper substrate. Typically, this type is installed when the slope is less than 10° (VanWoert et al., 2005). Extensive green roof is thinner, simple, and lighter kind of green roof where it is normally suitable for lightweight buildings. Usually, it is needed a shallow substrate of a depth about less than 15cm (Rahman et al., 2013).

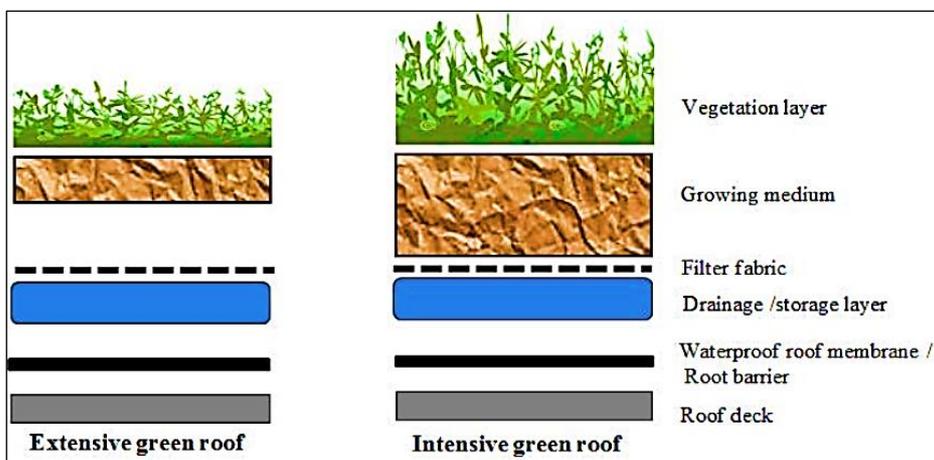


Figure 1. Computed Attic Temperature with Sealed and Ventilated Attic

### Benefit of Green Roof

According to Li et al. (2019), urban area was spotted in releasing higher amount of greenhouse gas (GHG) emission. Building sector has accounted up to 40% of the world’s energy consumption and more than 30% has contributed to the global GHG emission (Gong & Song, 2005). Hence, sustainable approach has been introduced to contribute to saving energy, reducing the emissions, and recycling materials. According to King et al. (2020), energy-efficient building contributes to life-cycle cost efficiency, improved market value or other economic benefits will be able to achieve economic sustainability. The use of green roof systems generated a wide range of benefits. According to Kingsbury and Dunnett (2008), the benefits only appear if a relatively large number of green roofs are installed in a particular area and will only be visible at the neighbourhood or city scale. The benefits of green roof can be classified into three main areas which is economic, environment and social. Table 1 below shows the economic, social, and environmental benefit of the green roof.

Table 1. Benefit of Green Roof

Benefits		Descriptions	Authors
Economic	<b>Lower the maintenance cost</b>	<ul style="list-style-type: none"> <li>• Operation and maintenance of the green roof are securing their positive impact.</li> <li>• Depends on size, characteristic, complexity, type of vegetation and market price.</li> </ul>	Feng and Hewage (2018) Bianchini and Hewage (2012)
	<b>Longer roof membrane life span</b>	<ul style="list-style-type: none"> <li>• Protection exerted by external layers of the roofing system on insulation and water proofing.</li> <li>• Improve building energy conservation.</li> </ul>	Rosasco and Perini (2019)
	<b>Boosting thermal performance</b>	<ul style="list-style-type: none"> <li>• Shading, insulation, evapotranspiration and increase thermal mass.</li> <li>• Better performance in the reduction of cooling load.</li> <li>• Enhance energy efficiency of building by preventing the penetration of solar heat into the building.</li> <li>• Improve of green roof building thermal insulation.</li> </ul>	Liu and Baskaran (2005) Mahmoodzadeh (2019) Ann et. al. (2015) Ascione et al. (2013)
	<b>Increase the property value and marketability</b>	<ul style="list-style-type: none"> <li>• Developing and improving green space in key location.</li> <li>• Better image and attract more visitors to come often, providing job and rental opportunities.</li> </ul>	Forest Research (2010)

	Benefits	Descriptions	Authors
Social	<b>Increase the aesthetic value</b>	<ul style="list-style-type: none"> <li>• More pleasant to experience or view from other buildings.</li> <li>• Include adapting exterior of architecture to meet desires of communities.</li> </ul>	Velazquez (2005)
	<b>Community engagement</b>	<ul style="list-style-type: none"> <li>• Allowing public to access to rooftop garden provides residents space to enjoy.</li> <li>• Involvement of local community will bring social benefit.</li> </ul>	Ozyavuz (2015)
	<b>Increase the recreational value</b>	<ul style="list-style-type: none"> <li>• Need for contract with nature.</li> <li>• Interact them with nature at any time without having to travel long distances.</li> </ul>	Drozdz (2019)
	<b>Reduce noise outside and inside building</b>	<ul style="list-style-type: none"> <li>• Reduce the noises generated in adjacent streets due to the high absorption coefficient of vegetation layer.</li> <li>• Work on the green roofs above low building.</li> </ul>	Berardi et al. (2014)
	<b>Improvement of air quality</b>	<ul style="list-style-type: none"> <li>• Plants reduce the air pollution through direct and indirect process.</li> <li>• Controlling the temperature variation of a building, heating, and air conditioning.</li> <li>• Photosynthesis process of plants isolate the CO<sub>2</sub> from the air.</li> </ul>	Yang et al. (2008) Schradler and Boning (2006)
Environment	<b>Reduce the Urban Heat Island (UHI) effect</b>	<ul style="list-style-type: none"> <li>• Building's roof top absorb energy from sun and reach high temperature.</li> <li>• Lower consumption of energy used by the building's occupants.</li> <li>• Cooling effect during the daytime can probably last throughout in the night due to the reduce of heat storage in urban canopy.</li> </ul>	Peng and Jim (2015) Liu et. al. (2012) Li et al. (2014)
	<b>Improves storm water runoff management</b>	<ul style="list-style-type: none"> <li>• Green roof systems store a large part of the annual rainfall releasing it later to the atmosphere through evaporation to help drains cope with severe downpour and reduce flash flood.</li> </ul>	Kingsbury and Dunnet (2008) Cantor (2008)
	<b>Reduce greenhouse gas emissions</b>	<ul style="list-style-type: none"> <li>• plants of green roof use atmospheric CO<sub>2</sub> during process of photosynthesis.</li> <li>• Lower ambient CO<sub>2</sub> concentration above and near roof of green plant.</li> </ul>	Rosasco and Perini (2019)
	<b>Reduce global warming</b>	<ul style="list-style-type: none"> <li>• Mitigate impact of global warming apart from cool roof and reflective materials.</li> </ul>	Ismail and Abdullah (2016)
	<b>Extra space for green area</b>	<ul style="list-style-type: none"> <li>• Provide a restorative environment that help alleviate stress and mental fatigue.</li> <li>• Beneficial impact on mental well-being and cognitive function.</li> </ul>	Van den Berg et. al. (2010) Cherrie et. al. (2018)
	<b>Increase biodiversity</b>	<ul style="list-style-type: none"> <li>• provide undisturbed habitat for microorganisms, insects, and birds.</li> <li>• Restore native plant species to the area.</li> </ul>	Brenneisen (2003) Li & Yeung (2014)

## ROLES OF GREEN BUILDING ARCHITECT

Architect will design buildings that mimic natural systems and have the capacity to reconnect with people in nature. According to Ferreira and Mendes (2004), most architect of modern design and construction find it easier to design and construct building if the nature does not exist. Therefore, the green building architect should use the sustainability concept to design and construction of buildings using the green building (Udomiaye et al., 2018). Moreover, Ferreira and Mendes (2004) said the concept and design of a building can be create through aesthetic, economic, social, and ecological sense. Kajtazi (2009) suggested that green

building architecture would be use in nature symbolism to create relations between architecture and its cultural context.

## METHODOLOGY

### Data Collection

Data collection in this research involves primary and secondary data. Type of data required for Objective 1 is secondary data. The secondary data are collected from literature review on the benefits of green roof. The source of secondary data involves in this research were in various form which is journals, conference papers, thesis, and websites.

The primary data for objective 2 is the data obtained from the questionnaire survey. A questionnaire is constructed based on the benefits of green roof derived from objective 1. A set of questionnaires were distributed among the expert architects in green building design.

### Respondent Sampling

There are two types of sampling including probability and non-probability sampling. The probability sampling method are used for this research. According to Alvi (2016), probability sampling is called as a random sampling or representative sampling.

This study's target population are green building architects. Therefore, the population of this research are assumed to have 120 in population size. The population size of architect was based on Green Building Index (GBI) official website. The sample size representative of the green building architect in this research will be determine by using the calculation of Taro Yamane. The sample of this research is calculated by using Taro Yamane (Yamane, 1973) formula with 95% of the confidence level. The calculation formula of Taro Yamane is presented as follows:

Where:

$$n = \frac{N}{1 + (e)^2}$$

n = sample size required

N = number of people in the population

e = allowable error (%)

Substitute numbers in formula:

$$\begin{aligned} n &= \frac{120}{1 + 120(0.1)^2} \\ &= 55 \end{aligned}$$

After calculated the sample size by using the formula from Taro Yamane, the number of samples is 55 respondents. Therefore, sample size of this study confidence levels at 95% and error is  $\pm 10\%$ . From this research, there are 80 data of respondents were managed to be collected.

## Data Analysis

Data on the benefits of green roof are analysed through content analysis. Content analysis is an approach to quantify qualitative information by systematically sorting and comparing items of information to summarize the data.

For second objective, data collected from the questionnaires distribution is analysed through Statistical Package for Social Sciences (SPSS). Frequency analysis and cross tabulation analysis was used to find significant green roof benefit and their placement. The cross-tabulation analysis in this study was conducted between most significant benefit of the green roof and the common placement of the green roof.

For the third objective, a framework has been developed based on the findings from the second objectives. The developed framework is based on frequency analysis which consists of an average mean value and a cross tabulation analysis. The framework offers details of a list of highly benefit of green roof based on building structure placement.

## FINDINGS AND DISCUSSIONS

### The Most Significant Benefit and Common Placement of Green Roof

This research has analysed the most significant benefit and common placement of green roof. This finding indicated that answers provided by each respondent were reliable and internally consistent. The questionnaires consist of questions related to 16 attributes of benefit of green roof and 5 common placement structure found from literature review.

**Table 2.** Mean Value Common Placement of Green Roof

Placement	Mean Value	Rank
Podium roof	4.25	1
Parking lot roof	4.22	2
Roof above occupied unit	3.98	3
Club house roof	3.88	4
Tennis court roof	3.58	5
Swimming pool roof	3.53	6

Table 2 shows the rank of common placement of green roof based on the opinion of expert architect. Based on the table above, the highest ranked for structure placement is at the podium roof with mean value of 4.25. Second and third rank are parking lot roof and roof above occupied unit by 4.22 and 3.98, respectively.

Table 3 shows the mean value of the overall benefits of green roof. Extra space for green area, increase the aesthetic value and reducing the urban heat island (UHI) effect ranked as the highest mean value by 4.55, 4.40 and 4.33, respectively. This indicates that most of the

respondents agree that these three benefits are the main benefits provided by the installation of green roof on a building.

**Table 3.** Mean Value of Overall Benefit of Green Roof

Benefits	Mean Value	Rank
Extra space for green area	4.55	1
Increase the aesthetic value	4.40	2
Reducing the Urban Heat Island (UHI) effect	4.33	3
Improvement of air quality	4.30	4
Increase the recreational value	4.28	5
Reduce global warming	4.25	6
Reduce greenhouse gas emissions	4.20	7
Increase biodiversity (attract beneficial insects, birds bee and butterflies)	4.20	8
Boosting thermal performance (energy saving)	4.15	9
Increase the property value and marketability	4.15	10
Community engagement	4.15	11
Reduce noise outside and inside building	3.75	13
Improves storm water runoff management	3.63	14
Longer roof membrane life span	2.90	15
Lower the maintenance cost	2.65	16

The mean value of overall benefit of green roof was rescaling using the index range formula. The maximum and minimum mean values for the benefit of green roof are 4.55 and 2.65. The index range for the benefits is 0.38. Overall, the average mean value for economic, social, and environmental benefit of green roof are tabulated in Table 4.

**Table 4.** Average Mean Value Based on Category of Benefit

Category	Average Mean Value
Economic Benefit	3.57
Social Benefit	4.18
Environmental Benefit	4.19

### Cross Tabulation Analysis: Benefit and Common Placement of Green Roof

The cross-tabulation analysis regarding the building structure placement and benefit of the green roof has presented different outcome for each of the benefit towards economic, social, and environmental. This cross tabulation also helps to examine relationships within the data that might not be readily apparent during the analysis process of the total survey from the respondents. Table 5 show the total number of respondents that have choose to agree and strongly agree for the relationship between green roof placement and its benefits.

Table 6 show the result from cross tabulation analysis. This analysis from cross tabulation generates the relation between benefit of green roof and building structure placement. From the analysis, most of the expert architects in Malaysia agrees that boosting thermal performance are achievable if the green roof was placed above occupied unit. This result may be due to the reason that thermal performance will give higher cooling performance toward the building thus will reduce the electricity usage and generate higher energy saving. This finding is aligned with studies by Santamouris et al. (2007) where occupied units that placed under green roof will harvest highest cooling benefits. Majority of the respondents agree that

green roof implement on all structure placement except roof above occupied unit can increase aesthetic value of the building. Extra space for green area is proven to be the best environment benefits of green roof implemented on all the suggested structural placement.

**Table 5.** Cross Tabulation between Structure placement and Benefit of Green Roof

Placement and Benefit		Roof Above Occupied Unit	Parking Lot Roof	Podium Roof	Swimming Pool Roof	Club House Roof	Tennis Court Roof
Economic	Boosting thermal Performance (energy saving)	18	12	10	6	12	8
	Increase property value and marketability	14	14	8	4	6	6
Social	Community engagement	18	14	10	4	10	8
	Increase aesthetic value	14	28	22	20	22	20
	Improve air quality	14	28	24	20	20	14
	Increase recreational value	18	28	24	18	18	14
Environment	Reduce greenhouse gas emissions	12	10	10	6	16	6
	Increase biodiversity	14	10	8	4	8	6
	Reducing UHI effect	20	24	26	20	20	16
	Reduce global warming	20	30	26	24	26	22
	Extra space for green area	24	32	36	28	28	22

**Table 6.** Overall Result of Cross Tabulation Analysis between Structure Placement and Green Benefit

Placement and Benefit	Roof Above Occupied Unit	Parking Lot Roof	Podium Roof	Swimming Pool Roof	Club House Roof	Tennis Court Roof
<b>Economic</b>	Boosting thermal performance (energy saving) <b>(18)</b>	Increase property value and marketability <b>(14)</b>	Boosting thermal performance (energy saving) <b>(10)</b>	Boosting thermal performance (energy saving) <b>(6)</b>	Boosting thermal performance (energy saving) <b>(12)</b>	Boosting thermal performance (energy saving) <b>(8)</b>
<b>Social</b>	Community engagement, increase recreational value. <b>(18)</b>	Increase aesthetic value, increase recreational value, improvement of air quality <b>(28)</b>	Increase recreational value <b>(24)</b>	Increase aesthetic value, improvement of air quality <b>(20)</b>	Increase aesthetic value <b>(22)</b>	Increase aesthetic value <b>(20)</b>
<b>Environmental</b>	Extra space for green area <b>(24)</b>	Extra space for green area <b>(32)</b>	Extra space for green area <b>(36)</b>	Extra space for green area <b>(28)</b>	Extra space for green area <b>(28)</b>	Extra space for green area, reduce global warming <b>(22)</b>

The result from cross tabulation analysis has reflect the outcomes of this study which is to develop a green roof structure placement based on significant green benefit framework. The framework was constructed based on data with higher value in cross tabulation between structure placement and green roof benefit. Figure 2 below shows that the most highly benefit of the green roof divided into three category which is economic, social, and environmental.

The illustration of Figure 2 shows that social benefit has more criteria compared to economic benefit and environmental benefit. The social benefits of green roof are increasing recreational value, increase aesthetic value and community engagement. From the framework, common building structure placements for social benefit was installed on parking lot roof. The economic benefit of green roof was found to be more efficient in boosting the thermal performance if the green roof was installed on all suggested structural placement except the parking lot roof. Thermal performance will give the cooling effect and found to be more benefitted for an occupied building. Moreover, green roof implementation on roof above occupied unit, parking lot roof, club house roof, swimming pool roof and podium roof are found to have high benefit to environmental on extra space for green area.

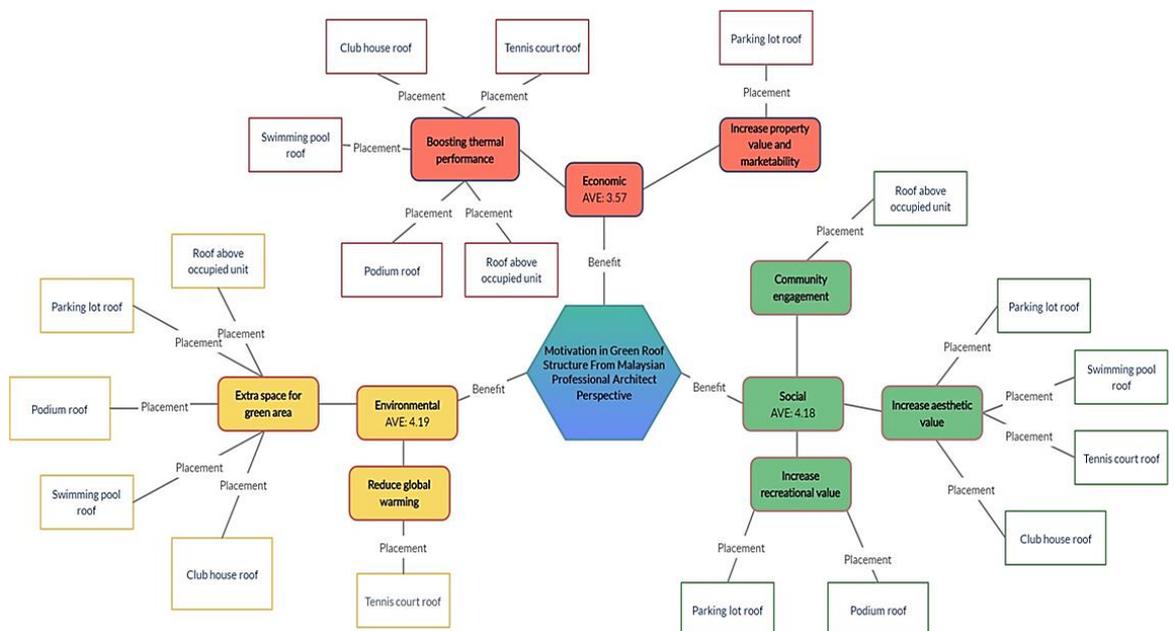


Figure 2. Framework Highly Benefit of Green Roof Based on Building Structure Placement

## CONCLUSIONS

There are many benefits of the green roof based on this research. The benefit of green roof can be divided into three categories which is economic, social, and environmental benefit. This research also covered issues on the common building structure placement. The results from this study have found that the green roof is highly efficient in boosting thermal performance, reducing electricity consumption thus saves more energy which is aligned with the finding from literature review. The developed framework shows that green roof placement on parking lot is able to give more social benefits to the users. Besides, economic performance of green roof can be fully optimized for implementation on roof above occupied building. However, the expert architects agree that the environment benefits of green roof in UHI effect, global warming and provide green space can be achieved on all suggested structure placement. This research is significant for developers, architects, and researchers regarding in green roof placement on building to optimize its benefits.

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# CASE STUDY OF TWO-STAGE EARLY CONTRACTOR INVOLVEMENT (2S-ECI) USED FOR SEISMIC UPGRADES AT QUEENSTOWN AIRPORT NEW ZEALAND

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## Abstract

Two-stage early contractor involvement (2S-ECI) provides a procurement pathway for involving contractors typically after concept design, with pricing based on preliminary and general costs and agreed margins applied to subcontractors. Then parties can work together to develop the design with contractor's buildability input, select subcontractors and agree what is typically a fixed price construction contract. This paper explores the challenges and benefits of 2S-ECI in New Zealand through a case study using semi-structured interviews with the project team on an airport alteration and seismic strengthening project. The project team consisted of a project manager, engineers, contractor's quantity surveyor and professional quantity surveyor (PQS). Findings build on the body of knowledge to help inform parties considering adopting 2S-ECI on their projects. In particular, the ability to de-risk projects involving continued client operations during the construction stage, and the need for contractual documentation to support 2S-ECI.

**Keywords:** *Early Contractor Involvement; Procurement; Alterations; Seismic Strengthening.*

## INTRODUCTION

This study explores the key stakeholder perceptions of two-stage early contractor involvement (2S-ECI) on an airport seismic strengthening project using four semi-structured interviews comprising the project manager, engineer, contractor's quantity surveyor (QS) and a professional quantity surveyor (PQS). The primary focus is to establish the perceived benefits and challenges of 2S-ECI, as well as any further improvements.

2S-ECI is a procurement pathway that involves the contractor before the project has been fully designed, typically to provide buildability input. Researchers have found that contractors providing buildability input has been linked to improved risk identification and management (Finnie, AMEER Ali, 2019, Laryea and Watermeyer, 2016; Pheng, Gao and Lin, 2015; Mosey, 2011; Rahmani, Khalfan and Maqsood, 2014; Song et al., 2006). Procurement systems associated with ECI as a procurement concept include design and build, management contracting, construction management or 2S-ECI (Finnie, AMEER Ali and Park, 2019).

2S-ECI is generally selected for construction projects that involve planning the logistics of construction around existing operations, securing resourcing in heated markets, maintaining client/contractor relationships, or providing specific design buildability and value management advice (Finnie, AMEER Ali and Park, 2019). Maintaining airport live operations whilst completing seismic strengthening work requires strong cooperation and problem-solving skills. Jorgensen and Emmitt (2007) found that a key focus is cooperative and partnering relationships, combining various individuals' competencies into joint-problem-solving, and involving specialist contractors in the design process (Gil et al., 2004, p496). 2S-

ECI may be used on a wide range of projects, with it being particularly beneficial to projects where the cost of disruption might outweigh any premium paid for the benefit of logistical planning and reliability, such as airport extensions or hospital alterations (Finnie, AMEER Ali and Park, 2019). This makes the study of 2S-ECI on the airport seismic strengthening project appropriate.

In 2019 a seismic strengthening and alterations project was completed on Queenstown airport in New Zealand with a construction period of 4.5 months and a value of \$1-10M. The project was moderately complex, as it involved splitting the building in half and installing a seismic gap, all whilst maintaining live operations. The extent of existing services was unknown, hence attributing to why the 2S-ECI procurement pathway was adopted. This aligns with previous studies that have found that 2S-ECI can be particularly suited to projects requiring logistical planning of construction to existing operations (Finnie, AMEER Ali and Park, 2019). The two-stage contract consisted of an invitation letter for the pre-construction stage followed by a cost reimbursement contract using NZS910:2013 *Conditions of Contract for Building and Civil Engineering Construction* (Standards New Zealand, 2013). The pre-construction stage pricing consisted of a fixed price for preliminaries and general and stated margins to apply to subcontractors and a budget estimate for the builder's work component. Once appointed, the contractor procured fixed prices for the subcontracted works which were evaluated with the client's consultant team. The procurement pathway adopted for 2S-ECI generally aligns with that described by Finnie, AMEER Ali and Park (2019) except that the builder's work component was undertaken on a cost reimbursement basis rather than a fixed lump sum.

Prior studies have researched the general benefits and challenges of 2S-ECI in New Zealand but have not been based on a specific case study. This case study also used a cost reimbursement construction contract which differs from the fixed lump sum contracts typified in previous studies. Therefore, this case study will explore the perceived benefits and challenges of 2S-ECI from a project team who recently completed a seismic strengthening project on an existing airport using a 2S-ECI contract with a cost reimbursement construction contract.

## LITERATURE REVIEW

The following literature review establishes what is known about 2S-ECI in terms of project suitability and its benefits and challenges. There is an emerging body of research on 2S-ECI in New Zealand, particularly the works by Finnie, AMEER Ali and Park (2018) who found that 2S-ECI may benefit projects that involve prefabrication or off-site manufacturing, Finnie, AMEER Ali and Park (2019) who interviewed construction professionals across New Zealand to establish user preferences of 2S-ECI, and Finnie, AMEER Ali and Park (2020) who evaluated pre-construction services (PCSA) to establish optimal contract provisions to support 2S-ECI.

### Early Contractor Involvement

Early Contractor Involvement (ECI) is a concept used to describe any procurement strategy that involves the contractor during the design phase, such as design and build (DB), management contracting (MC) or construction management (CM), or as its own procurement

system, typically referred to as a two-stage procurement process or 2S-ECI. The potential cross-over between these definitions may create confusion about its use, for example the construction stage contract in 2S-ECI may be for construction only or DB (Finnie, AMEER Ali AMEER and Park, 2018). ECI provides contractors with the opportunity to foresee risks associated with the construction, during the design stage, and provide buildability input to the client's consultant team, rather than traditional procurement where contractors may have only weeks to bid on fully complete designs (Mosey, 2011).

## **Project Suitability**

Finnie, AMEER Ali and Park (2019) found 2S-ECI best suited to projects involving alterations to existing buildings where the cost of potential disruption outweighs any premium paid to the contractor for their pre-construction services, such as work to hospitals or airports. This makes 2S-ECI well suited to the Queenstown Airport project.

2S-ECI can also be used to secure resources in a heated market through a more negotiated open-book pricing approach (Finnie, AMEER Ali, 2019; Whitehead, 2009). This was evident through Christchurch, New Zealand's construction market post the 2011 earthquake where demand exceeded the supply, meaning competitive pricing may no longer achieve the best value for money (Finnie, AMEER Ali and Park, 2019).

The negotiated more open-book approach to pricing in 2S-ECI can also support long-term relationships, and continuous improvement. This can support supply chain integration management (SCM) where contractors are used on multiple projects. Abdullah et al. (2017) case study found that relationships, communication, and contractual issues are key challenges in SCM. Sodal et al. (2014) found that contractors can contribute valuable design product information from previous projects including information about technical products. In return, the contractor benefits from ongoing relationships by achieving more certain and consistent workloads and reduced learning curves (Song et al., 2009).

2S-ECI may also be suitable for engaging contractors for design buildability on complex new builds or alterations. The New Zealand Transport Agency (2018) recommends that projects should be procured through ECI where there is scope uncertainty, that may benefit from fast tracking, constructability input, and engaging work packages during the design phase. New Zealand Government Procurement (2019) provides that ECI is best suited to large, complex, or high-risk projects because it affords an integrated team time to gain an early understanding of requirements, enabling robust risk management, innovation and public value. However, Finnie, AMEER Ali and Park (2019) found that interviews generally found less value for using 2S-ECI for new builds compared to complex alterations.

## **2-Stage ECI Benefits**

A key advantage identified in previous studies is the opportunity for contractors to work collaboratively with the consultant design team to improve planning and buildability (Mosey, 2011; Whitehead, 2009; Farooqui and Ahmed, 2008; Jergeas and Put, 2001). According to Finnie, AMEER Ali and Park (2018) 2S-ECI works can be collaboratively planned, harnessing the contractor's buildability knowledge to foresee risks and maximize value. The contractor may add value through aspects such as advising on resource availability,

identifying limitations in terms of cost, performance, access, and site conditions, engaging subcontractors, and providing more transparent costs. Sodahl, Laedre, Svalestuen and Lohne (2014) found through interviews that adjustments to structural systems and details early on are most often critical to effective constructability. Therefore, alterations to an existing airport building would particularly benefit from using 2S-ECI, as a key project feature is structural seismic strengthening.

The early planning 2S-ECI can reduce design changes and avoid delays and disputes during construction (Mosey, 2011) reducing contract variations and improving price and time surety through better planning (Finnie, AMEER Ali and Park, 2019; Mosey, 2011). An empirical case study from Song (2009) concluded that “the contribution from general contractors and subcontractors resulted in improved quality of drawings, improved flow of information and hence better progress relative to the schedule”. Finnie, AMEER Ali and Park (2019) found that the construction industry perceives a decline in the quality of design documentation in New Zealand over the past five to ten years, creating more variations and reducing price certainty. This is salient considering that the early planning through 2S-ECI has been found to iron out issues and reduce variations (Finnie, AMEER Ali and Park, 2019, Mosey, 2011).

Regardless of the contractor’s input, 2S-ECI affords them more for time contractors to plan the project compared with traditional tenders where contractors may have only weeks to price the job, driving pricing assumptions (Mosey, 2011). Pheng et al. (2015, p831) found that ECI may help improve productivity through reducing variability and cycle time, minimizing steps, and increasing output flexibility. Gil, Tommelein and Ballard (2004) found that shop drawings may be produced earlier and faster by reducing the time required for freshly appointed contractors to familiarise themselves with the project. This may be particularly advantageous for contractors working on existing building projects, where the client may benefit from appointing a contractor who has already worked on the building, as they would have a greater insight as to what they are dealing with. For example, the contractor will have more knowledge of existing layouts, and potential challenges and technical products.

Through the more open-book approach to pricing, 2S-ECI can be used to support ongoing client and contractor relationships (Finnie, AMEER Ali and Park, 2019). Integration across the project team can leverage its collective skills, knowledge, and experience to achieve success (Tey et al., 2018). Jorgensen and Emmitt (2008) found that ECI can help foster partnering relationships, and joint problem-solving through combining various individuals’ competencies, and involving specialist contractors in the design process (Gil et al., 2004, p496). Finnie, AMEER Ali and Park (2019) found that 2S-ECI both relies on trust and can help build trust across the project team.

## **2-Stage ECI Challenges**

Whilst most studies have shown the advantages of 2S-ECI, some have also revealed some potential challenges. Whitehead (2009) identified a range of problems with 2-Stage ECI, which includes the client incurring tendering costs, project team not working well together, appointing contractors too early, lack of competitive pricing, and new and unfamiliar contracts.

A case study by Sodahl et al. (2014) found that contractors generally have a strong cost focus, rather than the visual design appeal and provides that, even though the early collaboration between designers and contractors can be productive, the potential conflict of interest can threaten positive project outcomes. This may be mitigated by setting common goals and by involving the contractor once a concept design has already been established (Finnie, AMEER Ali and Park, 2018).

Other studies have shown that the lack of clear definition of 2S-ECI and associated contractual documentation as an area of concern. Finnie, AMEER Ali and Park (2019) found that most interviewees felt that 2S-ECI could be improved with clearer pre-construction agreements, in particular to set out the scope of pre-construction services and expected obligations of parties. Finnie, AMEER Ali and Park (2019) reasoned that, it is perhaps therefore unsurprising that most interviewees (across disciplines) “perceived client and consultant attitudes towards 2S-ECI as a barrier to its uptake, with some recommending further education in this area”. Moreover, Finnie, AMEER Ali and Park (2019) identify that 2S-ECI is difficult without a clear process framework.

The reviewed literature has provided general advantages and disadvantages of 2S-ECI. However, there is a lack of case studies specifically relating to the use of 2S-ECI in New Zealand. This case study aims to establish the perceived benefits and challenges from construction professionals who recently completed seismic upgrades and alterations on an existing airport using a cost reimbursement construction contract and whilst the client-maintained operations. Literature suggests that the airport project is well suited to 2S-ECI, therefore making this a good case study.

## RESEARCH METHODOLOGY

Four semi-structured interviews were conducted to collect primary data, which consisted of both planned and unstructured interviews. This allowed for more flexibility to explore reasoning behind given answers and to gain a more in-depth understanding of the participants perceptions using a qualitative approach.

A five-part interview questionnaire comprising 33 questions was adapted and modified from a study by Gameson and Sher (2009). Interviews took between approximately one and two hours. Covid-19 was an on-going pandemic during 2020, which had a significant impact on public hygiene and restrictions. Fortunately, New Zealand was at alert level one during the interviewing timeframe, therefore, interviews were carried out in person, except for the electrical engineer who was interviewed via Skype due to their location. The skype interview lasted approximately 75 minutes and explored the in the same depth as the interviews carried out in person.

- Section 1: General Questions. Collects general information about the interviewee (name, company, role, years of experience). [3 questions]
- Section 2: Background Information. Collects data about participants’ experience with ECI (number of ECI projects, value range, and type). [3 questions]
- Section 3: Case Study Project Information. Collects data relating to a typical facility (facility type, complexity, location, cost, time scale, head contractor or consultant, reason for ECI). [8 questions]

- Section 4: Contractual Issues. Collected data relating to specific contractual parameters (timing of contractor involvement, scope of pre-construction services, services by client's PM, formation of contractor pricing, whether contractor paid for ECI, form of construction contract price, contractual documentation used and key ingredients, risk considerations, lessons learnt). [14 questions]
- Section 5: Perceptions. Collects data about participants' overall perceptions of ECI (effect on pricing, timing, quality, risk clarity, project team composition, project suitability for ECI, and main barriers and opportunities to improve ECI). [4 questions]

Findings were coded based on each section including project suitability, timing, pricing, risk, team relations and composition, scope of pre-construction services, and clarity of the 2S-ECI process, and overall challenges and opportunities for improvement. Findings were tabulated into a spreadsheet which allowed for the interview transcript content to be analysed using a qualitative approach of themed content.

The four participants were selected based on their involvement in the seismic strengthening project and their level of experience in the construction industry. The interviews consisted of a project manager (15 years' experience), engineer (27 years' experience), contractor's quantity surveyor (9 years' experience) and PQS (24 years' experience).

Three participants had previous ECI experience prior to the seismic strengthening project through a range of commercial and residential construction, all ranging in values from \$1,000 - \$70,000,000. One participant had no experience of ECI prior to the seismic strengthening project.

The demographic spread of participants included Queenstown and Christchurch. The participants are also involved in various projects throughout New Zealand, therefore meaning their knowledge of 2S-ECI in Queenstown was able to be compared against different projects through various locations in New Zealand.

The Airport Seismic project was completed during January 2020; therefore, answers may be influenced by the memories of the project team members interviewed. However, the interviewees have been involved in various other projects on the airport since the seismic work was completed, therefore their perceptions of using 2S-ECI on the airport are likely to remain valid.

## **DATA ANALYSIS AND DISCUSSION**

The collected data explores the perceptions the use of 2S-ECI on the Queenstown Airport case study.

### **Project Suitability For 2S-ECI**

Participants identified various reasons for using 2S-ECI on construction projects in the New Zealand construction industry:

1. Projects that are working in a live environment (all participants).
2. Projects where you want a long-term relationship.
3. Commercial or infrastructure works relating to structures i.e., bridges and tunnels.
4. During a heated construction market where resources are scarce, such as shortage of tier 1 contractors, for example, Christchurch after the 2011 earthquakes.
5. Projects which are complicated from a design and construct point of view, for example, complicated structure and poor access to the construction site.

The use of 2S-ECI to secure contractors in a heated market is supported by previous literature which identified that procurement practices in post-earthquake Christchurch largely u-turned from lowest price conforming bids to more relational procurement strategies (Zuo, et al., 2013). 2S-ECI has also been found useful for securing contractors in a heated market for infrastructure work in Australia (Whitehead, 2009). Participants then identified the key drivers for using 2S-ECI on the airport seismic strengthening project:

1. Maintaining operations inside of a live operating airport.
2. The contractor's expertise and knowledge of the existing terminal.
3. Uncertainty around services and the extent of the existing services.
4. The client wanted a contractor that they could trust.

All interviewees identified the key driver for using 2S-ECI on the airport was to carry out exploratory work around existing services to ensure the airport could maintain live operations during construction. The contractor's QS noted that a key risk for the client involved removing the existing electrical cables because no one knew which cables were redundant which posed a 'big potential risk' because removing the wrong cables risked shutting down the airport. 2S-ECI enabled early exploratory work to address this risk. This is supported by Finnie, AMEER Ali and Park (2019) who found that securing the most reliable contractor may mitigate the risk of disruption, which could far outweigh any potential premium paid for early involvement. The PQS highlighted the benefit of utilizing a contractor with prior experience of past work on the buildings, whereas newly appointed contractors through competitive tender would have lacked previous lessons learnt and knowledge of the airport aviation rules "*whether that be airport security or maintaining live services.*" This was supported by the project manager who highlighted the importance of utilizing contractors with experience of the airport. This supports findings by Sodahl et al. (2014). The contractor identified that using a traditional competitive tender with a lump sum contract would have been difficult to compare 'apples for apples' between tenderers due to the limited design and unknown scope at the time of tendering. This supports Mosey (2011) who argued that traditional tendering can create more pricing assumptions.

## Timing

Due to the contractor's earlier involvement, they had a greater understanding of the scope and the existing building structure and services that they were working with. This allowed for a realistic construction program to be established due to the early involvement of contractors and subcontractors. All participants shared the same opinion that 2S-ECI provides a more realistic construction programme due to the contractor's early involvement and greater understanding of the project. The contractor's QS felt that the programme was more effective through 2S-ECI due to earlier involvement and "*better understanding of scope of works.*" The

PQS felt that *“risk is better understood due to the contractor being involved from the beginning. The contractor has a greater understanding of the works when they go to price, therefore the time aspect is understood better.”* The Engineer echoed that *“ECI provides more realistic construction programs, especially on staged projects.”* This is supported by Finnie, AMEER Ali and Park (2019) 2S-ECI procurement can take longer, but that early staging may be used to maintain construction completion dates.

According to the project manager, 2S-ECI resulted in a longer pre-construction phase as opposed to a traditional contract, due to the investigation works required to the buildings existing services. However, this was offset by the post contract construction works, where the number of variations was ultimately reduced due to the investigation works and early involvement. The design stage can be elongated, but ‘for the right reasons’, i.e., to reduce budget or buildability problems later (Finnie, AMEER Ali and Park, 2019; Mosey, 2011).

## Pricing

Given the reduction of variation claims during construction, all participants felt that 2S-ECI provided a higher level of price certainty due to the early investigation works. During the preliminary stages of the project a high-level concept design was created to enable the PQS to provide an estimate for the client board’s approval. Once the airport received the board’s approval, they engaged the contractor to complete ‘investigative work’ to further develop the design and fill in any gaps within the design documentation. The investigative work allowed the contractor and respective sub-contractors to further develop the design as well as gaining a better understanding of what they were dealing with. This was echoed by the Engineer who felt that 2S-ECI can give more certainty on subcontractor areas, such as pricing for the electrical cables at the preliminary stage. The contractor’s QS said that early involvement helped them refine the price and risk of *“where that price is going”* through better defining the scope of work, for example the exploratory works. Accordingly, the PQS thought that a contractor involved from the inception *“will have a greater understanding of the works when they go to price it.”* The PM explained how the design was able to be updated following the services investigation leading to better price certainty.

Originally the contractor priced the project as complete open book (cost reimbursable, with a budget estimate to complete the works), however, the client wanted less risk and preferred to fix costs where possible for cost certainty. 2S-ECI enabled the contractor to engage subcontractors during the inception of the project, which effectively led to them being able to fix sub-contractor pricing. The finalized pricing reflected fixed subcontractor trades (structural steel, metal roofing, metal windows, mechanical services, fire services, electrical services, and suspended ceilings), fixed preliminary and general, and builders work based on cost reimbursement.

Zuo (et al., 2013) found that the more transparent pricing of relational procurement may achieve lower project costs. However, Bajari and Tadelis (2001) found that cost reimbursement provides less price certainty than lump sum contracts and entails more auditing for claim certification. The key risk on the Airport project involved the extent of unknown existing services, therefore fixing the subcontracted trades after updating the scope of work following the exploratory works, offered more accurate and certain pricing than open book. The exploratory works meant that the project carried less contingency. If the project

was conducted through traditional tender, there would have been a greater contingency to factor variations during construction. This supports Mosey (2011) who argued that 2S-ECI can reduce variations during construction.

2S-ECI incurred a higher pre-construction cost for the project due to the contractor attending meetings on an hourly rate, subcontractors being engaged for investigative works, and the overall consultant cost impact due to a longer pre-construction phase. However, the higher 'entry price' was offset by the lower 'exit price' due to the discoveries identified in the investigation works. Finnie, AMEER Ali and Park (2019) identified that clients may pay a premium for early involvement due to the less competitive tension. However, the PQS argued that "*it's not about the entry price, it's about the exit price*", and they can be different' and that 2S-ECI can achieve a better managed exist price. Notably, Kings College London (2014) recommends using pre-construction milestones to maintain the overall programme and avoid slippage. Finnie, AMEER Ali and Park (2019) also found that some contractors do not charge for their early involvement on the basis that they secure the construction contract.

## Risk Management

Completing seismic strengthening works in an airport whilst live operations were maintained posed multiple project risks including existing redundant electrical cabling, the quality of the client's as-built drawings, and the risk of the builder's work done on cost reimbursement. Various collaborative risk management meetings were held.

**Table 1. Project Risk Factors**

Risk Factors	Comments
Existing redundant electrical cables	The exploratory works helped mitigate the risk of shutting down the airport. The engineer explained that a plan was developed in which the contractor removed approximately 10x cables per night, as opposed to doing them all at once. This meant that if the contractor's removed the wrong cable, it would only shut down part of the airport rather than the whole terminal.
Builders' work done on cost reimbursable contract	Due to the contractor's work being done over day and night shifts on a cost reimbursement basis, the PQS carefully considered productivity to maintain the budget, because workers are more productive during the day.
Clients current as-built documentation	The project manager provided that the airport as-built drawings varied and were unreliable. 2S-ECI enabled the project team to engage a 3D model of the existing services which was coordinated between all design disciplines and the contractor to understand the location and extent of existing services.

Engaging the contractor early enables the contractor to collaboratively manage the risks with the consultants (Finnie, AMEER Ali and Park, 2018). Whereas contractors generally have a limited opportunity to manage risks when bidding in a traditional tender (Finnie, AMEER Ali and Park, 2019; Murdoch and Hughes, 2015). This is evident in the airport project where the contractor was able to identify and manage the risks around existing as-built drawings and the unknown quantum of redundant electrical cables by carrying out exploratory work. Had the contractor been employed through a traditional tender they would not have had this opportunity, therefore leading to greater potential for variations. Indeed, the contractor noted that they would have priced the work differently through traditional fixed price tender due to the risks. This again supports Mosey (2011) that 2S-ECI reduces variations.

## Project Team Composition

All participants felt that 2S-ECI created a greater composition of the project team and improved team collaboration. The contractor's QS felt that 2S-ECI "*allows for the most appropriate workers to be involved in the project which specialize in that type of work.*" The contractor provided that competitive tenders typically only allow weeks to establish a project team after the contractor has been selected, therefore meaning that the most appropriate project team may not be available. 2S-ECI better enables the most appropriated workers to be selected. Previous literature found that when sourcing the subcontractors, the head contractor should engage specialist subcontractors to be involved early in the design where necessary (Sodahl et al., 2014). This was evident on the airport project, including the involvement of subcontractors for exploratory works. The engineer also highlighted the importance of involving contractors in the design process, which enables them to get a better understanding behind the design decisions being made. This is supported by (Mosey, 2011; Gil, Tommelein and Ballard, 2004). This can achieve better buy-in to those decisions i.e., from a buildability perspective reducing design changes during construction. As the engineer stated there's less alternatives for the contractor during construction because "*they've brought into the design in the first place.*"

These findings support previous studies that found that ECI supports cooperative partnering relationships, and joint problem-solving through combining various individuals' competencies (Jorgensen and Emmitt, 2008) and involving specialist contractors in the design process (Gil et al., 2004, p49) and leveraging collective skills, knowledge, and experience to achieve success (Tey et al., 2018).

## Project Team Relations

All participants felt that 2S-ECI requires good relationships and trust for it to be successful. This supports findings that trust is a central ingredient of relational procurement (Rahman and Alhassan, 2012; Ross, 2011; Toolanen, 2008; Rahman and Kumaraswamy, 2005).

The project manager noted that 2S-ECI also increases trust levels and has a more collaborative approach between the contractor and consultants, and that there is a greater collaboration between contractor and designer. This was echoed by the PQS who thought that 2S-ECI "*creates a more collegial dynamic within the project team.*" Equally the engineer felt that 2S-ECI "*Strikes up a good relationship right from the start.*" The engineer also said they have not experienced a bad relationship in the 10 years that they have been using 2S-ECI and that contractors are generally more proactive because they are not always guaranteed the project during early involvement.

These findings support Finnie, AMEER Ali and Park (2019) who found that 2S-ECI both relies on trust and can also improve levels of trust. They further support findings that contractors benefit from ECI through securing long-term client and consultant relationships, and that this contributes to sound profit margins, and improved client satisfaction (Rahman and Alhassan, 2012; Song et al., 2006).

## Scope of Pre-Construction Services

The contractor was involved 1.5-2 years before the project's construction started. They:

- Provided a proposed methodology for the scope of works identified in the engineers' design. This included how much work could physically be completed each night.
- The contractor and subcontractors completed exploratory works to get a better understanding of existing services and gain more information.
- Procured subcontractors, the majority of which were services related and were engaged early to reduce risk. The subcontractors were selected based on their work experience in the airport on previous projects.
- Contributed value management and buildability advice. The contractor was involved in numerous pre-construction design meetings where they provided advice around e.g., making steel members lighter and commenting on steel joints from a buildability perspective.

The PM was involved from the preliminary stages, and provided the following:

- Project programme.
- Managing the client's scope expectations and communicated this to stakeholders.
- Guided the client, designers and PQS through the design stage and managed stakeholders regarding the impact of works.
- Led risk management workshops.

The services provided by the PM and contractor generally align with those identified within previous studies (Finnie, AMEER Ali and Park, 2019):

The PQS was also involved during the first initial stages of the project, where they completed a high level 'concept estimate' for the client to go to the board and seek approval. They also analysed risks from a cost point of view, for example, how much of the work is completed at night compared to daytime. Finnie, AMEER Ali and Park (2019) identified that 2S-ECI generally adopts a more open book pricing approach, which leads to the client engaging a PQS for budget advice. This approach was relatable to the airport project, as the PQS was engaged to provide high level estimates for the board to seek approval.

The electrical engineer:

- Reviewed the contractor's proposed construction methodology.
- Reviewed the subcontractor procurement.
- Provided buildability advice which was checked and confirmed by the contractor.
- Contributed to risk management workshops. For example, completing the electrical cabling work "piecemeal", as opposed to all at once to help mitigate power outages to the whole airport terminal.

The engineer noted that the airport job was like no other project that they had previously been involved in. The project had a critical nature to it, which was shown through the number of risk meetings held. The electrical subcontractor was introduced during the pre-construction

stage of the project, where the engineer evaluated their methodology and provided input where necessary. This allowed for contingency plans to be implemented and for a realistic construction programme.

## Clarity of 2S-ECI Processes

The lack of guidelines and standard documentation available for 2S-ECI was a key area identified to improve the 2S-ECI process. The importance of involving specialist subcontractors to help manage specific project risks was also highlighted and important. The PQS highlighted the risk of paying a contractor e.g., \$250,000 for ECI services, only to remain silent during the design meetings. *“This isn’t adding value to the client, because ECI is about “buying the construction smarts” from contractors during the design phase of a project.”* The PM also highlighted the need for everyone to understand their roles in 2S-ECI And that the *“true value is when people take ownership of their role, for example, the contractor needs to be adding input in around design and buildability.”* Finnie, AMEER Ali and Park (2019) also found that 2S-ECI could be improved in New Zealand with clearer pre-construction agreements, in particular to set out the scope of pre-construction services and parties’ roles and responsibilities. Then, Finnie, AMEER Ali and Park (2020) established the key ingredients of a pre-construction services agreement (PCSA) to support 2S-ECI. Standard form contract documentation would improve clarity and help ensure the client knows what to expect from 2S-ECI. This is supported by the PQS comment who also noted that *“a better structure may be a document that says general rules etc., as currently the client doesn’t know what they’re buying. Everyone knows how ECI is done, however there is no formal structure that enables the client to know what they’re buying.”*

The engineer noted that the early involvement of specialist subcontractors is often overlooked, and how their involvement can help reduce project risk. The airport alteration project had a significant focus on existing services during the pre-construction stage, which saw the contractor bring in specialist subcontractors for advice.

## SUMMARY OF FINDINGS

The following table summarises the key findings from this case study.

**Table 2.** Summary of Key Findings

Provisions	Key Findings
Project suitability	<ul style="list-style-type: none"> <li>• Projects that are working in a live environment (all participants).</li> <li>• Projects where long-term relationships are desired.</li> <li>• Commercial or infrastructure works relating to structures i.e., bridges and tunnels.</li> <li>• To secure resources in a heated market where resources are scarce, such as shortage of tier 1 contractors, for example, after the 2011 earthquake in Christchurch, New Zealand.</li> <li>• Projects which are complicated from a design and construct point of view, for example, complicated structure and poor access to the construction site.</li> </ul>
Timing of involvement	<ul style="list-style-type: none"> <li>• Better planning and risk mitigation.</li> <li>• More realistic construction programme based on more time for the contractor to plan.</li> <li>• Longer pre-construction planning may be offset by a speedier construction stage.</li> </ul>
Pricing	<ul style="list-style-type: none"> <li>• Increased price certainty and reduced variations</li> <li>• May be higher entry price, but this can be offset by lower final exit rice.</li> </ul>
Risk	<ul style="list-style-type: none"> <li>• Enables exploratory works to improve the scope of works early and reduce the contingency.</li> </ul>

Provisions	Key Findings
Team relations and composition	<ul style="list-style-type: none"> <li>• Better contractor team composition than traditional tender.</li> <li>• Improved team collaboration and relationships and contractor proactiveness.</li> <li>• Relies on trust.</li> </ul>
Scope of pre-construction services	<ul style="list-style-type: none"> <li>• Contractor.</li> <li>• Construction methodology.</li> <li>• Exploratory works, including buy specialist subcontractors.</li> <li>• Value management and buildability advice.</li> <li>• Client's project manager:</li> <li>• Overall programme.</li> <li>• Stakeholder management.</li> <li>• Oversee design management.</li> <li>• Oversee risk management.</li> </ul>
Clarity of the 2S-ECI process	<ul style="list-style-type: none"> <li>• Need clearer industry guidelines.</li> <li>• Need clear role and responsibilities. for pre-construction services.</li> <li>• Need provision for engaging specialist subcontractors early.</li> </ul>

## CONCLUSIONS

This paper has case studied the use of 2S-ECI used for alterations at Queenstown Airport, New Zealand involving seismic strengthening. Key members of the project team were interviewed to establish their perceived benefits and challenges of using 2S-ECI in terms of project suitability, timing, pricing, risk, team composition, and clarity of documentation used. 2S-ECI was found to be well suited to the project. It provided an opportunity for early planning and exploratory work to establish the scope of work. This reduced risk and improved price surety, reducing variations during construction. The contractor was appointed once a concept design was developed and provided a construction methodology and engaged specialist contractors for the exploratory works.

The pre-construction stage was found to take longer than for traditional tenders, but this was thought to be offset by a faster construction stage. Similarly, the pre-construction stage cost more because due to the exploratory works and the contractor being paid for their early involvement (which is not always the case) however, this was thought to be offset by a lower construction cost. The project team comprising consultants and contractors was found to work well together and contribute their various disciplines to plan the project. The contractor's ECI team comprised those who could plan and price the work, not just an estimator tendering a bid.

The biggest challenge was found to be the lack of clear guidelines and contractual documentation to support 2S-ECI. It was suggested that standard form documentation outlining each parties' roles and responsibilities would be helpful. These findings inform those considering procurement strategies about the advantages and challenges when using 2S-ECI, particularly for technical alterations such as seismic upgrades and projects where the building remains in operation during the works. It also adds to the developing body of knowledge regarding the use of 2S-ECI in New Zealand.

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# THE SIGNIFICANCE OF MATURITY MODEL TO EMPOWER THE MAINTENANCE MANAGEMENT TOWARDS SUSTAINABLE PERFORMANCE OF PUBLIC FACILITIES IN MALAYSIA

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## Abstract

Malaysia's tremendous growth has led the public to demand outstanding facilities and services in terms of quantity and quality. The need for transformation by the local authorities in Malaysia is, therefore, necessary to ensure that the maintenance of public facilities can be effectively implemented. To mitigate this situation, local authorities must have a framework comprising standardised maintenance practices. This study is one part of the preliminary research in developing the standard maintenance management framework. One of the components of the framework is improvement tools that aims to assessing and improving the current maintenance practices which can inform the local authorities of their maintenance performance so that possible actions for improvement could be taken. Thus, this study is focusing on the maturity model as the improvement tool that offers five-levels of maturity with different standards. The maturity assessment can determine the current practices and promotes improvement by moving to the higher level of maturity. This process promotes motivation and continually enhance maintenance management practices by local authorities. The methodology adopted is systematic literature review to examine the significant impacts on their management through multiple published research relevant to the use of the maturity model within different industries. Several criteria and characteristics of maturity model is compared to determine the significance of maturity model. As the maintenance management consisting numerous processes and involving massive resources, it is recommended for the organisation to practise continuous improvement to prevent losses in time, cost and quality. Through the comparisons on different industries and maintenance management practices, the maturity model is seen to be beneficial in assessing and improving the organisation's performance and management. In conclusion, it will enable local authorities in creating competencies, cost-savings, and ensure the continuous improvement and sustainable performance of public facilities.

**Keywords:** *Maturity model; maintenance management; sustainable performance; public facilities.*

## INTRODUCTION

The local authorities in Malaysia are functioning under a dynamic business environment to suit the development in their local area. Conventionally, the responsibilities of the local authorities are to develop and deliver planning and to control the land use, community services, enforcement and regulation on development projects, administer and manage the financial and tax revenue in their administrative areas (Phang, 2008). The local authorities are correspondingly known as "local government" is the central bodies that responsibility to provide and maintain the facilities for the public. As stated in the Local Government Act 1976 (Act 171), the local authorities have the supremacy to control and manage all the area under its jurisdiction for public use. The provision of public facilities and infrastructures represent the investments made by the country promotes a better quality of life (Omar, Omar, Kamaludin, Othman, & Yusoff, 2018). Consequently, it is necessary for public facilities and infrastructures to remain well-maintained to ensure they can provide a better quality based on its intended purposes. The excellent quality of building features and appearance creates the sound and safe environment to the public towards sustainable development.

In Malaysia, most of the public facilities are held by the government, namely Local Government (local authority), State Government and Federal Government. The public facilities and infrastructures are consisting of community facilities, library administration, solid waste facilities, energy supply systems, land drainage system, flood protection and transportation networks and educational and health facilities. Each facility and infrastructure have the unique purpose of fulfilling the necessary services to the community while enriching the quality of life. Starting from 1967, the governments have initiated specific circulars and standards as the initiatives in ensuring the accomplishment of the implementation for various projects that are outlining the processes and procedures towards efficient maintenance management (Zakiyudin, Fathi, Rambat, Tobi, & Rejab, 2015). Across the development of the policies and guidelines, it demonstrates the obligation of the respective government to ensure the assets, facilities and infrastructures are managed effectively, improved continuously and maintained accurately towards its maximum lifecycle. The government has already taken the crucial steps in developing and directing the implementation standards and policies related to asset management and maintenance management. The responsibilities over the policies and regulations execution are beneath the specific ministries, departments and jurisdictions.

However, there are many issues of building maintenance related to local authorities in maintaining the public facilities under their area of administration. The issues were relating to facilities building performance (Suffian, 2013), the safety of users (Samsudin, Haron, & Bakar, 2012) and the growth of value in socio-economic (Lim, Abdul Malek, & Tahir, 2017). Many comments and arguments from various parties in the daily barrage of questions and complaints directly made in the media about poor condition and unsatisfactory performance of local authorities' facilities due to lack of maintenance culture (Islamiah, Sani, Mohammed, Misnan, & Awang, 2012). Moreover, according to Adnan, Fazry, Fauzi, Rahmat, & Supardi (2012) and Yunus, Razali, Zainudin, & Mohammed (2015), the local authorities in Malaysia are practicing reactive maintenance consisting of corrective maintenance and emergency maintenance. Therefore, need to examine the factors contributing to the unsatisfactory performance of the local authorities in managing and maintaining the public facilities becoming the primary concern in this study. As there is enormous pressure on the local authorities in delivering the services and improving the performance from the public, the local authorities need to discover the best alternatives to improve their performance to satisfy the public needs (Rahmat & Nawawi, 2017). Moreover, the local authorities need to examine their practices in managing and maintaining the public facilities to prevent the escalation of maintenance cost. Various factors are resulting in the increasing cost of maintenance. Therefore, Yunus et al. (2015) claimed that the local authority must improve their maintenance practices and measure the performance to assess the effectiveness in cost and quality services through standardized maintenance policy and approach.

The consideration of the maintenance management aspects of an organization will help the management to determine the potential strategies of solutions and formulate countermeasures to overcome the weaknesses. The strength of the current maintenance practices will guide the management team to improve towards better productivity and sustainability. The degree of maturity of the maintenance process should be defined to be able to support us during the planning actions to implement better strategies and propose the necessary improvements (April & Abran, 2012). This is vital for the management towards the successful advancement of the maintenance process and progressing of maturity level.

According to Hermans, Volker, & Eisma (2014), there are much organization has adopted and implemented the maturity model as their improvement strategies tool in the construction industry such as Supply Chain Excellence Maturity Model, Project Management Maturity Model, and Infrastructure Management Maturity Model. Therefore, this paper aims to explore the significance of the maturity model to empower the maintenance management towards the sustainable performance of public facilities particularly provided by the local authority in Malaysia.

## LITERATURE REVIEW

The local authorities act as the organization that delivering quality community services equally with the provision of the infrastructures and public facilities. They become the central-local public entity in the local area. The current concept of sustainable development has become the primary concern of various viewpoints. The mounting of issues concerning the overall quality of life of both present and future generations (Somasundram, Sambasivan, Rasiah, & Pei-Leng, 2018). This means that the local authorities need to encourage the economic wellbeing and social welfare of the society as they exercise significant influence by playing their roles. Hence, the local authorities must ensure that they are capable of performing effectively and efficiently.

The federal and state government has provided financial assistance or grants to the local authorities to helps the local authorities in managing their facilities and services (Vadeveloo & Singaravello, 2015). There are standards and guidelines to adhere to ensure the accountability of transparency. Like other federal and state agencies, the local authorities are expected to fulfil their obligations satisfactorily, yet the range of services provided is so wide making it is almost impossible for the local authorities to satisfy all its stakeholders fully. This has worsened by the existence of the state and federal governments as they are demanding what is expected from the government to support national and local goals (Lim et al., 2017). They are governing by the necessary legal framework and management system stipulated by the federal and state government to work effectively and efficiently in providing the facilities and services (Zakaria, Mamun, Nawi, & Razak, 2016). Based on the fact that the local authorities have the definite obligation of delivering the facilities and services to the public, therefore, the capability of the local authorities is diligently related to the capacity to manage its facilities and services. However, due to some limitations, some of the local authorities could not provide a better performance of the public facilities. The situation has creating complaints among users. Therefore, as the local authorities could not satisfy the needs of the public, they may at any rate make some improvements overtime to resolve the performance of the facilities. It should be started by improving their management by considering all the resources and capabilities of their organization. Thus, it is essential for the local authorities in Malaysia to assess their maturity of the maintenance process and practices before making further appropriate improvement. The assessment and measurement of the current capabilities of the local authorities should be conducted to identify the strengths and weaknesses within their maintenance management. The adequate resources and reliable capabilities must be embracing together with the appropriate performance improvement tool within the maintenance management to allow the local authorities achieve their desired value in maintenance for the public facilities.

## Public Facilities in Malaysia

Urbanization growth in Malaysia has developed swiftly. Thus, it has formed pressure on the authorities to deliver healthier and sufficient facilities and infrastructure for the public. It will just not only for better results, yet it should be essentially accessible and well-maintained towards viable management performance by the local authorities. Alike the other countries, the provision, and management of most facilities and infrastructure are under the responsibilities of the local authorities. Variety facilities such as community halls, public housing, public market, hawker centre, public toilets, hawker centre, parks, and amenities to fulfil the needs of the public under the local authority's region (Malaysia, 2006).

The provision of public facilities must be determined to provide the local people with a quality of life. The local authorities have to well-planned and taking into account various perspectives such as the design, the accommodation, the function, the location, and many other things, which means that the government must follow the specification and guideline that has set the standard of the provision for the facilities (Law Of Malaysia, 2006). The responsibilities carried out by the local authorities are essential to be determined to the effectiveness of their management of the public facilities. As the public facilities are the immovable asset, they tend to deteriorate and wear over time, so if they are needed to continue to provide quality and satisfaction, they need to be appropriately maintained. The major problem that will encounter if the facilities unable to serve and be used by the public, the more investments need to be made to overcome the problems (Rahmat & Nawawi, 2017). The investment comprises of the cost for the maintenance, and enormous resources are needed. The maintenance management practices play important roles as it covers the planning until the control stage. To ensure the public facilities can serve the public well, the best practices of maintenance management need to be planned and implemented effectively.

## Maintenance Management

For achieving the facilities effective performance, the maintenance has to be the priority to the local authorities and consider it as the strategic approach within their organization. Maintenance is an activity to maintain and preserve the condition of the building so that it can perform its intended function according to the relevant standard (Campos & Márquez, 2011). The proper application of a maintenance approach will extend the life span of the building and prevent damages while ensuring the satisfaction of the users. The maintenance management covers various elements such as leadership, organizational management, maintenance policies, planning and scheduling, resources management, information management, financial management and performance assessment and improvement (Gulati & Smith, 2009; Nagyova & Pacaiova, 2018; Rastegari, 2015). Each of the element is related and required to fulfil the maintenance activities. It appears that the harmonization between the sustainable maintenance operation and business objective is bringing the benefits to the organization (Aghili, Bin Mohammed, & Sheau-Ting, 2016; Mukelas, Zawawi, Kamaruzzaman, Ithnin, & Zulkarnain, 2012; Puçite & Geipele, 2017).

Tithóchta (2017) pointed out that value for money is the push factor for maintenance management through strategic facility planning, improvement of the workplace environment, and productivity and cost-effectiveness of asset management and maintenance. Through the growing awareness that maintenance adds value to the business practice, the company began

to view maintenance as an essential part of its operation (Stenström, Parida, Kumar, & Galar, 2013). Doos & Ibraheem (2016) believes that building needs maintenance to keep its designed performance and to assist in meeting the organizational goals and objectives. Iwaro & Mwashia (2013) clarified the value in sustainable cost and financial performance can be achieved by measuring the cost associated with the maintenance executed and its life cycle. It is well known that effective maintenance management is very much essential to upkeep the building and equipment for better performance and profitability of an organization (Gandhare, Akarte, & Patil, 2018). Since the maintenance management system is related to service and user satisfaction, one of the main goals of the organization must encompass the excellent delivery process (Olanrewaju & Abdul-Aziz, 2015). Most of these previous studies emphasized improvements in maintenance management can enhance productivity, customer satisfaction, and business process.

The maintenance management must be integrated into the quality management concept to meet the challenges posed by a dynamic and competitive environment. Many previous studies have shown that well-performed maintenance contributes to a significant impact on productivity and quality (Baidya, Dey, Ghosh, & Petridis, 2018). Over the years, due to the technology advancement, there are various policies, approaches, techniques, models, measurements and information systems that have been established by academician and practitioners that aim to support the maintenance activity to produce the better results and performance (Fraser, Hvolby, & Tseng, 2015). The performance measurement on the capabilities is crucial to determine the actual output, and the desired outcome is linked and not conflict with the business goals to avoid unnecessary loss (Stenström et al., 2013). In addition, several tools have been developed and established to benchmarking the performance such as performance benchmarking, balanced scorecards, six sigma and maturity model. Nevertheless, comparing to the numerous performance improvement tools, using maturity model may assist the overall process and reveal the principal elements and capabilities towards improvement through strategies and action needed to be undertaken (Satkunas, 2018).

## **Maturity Model**

A maturity model was established by the Software Engineering Institute, Carnegie Mellon University 1991, which was at first intended to assess software development (Carnegie Mellon University, 2002). Earlier, the basic maturity model has been assumed a higher maturity is connected and with the process capabilities and is measured then (Röglinger, Pöppelbuß, & Becker, 2012). Some of the definitions given for the maturity model are as follows:

- Paulk, Curtis, Chrissis, & Weber (1993) defined the maturity level as “the extent to which a specific process is explicitly defined, managed, measured, controlled, and effective”.
- Maturity implies a potential for growth in capability and indicates both the richness of an organization's process and the consistency with which it is applied in projects throughout the organization (Bruin, Rosemann, Freeze, & Kulkarni, 2005).

- In a study conducted by Pöppelbuß & Röglinger (2011), maturity implies evolutionary progress in the demonstration of a specific ability (related to people, processes, or objects) or in the accomplishment of a target from an initial to a desired or regularly occurring end-stage.
- Maturity models characterize theories about how organizational capabilities change in a stage-by-stage manner along an expected, required, or reasonable maturation path (Röglinger et al., 2012).
- According to Wendler (2012), the maturity model is "A structured collection of elements that describe the characteristics of effective processes at different stages of development". It also suggests points of demarcation between stages and methods of transitioning from one stage to another.
- PMI (2013) specified that maturity level is "The degree to which an organization practices project management measured by the ability of an organization to initiate successfully, plan, execute, monitor and control individual projects".

Based on the given definitions, the conventional idea of using the maturity model is consistency and repetitive practice, performance measurement, and improvement. (Paulk et al., 1993) have highlighted the organization is mature when the predictability, effectiveness, and control of the management process are expected to improve over time. The maturity model is used to evaluate the organization's performance in running their business activities and processes that consist of specific key areas and maturity levels. Meng, Sun, & Jones (2011) assert that the maturity models should encompass a few key aspects which maturity levels are, key process areas, goals, and essential practices to benchmarks for comparison and improvements.

## **Sustainable Performance**

Increasing complexities in functions of business have led to the emergence of new and comprehensive concepts in business management. In the current dynamic and rapidly changing workplace and globalized economy, the progress of organizational performance is associated with the growth of personal performance, knowledge, skills, and experience (Gareth & George, 2015). The expectation is that performance improvement efforts will logically culminate in important positive gains in performance for the host organization. Also, performance improvement can be viewed and pursued as a process functioning within the host organization.

As the public facilities are the immovable asset, they tend to deteriorate and wear over time, so if they are needed to continue to provide quality and satisfaction, they need to be appropriately maintained. Several major issues relating to the inadequate of maintenance technologies and innovations that limiting the maintenance work such as for aesthetic façade (Salim, Full, Salleh, Kamaruzzaman, & Azizi, 2018). Additionally, the major problem that will encounter if the facilities unable to serve and be used by the public, the more investments need to be made to overcome the problems (Rahmat & Nawawi, 2017). The investment comprises of the cost for the maintenance, and enormous resources are needed. The maintenance management practices play important roles as it covers the planning until the control stage. To ensure the public facilities can serve the public well, the best practices of maintenance management need to be planned and implemented effectively by the owner.

Hayat (2014) claimed that the local authorities are liable to ensure that the public facilities and infrastructure can well-performed to meet the level of satisfaction of the public. Thus, the best practices of maintenance management can help the organization to provide better value for money and enable improvement in the delivery of services by the service provider (Mong, Mohamed, & Misnan, 2018). The maintenance management conducted by local authority refers to the practices in ensuring the facilities are in the right shape, able to support the daily activities of the public, safe and sound to be used, and can contribute to the economic and social aspect of the local people. The goal of maintenance is to increase the value including the reliability, safety, availability, and quality of a building or equipment; hence reducing the need for further capital investment (Karia, Assaari, & Saleh, 2014). Maintenance management has particularities and important characteristics that have to be assessed and improves to achieve better performance. It is important to recognize the maintenance capabilities before making any improvements to provide a clear understanding of the maintenance management concept, its value, and performance.

## METHODOLOGY

The methodology adopted for the analysis is a systematic literature review to analyse the dimensions, concepts, and the significance of maturity models on their management through multiple published research relevant to the use of the maturity model within different industries. The discoveries of the significantly broader analysis through several comparisons of the significances that engaged a sensible and rational viewpoint were taken into account from various perspectives. The systematic literature review was conducted based on several steps which are (Strech & Sofaer, 2012):

1. Formulate the review question and eligibility criteria,
2. Identify all the literature that meet the eligibility criteria,
3. Extract and synthesize data, and
4. Derive and present data results that were presented in Table 1.

Hence, the examination of several keywords related to the characteristics of the maturity model becomes the criteria that may assist in identifying the importance of the utilization of the maturity model for maintenance management. The eligibility criteria are as follows:

1. The dimensions within each of the existing maturity models,
2. The concepts and their significance,
3. The maturity-level, and
4. The principles of assessment.

Workbooks and selected journals in hard copy and online were reviewed thoroughly which consists of established publishers such as Emerald, Elsevier, Wiley, Blackwell Publishing, Springer. The keywords related to the eligibility criteria were reviewed according to the selection of the literature ranging from the latest research since the 90s to 2020 which was based on articles published from various recognized journal such as Journal of Quality in Maintenance Engineering, Journal of Building Maintenance, Journal of Facilities Management, Property Management, Construction and Building Materials, Procedia Environmental Sciences, Procedia Engineering, Facilities, Journal of Building Appraisal,

Journal of Performance of Constructed Facilities and Construction Management and Economics and Malaysian Construction Research Journal.

## FINDINGS AND DISCUSSION

Every established maturity model has its characteristics to act as a supportive tool for evaluating the maturity of the organization (de Bruin, Rosemann, Freeze, & Kulkarni, 2005). In previous studies, different maturity models were developed by practitioners and expertise such as for project management, business management, healthcare, and manufacturing that aims for enhancing the maturity process within their organization (Leflar & Siegel, 2013). According to Oliveira & Lopes (2019), the maturity model can describe the current practices of the organization. Also, it can provide a prescribed plan to assist the progress and improvement towards achieving the objectives and goals (Chemweno, Pintelon, Horenbeek, & Muchiri, 2015). Likewise, Pigosso, Rozenfeld, & McAloone (2013) asserted that a maturity model could be used to compare the organization's practices with the standards and guidelines related to their management. The characteristics of the organization's maturity are related to their readiness and experience concerning the people, processes, technologies, and performance measurement of their practices (Pačaiová & Ižariková, 2019).

Notwithstanding the diversification of the existing maturity models from multidisciplinary, several numbers of characteristics can be recognized. Beforehand, Lahrmann, Marx, Winter, & Wortmann (2011) had summarized five main characteristics which were:

1. Maturity concept and significance

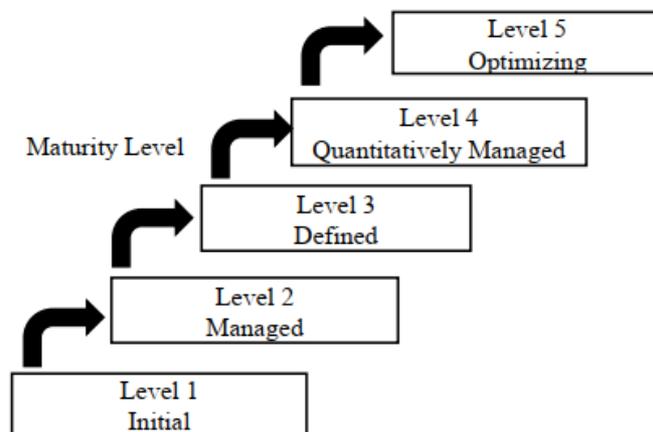
The maturity concept can be varied based on the business background of the inventor of maturity models. For example, Curtis, Hefley, & Miller (2016) and Willner, Gosling, & Schönsleben (2016) target the aspect of people's capability in the management, April & Abran (2009) focused on process assessment and improvement of software maintenance. Meanwhile, (Silvius, Schipper, & Nedeki (2013) emphasized maturity in sustainability for project management and Pigosso et al. (2013) contributed a maturity model for eco-design support and many other related organizations. maturities.

2. Dimensions

In the context of the maturity model, the dimensions are related to the structure of the subject of the analysis and assessment to be made on the object or organization (de Bruin et al., 2005).

3. Level

The usage of maturity levels is to distinguish the different capabilities in incremental order. Each of the levels contains the assigned description to denote the related maturity of the process (Carnegie Mellon University, 2002). Figure 1 shows the five-level of maturity. There are 5 levels of maturity; 1 - Initial; 2 - Managed; 3 – Defined; 4 – Quantitatively Managed; and 5 – Optimize.



**Figure 1.** Five-Level of Maturity

#### 4. Maturity principles

The principle of maturity is based on scoring the organization either for continuous maturity or staged maturity. Based on Fraser, Moultrie, & Gregory (2002), indicated the continuous maturity allows the scoring of the capabilities on different levels for each dimension, while staged maturity, limits the levels to defined stages and no specific description for the condition levels.

#### 5. The assessment process for maturity models.

The assessment is the approach to how the companies assess their capabilities based on the maturity model. The depiction of the scoring can be qualitative (using descriptions) and quantitative (using scale) (P. Fraser et al., 2002; Rosemann & De Bruin, 2005).

Within these specific characteristics and elements, some comparisons were made based on the established maturity model available in the field. The selected maturity models were chosen to point out their significance, characteristics, and elements within multidisciplinary domains as shown in Table 1.

The organizations that are utilizing the maturity models as an assessment tool in their practices and processes can gain some benefits such as (Nesensohn et al., 2016):

- Enabling the organization to assess the current capability of their organization to create any changes or improvement in a systematic manner.
- Providing the standards and guidelines and giving appropriate information to the respective management regarding the improvement strategies.
- Leading and strengthening the capability of an organization towards the excellence management culture; and
- Providing adequate information is essential for planning and guiding the organization through its continuous improvement efforts.

The model is envisioned as a tool that will assist the organization in improving their maintenance management processes and hence optimizing the reliability of the public facilities for the safety and comfort of the stakeholders (Omar, Kamaludin, Othman, &

Yusoff, 2018). Moreover, the focus on improving the maintenance process and activities, making the managers and personnel think about how they can benefit from the improvement made within their department. The assessment undertaken can ensure if they are moving towards effectiveness and efficiency maintenance management (Tarhan et al., 2015).

**Table 1.** Existing Maturity Models: Characteristics and Significance

Maturity Model	Dimensions	Levels	Significance	Principles of Assessment
Capability Maturity Model Integration (CMMI) (Carnegie Mellon University, 2002)	22 process areas including product integration, project monitoring and control, project planning, development and management requirement and technical solution	Five maturity levels 1-Initial 2-Managed, 3-Defined 4-Quantitatively Managed 5- Optimizing	Organizational process improvement	Qualitative continuous scoring
Energy and utility management maturity model for sustainable manufacturing process (Ngai, Chau, Poon, & To, 2013)	Energy and utility management practices establishment, standardization practices, strategic environmental management, continuous improvement	Five maturity levels 1-Initial 2-Managed, 3-Defined 4-Quantitatively Managed 5- Optimizing	Organization assessment and improvement	Qualitative continuous scoring
Eco-design maturity Model (Pigosso et al., 2013)	Eco-design practices, operational practices, techniques, and tools, the relationship among eco-designs practices	Five maturity levels 1-Incomplete 2-Ad-hoc 3-Formalized 4-Controlled 5- Improved	Implementation process and improvement	Qualitative continuous scoring
Healthcare Process Maturity (Tarhan, Turetken, & van den Biggelaar, 2015)	Five process area thread including organizational process management, organizational business management, domain work management, domain work performance and organizational support (30 practices)	Five maturity levels 1-Initial 2-Managed, 3-standardized 4-Predictable 5- Innovating	Healthcare process	Qualitative continuous scoring
A Measurement Model for Lean Construction (Nesensohn, Bryde, & Pasquire, 2016)	Eleven attributes including lean leadership, customer focus, way of thinking, culture, and behaviour, competencies, improvement enablers, processes and tools, change, work environment, business results and learning competency (sixty behaviours)		Organization practices	
Maturity Model for Strategic Collaboration in Sustainable Building Renovation (Johansen, Jensen, & Thuesen, 2017)	Eighteen critical attributes including tender bid evaluation, senior management, goal alignment, company value, budget transparency, risk sharing, control of price development and testing of innovation solutions, etc.	Five maturity level 1-Very low 2-Low 3-Moderate 4-High 5-Very high	Organizational improvement	Quantitative staging

Maturity Model	Dimensions	Levels	Significance	Principles of Assessment
Integrated Supply Network Maturity Model (Yatskovskaya, Srail, & Kumar, 2018)	Five capabilities (SSN Design, Network connectivity, network efficiency, network process development and reporting and product/service enhancement) and three significant strategies (resources sustainable allocation, water assessment techniques and corporate standards and policies)	Five levels of maturity: 1-Initial 2-Limited, 3-Defined 4-Managed 5- Mastered		Qualitative continuous scoring

(Source: Compiled by Authors)

Organizations can accomplish significant changes in their organizational maturity by first offering project-level consistency and continuing to improve their processes at the most advanced, organizational level, using both quantitative and qualitative data for decision-making. As there are lacking standard guidelines in Malaysia, the owner of the facilities needs to look for existing tools and criteria to assess the maintenance work to ensure the people are satisfied with the facilities (Woon & Zainordin, 2019).

As mentioned earlier, the maturity model is selected as the improvement tool to be part of the standard maintenance management framework for all levels of local authorities in Malaysia. The proposed framework is consisting of the resources and capabilities that will be evaluated through five-level of maturity to assess the current practices of maintenance management. there are several elements of maintenance management which are top management commitment, policy, guidelines and standards, organization management, planning and scheduling, work management, resources management, financial control, information management and performance assessment and improvement (Mong, Mohamed, & Misnan, 2017). Each of the element covers several processes and practices that should be highlighted by the maintenance department. Once the maturity level has been determined, it is depending on the organization to make further improvement to achieve better performance. Figure 2 shows the components that will be the basis for the proposed framework. There are 5 levels of maturity namely, 1 - Initial; 2 - Managed; 3 – Defined; 4 – Quantitatively Managed; and 5 – Optimize. Through five-level of maturity the current practices are to be assessed and scored and the organization can make the improvement by moving to the upper level of maturity with better characteristics and specifications. Each level has its justification, as stated in the scorecards that will be provided as the reference for the maintenance department. From there, the maintenance department can assess and evaluate the maturity level of maintenance practices. Each and every time the assessment is made, the maintenance department may identify the lacking areas or weaknesses within their management or barriers that hinders the effective maintenance management. Each of the capability attributes leads to the results achievements in any aspects that the department desire.

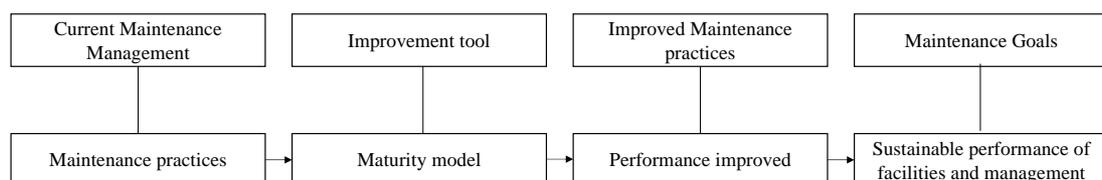


Figure 2. Maturity Model Part of The Proposed Framework

## CONCLUSION

For this study, the maturity model is considered as one of the best improvement tools to assist in achieving the sustainable performance of public facilities through maintenance management as well as the performance of the local authority in Malaysia. Hence, the consideration of adopting the design principles of descriptive and prescriptive based on the purposes of the maturity model is to provide a strategy for improving the maintenance management for local authorities in Malaysia. Primarily, the purpose of the application of the maturity model is to identify the current maturity level of the maintenance department of local authorities. Next, based on the current maturity level, any improvement can be made to achieve the desired maturity level through some guidelines and standards for improvement. The maturity model offers a better option to measure the process maturity towards making further improvements in maintenance management. Every local authority has different advantages and disadvantages within their management and capability. Consequently, it is appropriate to measure the maturity level of the maintenance process before conducting improvement strategies. The strategic, tactical and operational management may align their knowledge and skills in determining the best strategies for their maintenance activities. Indirectly, the continuous improvement based on the maturity model allows the better performance of maintenance management practices and processes, hence may assist to minimize the maintenance issues and reduce the impact on maintenance cost while achieving the maintenance department's objectives and goals. Many previous studies have shown better results by improving the maturity process of management and delicately will deliver the sustainable performance of facilities and services.

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# A STUDY ON PEDESTRIAN FACILITY IN TAYLOR'S LAKESIDE CAMPUS

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## Abstract

Government is employing a variety of redevelopment strategies in efforts to overcome the concerns related to road traffic congestion and pedestrian activities in the city center. Designs should cater predominantly for effective movement via walking, protection of pedestrians from snatch thefts, serious car accidents, and exposure to worsening climate conditions. The purpose of this study is to investigate the design and conditions of pedestrian's facility in Taylor's Lakeside Campus in relation to the pedestrian's safety and comfort. This study provides background information on the existing pedestrian facility's condition and aims to recommend the most suitable pedestrian facility by using innovative strategies. It integrates quantitative method by collecting data through questionnaires from students and staffs of Taylor's Lakeside Campus. Pedestrian walkway was divided into four routes to obtain the measurements at the four different sampling points simultaneously. The results showed that route from campus to PJS 7, Bandar Sunway has a high pedestrian satisfaction rate because it has a better pedestrian infrastructure compared to the other routes. Lack of walkway continuity, poor sidewalk pavement and road, lack of street furniture especially lighting, lack of roof and shades, and safety concerns are some of the commonly identified pedestrian infrastructure problems. This study should be able to provide a clear direction to the university on the problems and the recommendation for future development by understanding its existing built environment performance on comfort and safety in the occupancy stage of the systems lifecycle.

**Keywords:** *Pedestrian; Facility; Walkway; University.*

## INTRODUCTION

A pedestrian is any individual who is walking as their traveling tool for a distance throughout the journey. Pedestrians on the street are the most vulnerable road users (Banerjee, 2020) and the pedestrian walkway is built to create a comfortable, safe and well-connected quality of life on the ground layer. Pedestrian sidewalks and walkways are an essential component on the streets and roadways where pedestrians will have to experience comfort, accessibility, safety, and efficient mobility. Hawaii State Statutes defines "sidewalk" as the part of the street between the lateral or curved road lines and the adjacent lines of the property intended for use by pedestrians (Hawaii Department of Transportation, 2013).

Walking is one of the essential travel modes in Taylor's Lakeside Campus. However, there is a lack of attention towards the pedestrians; most of the concerns are towards needed facilities. The basic of pedestrian facility require are segregation between sidewalks and road that avoid any accident between vehicles and pedestrians. A safe pedestrian facility and other environmental-friendly walkway facilities are vital to ensure a comfortable walking environment (Kabade et al., 2018).

The primary concern of all pedestrian design is accessibility. All pedestrian facilities therefore need to be planned, designed, maintained and operated so that it is usable by everyone, including those with disabilities or using mobility aids. It is essential to address the various issue of a pedestrian while providing facilities for them. To be able to magnificently

design pedestrian facilities, we need to identify that pedestrian needs are wide-ranging, and our design approach needs to be flexible to meet the diversity of needs that are most important for pedestrians to be able to cross safe.

## RESEARCH PROBLEM STATEMENT

Pedestrians are always at danger of being injured in a car accident. University supposed to be one of the safest places. Unfortunately, the number of accidents between vehicles and pedestrians on school grounds is worrisome. Statistics and anecdotal evidence show how dangerous the Louisiana State University campus is to pedestrians. In the past five years, there have been 41 accidents between pedestrian and motor vehicle. In four of those accidents, the pedestrians had terrible injuries that left them harmed. One of the victims was put into a coma after she had spinal injuries in an accident, and it lasted for two weeks (The Lucky Law Firm, 2018). The lack of lighting and proper crosswalk facility are the primary reasons pedestrians are hit by vehicles. Sidewalks, crosswalks and streetlights are very advantageous, but these safety nets cannot save every pedestrian from getting hit.

Between 2001 and 2008, at Clemson University, there were 30 crashes involving pedestrians or bicycles, the most extreme in the Spring of 2007 when a student was involved in a crash with a transit vehicle while crossing the street within a crosswalk on campus resulting in serious injuries. This occurrence motivated a cooperative effort on the part of university parties to investigate the current state of pedestrian security on campus. The primary impetus for the research undertaken in this study was an effort to address this event, as well as those of the past, and to minimize or potentially prevent future catastrophic crashes. Because of heavy pedestrian and bicycle volumes, the well-being of these users is critical to the overall safety culture of a university (Dobbs, 2009).

Eliminating the risks that pedestrians challenge is a vital and achievable policy goal. It should not be accepted that pedestrian collisions are inevitable as they are both preventable and predictable. Pedestrian safety and walking environment have a relationship. Walking in an environment which lack of pedestrian facility increases the risk of pedestrian injury. Walking environments are expanded by pedestrian safety measures and contribute to social cohesion, local economic growth, urban renewal, reduced noise pollution and improved air quality. Implementing security measures requires involvement, informed decision-making and commitment by the relevant authority, government, NGOs and international organizations (World Health Organization, 2013).

Pedestrians tend to choose the quickest way to reach the destination. As factors to be fast, then their safety is often ignored. There are always complaints about the behaviour of the pedestrian by vehicle drivers. This is because many pedestrians ignore traffic conditions when they want to cross the roads, that will affect other road users. Therefore, facilities for pedestrians are significant (Namitha, 2019).

Malaysia recorded about 500 deaths by pedestrian, represents 7% each year of the total 6500 reported road traffic fatalities (WHO (2015) cited by Mohd Syazwan et al., 2018). However, according to WHO (2018), the number or percentage of pedestrian deaths cannot be determined in Malaysia as Malaysia is considered among the countries which do not have eligible death registration data (as Group 4). Whilst MIROS (2020) which analysed 289 road

traffic collisions from January 2014 until December 2016, concluded that only 1% of the crash cases hitting pedestrians in 2014 and 2016 respectively and none in 2015 but did not indicate the number of pedestrian casualty and the cause factors related to pedestrian accidents. There is no specific statistics record of pedestrian accidents or deaths around school or campus ground available in Malaysia. Even though there is no such definite statistics record to indicate accidents involving pedestrians and the causes of pedestrian accidents, the safety and the comfort of pedestrian walking environment should not be jeopardized.

As according to Farid (2015), architects and designers should collaborate with campus planners through taking the walkability aspect extensively to ensure a sustainable and friendly campus environment in the future. Walking is one of the essential travel modes in Taylor's Lakeside Campus. Virtually each trip starts and ends with a walk. The basic of pedestrian facility requirements are segregation between sidewalks and road that avoid any accident between vehicles and pedestrians. A safe pedestrian facility and other environmental-friendly walkway facilities are vital to ensure a comfortable walking environment (Kabade et al., 2018). Therefore, in this study, we seek to establish a sustainable and comfort design of pedestrian's facility by investigating the existing condition and safety of pedestrian's facility at Taylor's Lakeside Campus area.

## **LITERATURE REVIEW**

### **Important of Pedestrian's Facility**

Pedestrian's facility is a fundamental part of a transportation system. The importance of a proper plan not only to the improvement of new facilities, but also with the enhancement and retrofitting of current services for pedestrian use. When pedestrian accessibility is increased and existing facilities for pedestrians are upgraded, it is possible to anticipate larger percentages of pedestrians using the walkways or sidewalks. A study has shown that properly designed and maintained facilities motivate and encourage higher levels of pedestrian travelling. Usually, failure to install pedestrian facilities is due to underestimation, based on the insight that an environment of less pedestrian usage does not require improvements. In fact, pedestrians typically do not use the facility because it does not meet their requirements fully under its existing condition. From time to time, it is necessary to upgrade land use facilities and modifications to support more intense pedestrian trips (Otak, 1997).

Pedestrians need a safe and convenient use of facilities. The best public pedestrian infrastructure, if properly designed, could be the easiest to maintain and the most durable facility. Weak design of facilities may result in continuous issues and can discourage the usage if pedestrians felt uncomfortable, unsafe, or unprotected. Poorly maintained and designed infrastructure can be a waste of resources, money and a burden on community vitality (Federal Highway Administration, 1998).

### **Visual Study**

Visual study was conducted on the existing pedestrian facility around Taylor's Lakeside Campus. Figure 1 & 2 show that student used non-designated paths to reach their destination. Pedestrians are more likely to use the Route D as their trails as compared to Route C. Based on Google map, students require 9 minutes or less to reach the destination in term of time

taken for Route C. They require 4 minutes or less for Route D. According to David Spooner (2011), the 10-minute concept is essential in terms of the standard of human-sized layout. Therefore, we can conclude that Route C that recorded 9 minutes is at the bottom line of the design criteria as pedestrians would require to prepare and leave their resident early for not being late or missing the class. Pedestrians who residing in D'Latour tend to walk more towards academic blocks compared to the pedestrians who residing in DK Senza. Pedestrians tend to use the unofficial pedestrian sidewalks which is Route D. In Route D, pedestrians make their way up the concrete drainage cover, grass, and the vehicular as using Route C is time consuming. It can be seen in Figure 1 and 2 that pedestrians prefer to walk on the vehicular road. Walking time influences the decision of the pedestrians on its walking pathway. The sidewalks should be directive and efficient (Spooner, 2011).



Figure 1 & 2. Sidewalk at Jalan Taylor's (Route C & Route D)



Figure 3 & 4. Sidewalk at Jalan Taylor's (Route B)

Figure 3 and 4 show the reusability of path surface material which indicating path continuity without relevant differences in elevation. Due to the many different levels of elevation, this tends to make pedestrians more tired and has an impact on their safety and comfort. Nevertheless, pedestrians might still feel some dissatisfaction with continuous paths without significant differences in elevation.

Wrecked pathways were frequently experienced by the pedestrians. This could lead the possibility of the injury to be encountered on the walkway while accessing to their desired locations. A lot of path materials were broken along the way to the campus. This was due to poor maintenance and impact by the vehicles. Small damages occur most frequently due to the fragility of the pavement collided by hard objects or caused by natural factors (Figure 3 and 4).

## **Pedestrian's Attitude and Behavior**

Road users' behavior is important in understanding the local activities and related risks especially with pedestrian collision (Roberts et al., 1997). According to Hidayah (2012), understanding the purpose of a person crossing the road or walking in general, will directly provide information in planning pedestrian crossings and space in certain areas. The design of pedestrian walkways should be based on pedestrian attitude and behavior. Pedestrian from each age and gender will require different speed of their journey. For example, walking in the center of elderly people will give different effect in term of speed compared to walking among the university students in the campus area. Hence, the walkway should be designed based on the nature of pedestrians walking to produce better movement.

Pedestrians generally regard crossing in light traffic as a safe action. Therefore, they do not choose to travel through a marked crossing facility because they believe that it is more practical for them to cross. American study has shown that travelers are more inclined than occasional users to risk crossings at no designated road crossings, as they perceived no risk, for example, light traffic (Hidayah, 2012). They are also prone to be well aware of their journey and the vehicular environment and thus feel more secure in taking the risk. Pedestrians who are physically impaired, e.g. in a wheelchair, with crutches and heavy bags, are likely to take longer time to crossing the street, to feel more susceptible and to cross at marked road crossings (Taiwo Arungwa, 2016).

## **Ideal Design of Pedestrian Facility**

### *Sidewalk Improvement*

Sidewalks and paths in urban areas are usually constructed with Portland material (PCC) cement. This offers a clean, durability and easy maintenance surface finish, scoring a trend that can avoid cracking as the concrete sets and can suit historical patterns in a district if appropriate (Otak, 1997). The Institute of Transportation Engineers (ITE) guidelines (2019) suggest a 1.5 m (5 ft) minimum width for a sidewalk, that enables two people to go side by side or go comfortably. In Malaysia, a desirable minimum width of 2.0 m is to be provided for all sidewalks. Where there are restrictions on the right of way, a minimum of 1.25 m wide of sidewalks can be considered. The sidewalks are required to have all weather surfaces (Public Works Department (PWD, 1986; PWD, 2016)). For some new town developments such as Iskandar Malaysia, the provision for the sidewalk is wider. It varies from 1.25 to 2.5 m and should be provided along both sides of roads but need to be provided on at least one side of all local roads for residential areas. For sidewalk in commercial areas, it should be provided along both sides of roads (IRDA, 2011). Hence, a wider walkway should be installed around campus where high concentrations of pedestrians exist and should be fully accessible to all people and wheelchair users.

### *Lighting Improvement*

Without adequate overhead lighting, motorists or drivers may not notice pedestrians and stop in time. It is best to include a consistent lighting level along a street by placing streetlights along both sides of arterial streets. Pedestrian crossings at night may be supported with brighter or additional light. This comprises the lighting of walkways and routes to the crossroads. As pedestrian lighting, mercury vapor, incandescent or low cost high - pressure sodium lighting is frequently recommended as sodium lights are energy low, but colour distortion is high (Federal Highway Administration, 1998).

### *Pedestrian Bridge*

Pedestrian Bridge allows continuous movement of pedestrian separate from the traffic of the vehicle and may make crossing the street safer and accessible for people of all ages. Pedestrian bridges should have a minimum width of 8 feet (Department of Transportation, Georgia, 2019). Usually, the footbridge is designed across a street with a large traffic volume with pedestrians crossing the street. However, it should be a last resort step as it is a visually intrusive and extremely costly measure which these measures include ramps or elevators. Hidayah (2012), the decision to construct the footbridge is based on road width, volume of traffic and the pedestrian numbers crossed the road. In others, however, the footbridge is necessary, even if demand was limited.

### *Safety Railing*

Handrails are vertical features that are used to assist pedestrians in navigating up and downstairs and ramps, and to prevent pedestrian falls from elevated platforms or landings that is adjacent to a vertical drop or slope that requires a barrier. Steps are a vital element of a streetscape where the sidewalk deviates from the roadway slope. All safety railing must be planned and considered to fulfil with current International Building Code (Hawaii Department of Transportation, 2013).

### *Marked Cross*

It is vital, especially at night, to ensure that crosswalk markings are visible for drivers and motorists. The marked cross should not establish tripping or slippery hazards. Although cobblestones or granite are aesthetically attractive materials, they are not usually suitable for crosswalks. Inlay tape is one of the popular crosswalk labelling products, designed on existing or repaved paths. It is extremely slip - resistant, durable and reflective, and it requires no high maintenance standards. Although the initial cost is higher than the paint, both thermoplastic and inlay tape are cheaper in the long term. Inlay tape for new and resurfaced pavement is recommended, while thermoplastic could be a better choice for rougher pavement. Both thermoplastic and inlay tape are less slippery and more visible than paint when wet (Federal Highway Administration, 1998).

## RESEARCH METHODOLOGY

### Data Collection Method

The research technique used in this research is the quantitative method which involves the collection of data through questionnaires. Quantitative data collection was done through closed-ended questions. A media filling questionnaire was used as a web survey method. Quantitative data were subjected to statistical analysis. The survey was distributed among students, lecturers and general staffs of Taylor's Lakeside Campus. They are the primary users of the campus facilities because majority of them are living around the campus and are using the pedestrian facilities to the academic blocks. In contrast, other pedestrians who drive their vehicles will have to walk from the designated parking facilities to the academic blocks. Hence, students, lecturers and staffs from the Taylor's Lakeside Campus are the most suitable participants for exploring pedestrian satisfaction, as they have fundamental understanding of pedestrian walkway activity and space.

In this research, random sampling has been utilized to obtain relevant data from the population. A sample is chosen in such a way that it is equally likely that every possible sample of the same size is selected. Hence, it can simplify a population (Creswell, 2003). The formula created by Krejcie & Morgan (1970) is applied for this research to generate the minimum number of respondents required for the questionnaire survey. Based on the total population of student, lecturer and staff, the total sample size required of 365 samples is required as a baseline figure of respondents for the questionnaire survey. Each of the respondents is contacted through phone or other social network platform such as Facebook and Instagram regarding the invitation to participate in this research. The objective of the research is attached in the questionnaire cover to ensure that they are aware of the nature of the research before participating in the questionnaire.

The questionnaire is structured based on the main objective of the research into four sections. Section A aims to categorize the demographic background of the targeted respondents based on gender, occupation, type of transportation to campus and respondent's frequency level of using the pedestrian's facility on campus.

In Section B, respondents must rate on their agreement on each statement on the importance and necessity of pedestrian's facility at Taylor's Lakeside Campus. Section C intends to obtain the perception and experience of the respondents in term of safety and comfort on the existing pedestrian facility on Taylor's Lakeside Campus roads. In getting a more precise analysis, Taylor's Lakeside Campus roads are divided into four different routes as shown in Figure 5 as it allows the respondent to propose their viewpoint more specific on the road condition in each route.

Section D demonstrates several practical recommendations to readdress this issue for respondents to rate on their level of agreement on the recommendations proposed. This section also contains an open-ended question and respondents will have the opportunity to share their experience of an accident happened in the campus area due to the current condition of pedestrian's facility.

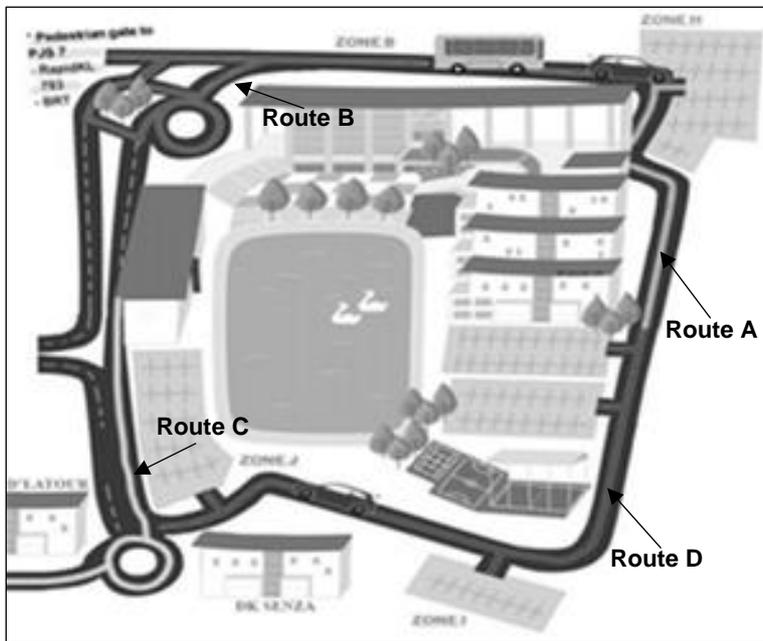


Figure 5. Survey Coverage Area

### Data Analysis Method

In Section B, C and D, the data from the questionnaire will be further analyzed using average index analysis. This method is used to derive the importance of pedestrian facility in Taylor's Lakeside Campus and the ranking for condition of the existing pedestrian facility on campus from the perception of the respondent, based on the 5-points Likert scale. The formula is as shown.

$$Average\ Index = \frac{\sum a_{ixi}}{\sum xi}$$

Where:

- ai = constant which represent of i
- xi = variable represent frequency
- I = 1, 2, 3, 4, 5

For identifying the level of agreement of the variables in this research, the data collected was analysed based on pre-determined range as shown in Table 1.

Table 1. Rating Scale for Average Index

Level of Agreement		
1.00 ≤	Strongly disagree	≤ 1.50
1.50 ≤	Disagree	≤ 2.50
2.50 ≤	Neutral	≤ 3.50
3.50 ≤	Agree	≤ 4.50
4.50 ≤	Strongly Agree	≤ 5.00

## FINDINGS

### The Need for Safety and Comfort While Using Pedestrian's Facility

A total of 365 of questionnaire surveys were distributed via social platforms and email. Among the 365 sets distributed, a total of 365 sets were completed within the stipulated timeframe. All sets of questionnaire surveys were filtered, and there was no incomplete data or contradicting data found. Therefore, all 365 sets of data are considered valid data, which shall be used for the data analysis of this study. 60.5% of the respondents are students studying in Taylor's Lakeside Campus, followed by lecturers and tutors who teach at Taylor's Lakeside Campus (22.2%) and staffs who work at Taylor's Lakeside Campus (17.3%). This shows that the survey involved not only students but also lecturers, tutors and staffs, who are all the primary user of pedestrian facilities.

**Table 2.** Importance of Pedestrian's Facility at Taylor's Lakeside Campus

Importance	Frequency of Respondents					Total of Respondents	RAI	Rank
	1	2	3	4	5			
I would like to live in a place where more of my daily needs can be met through walking	1	21	30	35	278	365	4.573	1
I would walk more if better facilities existed	1	8	32	64	260	365	4.556	2
Good pedestrian facilities add value to university	9	15	26	75	240	365	4.430	3
Taylor's management needs to spend more money on pedestrian facilities	0	31	28	75	231	365	4.368	4

Table 2 indicates the Relative Agreement Index (RAI) of the importance of Pedestrian's Facility in University. Among all the statements provided, respondents would like to live in a place where more of their daily needs can be met through walking which scored the highest RAI of 4.573. According to the Bicycle Federation of America Campaign (1998), walkable communities are living communities, and trends in real estate are increasingly showing people are choosing to live in 'livable' neighborhoods. Good schools have been a crucial factor for parents to decide where to purchase a home, but now many are concerned that their children can also go to school with great service in a walking distance. Nevertheless, respondents would walk more if better facilities existed has the second-highest RAI of 4.556 based on the results. The respondents believe that excellent pedestrian facilities should exist to encourage them to use the pedestrian facility more. This is justified by Federal Highway Administration (2000), whereby they claim that excellent pedestrian facilities can inspire pedestrians to traverse roads and streets in predictable and convenient locations. Moving on to the third-highest RAI of 4.430 where good pedestrian facilities can add value to Taylor's Lakeside Campus. The advanced footpath will provide a pedestrian - friendly campus which will provide the community a healthy and active way of lifestyle as emphasized by Saliza (2011) and Farid (2015). Besides, Taylor's management needs to spend more money on pedestrian facilities has the lowest RAI of 4.368. According to Leather (2011), this poses a challenge for policymakers and planners when it comes to planning for pedestrian facilities, particularly in urban areas with high levels of pedestrian traffic.

## The Condition of Pedestrian's Facility at Taylor's Lakeside Campus Area

Table 4 illustrates the pedestrian satisfaction on Taylor's Lakeside Campus roads based on the respondents' feedback on the existing pedestrian facility in Taylor's Lakeside Campus. Respondents were asked mainly on safety, security and segregation base on the routes as stated in Table 3. According to Table 4, the mean rating of the relative agreement index indicates the respondents' satisfaction on the existing pedestrian facility as per route, which shows that Route B has a better condition compared to the other routes. Conditions in the Route B seems to be safe and adequate. Thus, pedestrian movement on this trail is likely to be comfortable. Route B scores higher mean rating among the routes. The trail of Route B has sufficient and proper pedestrian facilities, which include speed bump, speed limit signage, sidewalk, roadway lighting, marked crosswalk, and refuge area. This implies that it is better to walk on the campus using this route unless the other roads have the similar conditions as Route B.

**Table 3.** Description of Walking Path

Walking Route	Description
Route A	Walking path from Taylor's Lakeside Campus Block B to Zone H car park, Mutiara Perdana
Route B	Walking path from Taylor's Lakeside Campus Block A to PJS 7, Bandar Sunway (area include Zone B car park)
Route C	Walking path from Taylor's Lakeside Campus commercial block to DK Senza Residence, D' Latour Bandar Sunway
Route D	Walking path from Taylor's Lakeside Campus Block E to Zone I car park, DK Senza Residence and D' Latour Bandar Sunway

Meanwhile, the relative agreement index shows that the mean rating for Route C generally is lower than the other routes, which means that Route C has the poorest conditions amongst the routes. Only 23% of the respondent agreed or strongly agreed that it is reasonably safe to walk the road. The reason for this low opinion of safety is that only 37% of respondents agreed and strongly agreed that there are adequate sidewalks on the road they identified, and 63% disagreed or strongly disagreed. On the other hand, 78% of the respondent disagreed or strongly disagreed that they felt comfortable while walking or crossing the route at Route C. Thereby, the pedestrian movement is probably uncomfortable compared to those in other routes. Similar opinions were held about their ability to cross these roads. In the Route C, 82% of the respondents disagreed or strongly disagreed that it was reasonably safe to cross the road in question. In general, the respondents were unhappy with the safety and quality of walkways on the roads in their communities.

Out of 4 routes, 3 of them receive low ratings regarding the pedestrian walkways as being well segregated from the vehicles is perceived as disagreeable by the respondents; the three routes include Routes A, Routes C and Routes D. This causes more danger to the pedestrians while walking on the sidewalk and it affects their comfort. This is possibly the explanation in this study why respondents believe that greater investments by the relevant authorities in pedestrian installations such as safety railings and marked cross or raised crosswalk are required. Another analysis shows the car park illegally on different routes. It seems that drivers tend to park their cars illegally beside the road in campus areas, especially along the Route D. However, there are still 45% of the respondents who agreed or strongly agreed that drivers park their cars illegally on the particular road. This supports the statements by Hidayah

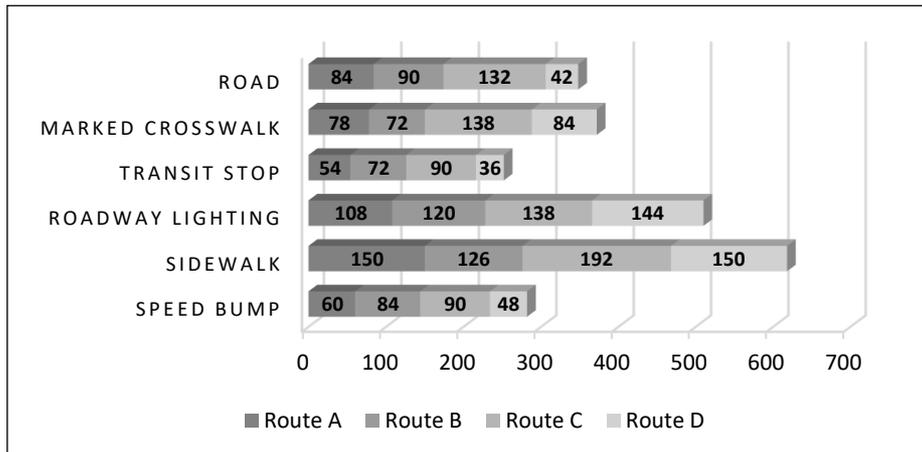
(2012) about the pedestrian risks of collision with vehicles and providing discomfort due to obstruction to the pedestrian path continuity (Spooner, 2011).

**Table 4.** Condition of Existing Pedestrian Facility in Taylor's Lakeside Campus

	Frequency of Respondents					Total of Respondents	RAI	Rank
	1	2	3	4	5			
<b>ROUTE A</b>								
Reasonably safe to cross the roads	58	124	24	160	29	365	3.104	1
Reasonably safe to walk on the roads	29	123	30	148	35	365	3.101	2
Car park illegally	65	130	36	77	62	365	2.841	3
Adequate sidewalk on the road	45	166	28	85	41	365	2.756	4
Feel comfortable while walking/crossing the roads	45	163	22	125	10	365	2.704	5
Adequate separation from the traffic	85	128	20	105	27	365	2.619	6
<b>ROUTE B</b>								
Adequate sidewalk on the road	22	87	26	160	70	365	3.463	1
Reasonably safe to cross the roads	27	75	22	200	41	365	3.419	2
Reasonably safe to walk on the roads	10	120	26	174	35	365	3.285	3
Adequate separation from the traffic	20	125	20	145	55	365	3.247	4
Feel comfortable while walking/crossing the roads	33	115	24	143	50	365	3.170	5
Car park illegally	60	120	30	110	45	365	2.890	6
<b>ROUTE C</b>								
Car park illegally	40	140	30	110	45	365	2.945	1
Adequate separation from the traffic	95	80	26	145	19	365	2.762	2
Adequate sidewalk on the road	90	135	20	90	30	365	2.548	3
Reasonably safe to walk on the roads	90	170	25	70	10	365	2.288	4
Feel comfortable while walking/crossing the roads	130	140	24	60	11	365	2.129	5
Reasonably safe to cross the roads	175	105	22	58	5	365	1.940	6
<b>ROUTE D</b>								
Car park illegally	40	110	28	92	95	365	3.252	1
Reasonably safe to walk on the roads	35	95	24	180	31	365	3.211	2
Reasonably safe to cross the roads	36	100	20	180	29	365	3.181	3
Adequate separation from the traffic	57	105	26	138	39	365	2.992	4
Feel comfortable while walking/crossing the roads	50	120	30	129	36	365	2.948	5
Adequate sidewalk on the road	55	127	26	118	39	365	2.888	6

In order to identify respondents' preferences for improvements to the facility, pedestrians were questioned to evaluate the different types of conditions. Figure 6 indicates the pedestrian facility, which is in bad maintenance and condition that jeopardizes the safety of pedestrians from the perspective of respondents. 42% of respondents think that the poor condition of the sidewalk is the primary reason that Taylor's Lakeside Campus's road is unsafe for pedestrians especially Route C. The second poor pedestrian facility, according to 35% of respondents, is the road lighting, especially at Route D, where the pedestrians travelling back to their hostel.

Marked crosswalk being in bad conditions, inconvenient for use by pedestrians, ranked the third poor pedestrian facility, consisting of 25% of respondents for this response. Further response options include vehicular road (24%), speed bump (19%) and transit stop (17%).



**Figure 6.** Number of Respondents' Perception of The Pedestrian's Facility Which in Bad Condition

At the end of the survey, respondents were given an opportunity to share their experience if any incident happened to them while using the pedestrian facility on campus. This primarily focuses on the pedestrian walkways' functional aspects, aesthetic elements and experiential. In general, respondents' input on the experiential category are mostly critical. Yet, there is one positive feedback where the respondent feels more comfortable traveling along Route D pedestrian roadways with the existence of sidewalk trees. The most significant issue is the sense of danger, as they have to share the road with vehicles. This is shown in Figure 2 where there is insufficient pedestrian sidewalk accessible and the pedestrians have to travel along and cross the street. It brought us to the next point at which pedestrians become uncomfortable when crossing the road. One of the respondents highlighted that the crosswalks could be considered one of the most dangerous areas because the distance of the pedestrian is very close to the motorized vehicle. One of the respondents was frustrated because of the condition of pedestrian sidewalks is too poor and dangerous on Route C which causes the student to be injured. Majority of the respondents felt that it is important and appropriate to include the covered footpaths. They highlighted that during the rainy season, the problem worsens which makes people feel uncomfortable walking. They end up walking early in the morning or find a different transport mode for their trip to their campus and back to the car park area and hostel. Due to the lack of pedestrian facilities provided, the pedestrian chooses to travel on the vehicular road. The respondents expressed concerns about the quality of the sidewalk in terms of accessibility. The barriers and disturbances on the roadway were also an issue for pedestrians who are disabled.

### Implementation of The Pedestrian Facility at Taylor's Lakeside Campus

Table 5 indicate the Relative Agreement Index (RAI) of the proposed implementation of pedestrian facilities at Taylor's Lakeside Campus which include the construction of pedestrian bridge and bike lane. Based on the data from Table 5, majority of the respondents place a huge value on having pedestrian bridge at Taylor's Lakeside Campus. Among all the statements provided, the construction of pedestrian bridge in campus will ensure the safety of

pedestrians with the highest RAI of 4.485, followed by the second-highest RAI of 4.277 and the third-highest RAI of 4.260 which the construction of pedestrian bridge will benefit the respondent and motivate them to utilize the pedestrian bridge respectively. The respondents believe that the pedestrian bridge should prevent them from any accident or injury throughout their walking to campus. This is justified by Institute for Transportation & Development Policy, USA (2019), whereby pedestrian bridges will not only promote livable, sustainable lifestyles, but they also will create for the pedestrian's safety by relocating pedestrians out from the direction of moving vehicles. Besides, Table 5 also indicates the necessity for Taylor's Lakeside Campus to provide bike lane with the highest RAI of 3.499 where the construction of bike lane will benefit the respondent (the second-highest RAI of 3.252) and motivate them to cycle more to campus (the third-highest RAI of 3.077). This is justified by Balsas (2003), whereby large proportions of students reside around campus or within a short bicycling and walking distance from campus are common in many universities and colleges. Therefore, walking and cycling are the preferred mode of travel to get to the campus and travel around the campus.

**Table 5.** Importance of Pedestrian's Facility at Taylor's Lakeside Campus

	Frequency of Respondents					Total of Respondents	RAI	Rank
	1	2	3	4	5			
<b><i>Propose to construct a pedestrian bridge from campus to hostel nearby example PJS 7, Mutiara Perdana, DK Senza and D'Latour.</i></b>								
Will the implementation of pedestrian's facility, ensure your safety in crossing the road	0	12	20	112	221	365	4.485	1
Will it benefit you if Taylor's Lakeside Campus construct a pedestrian bridge in campus	0	12	30	168	155	365	4.277	2
What is the likelihood of you to utilize the pedestrian bridge on campus	0	28	22	142	173	365	4.260	3
Do you think it is a necessity for Taylor's Lakeside Campus to provide pedestrian bridge	18	61	26	120	140	365	3.830	4
<b><i>Propose to construct Bike Lane in campus to bring convenience to the student who travel from their hostel (PJS 7, Mutiara Perdana, DK Senza and D'Latour) to campus.</i></b>								
Do you think it is a necessity for Taylor's Lakeside Campus to construct bike lane around campus	27	73	24	173	68	365	3.499	1
Will it benefit you if Taylor's Lakeside Campus construct bike lane in campus	20	134	20	116	75	365	3.252	2
Will the implementation of pedestrian's facility motivate you to cycle to campus	40	130	26	100	69	365	3.077	3
I will prefer cycling to campus instead of walking	55	110	30	100	70	365	3.055	4
I will utilize the bike lane on campus if it is constructed	50	135	18	80	82	365	3.025	5

## CONCLUSION

Walking is one of the essential travel modes in Taylor's Lakeside Campus. The safety and comfort level of the pedestrian facility are a vital element and needed to be put into consideration in planning a pedestrian-friendly campus by designing pedestrian facility predominantly for effective movement via walking, protection of pedestrians from snatch

thefts, serious car accidents, and exposure to worsening climate conditions. Facility issues including lack of provision of a proper pedestrian walkway, lack of covered pedestrian walkway, insufficient roadway lighting and adequate separation from the vehicular roads are the factors to be looked for improvement. Imposing parking ticket for illegal car parking which is blocking the pedestrian path can be one way to resolve the problem. The shaded pedestrian paths are essential and necessary to be incorporated as the issue worsens during the rainy season, which makes pedestrians feel discomfort to walk to their hostel or walked to the car park area. This will also discourage them from walking on the vehicular path.

The pedestrians believe that excellent pedestrian facilities should exist to encourage them to use the pedestrian facility more rather than driving. This can set a standard for the design of the pedestrian facility in the countries specifically for the tropical climate through more profound studies need to be conducted before establishing it. In this way, the pedestrian facility design will be meeting minimum standards of sustainability and will promote sustainable mobility and pedestrian-friendly campus.

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# FACTORS CAUSING WORK-FAMILY CONFLICT (WFC) AMONG THE CONSTRUCTION PROFESSIONALS IN KUCHING, SARAWAK

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## **Abstract**

Work-family conflict (WFC) is an important issue that needs to be taken into consideration regardless of countries and cultures all over the world. Nevertheless, the characters and dimensions differed in the different working industry. In the construction industry, construction professionals play an important role in completing the construction project in time within the approved budget at a high-quality end product. Moreover, the working environment in the construction industry is considered to be challenging in which it will impede an individual's family life in terms of time, strain, and behaviour. Therefore, this research paper attempt to identify the underlying factors causing WFC of the respondents working in the Kuching construction industry. This research paper utilizes a quantitative approach. A total number of 200 questionnaires, designed using Google doc form were collected. This research is statistically descriptive orientated and Statistical Package for the Social Science (SPSS) software was being adopted to analyse the data obtained. The findings revealed that long working hours and inflexible work schedule are the most significant factors that lead to WFC in the Kuching construction industry. Thus, this research paper designed to provide an overview to the organisations and construction professionals in implementing the techniques to minimise the level of WFC so as to achieve balancing between work and family domain.

**Keywords:** *Construction Professionals; Work-Family Conflict (WFC); Factors.*

## **INTRODUCTION**

Sarawak is considered as a developing state within the developing country, Malaysia and its capital city is Kuching. In Kuching, the common working hour for the construction industry per week is 48 hours within the year 2017 (Department of Statistic Malaysia, 2018). However, an excessive amount of time spent at workplace will end in less time available for non-working life (Malay Mail, 2019), and thus having a poor relation with their family (Fursman, 2008).

In the construction industry, especially for those who are working in the contractor firm, construction professionals are normally encountered an extremely high volume of work pressure (Helen, Francis & Turner, 2010; Wahab, 2010). Moreover, employees in the Sarawak construction industry had reported that they had excessive workloads, rising shift workloads, and not getting a reasonable paid (Hassan, Dollard & Winefield, 2010). Not only that, construction professionals also often go home with disappointed feeling due to ample workload and challenging duties, and being discourteous by the family members (Wu, Wu, Li & Dan, 2018). With regard to this current scenario, it highlighted that the construction professionals in the construction industry is under tremendous pressure (Hassan et al., 2010), and this would lead to work-family conflict (WFC).

Although there are numerous studies in Malaysia concerning WFC were being conducted in the view of different professionals' background from different fields, lack of study being conducted concerning the WFC amongst construction professionals. Nevertheless, there are

certain studies had been carried out concerning the factors causing work stress due to family in the construction industry. For example, in the Australian construction industry, the average working days for workers are 6 days. However, it was reported that the construction workers were struggling in an intensive volume of WFC, and this conflict was mainly caused by too many jobs demands, such as lengthy and uneven working schedules. It also claimed that WFC could be able to function as a connection tool between the work-schedule demand and worker burnout (Turner & Mariani, 2016). Hence, obtaining support from the supervisor is particularly important to balance the correlation between WFC and worker burnout.

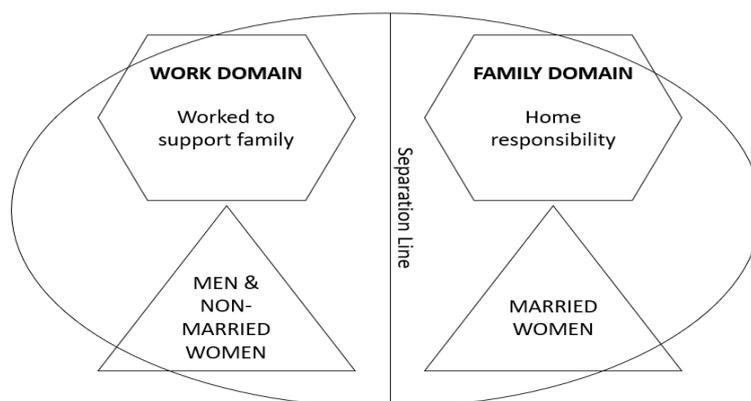
Similarly to the construction sector in Hong Kong, it was reported that the relationship between 'burnout' and work-family stressors among the construction professionals are weaker. Burnout is generally resulted from the interconnection of individual factors and features of the work and family. Burnout of an individual can be infectious which will affect the non-working life, such as the family. It has been further explained that lengthy working hours and job unsecured were negatively associated with the participation of family events which will lead to increase in the divorce rate. These factors are to some extent related to WFC in the construction industry (YIP, B Rowlinson, Kvan & Lingard, 2005). Hence, the aim of this paper is to identify the underlying factors causing the WFC.

## LITERATURE REVIEW

This section begins with the brief explanation on the concept of work and family by using the separate-spheres and overlapping-spheres model. Next, the WFC definition is also explained. Lastly, the factors causing WFC are being elaborated.

### The Concept of Work and Family

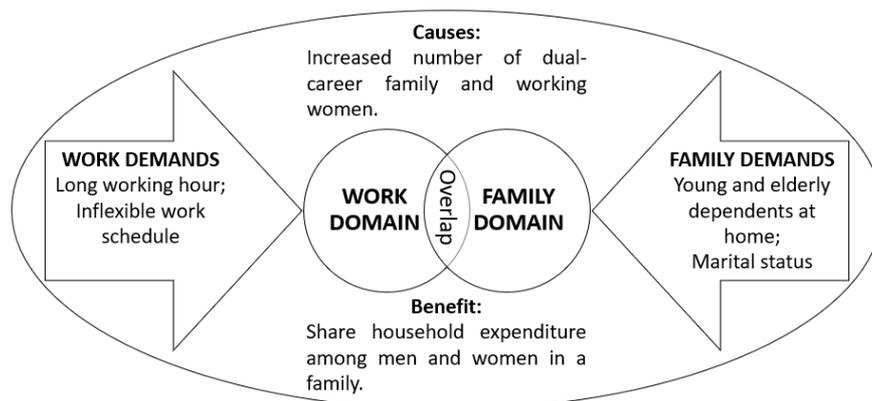
The separate-spheres model shown in Figure 1 indicates a separate point of view that was being promoted at the very beginning of the study on work and family (J. Y. Liu & Low, 2011). The fundamental separation present in the work and family domains, and participation in each field is presumed that they will not influence each other (Fredrik-Goldsen, K.I. & Scharlach, 2001). For example, during the early time, home responsibilities were mostly being cited by women as a reason for not participate in the working industry after they got married (Steven Hipple, 2015), while men were mostly worked to support his family (Ranson, 2012).



**Figure 1.** Separate-Spheres Model (Source: Adapted from J. Y. Liu & Low (2011))

As people are getting richer in the past few years, it is conceivable to have one person in a family to supply all the living expenses of a household (J. Y. Liu & Low, 2011). Due to the increasing number of elderly and young dependents and life expectancy in a household, taking care of the young and elderly dependents are getting more important as part of the responsibility of the family (Hein, 2005). For instance, with only one child in a family that will lead to a “Four-Two-One” issue when the child grows older, as he or she will need to deliver monetary assistant for his or her 2 parents and also 4 grandparents. If the child is working in the construction sector, he or she will definitely encounter more pressure in terms of long working hours, inflexible working schedules, and etc., compared to other sectors. In this situation, the younger generations will have massive responsibilities compared to the older generations (J. Y. Liu & Low, 2011).

It was claimed that the value of “non-standard” working style among the younger employees in the construction industry is higher and it allows them to reach the job and life satisfaction (J. Y. Liu & Low, 2011). Due to these changes, the employees are no longer to put in all their energy or attention to their job, and presume that there is a need to have an understandable separation between the family and work lives (Helen Lingard & Francis, 2007). However, the separate-spheres model promoted by Liu and Low (2011) had successfully delivered an understanding of the interlinked nature of workers’ work and family lives.



**Figure 2.** Overlapping-Spheres Model (Source: Adapted from J. Y. Liu & Low (2011))

The overlapping-spheres model shown in Figure 2 indicates an overlapping point of view that was being presented to replace the separate-spheres model and described that the spheres for both family and work are overlapping substantially. In other words, anything happens in one sphere will definitely bring significant effect to another sphere (J. Y. Liu & Low, 2011). For instance, working overtime in the office to complete tasks given will consume the time reserved for family activities.

From the past reviews, many researchers had conducted the analysis to interpret the correlation procedures between family and work-life of the wage-earners. Among all, numerous have been widely managed by the role concept (Korabik, Lero & Whitehead, 2008). The procedures have been categorized into three aspects, which are positive, integrative and negative; and for work to a family interface, the approach of dominant conceptual is considered as a negative aspect (J. Y. Liu & Low, 2011).

Under the role concept, people are assumed to have a limited portion of resources in terms of energy and time. Both domains were fighting for the resources all the time (Korabik et al., 2008). The reason causing WFC is that the individuals, no matter male or female, consolidated the demands for both family and work of their life (J. Y. Liu & Low, 2011).

Besides that, under the positive aspect for work to family integration, Kaiser, Ringlsetter, Eikhof, and Cunha (2011) had claimed that the advantage of integration between work and family roles is that it can help to reduce the value of shifting the roles and also help to make use of the resources effectively, for example, time. In a married couple, there are resources for example spouse instrument support that could be donated to well-being as well as eliminating the strains between both roles (Halbesleben, Zellars, Carlson, Perrewé & Rotondo, 2010).

### The Definition of Work-Family Conflict (WFC)

Work-family conflict (WFC) has been described as a form of inter-role conflict which the role pressures from the work and family domains are mutually incompatible in some respect (Wu, Duan, Zuo, Yang & Wen, 2016). WFC will only occur when an individual does not have the ability to fulfil the job demands and at the same time, manage the role demands as a spouse or parent (Chandola et al., 2004). WFC also described in the construction industry as the incompatibility of role pressures between work and family for construction professionals (Wu et al., 2018).

### Factors Causing WFC

The factors causing WFC categorised into three (3) groups, namely working factors, family factors, and individual factors. Figure 3 below shows the different factors under different groups. Under the working factors, there are long working hours and inflexible work schedule. Meanwhile, under the family factors, there are marital status and number of dependents (young and elderly). Last but not least, under the individual factor is age. These five variables were determined based on the overlapping-spheres model in Figure 2.

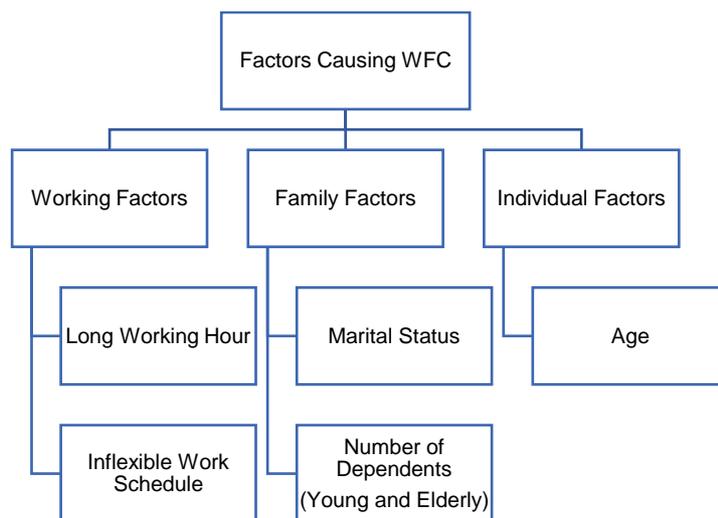


Figure 3. Factors Causing WFC

## **Long Working Hour**

Bowen, Edwards and Lingard (2013) argued that there were different professionals encountered different stresses due to different work responsibilities and the number of working hours. These stresses will actually bring negative outcome to the family in terms of bad attitude towards family members, and thus will lead to WFC. Besides that, Lingard, Townsend, Bradley, and Brown (2008) also argued that longer working hours in the construction industry had raised the employee's concerns that it will affect their family life negatively, such as poor relationship with family members (H Lingard et al., 2008; Omar & Sallehudin, 2018).

## **Inflexible Work Schedule**

Inflexible work schedule is also known as non-standard work schedule and it refers to all other work schedules including night, evening, or rotating schedules, variable hours, and weekend employment (H. Liu, Wang, Keesler & Schneider, 2011). It is being presumed that the construction professionals would work a non-standard working schedule. However, this will actually destroy the balancing between work and family life (H Lingard et al., 2008). Hosking and Western (2008) supported by Wu, Duan, Zuo, Yang & Wen (2016) argued that working on weekend and uneven shift had resulted in high WFC among the construction professionals in the construction industry. Besides that, the level of parental success feelings will be reduced when the construction professionals worked a non-standard working schedule. This is due to the lack of time for them to share with their family members and to discipline and keep their eyes on their children (H. Liu et al., 2011).

## **Marital Status**

Family involvements and the rate of divorce correlates to the long hours of work, as the professionals are expected to work for long hours due to the demanding and competitive working environment (Helen Lingard & Sublet, 2002). The irregular working hours of employees in the respective industry too affects deeply towards the employee's low marital quality, and inflexible work schedules too leading to high rates of divorce especially among the married couples with children (H Lingard et al., 2008; Cerrato & Cifre, 2018). Married couples with children who are younger require more attention and resources give a more pronounced impact towards the working individuals towards his/her family responsibilities balance which reported a higher conflict at home between younger children and working parents (Bowen, Govender, Edwards & Cattell, 2018).

## **Number of Young and Elderly Dependents**

The obligations towards the family of a construction professional increase via marriage and children's arrival, which in turn increases their WFC (Darcy & McCarthy, 2007). The greater experiences of WFC are mostly due to the demands which are unpredictable, which includes an arrangement for childcare, and sick children care. Such demands eventually lower the control levels over work and family bonds, which in return causes a greater WFC. Nevertheless, such demands will decrease as children grow older and lowers down the parents' stresses (Ahmad & Justice, 2014). Hepburn and Barling (2014) stated that the working construction professionals who provides elderly care responsibilities reported to

have missed their work, working schedules changed, and works interrupted. Elderly care responsibilities showed how this particular responsibility is a sensitive indicator related to the working professionals' works such as being late to work or leaving early from work which eventually leads to WFC. This is due to elderly requiring help or assistance for their basic necessary needs such as baths, eating, or even transportation for medical check-ups (Naldini, Pavolini & Solera, 2016).

## **Age**

In younger adulthood (aged 18-30), most of the people at this stage will pay more attention to their individuality, such as further their study, start to work, or start to form their own family (Huffman, Henning & Goh, 2013). Therefore, the working construction professionals at this stage will not encounter a very high level of WFC due to fewer responsibilities in both the family and work domains (Sweet, Pitt-catsoupes, Hovhannisyan & Pasha, 2010). In middle-age adulthood (aged 31-49), most of the people in this stage started to take greater accountabilities in both the family and work domains. The responsibilities are likely expanding (Huffman et al., 2013), as most of them in this stage are required to raise their children and support their elders at home (Xia, Zhong, Wang & Tiong, 2018). In older adulthood (aged 50 and above), most of the people at this stage are having matured and firm interests in both work and relaxation as they are not having younger children (e.g. children aged 0-10) at home, but having a chance of forming a healthy relationship with family members (Huffman et al., 2013). However, working professionals in middle-age adulthood can be said to have the greatest level of WFC compared to those in younger and older adulthood.

## **METHODOLOGY**

In order to achieve the objective of this study, the positivism paradigm was implemented that comprise of literature review and online questionnaire survey. The positivism enables the researcher to identify how the factors would lead the construction professionals to WFC in reality through online questionnaire survey, that the questionnaire derived from the review of the literature. In addition, this study adopted stratified sampling in which the construction professionals were divided into different strata based on their professional background namely Architect, Quantity Surveyor, Engineer (Civil, Mechanical, and Electrical), and Project Manager. From that, samples are being selected randomly from each of the strata to carry out the survey.

### **Sample Size and Data Collection**

After obtaining the targeted population and sample, next step is to calculate the number of sample size by using the Slovin's Formula as stated below. Assuming the level of confidence is 95%, therefore, the margin of error (precision) is 5%. The calculation of sample size as followed:

$$n = \frac{N}{1 + N(e)^2}$$

Where, n = Sample Size

N = Population size

e = Margin Error (Precision)

Source: Adopted from (Taherdoost & Group, 2017a)

Population of registered Architects in Kuching = 256

$$\therefore \text{Sample Size} = \frac{256}{1 + 256(0.05)^2} = 156.10$$

Population of registered Engineers in Kuching = 1,132

$$\therefore \text{Sample Size} = \frac{1,132}{1 + 1,132(0.05)^2} = 295.56$$

Percentage of Architects in Kuching from Sarawak =  $(256/302) * 100\% = 84.77\%$

Percentage of Engineers in Kuching from Sarawak =  $(1,132/1,416) * 100\% = 79.94\%$

Population of registered Quantity Surveyors in Sarawak = 371

Estimated population of registered Quantity Surveyors in Kuching =  $371 * [(84.77\% + 79.94\%)/2]$   
= 306

$$\therefore \text{Sample Size} = \frac{306}{1 + 306(0.05)^2} = 173.37$$

Percentage of Architects in Sarawak from Malaysia =  $(302/5,152) * 100\% = 5.86\%$

Percentage of Quantity Surveyors in Sarawak from Malaysia =  $(371/4,502) * 100\% = 8.24\%$

Population of registered Project Managers in Malaysia = 179

Estimated population of registered Project Managers in Sarawak =  $179 * [(5.86\% + 8.24\%)/2]$   
= 13

Percentage of Architects in Kuching from Sarawak =  $(256/302) * 100\% = 84.77\%$

Percentage of Quantity Surveyors in Kuching from Sarawak =  $(306/371) * 100\% = 82.48\%$

Estimated population of registered Project Managers in Kuching =  $13 * [(84.77\% + 82.48\%)/2]$   
= 11

$$\therefore \text{Sample Size} = \frac{11}{1 + 11(0.05)^2} = 10.97$$

A total number of 636 questionnaires distributed to the targeted construction professionals in Kuching that comprise of 156 Architects, 173 Quantity Surveyors, 296 Engineers (Civil, Mechanical, and Electrical) and 11 Project Managers. The questionnaires were distributed to the respective respondents through their official email by using google doc form link. The whole set of questionnaires divided into two sections, which is Section A and Section B. Section A was to identify the demographic background of the targeted construction professionals. Whereas, in Section B, it reflects the objective of this study which

is the underlying factors that caused WFC. In addition, for Section B, the responses are recorded according to the five-point Likert scale (1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree).

## Response Rate

Table 1 shows the response rate from each construction professionals. There were 636 questionnaires being distributed to the targeted professionals in Kuching, and only 200 of them had appropriately filled and returned the questionnaire, thus, generating a response rate of 31.45%. For registered Architect, there were 48 out of 156 returned the questionnaires, that indicated the response rate was 30.77%. Meanwhile, for the registered Quantity Surveyors, there were 55 out of 173 of them have returned the questionnaires, and this indicated the response rate was 31.79%. Next is the Engineers that consist of Civil and Structural Engineers, Mechanical Engineers, and Electrical Engineers. Out of 296 Engineers, only 91 of them have returned the questionnaires that shows the response rate was 30.74%. Lastly, there were 6 out of 11 registered Project Manager have returned the questionnaires, resulting a 54.55% of response rate.

**Table 1.** Response Rate from Each Construction Professionals

Construction Professionals	Sample Size	Frequency	Response Rate
Architect	156	48	30.77%
Quantity Surveyor	173	55	31.79%
Engineer	296	91	30.74%
Project Manager	11	6	54.55%

(Source: Researcher)

## Data Analysis

Data analysis for this study is the statistical approach which adopted descriptive statistic. Descriptive statistic is best used to summarise the data obtained (Watier, Lamontagne & Chartier, 2016). Moreover, this statistical approach help the researchers to analyse the outcome, correlation, and design of the research variables (Jung, 2019). The data obtained need to be edited, coded, keyed in, and checked. The aim of editing the data is to examine the data completeness, as well as to determine the error and assess the readability. Coding is the process of converting data gathered from the questionnaire survey into figures. After all the data have been coded, it will then keyed into Statistical Package for the Social Science (SPSS) (Jung, 2019). This is because, the SPSS helps to analyse the data in many different statistic form (Ashirwadam, 2014).

## FINDINGS AND DISCUSSION

All the data collected from questionnaire have been analysed and interpreted. It starts with the frequency analysis of the construction professionals demographic background, followed by the descriptive analysis of the variables used to identify the underlying factors causing WFC. The analysis of the findings presented in tables and pie chart.

## Demographic Background

In Section A, targeted respondents are required to provide their profile by answering all the questions under this section. There are ten questions under this section, which are gender, age, profession, qualification level, marital status, number of children (if married), years of working experience, average hour worked per week, work-week pattern type, and size of company. The frequency and percentage of the demographic characteristics are quantified and presented as shown in the Table 2.

**Table 2.** Frequency and Percentage of Demographic Backgrounds

Demographic Backgrounds	Options	Frequency	Percentage (%)
Gender	Male	115	57.5
	Female	85	42.5
Age	Below 29 years	34	17.0
	30 – 39 years	59	29.5
	40 – 49 years	59	29.5
	50 – 59 years	37	18.5
	60 years and above	11	5.5
Profession	Architect	48	24.0
	Engineer	91	45.5
	Quantity Surveyor	55	27.5
	Project Manager	6	3.0
Academic Qualification Level	SPM	21	10.5
	STPM	9	4.5
	A-Level or Diploma	57	28.5
	Bachelor's degree	101	50.5
	Master's degree	12	6.0
	Doctor of Philosophy	0	0.0
Marital Status	Single	45	22.5
	Married	155	77.5
Number of Children (If married)	None	47	23.5
	1 – 2	61	30.5
	3 – 4	53	26.5
	5 – 6	39	19.5
Years of Working Experience	Less than 5 years	32	16.0
	5 – 10 years	34	17.0
	11 – 15 years	34	17.0
	16 – 20 years	33	16.5
	20 years and above	67	33.5
Average Hour Worked Per Week	Below 40 hours	0	0.0
	41 – 50 hours	79	39.5
	51 – 60 hours	71	35.5
	61 – 70 hours	47	23.5
	71 hours and above	3	1.5
Work-Week Pattern Type	5 days work week	31	15.5
	5½ days work week	44	22.0
	6 days work week	76	38.0
	6½ days work week	42	21.0
	7 days work week	7	3.5
Company Size	1 – 10 employees	18	9.0
	11 – 50 employees	53	26.5
	51 – 100 employees	67	33.5
	> 100 employees	62	31.0

(Source: Researcher)

## Factors Causing Work-Family Conflict (WFC)

As show in Table 3, there are five factors that caused the WFC which are long working hour, inflexible work schedule, number of young and elderly dependents, marital status, and age. (Note for mean value: Strongly Disagree = Less than 1.49; Disagree = 1.50 – 2.49; Slightly Agree = 2.50 – 3.49; Agree = 3.5 – 4.49; Strongly Agree = 4.50 – 5.00).

**Table 3.** Results of Data Analysis for Section B

Factors	Mean	Remark	SD	RII	Ranking
Long Working Hour	4.18	Agree	0.847	0.835	1
Inflexible Work Schedule	3.98	Agree	0.783	0.796	2
Number of Young and Elderly Dependents	3.79	Agree	0.743	0.757	3
Marital Status	3.52	Agree	1.027	0.703	4
Age	3.48	Slightly Agree	0.896	0.696	5

(Source: Researcher)

The mean of all the questions in Section B are varies, which are slightly agree and agree. The mean values are also varying, one question is with the mean value of 4.00 and above, four questions are with the mean value of more than 3.50 but less than 4.00, and one question is with the mean value of more than 3.00 but less than 3.50. However, overall mean calculation was carried out to identify the factors that lead to WFC in Kuching industry of construction.

$$\text{Overall Mean} = \frac{4.18 + 3.98 + 3.79 + 3.52 + 3.48}{5} = 3.79$$

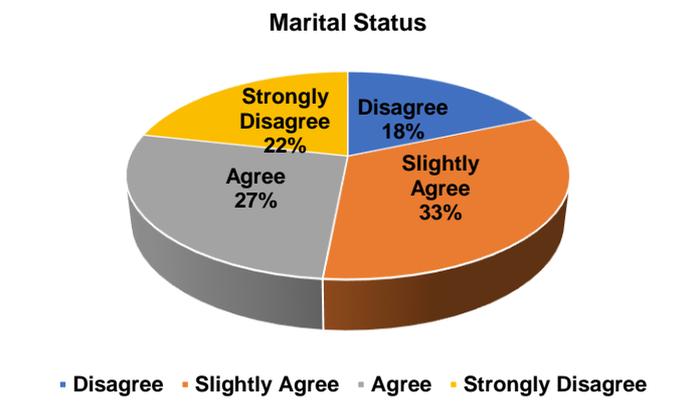
Long working hour was the main factor that caused WFC among the construction professionals. As shown in Table 2, more than half of the construction professionals (60.5%) were reported to have work an exceptionally long hour per week (51 hours and above), especially those who are based on construction site. On the other hand, the remaining construction professionals (39.5%) who mainly worked in the headquarters were reported to have work less than 50 hours per week. Thus, the findings are consistent with the statement presented by Helen, Francis and Turner (2010) and Bowen et al. (2013) in interpreting the working hours of the construction professionals in the respective industry.

The next factor is inflexible work schedule. As shown in Table 2, majority of the constructional professionals (62.5%) were reported to have work on non-standard schedule (6 days and more) in the respective industry. Hence, the findings support Hosking and Western (2008) and Lingard, Townsend, Bradley and Brown (2008) findings who revealed that working on weekend and uneven shift had resulted in high level of WFC, especially those with higher position.

In addition, the number of young and elderly dependents is one of the contributed factors to the WFC. According to the analysis in Table 2, nearly half of the construction professionals (46%) were reported to have more than 3 children to take care. Children with younger age are more likely to affect the level of parents' stress level. Ahmad and Justice (2014) revealed that the child's age was strongly correlated with WFC, where the level of WFC will decrease as the child grow older. Besides that, Hepburn and Barling (2014) found that the elderly care

responsibilities was positively associated with WFC. Similar finding found by Naldini, Pavolini and Solera (2016) that the elderly caregiving by the working professionals had reduced their working hour.

The next factor is age. Huffman, Henning, and Goh (2013) revealed that adulthood had been divided into three group, such as age 18-30 years old (young), age 31-49 years old (middle-age), and age 50 years old and above (older). According to the analysis in Table 2, more than half of the construction professionals (59%) were in the middle-age, followed by older age (24%) and younger age (17%). The findings are equivalent with Huffman, Henning, and Goh (2013) and Xia, Zhong, Wang and Tiong (2018) who found that middle age encountered the greatest level of WFC compared to younger and older age. Besides that, it is also correspondent with the study conducted by Liu and Low (2011) who found that older age encountered the lowest level of WFC compared to younger age and middle age.



**Figure 4.** Marital Status Factor

In term of the marital status factor, it has a standard deviation value of 1.027, which is slightly higher than 1 (standard value). This indicates a high variation of the mean value. Based on the data from Figure 4, 40% percent or the respondents had disagreed or strongly disagree with this factor. Furthermore, among all the factors, this factor has the highest number of individuals who disagreed, especially those who are single, and gendered male. This is because the individuals who are single may not know how high the responsibility of married individuals is in supporting their family and family-in-law. Apart from that, some of the married men certainly do not understand the hefty household responsibilities that mostly encountered by married women, for example doing the household works and taking care of children and elderly (Cerrato & Cifre, 2018).

**CONCLUSION**

The present study revealed that a source of stress can lead to some negative effects, like life and job dissatisfaction, job burnout, health risks increased, psychological distress, and high turnover rate of the professionals. Therefore, the strategies to eliminate WFC are essential for the professionals as well as organisations to prevent the occurrence of the negative consequences caused by WFC. By doing so, this present study had positively provided an overview to the constructional professionals regarding the forms of WFC they might encounter, and the factors that lead them to WFC.

The findings revealed that long working hour and inflexible work schedule were the main factors that lead to WFC. In order to reduce the working hours, the construction professionals should have a proper time management to balance their time for the two domains. To increase the work schedule flexibility, the construction professionals should have more power to decide their working schedule, so that they will have more time available for family's activities.

Besides that, the organisations must provide enough support to their employees, so that they will have good motivation and high level of energy while working, and thus will not affect their family members. The organisations should not assign tasks to their employees at the last minutes, as this would require them to adjust their schedule to fit the works. Last but not least, the construction professionals could also discover their own techniques to reduce WFC by referring to the present study.

## SIGNIFICANCE OF THE STUDY

Once this study is being emphasised, it is hoped that the result from this study would assist future researchers to shape a proper guideline in studying the aspect of WFC in the construction field and any other field. It is hoped that this study would be able to benefits construction professionals and organisations by delivering more understanding to all three forms of WFC that might be encountered by them.

It is also hoped that the result of this study would encourage further attention to be paid by the construction professionals on the WFC and also get to know the factors causing WFC. With that, organisations would be able to involve in the activities that would help to eliminate employees' WFC, so that the employees are able to implement these practices in their daily life. When individuals are able to obtain balancing between the household and work, it will help to enhance the productivity at work and maintain a healthy connection with their family.

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# IMPACT OF VARIATION ORDER ON PUBLIC INFRASTRUCTURE PROJECTS IN SARAWAK

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## Abstract

The need to make improvements for construction project is a part of practical fact. Nevertheless, the most thoughtful planned project may require to be changed due to a variety of factors. Contracts usually specify when and what time the contractors have to finish the work, yet many construction projects struggle with delay, financial problems and disappointed results due to the inadequate attention paid to determining the variation orders. Moreover, the greater number of variations in design has led to higher cost and lower cost reliability in the construction industry. Hence, variation orders are the most detrimental and stressful occurrences in the project. As a result, the existence of variations often led to frustration among project participants. Therefore, this research paper attempt to examine the impacts of variations on public infrastructure projects in Sarawak. This research paper utilizes a quantitative approach via desk research, questionnaires, and observations. Out of 239 numbers of questionnaires distributed, 85 were duly completed and returned from the contractor firm registered under Construction Industry Development Board (CIDB) Grade 7 in Sarawak. The data obtained was analyzed using descriptive analysis by Microsoft Excel software package. As a result, it was indicated that project cost increase, completion schedule delay and delay in payment are the most important impacts of variation orders on public infrastructure projects. Research results would act to strengthen and simplified existing variation order management practices and take constructive measures to minimize the negative impacts of variation orders.

**Keywords:** *Variation Order; Public Infrastructure Projects; Impacts.*

## INTRODUCTION

Contracts usually specify when and what time the contractors have to finish the work, however, many construction projects struggle with delay, financial problem, and disappointed results due to the inadequate attention paid to determining the variation orders (Maarouf & Habib, 2011). The need to make improvements to a project is a part of practical fact. Even the most thoughtful planned project may require to be changed due to a variety of factors (Arain & Low, 2005). Besides, variation orders are the most detrimental and stressful occurrences in the project as they influence the value and date of completion of the projects (Msallam, Abojaradeh, Jrew, & Zaki, 2015). Mohammad, Ani, Rakmat, & Yusof (2010) also stated that one of the main challenges facing the construction industry is the problem of variation order during the construction process. Variations can be reduced when the collective research is conducted as soon as possible so that the issues can be found and make advantageous variations (CII, 1994). Memon, Abdul Rahman, & Abu Jamil (2014) stated that variations are often normal in all public projects in the background of Malaysia construction industry. Project Monitoring System of the Public Works Department of Malaysia in 2016 announced that most projects tend to have variations which led to many problems and dissatisfaction among construction project participants, including delays in procurement of different works (Judi, Musaffa, & Nayan, 2017). Nachatar, Hussin and Omran (2010), indicate the use of the term “variations” in construction contracts usually refers to a change directed by architect, contract manager or client. Construction variations refer to changes in design, quality, changes in quantity including modification in materials or products used in

the project and any materials removed from the site which is not in compliance with the contract (Asamaoh & Offei-Nyako, 2013). A major change to the project would possibly result in an adjustment between stakeholders to the contractual terms of the agreement. Therefore, careful consideration must be taken of each variation (Okada, Simons, & Sattineni, 2017).

## RESEARCH OBJECTIVE

The purpose of this research is to examine the impacts of variation orders on public infrastructure projects in Sarawak.

## LITERATURE REVIEW

Persatuan Akitek Malaysia Standard Form of Contract (PAM 98) defines variation as a change or modification to the design, quality or quantity as shown in the contract drawings and described or mentioned in the contract bills. Variation orders can be categorized into two types which are beneficial variations and detrimental variations. Beneficial variations are changes that help to enhance quality, lower the expenditure, schedule or project difficulty. On the contrary, detrimental variations reduce the value of the owner or negatively affect a project (Arain & Low, 2005).

Variation orders occur for various reasons such as predictable and not predictable. Some arise from a genuine change in circumstances and others from the inadequacies of the design team itself (Yadeta, 2014). The main causes of variation orders on construction projects are insufficient working drawing information, inconsistencies in design, disputes between contract documents, adjustments in plans or scope by clients, obstacles in the timely decision making process, ineffective project goals, and the substitution of materials or procedures, disparities in site conditions, lack of skilled manpower, the expected productivity of the contractor and the financial problems of the contractor (Sunday, 2010).

## Impacts of Variation Order on Public Infrastructure Projects

### *Project Cost Increase/Overrun*

Not all the variation orders will be resulted in increasing of construction costs. This is because omissions in a project is actually helping to reduce costs while additions as the name means increase in the project costs (Yadeta, 2014). Any change or extension of the project during project execution can lead to rework and demolition of any project portion and ultimately raise the project cost (Memon & Rahman, 2014). Variation orders will lead to direct and indirect costs of construction project (Enshassi, Arain & Al-Rae, 2010). Direct costs are the additional expenses incurred to carry out the activities of the current variation orders (Lusca, Aigbavboa & Thwala, 2015). According to Mahmud et al. (2020), cost overruns in the pre-construction phase are measured by the difference between the predicted cost at the start of construction and the decision date, while cost overruns in the construction phase are measured by the difference between the final construction cost and the predicted cost on the following dates: Start time.

### *Overhead Expenses Increase*

The sequence of variation order must go through multiple stages of and must be checked before they can even be enforced (Nachatar, Hussin & Omran, 2010). Variation order indicate some minor or major differences between the owner and the contractor regarding the contractual scope agreed. Proper documentation is essential for having the changes accepted and unanimously agreed by all parties. (Hwang & Low, 2012). Additionally, variation order even needs to perform the process method, instrument and report (Memon & Rahman, 2014). This process is to make sure that all involved parties are fully advised and recorded of the proposed variations. Therefore, the legal documents and paper procedures relating to the negotiated variations require further expenditure (Hwang & Low, 2012).

### *Delays in Procurement*

Delays in procurement start to appear which require new materials and additional equipment. It can require new specialized materials or equipment to become the project's resources (Hwang & Low, 2012). In the construction process, procurement delays require specific equipment, tools and materials which in turn contribute to higher overhead costs (Ghenbasha, Omar & Ayob, 2018).

### *Payment Delay*

There was regular delay in payment due to variation order of construction projects (CII, 1990). Variation order will impede the progress of the project, which leads to delays in achieving the target during the construction process (CII, 1995). This can potentially impact the payment to contractor. The delay sometimes can cause serious problems and eventually lead to delays in payment to the subcontractor because the main contractor may not be able to pay the fees unless they get paid by the client first (Yadeta, 2014).

### *Delay in Completion Schedule*

Completion of an activity may be delayed due to delayed commencement or extended duration of the activity. Although the start of an event may be postponed for certain reasons, its duration may be prolonged for some other reasons. Delayed completion of an operation can causes delays in the subsequent activities, which may lead to delays in completion of the project (Hamid, Botiti and Mohandes, 2015).

### *Logistics Delay*

Due to variations that required new materials and equipment, logistics delays can occur (Yadeta, 2014). This is because time is taken for the materials and equipment on site to be ordered/ booked and transported. Therefore, delays in logistics were encountered in every construction project where new materials, instruments and equipment were needed for variations in the construction process (Yadeta, 2014).

### *Progress Affected with No Delay*

Variations can affect progress and quality of a projects. Time is important during the construction (Nachatar, Hussin & Omran, 2010). Time has an equal monetary value during project implementation, even though the project team does its hardest to keep the timetable for completion of the project intact. However, only significant variations will impact the completion time of the project (Arain & Low, 2005; Yadeta, 2014). Therefore, variation order would impact the progress of the project with no delay in the date of completion of the project.

### *Reworks and Demolition*

Reworks and demolition happen especially when the construction has just started or is already in the process of construction (CII, 1990; Hwang & Low, 2012). Design variations also result in rework and demolition if the variations occur during the construction process or if they are completed (Bello & Saka, 2017). Rework and demolition are possible impacts of variation orders, depending on the nature of variations occurring. The variations in the design phase do not require any rework or dismantling at the construction sites thus the impacts are likely due to variations during the construction process (Yadeta, 2014). Depends on the occurrence of variations, minor or major reworks might be needed (Hwang & Low, 2012).

### *Quality Degradation*

If variations are frequent, they may potentially affect the quality of works. Quality may be compromised as contractors try to compensate for losses, they are not optimistic about recovering (Bello & Saka, 2017). According to Lusca et al. (2015), the impact of one phase work that is being changed on another phase of work that is not being changed refers to the indirect delay or interference. Interferences may lead to quality defects. Hence, it may be assumed that variation orders lead to quality degradation of the construction project.

### *Disputes Among Professionals*

The construction project establishes a professional partnership between the contracting parties. Through successfully completed project provides participants with an additional experience, and their credibility builds up. Nonetheless, conflicts can occur between contracting parties because of the variation orders (Bello & Saka, 2017). The occurrence of variation orders can affect professional relations and therefore lead to disputes (Yadeta, 2014). If the contractor is dissatisfied with the client consultant's assessing the value of variation, misunderstanding may occur. Contracting parties should debate the cost of the variation, the time impact, and the due compensation (Bower, 2000; Bello & Saka, 2017).

### *Poor Safety Conditions*

Variations may affect the safety conditions of construction projects (Yadeta, 2014). Changes in construction methods, materials and equipment may require other safety and health measures (Arain & Low, 2005; Bello & Saka, 2017). Client should always ensure the workers are in a safe working environment. If new machinery or other forms of contracting are used, necessary and additional safety measures must be planned for the workers (Hwang & Low, 2012).

### *Additional Payment to Contractor*

Variation in construction projects may cause to additional payments to the contractor. The contractor looks forward to variations in the construction project due to extra fees (Yadeta, 2014). Hence, in order to receive additional payments and maximize their benefits, some contractors also search for ways and reasons to initiative variations during construction.

### *Poor Professional Relations*

Variations are a significant source of controversy over construction. Professional relations can be influenced by variations, leading to conflicts (Yadeta, 2014). The issuance of variation orders' works contributes to the incidence of conflict and raises the degree of tension for the contractor as he has to deal with delays and disruption events. The impact affects individual events of delay and interruption where their presence looks negligible and manageable. However, as the delay and interruption events caused by the multiple orders of variance, they also communicate with each other, impacting the unchanged job with greater disruption and efficiency (Shamsudin, 2017). This is more controversy for the contractor team as this condition often contributes to the rise in costs, reduction in productivity and losses that the contractor must bear on his own (Melany, 2014).

### *Blemish Firm's Reputation*

As a significant source of construction allegations and conflicts, variations are referred to. The claims and disputes can adversely affect the reputation of the company, leading in serious cases to insolvency. The probability of professional conflicts is often increased by variation. Conventionally, with all the actors involved in the construction process, variations present challenges (Yadeta, 2014).

### *Labour Productivity Degradation*

Variation orders have a directly related to the productivity of individuals and groups, particularly in the absence of materials and knowledge, and the work is out of sequence (Alsuliman, Bowles & Chen, 2012). Variation orders often associated with job interruptions, delays and adjustments do have a detrimental effect on productivity of labour (Nachatar, Hussin & Omran, 2010). Working overtime may make worker demoralized and reduce workers' productivity (Hwang & Low, 2012). If it is necessary to work overtime for a long time to make up of the delay, it is expected that the productivity of workers will be greatly affected (Nachatar, Hussin & Omran, 2010).

## **RESEARCH METHODOLOGY**

In this research, questionnaires survey has been used as a key tool for data collection to examine the impacts of variation orders on public infrastructure projects in Sarawak. According to Mathers et al. (2009), questionnaire surveys are useful and relevant data from a huge number of individuals. Categorical questions were used to gain the profile of the respondent in this research, while rating questions were used to obtain the opinions of respondents on the impacts of variation orders on public infrastructure in Sarawak. To assess the degree of agreement/disagreement between the respondents regarding the impacts of

variation orders on infrastructure projects, a five-point Likert’s scale was applied. The results were graded by using Likert’s scale which placed in ascending order as 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree while 5 = strongly agree (Memon & Rahman, 2014).

Targeted respondents for this research are contractors under Grade 7, who have certified under the Construction Industry Development Board (CIDB) in Sarawak. Identified groups are contractor quantity surveyors, engineers, and architects. However, only three cities in Sarawak State namely, Kuching, Sibul and Bintulu were chosen for this research (Table 1).

**Table 1.** Sample size for selected contractors in selected Sarawak Cities (CIDB, 2020)

Cities	Registered Contractor
Sibu	46
Bintulu	55
Kuching	494
<b>Total</b>	<b>595</b>

The sample size is calculated by using the Slovin’s formula in Figure 1.

$$n = N / (1 + Ne^2)$$

Where:

- n = Number of samples,
- N = Total population and
- e = Error tolerance (level).

**Figure 1.** Slovin’s Formula (Glen, 2012)

The researcher concentrated primarily only 595 numbers of Grade 7 contractors. By using the formula in Figure 1, the population is 595 and the error tolerance is allowed 5% which is 0.05, therefore, the number of samples is 239. A total 239 copies of questionnaires has been sent to the intended respondents who are participated in public infrastructure projects. Data collected from the questionnaire survey were analysed by using Google Form analysis and Microsoft Excel to obtain mean and standard deviation. As recommended by Ramachandra (2013) and Shamsudin (2017), within this research the descriptive statistics is applied. Descriptive statistics are the interactive and graphical approaches used in questionnaires to coordinate, interpret and show the data that has been collected. Mean, mode, median, standard deviation, maximum and minimum of the data has been provided in this technique. The questionnaire survey has examined using descriptive statistics and the results has presented in the tables format. Besides, the internal coefficient approach has been used in current research.

The Cronbach’s Coefficient Alpha was determined to evaluate how items correlate among with each other. Cronbach Alpha coefficient ranges from 0 to 1; the closer the coefficient is closer to 1, the more accurate it is. The Cronbach’s Alpha coefficient is computed as follows in Figure 2.

$$\alpha = \left[ \frac{Kr}{1+(K-1)r} \right]$$

**Figure 2.** Formula for Cronbach's Coefficient Alpha (Oloo, 2015)

Where  $\alpha$  = Cronbach's Coefficient Alpha

K = the number of items considered, and

r = the mean of the inter-item correlations the size of alpha is calculated by the number of items in the scale and the mean inter-item correlation.

## FINDINGS

It is important to include the respondents' profile in the quantitative analysis, as the different backgrounds of each respondent may influence the individual opinion. Out of 239 numbers of questionnaires distributed, 85 numbers (36%) were duly completed and returned. The data was therefore analysed based on 85 valid questionnaires returned. There is total six (6) questions under this section in questionnaires which are state, current working position, working experience, experience in administration of variation order, experience in administration of variation order particularly on public infrastructure projects and origins agent of most variation orders. The frequency and percentage of respondents' background are presented as shown in Table 2 below.

**Table 2.** Respondents' Background

Respondents' Background	Category	Frequency	Percentage (%)
State	Kuching	51	60.0
	Sibu	17	20.0
	Bintulu	17	20.0
Current Working Position	Architect	26	30.0
	Engineer	18	21.0
	Quantity Surveyor	33	39.0
	Others	8	10.0
Working Experience	Less than 5 years	35	41.0
	6 to 10 years	30	35.0
	11 to 20 years	18	21.0
	More than 20 years	2	3.0
Administration of Variation Orders	Yes	81	95.0
	No	4	5.0
Administration of Variation Orders Particularly in Infrastructure Projects	Yes	65	76.0
	No	20	24.0
Origins Agent Resulted to Variation Order	Client	41	48.0
	Consultant	19	23.0
	Contractor	25	29.0

All the respondents are from three different cities which are Kuching, Sibu and Bintulu. Nearly half of the respondents involved in this study were came from Kuching. Secondly, the respondents were asked to choose the current working position in the company from a list of

four options, namely; Architects, Engineers, Quantity Surveyors and “Others”. The “Others” meant a position not connected to the three job positions mentioned. The professional group that participated the most in this study were quantity surveyors with 39% of the response rate and followed by architects and engineers. Besides, there are 35% of respondents have been in the construction industry for the period 6-10 years, 21% of respondents had experiences 11-20 years and few (3%) respondents had experiences more than 20 years. This is also worthwhile for this study because fewer than five years of experience means that most of the participants may have been participating in at least an infrastructure project that lasted as long as three years. In addition, most of the respondents were having experiences in administration in variation order especially in public infrastructure projects. Client was the predominant origin agent of most variation orders. This is because, although the client is participated in the pre-construction planning process of the project, it is often difficult to determine the client’s exact specifications.

Cronbach’s alpha coefficient of reliability test was used to assess the accuracy of the data obtained. Cronbach’s Alpha coefficient used to measure the reliability ranges from 0 to 1; the closer the coefficient is to 1, the more accurate the scale with the condition that the scale should be above 0.7 with more than ten items (Mohajan, 2017). It has been measured using Microsoft Excel software package. The values of Cronbach’s Alpha for Section B of the questionnaire are 0.919, which is considered to be excellent and meets the reliability test requirements.

**Table 3.** Impact of Variation Orders on Public Infrastructure Projects in Sarawak

Variables	Mean	Standard Deviation	Remarks
Project Cost Increase / Overrun	4.21	0.74	Agree
Delay – Completion Schedule	4.12	0.76	Agree
Delay – Payment	3.96	0.91	Agree
Overhead Expense Increase	3.95	0.92	Agree
Additional Payment to Contractor	3.93	0.86	Agree
Delay – Procurement	3.80	0.88	Agree
Reworks and Demolition	3.68	0.85	Agree
Delay – Logistics	3.64	0.79	Agree
Disputes Among Professionals	3.61	0.95	Agree
No Delay – Progress Affected	3.59	1.11	Agree
Poor Professional Relations	3.56	0.98	Agree
Labour Productivity Degradation	3.51	0.96	Agree
Quality Degradation	3.49	0.93	Neutral
Blemish Firm’s Reputation	3.49	1.01	Neutral
Poor Safety Condition	3.41	0.98	Neutral

The impacts of variation orders on public infrastructure projects have been ranked by comparing their mean score (Table 3). Project cost increase/overrun (Mean=4.21), completion schedule delay (Mean=4.12), delay in payment (Mean=3.96), overhead expense increased (Mean=3.95) and additional payment to contractor (Mean=3.93) were the most impacts of variation orders on public infrastructure projects in present study. In contrast, quality degradation (Mean=3.49), blemish firm’s reputation (Mean=3.49), and poor safety condition (Mean=3.41) were the three least significant impacts of variation orders. The discussion on the five most important and three least important impacts of variation orders on infrastructure projects in Sarawak has been amplified as follows:

### *Project Cost Increase/ Overrun*

Result found that project cost increase/ overrun was the first important impact of variation orders on infrastructure projects in Sarawak. This may be due to the fact that most of the infrastructure projects have a contingency sum which are often used up due to constant and huge variations. In each construction project, a contingency sum is typically allocated to cover potential variations in the project, while keeping the total cost of the project unchanged. However, regular major variations can lead to increase in costs and overrun in the contingency amount (Oloo, 2015). Many studies on highway infrastructure projects have shown huge cost overruns that have remained constant year after year (Creedy et al., 2010; Mahmud, 2020).

### *Completion Schedule Delay*

The impact with second highest mean was completion schedule delay. This finding is consistent with the previous study of Memon and Rahman (2014). The consultant group of the respondents assumed that completion schedule of a project will be postponed if there was a variation order and the most obvious effect of variation orders from all points of view. They noted that cost overruns had a major significant effects on project performance. Yadeta (2014), revealed that the completion schedule is the common impact on public construction projects that improved the accuracy of the response to be concluded.

### *Payment Delay*

Variations will influence the process of payment to the contractors, as the main contractor would not be able to pay to the subcontractor until the client has paid. Previous study from Arain and Low (2005) indicated in order to reduce the delay in payment of the projects, the nature of variation orders must be clearly defined.

### *Overhead Expense Increase*

The fourth most important impacts of variation orders on public infrastructure projects in Sarawak was increase in overhead expenses. This might reflect the difficulties faced by the contractors in cases where the variations ordered give rise to an extension of time. Besides, the extended project duration does not grant the contractor the right to obtain monetary compensation and so the contractors have to extend their resources to cover the overhead costs. Yadeta (2014) and Oloo (2015) similar study stated overhead expenses for all the parties involved would raise a lot of professional and documentation that needs to be completed.

### *Additional Payment to Contractor*

Additional payment to contractor was the fifth most important impacts. In the previous study of (Yadeta, 2016), it was reported that additional payment to the contractor increases when the amount of work increases when the different items are assessed. This adds value to the contractor. In addition, this is because variations typically mean additional works that can be seen as a common source of additional payment to the contractor. Many contractors will consider variations in the project to be another means of achieving their project margins.

### *Quality Degradation*

Quality degradation has the third lowest important impact in present study. Quality degradation might occur due to the frequent of variation of a project which may cause the contractor cutting corners in order to compensated for the loss. The contractor could have tended to compensate for the losses by doing the works in simple and easy manner rather than following the specification given (Shamsudin, 2017).

### *Blemish Firm's Reputation*

Blemish firm's reputation ranks second lowest mean. The financial status of the contractor reflects the company's reputation as an indicator of the performance of the project (Wai, Yusof, Ismail & Ng, 2013).

### *Poor Safety Condition*

Poor safety condition has the lowest mean. This may be due to the fact that some of the respondents did not agree that variation in construction techniques, materials and equipment would result in additional health and safety measures (Yadeta, 2014).

## **CONCLUSION AND RECOMMENDATION**

The objective of present study was achieved by examined the impacts of variation orders on public infrastructure projects in Sarawak. Out of fifteen impacts of variation orders on public infrastructure projects, the top five impacts were determined in the present study, which are project cost increase/ overrun, delay in completion schedule, delay in payment, overhead expense increase and additional payment to contractors. Besides, the least three important impacts were quality degradation, blemish firm's reputation and poor site condition. In summary, the construction players are recommended to pay proper attention to the nature of the project and that the cost of the project in order to prevent the value of the project increases the original expected expenditure. For instance, carry out detailed and appropriate preparation, complete detailed drawings at the tender stage and supervision of work by an experienced supervisor. The present study will benefit the professionals involved with public infrastructure projects where professionals can learn about the downstream consequences that could aid in the useful assessment of variation orders.

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# PRIORITY OF COMPETENCY OF QUANTITY SURVEYORS: STUDENT, FRESH GRADUATE AND EMPLOYER'S PERSPECTIVE

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## Abstract

As tertiary education becomes more easily assessable by the general public and stronger competitions amongst peers are emerging, employers' expectations towards a fresh graduate's knowledge and skills are also increasing. While programs provided by universities are structured to meet the general requirements so as to be able to qualify for accreditation by the Pacific Association of Quantity Surveyors (PAQS), Royal Institution of Chartered Surveyors (RICS) and Board of Quantity Surveyors Malaysia (BQSM), variations between different institutions still exist due to emphasis on different areas. This results in fresh graduates with varying levels of competencies being produced and employers generally feeling that graduates' competencies are lacking in certain areas as each party prioritizes a different skillset from the other. This research aims to determine the gap between the different type of skillsets that students, fresh graduates and employers deems to be necessary for the job. Surveys will be conducted among employers, fresh graduates and Quantity Surveying students to identify the skillsets sought after in the profession. The findings showed that students and fresh graduates were able to identify the skills most prioritized by employers, in terms of the category of skills that were necessary for the traditional roles of a Quantity Surveyor but a mismatch still existed in other less traditional skills. This study also aims to provide students and educational institutions with further insights as to the areas in which current students and graduates are lacking in to increase their employability.

**Keywords:** *Actual competency; expected competency; employability.*

## INTRODUCTION

The construction industry plays a vital role in a country's economic and is one of the booming industries in the world. Statistics show that as of 2018 it remains as one of the major industries in Malaysia and consists of 1,257,800 employed persons which is 8.5% of the total of employed persons in Malaysia (Department of Statistics Malaysia, 2019). Malaysia has a large construction industry with a total value of RM145.5 billion of construction work done in 2018 (Department of Statistics Malaysia, 2019) despite contributing only 4.5% of the country's total gross domestic product (GDP) in 2018. Although Malaysia's construction industry is forecasted to display a slower growth in 2019, the industry's contribution to the GDP will maintain at positive levels. This shows that the construction industry is stable and its growth has been maintained despite Malaysia's recent slowdown in the overall economy. As such, it is important that the workforce is up to par with the demands of the industry.

An important party in the construction industry is Quantity Surveyors, who have been around in Malaysia since the 1930s due to the migration of several Quantity Surveyors from the United Kingdom. Since then, the role of a Quantity Surveyor has gradually evolved due to the improvements of technology, resulting in a change in the complexity and magnitude of construction projects. Quantity Surveyors are important as they ensure that construction projects are completed within the provided time constraints and budget, with the primary goal

of keeping expenses to a minimum without compromising on the quality of the end results or failing to adhere to relevant construction regulations.

According to Highfield Professional Solutions (2017), the unpredictability of today's ever-changing market conditions, the development and implementation of new technology and 'green' building has meant that the role of the Quantity Surveyor has gradually evolved to meet and satisfy this new demand. As such, Quantity Surveyors are no longer expected to only be capable of doing measurement but are also expected to be equipped with contractual knowledge, construction technology knowledge, building economics knowledge and so on.

Employers now place much emphasis on hard and soft skills that 85% of job success originates from possessing well-developed people and soft skills (Mann, 1918). The leading causes of unemployment due to soft skills that are often cited are a low proficiency in English and graduates' lack of exposure to real-world situations (Alias, 2017). This goes to show that although our education system is constantly undergoing improvement, students and graduates alike still fail to meet the expectations of employers due to the increase in competition within industries.

## **PROBLEM STATEMENT**

In Malaysia, the education system has long since been a frequent cause for debate among peers, parents and the community. As the world and technology continues to improve, students are also expected to match the pace at which the rest of the world is growing and the learning process in the classroom is never enough for the students anymore. As such, it becomes increasingly important that the incompetence of graduates have to be identified to overcome the deficiencies and so they are able to remain competent for the rapidly growing industry.

A discrepancy exists between the skills sought after by an employer and the skills that Quantity Surveying graduates think employers are seeking in the employees that they hire (Wilkinson, 2016). Students are often not well aware of what employers expect and look for in the graduates they hire until it is time for them to seek for employment and job opportunities. This is fortified by a research by Accenture in 2015 which showed that employers' expectations and graduates' assumptions are not aligned. As such, graduates fail to meet the expectations of employers and result in unemployment due to a lack in their skillsets. The QS Global Skills Gap in the 21st Century report suggests that there are "sizable and consistent disparities" between employer expectations and student skills.

There is a clear mismatch between the skills needed by the industry and what students believe "employers value most in new recruits" (Aziz, 2018). General studies and researches have been done on an international and local basis (Henrich, 2016; Ame, 2014; Gibbs, Steel & Kuiper, 2011), however not much research has been done on the Quantity Surveying field (Abdullah & Haron, 2007).

As such, this study aims to identify the types of skills that employers, graduates and students each deem to be important and thus highlighting the discrepancies between both views.

## LITERATURE REVIEW

The process of evaluating the performance of an individual is often based upon a set of standards or a preset group of indicators to be able to evaluate the performance on a consistent and comparable manner (Chua, 2000). However, the main issue lies not within the process of evaluating performance and competencies of employees but that there exists a mismatch between the skills needed by the industry and what students believe that “employers value most in new recruits” (Aziz, 2018).

Competency and skill are similar on a fundamental level in the sense that both refer to an ability that an individual acquires through experience and practice. However, the skills that an individual possesses determines the specific type of activity or area of specialization that their past experience and training has prepared them for; whereas a competency incorporates an individual’s “skill” into working behaviours which allows them to exhibit the capability perform proficiently (Beckett, 2018). Inherently, a skill represents one of the three aspects that constitute competency, the other two aspects being ability and knowledge (Sturgess, 2012).

Another difference between a skill and a competency is that competency defines the requirements for success on the task or workplace in broader and relatively more comprehensive terms than a skill does (Sabry, 2017). As such, competencies essentially describe how a person’s behaviour leads to the desired results in their position and responsibility (McNeill, 2019). According to Aja Davis Isble (n.d.), competency is a trait that potentially could allow an individual to stand out amongst others (as cited in McNeill, 2019). Competency is a combination of skill, knowledge and behaviour that allows one to be successful in their job while a skill is an ability specifically learned that is required to perform well a specific task.

Functional, or Technical Competencies, refers to the roles, functions and processes within an organization and includes the knowledge and skill of a number of practices that are required for the successful completion of a task or job (Sturgess, 2012). Unlike core competencies, functional or technical competencies are specific to particular industries (Zamboni, 2018). A functional competency that is applicable in the Quantity Surveying field may not be relevant in the Chemical Engineering industry. In comparison to other competencies, functional or technical competencies are relatively easier to acquire (Shakir, 2009).

Another important skill required by Quantity Surveyors is the proficiency and expertise in construction technology knowledge. It is identified as one of the skills and knowledge that a Quantity Surveyor requires in order to maintain their important position within the building industry (Rahmani, 1983).

### Student and Graduate’s Perspective

Recent surveys show that students are starting to place less emphasis on hard skills as they are perceived to be of less importance in comparison to the various forms of soft skills (Nilsson, 2010). However, a study shows that majority of employees actually do not understand in which aspects they are lacking in, let alone to be able to improve them (Chinta, 2017). Another study shows that students who are about to enter the working environment

were actually unaware of the type of skills that employers would expect (Gibbs, Steel & Kuiper, 2011). Furthermore, they were also not highly exposed to peers or professionals of their field prior to entering the industry as employers would prefer (Raybould & Sheedy, 2005).

Students ranked five out of fifteen attributes that they perceived to be of most importance to employers with strong work ethics, integrity and communication skills to be the three most important attributes sought in an employee (Griffin, Cangelosi & McMurtrey, 2017). Another study by a local university showed that there existed a higher level of mismatch between the perception of employers and undergraduates regarding its importance (Wye, 2009). The mismatch existed in skills such as planning, decision making, problem solving, critical analysis, negotiation and oral communication.

### **Employer's Perspective**

A 'competency gap' between the current local university QS graduates' soft skills' performance and their expectations were identified (Shafie, Khuzzan & Mohyin, 2014). Employers are of the opinion that it is consequential that employees have a certain set of skills and particular behaviors to ensure good performance and cooperation with other members of the team or organization. Qualities that an employer values most are strong work ethics, communication skills, team cooperation, and willingness to take the initiative.

A study by Mahbub (2003) showed that employers expect graduates to be equipped with mental and physical endurance, the initiative to learn and work, as well as strong written and oral English proficiency. In regard to the Quantity Surveying profession, the study showed that employers stressed much on construction technology knowledge, contract administration and generally more exposure to the profession itself. Employers also expressed that they required graduates to be able to fit instantly into the working environment and the teams so as to be able to contribute towards the company.

Another study has discovered that employers prioritize interpersonal and vocational skills, which are the ability to interact and deal with other individuals are perceived to be as important as skills that are specific to each field and were obtained through education (Hernandez-March, Martin Del Peso, Leguey, 2009). However, the study also showed that mismatches existed in skills regarding decision-making abilities, negotiation skills, problem solving skills, organizational and also leadership abilities. A study also highlighted that communication skills, critical thinking, creativity, and problem-solving skills were some of the top skills that employers felt graduates had to possess (Shafie, Khuzzan & Mohyin, 2014; Ranjit, 2009).

Employers expect and are of the opinion that current graduates enter the labour force with acceptable levels of preparation (Hernandez-March, Martin Del Peso, Leguey, 2009). However, employers have also been expressing their concern over the quality and performance of graduates who are joining the profession (Chua, 2000). In a study conducted by Zaliza Hanapi and Mohd Safarin Nordin (2014), it was discovered that there were employers who gave negative comments on graduates and commented that they do not have the appropriate skills and qualifications to meet the industry's needs. This is also supported

by a study conducted in which it was found that there were graduates who lacked training and were incompetent in certain areas of expertise (Ogunsina, Ekwus Obiegbu & Adeniyi, 2018).

Although of a lower extent, deficiencies that appeared in regard to competencies that were related to a professional setting were mainly time management, coping and working with pressure and teamwork. (Candy & Crebert, 1991; Crebert, Bates, Bell, Patrick & Cragnolini, 2004). Another study by Schooley (2017) found that employers think graduates are not equipped with the soft skills necessary to work in their companies but graduates actually believe they are ready and have the skills needed in the industry. It was also found that the top three soft skills that had competency gaps were analytical thinking, problem-solving, communication skills, the ability to work independently and decision-making skills (Shafie, Khuzzan & Mohyin, 2014).

However, there were also employers who reported that they were not as unsatisfied with graduates' performance as speculated. 70 percent of employers actually claimed that university graduates actually do not require more than six months to improve to an extent that they meet the necessary requirements to perform the tasks and works that they were hired for (Deaconu, Osoian & Zaharie, 2014). The study also discovered that employers were mostly satisfied with graduates' capabilities of taking up responsibility, efficient in activity planning and organization as well as prompt and effective time management (Deaconu, Osoian & Zaharie, 2014). This proves that although there are graduates who fail to meet the employer's expectations, this occurrence does not occur evidently across every industry or is an unavoidable phenomenon faced by employers whenever recruiting fresh graduates.

In the graduates' defense, fresh graduates of the construction industry are usually subjected to unfair criticism and expectations by employers as they are fresh to the working environment and such professional settings which results in their capabilities being limited by their lack of exposure and experience. Furthermore, university courses are not entirely created in response to an employer's demands or needs, resulting in graduates leaving university to find themselves struggling to adapt to the expected levels of competency. That said, this gap can be bridged by institutions properly adjusting their syllabus so as to be able to produce graduates that meet the industry's demand.

## **RESEARCH METHODOLOGY**

There are three types of research techniques appropriately and commonly applied in a research study which are qualitative, quantitative or a mixture of the two methods. Although the qualitative and quantitative techniques are the two most significantly used types of research techniques. The research technique selected for this study will be the quantitative technique, specifically using questionnaires, due to the nature of the objectives and the data needed for this study. The selected research technique will be further explained in the subchapters.

### **Data Collection Method**

Quantitative research technique is used to collect data needed, specifically the survey method through the use of questionnaires. This research method is preferable for this study

as it allows the collection of statistical data that is easy to analyse and reduces the costs required for this study.

A questionnaire is designed to ensure that it is capable of gathering data and information that is required to achieve the objective of this study and then distributed to the targeted population sample of consultant Quantity Surveying firms, Quantity Surveying students and fresh graduates. The responses are collected and tabulated for analysis purposes and to obtain a conclusion from the results. A ranking system is utilized for this section of the questionnaire, which requires respondents to rank the skills based on their own prioritization instead of a rating system which would allow respondents to give same scores to different skills. As such, each question in this section does not have similar parameters to a Likert scale as it is dependent on the skills listed in each category.

Furthermore, due to the nature of this study, open ended questions are avoided as much as possible as the responses are difficult to be analysed statistically or to obtain a common pattern throughout all the responses. Open ended questions are those in which it requires a more detailed answer that consists of more than one worded answer, usually in the form of a sentence or even a paragraph depending on the complexity of the question itself.

The quantitative research technique places great emphasis upon objective measurements and the mathematical, numerical or statistical analysis of data that is gathered through questionnaires, surveys and polls or through the manipulation of existing statistics and data with the use of computational methods (Babbie, 2010). This research technique places its focus on the collection of numerical or statistical data and generalizes it across communities or to provide an explanation towards a specific phenomenon (Muijs, 2010). The findings of the questionnaires, polls or surveys are obtained by computing and tabulating all responses into a database which is then converted into figures or percentages that can be analysed and represented in a graphical manner to reach a final conclusion.

## **Data Analysis Method**

As the questionnaire uses a ranking system for respondents to rank the given skills based on their own priorities, the Weighted Average Ranking method is utilized to analyse the results obtained in this section of the questionnaire. This method calculates the average rank of each given choice and thus the skill that is most prioritized by students, fresh graduates and employers respectively can be seen from this analysis method. The skill with the highest average score is the skill that is ranked most important by each target population.

In this analysis method, the weights applied to each ranking is opposite of its rank. In layman terms, the skill ranked last is assigned the smallest weight, which is 1 and increases across the ranks until it reaches the maximum weight; thus, the skill that is ranked first by the respondent is assigned the largest weight based on the maximum number of skills there are. If there are a total of eight skills, the largest weight will be 8 and so on. The default weights that are assigned to each rank cannot be simply changed, meaning that the largest weight will always be the maximum number of skills given in that question.

$$\text{Weighted Average Ranking} = \frac{x_1w_1 + x_2w_2 + x_3w_3 \dots + x_nw_n}{n}$$

w = weight assigned to the designated ranking

x = total number of responses for each corresponding ranking

n = number of respondents

This study aims to study the mismatch in the expectations of competency skills and levels by employers and students. As such, the sample size of this study focuses on students undertaking their Bachelor's in Quantity Surveying, undergraduates (who are categorized as those who have graduated no longer than three years) and also firms registered as Consultant Quantity Surveying practices, which consist of 248 firms and represent the employers' side to the study, with all three categories limited to within the Klang Valley. The Krejcie and Morgan formula is employed to calculate the required sample size for this study.

$$S = \frac{X^2NP(1-P)}{d^2(N-1) + X^2P(1-P)}$$

Where:

S = Required sample size

X<sup>2</sup> = Table value of chi square for one degree of freedom at the desired confidence level (3.841)

N = Population size

P = Population proportion (assumed as 0.50 to provide maximum sample size)

d = Degree of accuracy expressed as a proportion of 0.05

By applying the aforementioned formula, the necessary sample size to represent the final year student's population is 228 responses from the total population size of 560 students. For fresh graduates, the sample size required is assumed to be the same as students as the information was not disclosed by the respective universities; the sample size needed to represent the employer's population is 151 respondents from the 248 registered Consultant Quantity Surveying firms.

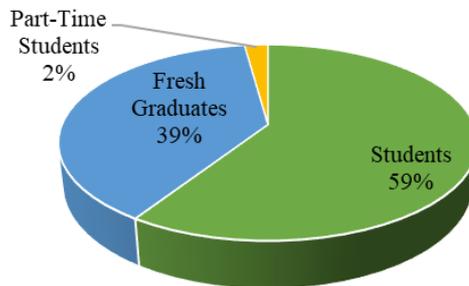
Two different sets of questionnaires are prepared to be distributed to the different target populations, with Quantity Surveying undergraduates and fresh graduates being the first target population and Consultant Quantity Surveying firms as the second target population. The two sets of questionnaires consist of four sections, which comprise of the demographic profile, priority of skills and the Expected vs Actual Competency Level of Graduates as the third and fourth section. In this questionnaire, only close ended questions are used.

## DISCUSSION AND KEY FINDINGS

The questionnaire was emailed to 248 registered consultant quantity surveying firms in Klang Valley. 62 responses were received from employers which is approximately 41% of the total sampling size required. The response rate is sufficient to form a valid and justifiable conclusion. A similar questionnaire specifically designed for students and fresh graduates were also distributed to the target population in several universities. A total of 186 responses

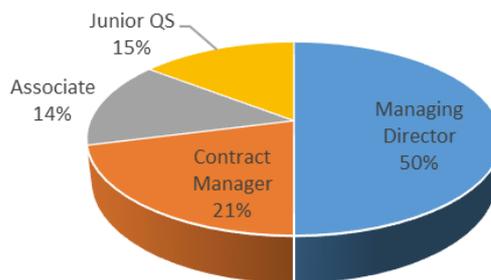
were recorded from the questionnaire distributed to students and graduates, out of which 114 were responses from students and another 72 from fresh graduates. The response rate of student and fresh graduate respondents is 50% and 32% respectively.

### Demographic Analysis



**Figure 1.** Respondents' Current Education Status

Figure 1 shows the percentages of students and fresh graduates who participated in the questionnaire. From the 186 responses collected from the first set of questionnaires for students and fresh graduates, 39% of the respondents were fresh graduates, 59% were students and the remaining 2% were part-time students. For the purpose of this study and to simplify the analysis of this data collected, the responses of the 2% of part-time students will be tallied together with the 59% of student respondents and analysed accordingly.



**Figure 2.** Respondents' Current Position in The Company

Figure 2 shows the distribution of the respondents' current position in the company from the second set of questionnaires sent out to consultant Quantity Surveying firms. Out of all the respondents who participated in the survey, 50% were managing directors and 21% were contract managers in their respective companies. The questionnaire also received 15% of responses from junior Quantity Surveyors and the remaining 14% were received from associates of the company.

Figure 3 illustrates the years of experience of respondents from the employer's group who participated in the survey. 50% of respondents had more than 20 years of experience; followed by 14% of respondents having between 15 to 20 years of experience. Respondents with 10 to 15 years of experience occupied 13% of the total number of respondents while those with 3 to 10 years of experience occupied 18% of the total number of respondents. Lastly,

respondents with less than 3 years of working experience occupied only 5% of the total number of respondents who participated in the survey.

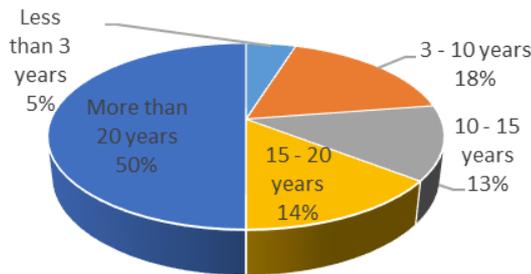


Figure 3. Respondents' Years of Experience

### Analysis of Questionnaire Survey

The skills are categorized into six categories, namely Technical Skills, Professional Skills, Financial Skills, Legal Skills, Managerial Skills and Soft Skills. The analysis is done for each category by comparing the results obtained from each population group.

Table 1. Priority of Technical Skills

Technical Skill	Ranking from Each Perspective		
	Student	Fresh Graduate	Employer
Contract Preparation	1	1	1
Construction Technology	2	3	2
Building Services	4	2	3
Project Scheduling	3	4	4

Table 1 illustrates the summarized ranking analysis of all three perspectives. From this analysis, it is conclusive that contract preparation is seen as the most important technical skill and construction technology is overall the second most important skill. Employers and fresh graduates ranked building services as the least most important skill while students ranked it as third most important. Although a unanimous opinion is not achieved, project scheduling can be viewed as the least important skill as it was viewed as either the least or second least important skill. There is a greater dispute on building services as there is no similar ranking observed between the three perspectives. The findings above are in line with those by RICS (2017) and Budia (2014) in which they identified contract preparation and construction technology as two of the main technical skills a competent professional Quantity Surveyor should have.

Table 2. Priority of Professional Skills

Professional Skill	Ranking from Each Perspective		
	Student	Fresh Graduate	Employer
Preparation of BQ	1	1	2
Measurement	2	2	1
Preparation of Claims	3	3	3
Preparation of Final Account	4	4	4

Table 2 shows that all three target population groups reached a general consensus on the priority of preparation of claims and preparation of final account being the third most important and least important professional skills respectively. It can be observed that there is lesser dispute in this category of skills. The only difference is between the preparation of BQ and measurement, where students and graduates think that preparation of BQ is most important, whereas employers prioritize measurement skills most. The findings above are in line with those by Owusu-Manu, Edwards, Holt and Prince (2014) in which they identified measurement and the preparation of BQ as two of the most important skills.

**Table 3.** Priority of Financial Skills

Financial Skill	Ranking from Each Perspective		
	Student	Fresh Graduate	Employer
Estimating	1	2	1
Budgeting	2	1	2
Data Accrual	3	3	3
Reporting	4	4	4

Table 3 shows that all three groups reached a uniform opinion that data accrual ranks as the third most important financial skill and reporting ranks as the least important skill out of the four listed skills. Both students and employers view estimating as the most prioritized financial skill and budgeting as the second most important skill, although fresh graduates are of the opinion that budgeting is more important than estimating.

It can also be observed here that there is little dissimilarity. The only notable difference is between the importance of estimating and budgeting. Both students and employers believe that estimating is more important for a Quantity Surveyor, whereas fresh graduates prioritize budgeting skills most. Estimating and budgeting being ranked as the top two most important financial skills is in line with other studies which also stated the importance of these skills towards preventing a project cost overrun from happening which is one of the major roles of a Quantity Surveyor throughout the entire construction process (Nagalingam, Jayasena & Ranadewa, 2013; Willis, Ashworth & Willis, 1994).

**Table 4.** Priority of Legal Skills

Legal Skill	Ranking from Each Perspective		
	Student	Fresh Graduate	Employer
Contractual Issues	1	1	1
Procurement Method	2	3	2
Knowledge of PAM Form	3	2	3

It can be concluded from Table 4 that all three groups reached a uniform opinion that contractual issues rank as the most important legal skill. However, for the remaining skills, a uniform opinion was not obtained. Both students and employers view procurement methods as the second most prioritized legal skill and knowledge of PAM form as the least important skill. Fresh graduates think that knowledge of PAM form is more important than procurement methods. Similar to the analysis on Financial Skills, there is little dissimilarity observed. From this, it can be noted that generally all three target groups reach a consensus on the priorities of each skill. This shows that all three target groups know the importance of the skills and what is expected of the Quantity Surveying profession as a whole as Quantity Surveyors are also contractual professionals. This is in line with the findings of Ashworth and Hogg (2007)

which found that Quantity Surveyors are expected to be able to provide legal advice regarding contractual obligations, the most suitable procurement method and legal rights.

**Table 5.** Priority of Managerial Skills

Managerial Skill	Ranking from Each Perspective		
	Student	Fresh Graduate	Employer
Project Management	1	1	3
Financial Management	2	2	1
Facilities/Resource Management	3	3	2

No uniform opinion was formed and a huge discrepancy is observed between the skills ranked as most and least important by each group. Table 5 shows that a mismatch exists between the skills employers seek and what graduates believe employers value most (Aziz, 2018). While students and fresh graduates view project management as the most important skill, it is viewed as the least important by employers. The skill employers prioritize most is financial management, which is only viewed as second most important by students and fresh graduates. Subsequently, employers view facilities /resource management as the second most important skill but students and fresh graduates view it as the least important.

**Table 6.** Priority of Soft Skills

Soft Skill	Ranking from Each Perspective		
	Student	Fresh Graduate	Employer
Communication Skills	2	2	1
Problem Solving and Critical Thinking	3	3	2
Personal Skills	4	4	5
Interpersonal Skills	1	5	3
Leadership Skills	5	1	4
Communication Skills	2	2	1

Table 6 shows the summary of the analysis for soft skills. From the analysis above, no uniform opinion was formed in this category of skills as well, showing that a mismatch between the skills employers seek and what graduates believe employers want exists (Aziz, 2018). Large discrepancies can be observed between interpersonal skills and leadership skills, although some minor discrepancies also exist in the other listed skills. Students and fresh graduates view communication skills, problem solving and critical thinking as the second and third most important skill, but employers view it as the most and second most important skill.

The findings are still in line with those by Mason, Williams and Cranmer (2009), in which they identified communication skills as an important qualification that is necessary for graduates to excel in. Personal skills is viewed as one of the least important skills as all three target groups gave it very low ranking, which is either fourth or least important skill. Interpersonal and leadership skills both obtained very mixed rankings. Both skills were either ranked most or least important, showing a huge disparity between the opinions of students and graduates. However, it obtained a middle ranking from employers as interpersonal skills ranked third while leadership skills ranked fourth most important. From this table, it can be observed that students and fresh graduates failed to identify what soft skills employers prioritized most.

## CONCLUSION

The analysis of the overall results shows that students and fresh graduates were able to identify the skills most prioritized by employers, in terms of the category of skills that were necessary for the traditional roles of a Quantity Surveyor such as Technical Skills (Contract Preparation), Financial Skills (Estimating) and Legal Skills (Contractual Issues). However, for the other categories, students and fresh graduates did not manage to identify the skills that employers prioritized most. From the findings of the study, it can be seen that there have been some improvements from the study conducted by Gibbs, Steel and Kuiper (2011) which identified that students entering the industry were actually unaware of the type of skills that employers would expect as students and fresh graduates were able to identify some of the top skills prioritized by employers in this study.

A slightly higher level of mismatch existed in other skills such as Professional Skills and Soft Skills which are also some of the types of skills highly valued in the industry (See, 2016) as students and fresh graduates partially failed to identify the skill most prioritized by employers. Out of all categories listed, students and fresh graduates had the worst misconception of Managerial Skills as they completely failed to identify the most important skill which is Financial Management. The skill they ranked as most important was Project Management but was in fact the least prioritized skill by Consultant Quantity Surveyors. This shows that there is a high level of mismatch between the employer's perception and students and fresh graduate's perception of the importance of the skills (Wye, 2009).

Although the aims and objectives of the study have been achieved, there were still certain limitations that the study was subjected to during the entire research process. The first limitation of the study is the low response rate of the questionnaires. Although the minimum response rate was achieved for the responses collected, the employers' and fresh graduates' response rate can be increased to obtain even more accurate results that can better represent the two target groups in Klang Valley. The employers' response rate could also possibly be affected by the Covid-19 situation as the questionnaires were distributed during the Movement Control Order and many firms were not allowed to operate. Another limitation is that only students and fresh graduates from private universities were included in the respondents as public and private university graduates may have different views and opinions due to the difference in their education system. Furthermore, only Consultant Quantity Surveyors were included in the survey respondents as Contractors would have different priorities due to the different nature of work.

This study can provide further and more detailed insight into the various skills prioritized by each target group and the expected and actual performances of graduates from all three perspectives. Further study can be done to identify the contractor's and developer's point of view as they may have different priorities from Consultant Quantity Surveyors as Quantity Surveyors working in a contractor or developer's firm have very different scopes of works. This could provide insights for students to understand what contractors and developers seek instead of only understanding a consultant's needs. Further studies can also be done on recommendations or ways to improve the current syllabus and education system so that graduates produced are more well-balanced especially in terms of soft skills so they can meet employer's expectations and industry's demands.

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# FACTORS AFFECTING FIRST TIME BUYERS' DECISION IN PURCHASING A RESIDENTIAL PROPERTY IN SELANGOR

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## Abstract

House is one of the most fundamental human needs of each individual. Due to the escalation of house prices in Malaysia, younger generations with just a few years of working experience could not manage to purchase their first property in the shortest possible because of the rapid population growth. Younger generations are the Millennials born between 1983 and 1998, aged in the period between 21 years and 36 years. Millennials are expected to be the biggest spenders in the nation when they step through their primary earnings and spend to satisfy their needs and wants, thereby having lesser savings in their saving account. Many young couples are struggling in terms of debts and loans due to their lavish lifestyle and with the escalation of property prices, it is very tough to purchase their first property. Due to population growth and urbanization in Selangor as well, developers tend to build more residential properties without catering and taking into consideration the needs and demands of new potential house buyers. The unaffordability housing price decreases the homeownership rate among the younger generations. This study aims to identify the factors that influence the decision making by the first-time buyer of Millennials in purchasing a residential property, to determine the preferred house types among Millennials and to study the factors for the low house ownership among Millennials. Quantitative research method had been selected to achieve the research objectives. The main objectives are achieved positively which shows that financial factor is one of the key concerns for first-time house buyers, followed by locational, neighbourhood and structural factors.

**Keywords:** Residential Property; House Preferences; Property Prices.

## INTRODUCTION

A house/property is one of the most important human needs as it provides us shelter, security and privacy. Owning a property has always been one of Malaysians' primary goals as it is a way of expressing their aspiration and value of life (Tan, 2008). According to the Department of Statistics Malaysia, since the 1990s, Malaysia's population has been steadily increasing by roughly about 2% each annum. From a population of 31.52 million in 2018 to 32.06 million as of October 2019, there is an increase of 0.54 million people (approximately 1.7% population growth nationwide). Based on this statistical significance, there is a rise not only in population but also in urbanization to accommodate and satisfy the needs of the additional 0.54 million Malaysians in the year 2019.

Due to the escalation of house prices in Malaysia, younger generations with just a few years of working experience could not manage to purchase their first property in the shortest possible because of the rapid population growth. Such focused younger generations are the Millennials born between 1983 and 1998, aged in the period between 21 years and 36 years.

Currently, Selangor is undergoing lots of development due to population growth and modernization. With the presence of rapid development, developers continue to construct more and more residential properties in Selangor without catering and surveying people's

needs and demands in Selangor. In this 21st century, with proper education and the advancement of technology, citizens are getting more knowledgeable and demandable. Therefore, property buyers nowadays not merely look into property prices, but also on many different factors.

As an action to support first-time house buyers, our government launched several projects such as My First Home Scheme, One Malaysia People's Housing Scheme (PR1MA) and others. However, most of these schemes did not meet the buyers' needs and preferences due to inadequate space and privacy (Tan, 2012). Furthermore, some of the projects remain unsold due to the price factor, poor location with inadequate amenities and facilities, poor neighbourhood, design factor and much more. Thus, developers or government should consider householders' needs as different householders have different house ownership criteria. (Tan, 2008).

Additionally, by adapting to suit household needs, developers can tend to inspire homebuyers. (Aarland & Nordvik, 2007). Housing developers need to understand the buyers' demand as they differ in perception, opinion and preference before purchasing a house (Tan, 2011). Furthermore, Tan (2011) mentioned that projects under the affordable housing scheme for first-time buyers must be well planned to prevent these schemes turned into slums that do not offer a healthy environment to the occupants. According to Friedman (2000), first-time house buyers have different expectations from experienced home buyers, and most of their choices are based on affordability. On the other hand, Tan (2011a) declared that households have other concerns before they rent or purchasing a housing unit, such as location, neighbourhood factors, symbolic characteristics and investment purpose.

## **PROBLEM STATEMENT**

According to the 2015 Malaysian Property Market by the Department of Valuation and Property Services (JPPH) and the Ministry of Finance Malaysia, although it indicated that market volume transactions were slowing down, the residential sector continued to dominate the overall property market by having the highest transaction amount among other sub-sectors. Despite the strong growth of the residential property market in Malaysia, due to over construction and availability of properties, younger generations are having trouble owning a property and thus delaying the ownership rate on their first home. The home price inflation acts as a barrier to increase the homeownership rate among the younger generation where their wages do not increase in proportion with the house price inflation rate over the past decade (Tan, 2012). This statement can be supported with the Property Industry Survey conducted by the Real Estate and Housing Developers' Association (REHDA) in the first half (1H) of 2015 where bank loan rejection over sales is getting more serious with a rise from 29% to 35% as banks require more supporting documents to ensure buyers' capability to repay the borrowings. This increases the difficulty for the young generations to own their first property in the shortest time possible.

In addition, Bank Negara Malaysia (BNM) indicated that they will provide necessary guidance to individuals, especially first-time house buyer to loan within their capacity to repay the debt by recommending suitable loan plans to be taken and various actions that could be taken to save up money, also safeguarding them from falling into financial difficulty due to over-borrowing. According to Property Industry Survey conducted by the Real Estate and

Housing Developers' Association (REHDA) in the first half (1H) of 2015, the bank loan rejection over sales is getting more serious with a rise from 29% to 35% as banks require more supporting documents to ensure buyers' capability to repay the borrowings. Therefore, first-time buyers with weak financial backup and background are having issues in paying off the property down payment.

This study strives to obtain the objectives which are to identify the factors that influence the decision making by first-time house buyers, to determine the preferred house types among Millennials and to study the factors for the low house ownership among Millennials.

## LITERATURE REVIEW

In Malaysia, there are lots of types of property available in the market. This includes condominiums, apartments, flats, terrace houses, link houses, bungalow, semi-detached houses, etc. As the Malaysian government provides clarity in its fiscal policies, the residential housing market is seeing more motivated sellers and discerning buyers. It is seen that the Budget 2019 policies should also help the property market, as these are designed to aid first-time homebuyers.

Referring to NAPIC's collected data on end of 2018, the number of overhang and unsold properties have increased to a total of 32,313 units, valued at RM19.86bil in 2018, an increase of 30.6% in volume and 27% in value in comparison to year 2017. Aina (2016) made a hypothesis where the lesser the new property launches, the more the beneficial the market because it helped to reduce the number of overhang and unsold properties over the next few months.

### **Factors Affecting First-Time Buyers' Purchase Decision in Residential Property**

#### *Financial Factor*

Financial factors act as a barrier for first-time buyers to buy a house and it is very crucial to first examine one's affordability before purchasing a residential property (Reed & Mills, 2007). Financial factors such as buyer's income, house prices, ability to obtain loans and interest rates are important factors that influence the buyer's purchase decision in residential property compared to many other factors (Kupke, 2008).

Price is one of the major influencing factors in purchasing a property as it involves a huge amount of payout (Megbolugbe, Marks & Schwartz, 1991). Malaysia is currently facing a property bubble which due to the rapid growth of land and home prices has slowly wipe off housing affordability (Abdullah, Nor & Jumadi, Arshad, 2012). In response, the Malaysia government did introduce affordable housing schemes to assist the first-time buyers, reducing and minimizing the burden to own their first house (for examples: My First Home Scheme, One Malaysia People's Housing Scheme (PR1MA) and Rumah Selangorku, etc.) to overcome the issue of housing affordability for the first-time buyers especially the young adults whose salaries grow slower than the property price (Tan, 2012).

Interest rate is one of the main concerns of first-time buyers before buying a property. Most buyers obtain their finance from bank loans and pay back the mortgage interest progressively (Abdullah, Nor & Jumadi, Arshad, 2012). As such, small changes in the interest rates will result in an amount of money depending on the loan taken which in turn discourage the potential buyers (Tan, 2011). In Malaysia Budget 2014, the government increases the Real Property Gains Tax (RPGT) to control the speculative activities in the housing market. Additionally, the government also urge developers to execute the Developers Interest Bearing Scheme (DIBS) to benefit house buyers to make payment only when the building is fully constructed (Tan, 2011). However, investors or buyers have to pay the remaining interest only when the project is abandoned. Furthermore, Goods and Services Tax (GST) which was implemented on 1st April 2015 is concerning for house buyers even though residential properties are exempted for GST. However, property prices are anticipated to increase because GST does increase the overall construction cost. Therefore, the government should control the interest rates occasionally to assist potential buyers and stabilize the property market. In short, low-interest rates will attract more potential buyers and investors on purchasing a property.

### *Locational Factor*

Convenience is considered an important aspect for individuals in the 21st century. A convenient location is related to the proximity and accessibility towards amenities and facilities nearby such as public transportation, schools, and shopping malls (Levine, 1998) (Clark, Deurloo & Dieleman, 1994) (Kupve, 2008) (Tan, 2011b). Studies conducted in the Australia, Ireland and United Kingdom state that house buyers would consider distance to workplace and city or town before purchasing their first house for their convenience (Daly, Gronow & Jenkins, Plimmer & 2003). Studies also found that locational factors play a major role in affecting buyers' decision in property purchasing (Haddad, Judeh & Haddad, 2011) (Ratchatakulpat, Miller & Marchant, 2009) (Abdullah, Nor & Jumadi, Arshad, 2012).

### *Neighbourhood Factor*

The neighbourhood environment is the place we interact daily as it is in the housing area. Thus, the neighbourhood plays an important consideration before purchasing a property (Wang & Li, 2004). House buyers are willing to spend for a house located in a safe neighbourhood, at the same time, providing good indoor and outdoor environmental quality for a better quality of life (Tan, 2011b). Surrounding environment regarding cleanliness, level of pollution and neighbourhood safety are significant factors before deciding on purchasing property (Tan, 2011a) (Chapman & Lombard, 2006).

Perception of safety is vital to the household when making a decision especially for those who have family and children (Andersen, 2009). Safety is the number one priority as the rate of criminal activities has been on a rise. Kuala Lumpur, Petaling Jaya and Johor Bahru are the three main states rated as the most dangerous area in Malaysia due to the significantly higher crime rate compared to average. Thus, a safe neighbourhood has become one of the main concerns.

Studies also showed the impact of neighbourhood environmental qualities towards house price over Europe, Asia and USA such as the green space and water landscape recreation parks and open spaces (Luttik, 2000). These studies concluded that people are willing to pay more to live in a healthy and good quality of the environment.

### *Structural & Architectural Factor*

Structural factors, referring to the condition and quality of the property play an important role in housing attributes at overseas (Fierro, Fullerton & Donuan, 2009). The most common structural attributes such as building age, quality and size of the property, number of bedrooms and bathrooms available convenience (Daly, Gronow & Jenkins, Plimmer & 2003) (Laakso & Loikkanen, 1995) (Tan, 2012).

The structural attributes of property such as the built-up area and interior and exterior design will affect first-time house buyers in purchasing residential properties in Malaysia (Sean & Hong, 2014). Additionally, they also mentioned the impact of housing design do affect the potential buyers in the Netherlands as buyers have their requirements and demands. Therefore, each of the structural factors will bring a positive or negative impact on the property price.

## **Preferences of House Buyers' in Purchasing Residential Property**

### *Neighbourhood Factor*

Malaysia 2016 Crime & Safety Report shows Malaysia has a high crime rating, especially in Selangor. Hence, safety becomes a major issue for property purchaser in Selangor, therefore, potential house buyers are willing to pay for extras to live in gated and guarded residential not only for safeguarding themselves but also to benefit the next coming generation (Tan, 2008). Security features such as CCTV, security workforce and perimeter fencing, which helps to secure the occupants and not becoming a victim of crime. As a result, higher property values could be reflected due to the gated-guarded neighbourhood. Households are willing to pay more to improve and enhance the security features in the neighbourhood (Sean & Hong, 2014). In short, it concludes that households are willing to stay in a neighbourhood with low crime rates and with higher and tighter security levels even it incurred a higher capital to purchase.

Households which also reflected in property prices are highly favourable with good environmental qualities (Tan, 2011a). In addition, the air is one of the household preferences in Indonesia which relate to a higher property price because Indonesia has a higher air pollution rate (Wang & Li, 2004). Furthermore, most households refused to stay in a neighbourhood with a poor water supply and noise pollution, which in turn adversely affects the value of land and property (Iman, Hamidi & Liew, 2009).

The proximity to parks is preferred by households (Jim & Chen, 2006). A study carried out showed that the house value could increase at an approximate of 5~6% by having green spaces or park within a close radius with the residential area (Tan, 2010a).

### *Locational Factor*

Location referred to the placement of the particular house and was concerned by buyers when purchasing a house (Wang & Li, 2004). Locational factor has become one of the major factors that house buyers will consider before purchasing their house. Besides that, accessibility is concerned by the house buyer. However, the selection of housing location may differ from the characteristics of each individual's socio-demography.

Distance will affect the decision of buyers to purchase a property. The distance is considered mainly for the house buyers because they prefer a house that is nearby the place, they will go frequently without spending much time on the road or in-transit (Levine, 1998). There is a hypothesis where the closer the distance between the house and the desired location, the more beneficial it is to the household as this reduces the transportation expenses and time wastages (Wang & Li, 2004). Approximately 32% of the people prefer to stay closer to the workplace as compared to other variables as travelling to the workplace is a daily routine (Wang & Li, 2004). Therefore, staying nearby the workplace can save time and petrol cost, at the same time, reduces the risk of showing up late to work.

Local Amenities are the services provided for people's conveniences such as healthcare, shopping malls, and schools. Therefore, local amenities are one of the most common factors for property buyers in decision making, especially in China (Wang & Li, 2004). Often, public transportation plays an important role in property development because it enables people to travel from one location to another location conveniently.

On the other hand, it is beneficial for the children when staying near to school (Clark, Duerlon & Dieleman, 2006). Studies have shown that children who walk to school are more independent as they have better time management, at the same time, waives off the school bus fees. Additionally, parents prefer to stay near to the school due to shorter travelling time, as they always pick up and drop off their children personally to school (Wang & Li, 2004).

Buyers can benefit from using public transportation as the site provide seamless access to it while compared to owning private transportation which in turn can be expensive. Thus, the property value is usually higher for properties which have easy access to public transportation comparing those properties that are located at areas without access to public transportation. However, purchasing an overpopulated location could deter most households, leading back to the neighbourhood factor under sound pollution (Haddad, Judeh & Haddad, 2011).

### *Structural Factor*

One of the most common attributes that will influence the preferences of the buyers is the size of the lots. Households tend to live in a larger house because they have a larger span of usable space (Tan, 2011b). Additionally, usable space plays a significant part in the decision-making process for buyers. Most households are increasing the size of the house from time to time, as it shows the luxurious side of the households by house renovations (Clark, Duerlon & Dieleman, 2006).

In addition, due to the size of the household, some households may prefer a larger space while some prefer a smaller space to reduce the necessary maintenance costs. The size of the house is the third significant factor a house buyer should consider when buying a home. This indicates house size acts as a slightly insignificant factor to be considered by house buyers (Tan, 2011).

Due to the privacy issue in Saudi Arabia, the number, as well as the size of the bedrooms and bathrooms, matters to the housing attribute (Opoku & Abdul, 2010). In addition, it was observed that Western households prefer to weigh the number of rooms or bathrooms before purchasing any form of property (Kauko, 2007). The number of rooms is therefore one of the major determining factors (Al-Momani, 2000).

In addition, interior and exterior designs are also a big concern of buyers before they buy a house (Opoku & Abdul, 2010). Buyers prefer to take into consideration of the interior and exterior architecture and the materials used before buying a home. Thus, when buying a house, interior and exterior design are important for buyers (Haddad, Judeh & Haddad, 2011).

## **Reasons for Low House Ownership Among Millennials**

### *Financial Factors*

Malaysia housing has experienced rapid growth and oversupply of properties over the last twenty years as a result of the younger households' low ownership. Financial factor is also one of the factors why younger generations have low house ownership, not only in Malaysia but in other developing countries as well. Due to the tightening of loan conditions and unfavourable market conditions, home buyers, particularly young adults are facing financial difficulties. Thus, most of them are unable to meet the minimum down-payment that, in effect, acts as a barrier to home buyers, particularly for the younger generations who lack strong financial support (Fierro, Fullerton & Donjuan, 2009).

It is confirmed that house prices are closely correlated with youth household income (Ortalo & Rady, 2006). Additionally, a research done found that the increase in house price would slow the younger generation in buying a property in the fastest possible period (Fry, 2013). However, the young generation prefers to have a lavish lifestyle, which in turn affects their financial status. Therefore, the young generation should save and afford what they can manage within their budget.

### *Changes of Life Stage of Households*

According to International Business Times (2016), the percentage of young generation age 18 to 29 is rising from 52% in 2004 to 64% in 2014, showing an average rise of 12% in 10 years. In addition, changes in the life stage of the household would directly affect the households' needs and wants. Marriage and ownership of a house are strongly correlated with each other as well (Fry, 2013). A newly married pair, for example, tend to buy a house to maintain a long-term committed relationship (Clark, Duerlon & Dieleman, 1994). Additionally, dual-income households would tend to make homeownership more accessible. Married young generations tend to earn more, putting more effort on earning money than the single ones as they have burdens and have to take care of their own created family which give

a positive impact on house ownership (Fry, 2013). Hence, delay in marriage will negatively influence the house ownership rate.

Moreover, half of the young adults today stay with their parents, also known as the Millennial Generation (Fry, 2013). That is due to the evolution of the world, where the cost of living is significantly higher, the unemployed young adults tend to stay in their parent's home before owning their own house. Normally, the financial support of the young generations relies on their parents, too. According to the same report, he argued that there is a mixture of economic, educational and cultural factors that, in effect, influence the younger generation to lengthen the period of living in the parental home. Hence, parental home is one of the factors which delay the house ownership among the younger generations (Rugg & Ouilgars, 2015).

### *Renting*

There is an increasing number of people who have struggled to save a house purchase deposit because of rates that are not affordable (Andrew & Pannell, 2006). He claimed that house rental demand has increased as a result of rising property prices. According to a survey, younger generations prefer to rent rather than own their own house, even though they do not face any issues with their down payment because they like the variations and differences in their living environment. Mobility is one of the reasons for renting out as a comparison to owning a house as the study-based young generations moved more than twice a year. Renting offered a high degree of stability and a lower amount of initial cost compared to purchasing a house because only a deposit sum is charged when renting a house compared to the high down payment when buying a home (Rugg & Ouilgars, 2015).

In addition, house ownership demand has plummeted due to high initial investment and financial restrictions, as well as insufficient cash to pay off the mortgage loan (Ortalo & Rady, 2006). In addition, it is also found that cost of renting is relatively lower than house owners who are highly favourable and preferably by the younger generation. In fact, the occupant can just move and shift out as soon as the rental agreement/contract is up and does not need to be responsible for the land and property, thereby ending the relationship between the occupant and the owner of the building. On the other hand, the house owners will have to look for another tenant once the current contract period with the current tenant is up, and this takes up time as well (Megbolugbe, Marks & Schwartz, 1991) (Timmermans, Molin & Van, 1994).

## RESEARCH PROCESS & FRAMEWORK

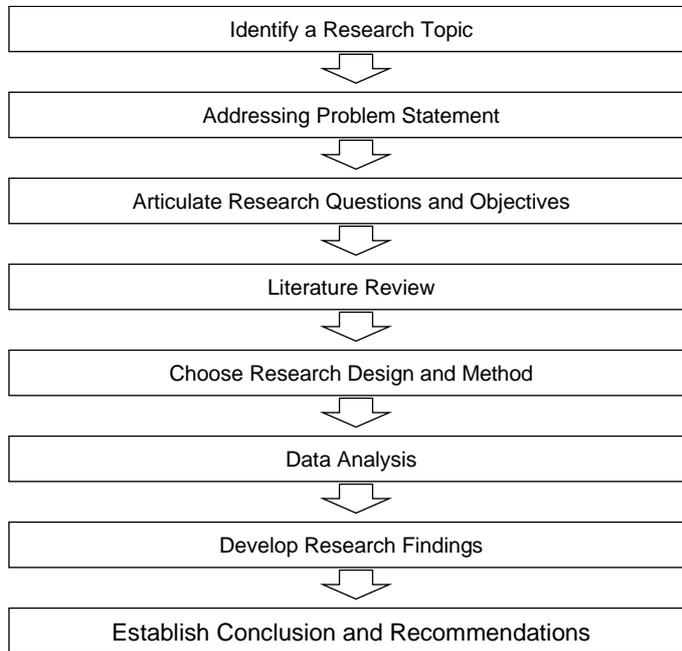


Figure 1. Research Process

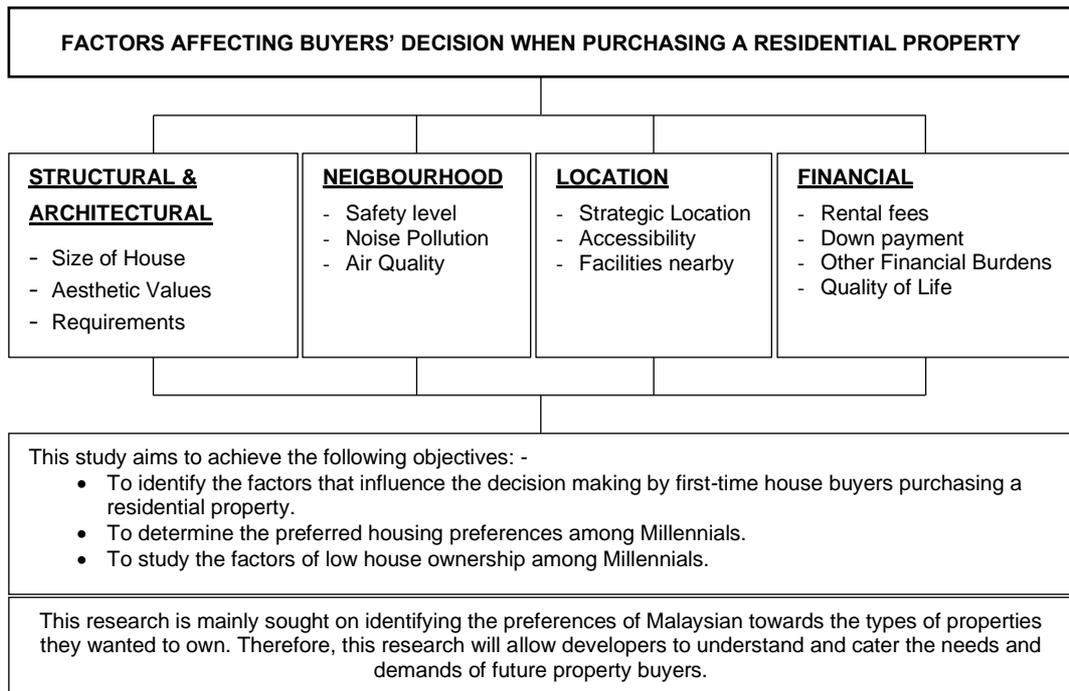


Figure 2. Research Framework

## RESEARCH METHODOLOGY

This study will be focused on younger generations, in between ages 21-35 years old. Young generations are defined as those who are born from 1980 and getting employed after 1st July 2000. Selangor is selected as the focus area due to the highest population density in Malaysia (Department of Statistics Malaysia, 2015). Also, people aged 21-35 years old takes up 44% of the population in Malaysia, estimated at 13.9 million people in 2016. By using the formula created by Krejcie and Morgan (1970), a sample size of 384 respondents is required in this study.

Quantitative research method had been selected to achieve the research objectives. The purpose of conducting a quantitative study is to identify the relationship between the factors that influence first-time buyers (independent variable) and their decision in purchasing residential property in Selangor (dependant variable). Based on past researchers, quantitative study is relatively more appropriate as it quantifies the issue by gathering and analysing data in numerical and statistical form across a larger sample size.

Questionnaire is the most common tool for collecting primary data. A questionnaire consists of a list of structured and tested questions, presented to people to obtain information. A well-developed questionnaire provides accurate information to the researcher and offers a faster process by designing closed-ended questions which directly answers the research objectives. This study focuses on the younger generations who are currently working or living in Selangor. Thus, 400 questionnaires were distributed and sent to the target respondents.

The questionnaire comprises of three sections: -

- Section A, the demographic profile of each respondent, inquiring the gender, age, status, profession, and their household income.
- Section B will discuss the factors that will affect their decision making in purchasing residential property as a first-time buyer. Each factor will then be divided into sub-factors and respondents are required to rate the degree of importance according to the 5 points Likert Scale given in the questionnaire.
- Section C will look at the first-time buyers; preferences if they are looking for their first house. Similarly, respondents are also asked to indicate the level of agreement based on the statements provided by using 5 points Likert Scale.

Relative Importance Index (RII) is the method to determine the most significant factors which affecting first-time buyers' purchase decision and preferences, based on the five-point Likert scale ranged from 1 (Not Important) to 5 (Extremely Important).

The ranking method will be applied to this research. In this research, this method identifies the ranking of factors by positions which are financial factors, locational factors, neighbourhood factors and structural factors, where no position is in the same place. Besides, the ranking method is often understood by many and presentable.

## DISCUSSION & KEY FINDINGS

A total of 385 sets of questionnaires were sent out to the target respondents in Selangor. The response rate of the questionnaire survey is 32.7% where 126 responses and feedback are received from the respondents, however, a total of 4 responds was rejected as either they are not first-time house buyers, or they exceed the age of 35. Therefore, only 122 sets of completed questionnaires were taken into consideration in the data analysis.

### Factors Affecting First-Time Home Buyers' Decision

**Table 1.** RII of Factors Affecting First-Time Home Buyers' Decision

Type of Factors	Degree of Importance					RII	Rank
	1	2	3	4	5		
<b>Financial Factors</b>						<b>0.914</b>	<b>1</b>
Property Price	-	-	7	25	90	0.936	
Ability to Obtain Finance Assistance (i.e., loan)	-	1	7	37	77	0.911	
Payment Terms (down payment, interest rate)	-	-	10	44	68	0.895	
<b>Locational Factors</b>						<b>0.778</b>	<b>3</b>
Closeness to Workplace	-	-	13	44	65	0.885	
Closeness to Amenities (i.e., shops, schools, etc)	-	2	12	77	31	0.825	
Closeness to City or Town Centre	-	15	48	42	17	0.700	
Closeness to Local Public Infrastructures (i.e., LRT stations, MRT stations, Bus Stop, etc)	6	17	42	23	34	0.702	
<b>Neighbourhood Factors</b>						<b>0.814</b>	<b>2</b>
Quiet Place (low density population)	3	9	40	39	31	0.741	
Green Space	2	21	42	33	24	0.692	
Low Crime Rate	1	-	1	25	95	0.949	
Environmental Cleanliness	-	-	13	51	58	0.874	
<b>Structural Factors</b>						<b>0.708</b>	<b>4</b>
Building Quality	1	4	32	31	54	0.818	
Number of Bedrooms	-	15	53	42	12	0.684	
Number of Bathrooms	-	24	64	21	13	0.638	
Building Layout Design	2	15	53	29	23	0.692	

From the result shown in Table 1 above, it is noticeable that financial is the most influential factor before making a decision when purchasing a property with the highest overall average RII of 0.914. This data is supported by a statement made by Reed and Milks (2007) where financial is the top priority when buying property. The RII value specifically on the property price is 0.936 which shows that the price of the property is the top consideration. It is stated that property price is one of the most important factors when buying the first house (Abdullah, Nor & Jumadi, Arshad, 2012) (Kupke, 2008). The RII values for the ability to obtain financial assistance and payment terms are 0.911 and 0.895 respectively, just slightly below the RII of the property price factor which shows both of these elements should not be left out and should be taken into consideration.

Next, the neighbourhood factor is ranked second with an average RII of 0.814. With the RII of 0.949 specifically on the low crime rate factor, it is clear that safety is the top priority among the people living in Selangor. According to Tan (2011a), the crime rate in Selangor is unusually high compared to other states of Malaysia and therefore, Selangor house buyers

tend to take safety factors into deep consideration and are willing to spend more just to live in a safer neighbourhood. Also, the environmental cleanliness factor has a high positive response with the RII of 0.874. This shows that the people of Selangor take environmental cleanliness and level of pollution into consideration nearby their living area. The RII values for a quiet place and green space factor are 0.741 and 0.692 respectively, slightly lower compared to low crime rate and environmental cleanliness factor.

Moving on, the locational factor is ranked third with an average RII of 0.778. The location of the house plays an important role for first-time house buyers' decision before purchasing the first home (Abdullah, Nor & Arshad, 2012) (Haddad, Judeh & Haddad, 2011). With an RII of 0.885 and 0.825 specifically on the closeness to workplace and closeness to amenities respectively, it is known that the people of Selangor consider the convenience of them going to their workplace and to buy daily items and products. The house value depends on closeness to local amenities as the shorter travel distance between houses and local amenities, people can save more time. The RII values for closeness to city or town centre and closeness to local public infrastructures are 0.700 and 0.702 respectively.

Last but not least, the structural factor is ranked fourth with an average RII of 0.708. With RII values of 0.818, 0.684, 0.638 and 0.692 for building quality, number of bedrooms, number of bathrooms and building layout design respectively, it is shown that the overall structural factor is not the top priority and consideration when purchasing the first property, but there is still a presence of demand for it.

## First-Time House Buyers' Preferences

**Table 2.** RII of First-Time House Buyers' Preferences

Type of Factors	Degree of Importance					RII	Rank
	1	2	3	4	5		
<b>Locational Factors</b>							
I would consider the proximity to workplace	-	-	13	44	65	0.885	3
I would consider the proximity to local amenities (i.e., shops, schools, etc)	-	-	15	71	36	0.834	5
I would consider the proximity to city or town centre	-	3	47	52	20	0.746	8
I would consider the proximity to local public infrastructures (i.e., LRT stations, MRT stations, Bus Stops, etc)	3	17	40	35	27	0.708	10
<b>Neighbourhood Factors</b>							
I would consider the indoor and outdoor environment quality (i.e., Cleanliness, Level of Pollution, etc)	-	-	12	53	57	0.874	4
I would consider the green surroundings (i.e., park, open spaces, etc)	-	15	44	32	31	0.730	9
I would consider the neighbourhood safety (i.e., low crime rate)	-	-	2	20	100	0.961	1
I would consider a gated and guarded neighbourhood	-	1	7	40	74	0.907	2
<b>Structural Factors</b>							
I would consider the built-up area (square feet)	-	1	37	56	28	0.782	6
I would consider the number of bedrooms and bathrooms	-	15	58	29	20	0.689	11
I would consider the size of Living Room	-	16	56	31	19	0.687	12
I would consider the size of Kitchen	1	26	45	27	23	0.674	13
I would consider the interior and exterior design	-	8	38	46	30	0.761	7

The top three most significant house preferences are neighbourhood safety (i.e., low crime rate), gated and guarded neighbourhood and proximity to the workplace. From the results above, it is clear that these three factors are the top considerations and determinants which affect the decision making for first-time house buyers.

Due to the escalation of crime rate in Selangor, people tend to put safety as the top priority, thus this increases the demand for consideration of safety and a guarded neighbourhood, thereby safety aspect has become the main consideration before purchasing properties (Tan, 2011a).

Proximity to the workplace is also another crucial preference for first-time house buyers. According to table 4.3.2, a majority of 70% of the respondents are aged between 21-25, which indicates most of them are either fresh graduates or entering the workforce as a new employee, thus leading to an increased demand for looking for houses nearby their workplace to able to reach their workplace on time. This data also conveys that the people of Selangor does not prefer the long distance and time taken on driving to work and back home due to the heavy density of traffic where Selangor has a high traffic volume during peak hours which leads to a waste of time and lateness to work (Tan, 2011a).

For the proximity to local public infrastructure preference, there are mixed opinions in it which explains the middle-ranking of this preference. For those who take public transport very frequently to their workplace or any other locations, this factor will be one of their top priorities and vice versa.

Last but not least, the built-up area is the most significant preference among other preferences under structural preference. However, the size of the living room and kitchen are slightly insignificant with RII values of 0.687 and 0.674 respectively. These results are pretty similar to the study carried out by Tan (2011).

## **CONCLUSION & RECOMMENDATIONS**

Based on the results obtained, the two main objectives are achieved which are identifying the factors that influence first-time house buyers' decision in purchasing residential property in Selangor and determining the house buyers' preferences when purchasing a property. Furthermore, the third objective is achieved by conducting self-study and data relation from objective one and two which in the reasons for the low house ownership among the Millennials.

Although all the three objectives are met in this research, there are limitations to this research. One of the most important limitations of this study is the slightly insufficient response rate of the respondents at 32% where there are only 126 respondents out of 385, thus the data might not be the most favourable and accurate to be used for other future researches. As for the findings of this study, three limitations are being applied which are this study only covers the Selangor state, this study is designated for only individuals who have never bought a property before and this study only focuses on individuals age 21 to 35 years old.

Therefore, there are some recommendations to further this research. The house price index for Malaysia continues to grow year after year which impacts Millennials to purchase their first home due to their lavish lifestyle, ringgit depreciation, the increase of cost of living and many other factors. Thereby, recommended future research can be based on how to promote house ownership among the Millennials in Malaysia, in terms of government actions such as subsidiaries and housing plans or other solutions. Another recommended research is to study and analyse the current government housing plan schemes (such as PR1MA and Rumah Selangorku), on how it can help Malaysians and the limitations of these housing schemes imposed by the government.

This study established that financial factor is one of the key concerns for first-time house buyers, followed by locational, neighbourhood and structural factors.

Furthermore, housing needs and preferences differ from one another. Therefore, developers and construction companies should consider the demands of Malaysians to cater to the different needs and preferences for the younger potential house buyers.

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# EVOLUTION OF WOMEN IN THE CONSTRUCTION INDUSTRY: QUANTITY SURVEYORS' PERSPECTIVE

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## Abstract

While the proportion of men to women is more prominent in the construction industry, an ever-increasing number of females are making vocations into the sector. Despite the symbolizing gain, women are still confronted by a significant number of barriers such as: advancement in the organization's hierarchy, work-life imbalance, and the lack of professionalism in human resource management. Many recent studies on working women in the industry have very limited information about development of the specific gender over the past decades. In the context of depicting the evolution of women in the construction industry, the objectives of this research paper are: (i) to explore factors encouraging women into the field, (ii) to identify the challenges faced, and (iii) to assess the perceptions towards women working in construction roles. A clearer vision of women's evolution was achieved by conducting a study from the outlook of 13 individuals registered with the Board of Quantity Surveyors Malaysia (BQSM) in Klang Valley through qualitative approach. Results from the viewpoints, viz those of professional men and women manifested the advancement of women, particularly within the construction industry, through societal changes and modernization of cultural beliefs gauging the increased of women's participation in the exclusively male-established sector. It was also found that stereotyping and discrimination against women, though subtly, persists to the present day in terms of perceptions and practices which serve as a yardstick to improve the construction industry. Such information further contributes to the understanding of women's career progression and encourage more female into the construction industry for the possibilities and opportunities which lie ahead.

**Keywords:** *Women's participation; Construction industry; Evolution; Career barriers; Career development.*

## INTRODUCTION

The construction industry has historically been described as a non-traditional, male-dominated occupation for women. As perceived by the general public, a woman's primary duty is to be the main provider in family care, that is, the feminine condition in the context. In defiance of the industry being closed off to women as well as traditional expectations, an influx of female employees in the sector has been demonstrated furthering the endorsement of gender equality (Gassaway, 2019). Phenomenal efforts of the government, many companies, associations, and organizations rallied behind in support for women in construction, as will be proved of the prominent growth of women in the construction industry. Howbeit so, the public's apprehension of such accomplishment remains moribund which leads to a void with regards to the current state of women in the construction industry (Buncio, 2019). The overall message is that there is much to be discovered on the topic instead of completely analysing the situation through the interpretation of numeric results. Numbers can be deceiving as the affair regarding the misconceptions relative to women in the construction industry continues to be trivialized (Shanmugam, et al., 2007). The literature is replete with findings focused on the involvement of women in the construction industry, but little research exists on the transformative change of the industry in terms of its female workforce which centralizes to historical and modern perceptions about women working in the field. This research will look at the factors leading women into the construction industry,

challenges faced within, and perceptions of their counterparts, under the influence of social evolution.

## LITERATURE REVIEW

### Evolutionary Change

Williams (2011) has suggested that the coining of new gendered terms in the English-speaking society, including *femininity*, began during the English medieval period from the late 14th through the 15th century. In response to cultural changes, avant-garde Middle English writers had carried out linguistic and literary experimentation with unprecedented ways of visualizing and exemplifying women's lives and encounters. Many scholars associate women with the roles of maiden, wife, or widow. The construct of traditional femininity idealizes dignity and modesty, wherein tasks considered as such including baking, gardening, caring for children and home – equally known as “Women's work”, which may also refer to chores particularly within the home. Goffman (1990) further added that women are socialized to portray themselves as “precious, ornamental and fragile, uninstructed in and ill-suited for anything requiring physical exertion” and to project “shyness, reticence and a display of frailty, trepidation and ineptitude.” The traditional society focuses on the obsession with aesthetic and appearances – women's clothing and looks – as well as the conventional duties reckoned to women being a woman. As reviewed by those studies that summarized and offered the ideology of femininity, the construction industry was never in discussion.

For the past two decades, “girl power” has become a prevalent manner of portraying the success of women in American culture. A new study has found that femininity today is associated with attributes of being independent, outspoken, compassionate, wisdom and creativity, which appears to contradict the traditional citation of femininity (Hosie, 2018). The verity for a modern woman involves the opportunity to approach masculine power that has never been conceivable, such that women can be career-committed working mothers. In 2007, The Nation stated that women can do anything the very same their counterparts can, and better (Pollitt, 2007). Widespread reports referred to these women who can do it all as “alpha girls”, in which they escaped from the confinement of former stereotypes, hence pioneering a gender takeover (Sumra, 2019). In precis, women in modern society are adopting a more fluid scale of behaviours, temperaments, and potentiality. Though the aspect of femininity is evolving, it does not interpret as a complete role reversal. Women are still revelling and embracing traditional feminine values, but in a way that allows them to pursue other things as well (Lagroue, 2015). In the sense of delving into a new horizon where the boundaries between femininity and masculinity become blurry, women are seen as prospective workforces in industries with traditionally masculine culture, specifically the construction industry (Arnholz, 2020).

### *Historical State of Women in the Construction Industry*

The construction industry was one of the earliest where wage labour emerged and became firmly established. Moreover, it was one of the main industries where laborers were modulated by enactment, prominently the Ordinance of Laborers 1349 and the State of Artificers 1563 (Clarke & Wall, 2006). Though it is the only industry with an industrial training board and a statutory levy, it remains the most gender-specific or gender-segregated

sector in the economy where the latter is often overlooked. Indeed, there is by no means the male exclusivity and those contributions of women that have succeeded in participating credited in many paperbacks on the history of the construction industry (Hatipkarasulu, 2011).

Back to the 14th century, apprenticeship was the only route of involvement in the construction industry and was a male-dominant institution. Sheridan (1992) remarked that the debarment of women from apprenticeship contracts was to ensure that the inheritance of property and power persisted with the privileged group. The exception in this closed guild system wherein women were either a mistress working on her own account or a widow who embarked on behalf of her deceased husband. Sheridan was granted the right to become a member of the company, though she did not have equal status and usually restrained from advancing in the hierarchy (Woodward, 1995). It was no doubt that the females were confronted with competitive fear and derogatory comments from their male co-workers (The New York Times, 1992). Aside from the hostile working environment, there was an apparent disparity in wages between men and those women who are found in the company records, with estimation at between 50% and 70% less than their male co-workers (Bardsley, 1999; Bennett, 1992).

Despite the unfair treatment women had come across in the workplace, the stemming of the Statute of Artificers 1563 had concomitantly paved the way for female workforces. Essentially, the Statute was not gender-specific as it referred to apprentices as ‘persons’, ‘boys’ and girls’ and to ‘masters and mistresses’ (Davies, 1956). The male exclusivity was continued to be threatened as there was a severe labour shortage caused by the First World War. Despite the reluctance of employers and trade unions in recruiting women, they were later taken in with the condition of undertaking only parts of skilled job customarily done by men (Braybon, 1981). The gist was to ensure that women remained in subordinate position. Howbeit the constraints, the quick learning ability, diligence, productivity, and exceptional performance possessed by the women had thrust them into the limelight. Though their achievements were not honoured by the building trade unions (Briar, 1997). In general, there was little support from men.

### *Current State of Women in the Construction Industry*

The society has advanced and evolved tremendously in a few generations and in many ways. An intuitively obvious change has been the rising of women in business world. Women have broken the shell of norms and conservative traditions such that the progression in leadership and the potentiality to take up challenges. Over the last decades, the language of gender equality, diversity and inclusion in the workplace have been emphasized into the ears of construction employers. There are substantial accomplishments in where women can be found working at building sites, operating large machinery, or taking up managerial roles that are within the construction industry. In fact, National Association of Women in Construction (2018) specified the overall participation of women in the construction industry is a steep increase of over 51% since 1985.

While women’s participation in the industry has multiplied in the current century, there is still much more to be concerned such that the long-standing issue of gender inequality remains within the industry, equating the phenomenon over the last centuries. And this only proves the proportional numerical growth of both genders, other than the lenient regulations.

Realistically, has the construction industry veritably evolved? In conformity with data by the Office for National Statistics (ONS), the percentage of female construction workforces in general does not exceed 15%. Further, recent research by the General, Municipal, Boilermakers (GMC) trade union reveals that it will take about 200 years to achieve gender equality in the construction industry at the current rate of growth (O'Connor, 2019). Lack of diversity is an issue that cannot be solved overnight. As dreadful as it sounds, there is no simple or direct solution to reduce gender inequality in the workplace or the construction industry alone.

Regardless, many initiatives from general industry support to bracing young and upcoming generations of women in construction that organizations and associations are rallying behind to build a better workforce. Some of the prominent stratagem being Groundbreaking Women in Construction (GWIC), Women in Construction Summit, Women Construction Owners and Executives (WCOE) and Professional Women in Construction (PWC) (Ellis, 2019).

### **Women's Participation in the Construction Industry**

Globally, the participation of women in the construction industry is believed to bring about many positive effects to the sector. Not only will the industry start reaping the perquisite of narrowing the labour gap, but a diversified workforce tends to introduce multitudinous benefits for the corporation as well. For example, in the United States, a study conducted by Forbes in year 2018, has found that companies that put diversity into practice lead to 19% more revenue than their counterparts (Powers, 2018). Other than the production of increased earnings, the addition of women in the construction industry will therefore present the following benefits:

Variety of perspectives. Besancon & Lubart (2008) proclaimed diverse studies supporting the hypothesis that women are considered more creative. According to the research by Ulger & Morsunbul (2016), it was found that women possess higher originality and strengths on the subscales of creative thinking. Thus, the immersion of women's fresh perspectives will foster more innovation and creativity which in turn, driving the industry forward.

Improved performance. Decision revolution refers to the inclusive behaviour in terms of respective participants where women are being included in decision making procedure. The simple concept of inclusive allows women to have strategic-thinking skills in the ability to develop effective plans and contribute directly to the bottom line. Further, in a study by Cloverpop shows a direct link between inclusive decision making and better performance of 60% (Larson, 2017).

Heightened company reputation. With the rise of feminism, in part, by the millennials; many of whom opines that feminism is of the essence to their identity. When contractors become proactive about recruiting women for positions in respect of the movement, this creates a more desirable workplace culture and is appealing to current and prospective employees, particularly the females (Buncio, 2019).

## Factors Leading Women into the Construction Industry

Career development theories offer diverging perspectives in the aspects of individual developmental needs and organizational fit. The application of these theories, therefore, contributes to women's career choices in the result of shaping their work identities (Gothard, 2001). Three popular theories include: Holland's (1997) *Theory of Vocational Personality and Work Environment* (career decision-making through one's personality), Krumboltz's (1979) *Social Learning Theory* (career decision-making through economic, sociological and personality variables), and Super's (1957) *Life Span Developmental Theory* (career decision-making through 'self-concept').

Besides, critical government strategies include the introduction of the Equality Act 2010 which brings together over 116 independent legislations into a single duty. The bill provides protection against discrimination in the workplace and extending it to cover the 'protected characteristics' of sexual orientation, pregnancy and maternity, and gender reassignment (The National Archives, 2010) which are of importance in reviewing the involvement of women in the construction industry.

The government has brought about changes to the construction industry, still and all the phenomenal efforts taken by organizations, corporations and associations also play a role in leading women into the industry. The initiatives that accelerate female construction workforces being *Built by Both* (a networking and educational platform) (Barratt Golden Bricks, n.d.), *Build like a Girl* (construction workshop for girls in the seventh and tenth grade) (GSCO Admin, 2019), *National Association of Women in Construction (NAWIC)* (the most influential and the most extensive resources for women in construction) (NAWIC, n.d.), and *Women in Construction Malaysia (WIBM)* (a networking association for Malaysia's women in construction) (WIBM, 2017).

## Barriers for Women Entering the Construction Industry

A case study by English & Jeune (2012) assembled all facets into three broad categories: marketing, sociocultural issues, as well as industry, culture, and environment.

### Marketing

*Poor industry image and visualisation.* The construction industry is perceived as a macho, hostile, challenging and dangerous environment (Fielden & Davidson, 2001). Unfortunately, the construction industry fosters a patriarchal image that is male-dominated, male-identified, and male-centered (Zuska, 2009). It also involves in a culture that oppresses women (Gurjao, 2017). Added negativity towards the construction industry including many people believe that it is a rough and dirty job, one that is not a place for women (Kleiner, 2018).

*Biased recruitment practices and procedures.* Regardless of anti-discrimination laws, it seems as though the misconceptions have been encrypted. There exists an unconscious bias which affects one's decision in hiring, such that certain jobs are considered "too hard" or "unfitted" for a gender or the other. Sometimes this unconscious bias can be subtle that many may not even realized about it themselves, which also stemmed from what is considered the

qualities of femininity or masculinity (Davey, 2019). Even so, there are still some pathetic scenarios where sexism is not unconscious at all.

### *Sociocultural Issues*

*Societal roles and cultural beliefs.* Though there is an evolvement in the social role of women, specifically in the direction of taking a profession, there still lies the traditional views in which cannot be given up completely. The dominating social role of women is as housewife—that lady of the house, in taking care of the family and focusing on children and their happiness (Eagly, Wood, & Diekman, 2000). This social role of women are consistent stereotypical traits attributed to women.

*Personal female attributes.* Research by My Confidence Matters (2019) shows that among 2,500 respondents, 79% of women lack of confidence on a regular basis as compared to men withholding 62%. This provided one of the reasons women might be ducking out of certain professions is their lacking confidence in the ability to compete in fields that men are stereotypically portrayed to perform better. This female confidence challenge where women underestimate their own abilities and performance is known as the “imposter challenge” by Clance & Imes (1978). The weak self-confidence thus holding some women back as they odd themselves out of pursuing in professions they believed they will not excel in (Coffman, Gennaioli, Shleifer, & Bordalo, 2019).

### *Industry, Culture and Environment*

*Male-dominated culture.* The construction industry is heavily male dominated in which it has historically been a challenge to recruitment and representation of women (Donaldson, 2018). In a survey conducted with all alumnae from Murray Edwards College (2014), a woman in her mid-30s summed up the male-dominated culture in her workplace, describing it as ‘designed by men, for men,’ with a male culture and set of values. This phenomenon itself stems the mindset in women that the construction field is a “man’s place”. Wong (2019) confirms this statement by adding that it is difficult for a woman to break into the male-driven business networking circles.

*Remuneration discrimination.* Construction industry is one of the sectors with the highest gender pay gaps, according to the latest figures for 2018 (Garner, 2019). Last year, a Royal Institution of Chartered Surveyor (RICS) survey found that men were paid 36% more than women even though both genders carry the same job (Ing, 2019). As for 2019, a salary survey by RICS and Macdonald & Company reports that though the gender pay gap in construction has narrowed significantly to 20%, the sector is still among the least equal nationally.

*Hostile work environment.* Women working in construction are subject to derogatory remarks, harassment, and physical assaults. Among these, the most intolerant being sex-based harassment. A survey done by ENR in 2018 reports that 66% of women have encountered sexual harassment or gender bias within the industry, and nearly 60% voicing that they have witnessed it (Rubin, Tuchman, Powers, Cubarrubia, & Shaw, 2018).

## Challenges for Women in the Construction Industry

It appears as if women are in a constant battle to claim their rights under the torment by unjust treatment in the sector. Khoo (2017) highlighted that woman in the construction field including Quantity Surveyors, Architects, Engineers, Project Managers and other related professions, are at a disadvantage when competing and acquiring the work as deals are often brokered in male-driven business networking, such as entertainment, luxury car clubs or golfing. Furthermore, notable challenges including lack of women role models, undervaluation of women's work and phenomenon of glass ceiling phenomenon in construction.

### *Lack of Role Models*

According to a Randstad survey of over 450 employers in the construction industry, the result shows that almost half of respondents had never had a female chief executive, a quarter had had one female boss and only 5% had had three female managers (Randstad, 2019). The deficiency of women in the top management is evident, particularly within the construction industry (Shanmugam, Amaratunga, & Haigh, 2006). Moreover, the shortage of women made the records of strong female role models even miniscule, indicating that there is not much to aspire to. A role model can affect one's beliefs, or possibly change their entire outlook on life. Like a ship without direction or destination, an individual without an embodiment of success is fruitless.

### *Undervaluation of Women's Work*

Number of people claimed that women should opt for higher-paying fields if they seek for gainful remuneration. Yet the fact of the matter demonstrates otherwise as the relationship between popularity with female workforces and earnings proved to be inversely proportional (Miller, 2016). A noticeable phenomenon being the more artistic careers such that designers experienced their wages cut by 34% as women began to outnumber men in the industry. Biology used to be an honoured field in science, however the wages slimmed down by 18% as more women became biologists. The statement where jobs are paying less when "feminized" is said to be valid. Hence, the vision of encouraging more women to venture into the construction industry may be considered as a threat than a plausible acquirement, judging that there still exists an apparent gender pay gap within the industry.

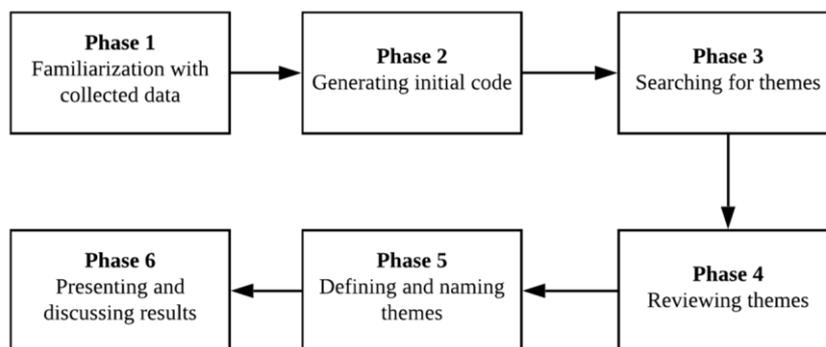
### *Glass Ceiling Phenomenon in Construction*

The glass ceiling is a metaphor portraying the challenges experienced by women trying to advance to the top levels of workplace (Weyer, 2007). The theory establishes the barriers in which women are deprived of promotion to higher levels of hierarchy within their organization, thus preventing career progression (Flávia, Lucia, & Liliana, 2010). An effortless war of determining the situation is to go "window shopping" on the webpages of established construction companies to identify the beholder of top management positions. Ultimately, the result appears indisputable. This naked truth of gender disparity in the construction field trickles down to the reluctance of women ever considering a career in the industry knowing there is little opportunity of professional advancement as well as

undergoing potential discrimination for the time being (Amaratunga, Haigh, Lee, Sahn mugam, & Elvitigala, 2006).

## RESEARCH METHODOLOGY

Male and female registered with the Board of Quantity Surveyor (BQSM) have been earmarked for an all-inclusive data. With both genders who had been or currently working in the construction industry, it probes additional and realistic details into the field. The focus is on men and women's working experiences with their counterparts, but an attempt is made to consider the generic opinions that can be of importance to assess the research topic. Data collected through semi-structured techniques with open-ended questions include standpoints and insights of 13 interviewees. It was then analysed manually using thematic analysis, which involves the compilation of all materials within the scope of research: transcripts of individual interviews conducted, research objectives and questions, as well as the inclusion of other related secondary resources. Subsequently, the interpretation of qualitative data involves the process of distinguishing patterns or concepts emerging from participant testimonies (Attride-Stirling, 2001). The fundamental operation of thematic analysis is therefore the thematization (Paillé & Mucchielli, 2016). Thematization is useful for summarising a set of data into a well-structured approach of data handling which consequently produced a clear final report. It is considered a rigorous approach to subjective occurrences that is greatly appropriate to search as means of examining current trends and complexities (Tojo & Takagi, 2017). Braun & Clarke (2006) developed a six-phase framework for conducting thematic analysis (refer Figure 1). Therefore, thematic analysis is used in this research study as it is practical in scrutinizing viewpoints of research participants, underlining similarities and differences as we all as developing unanticipated insights.



**Figure 1.** Braun & Clarke's Six-Phase Framework for Doing a Thematic Analysis  
(Source: Labra, Castro, Wright, & Chamblas, 2019)

## RESULTS AND DISCUSSION

### Demographic Profiles of Interviewees

The respondents were retrieved from the list of members registered under BQSM with experience of many years which essentially dictated their extent of knowledge and apprehension about the changes undergone the umbrella body of construction sector. Due to their industrial experience and definite understanding of insight, the respondents were able to provide in-depth facts for this research.



**Table 4.** Coding Matrix of Probable Factors Expressed by Interviewees

<b>Category A: Factors Prompting Choice of Career</b>		
<b>Theme 2: Probable Factors</b>		
<b>Interviewee</b>	<b>Data Transcript</b>	<b>Code</b>
R1	"I would suggest that the <b>government, Ministry of Education</b> as well as of <b>Higher Education</b> , and the <b>private sectors</b> to <b>promote and encourage</b> women to join the workforce in the construction industry."	A2a A2b
R2	"Women are actively participating in the construction industry already. The main consideration should be the <b>image of the industry that needs to be improved.</b> "	A2a A2b
R3	"Rather than the industry itself, as I see it women should understand about <b>psychological and emotional management</b> in order to <b>prepare themselves</b> to work in the industry."	A2e
R4	"...awareness among the men that <b>women are nothing less</b> in terms of knowledge and capability in handling project. <b>Cooperation</b> among women and men in the industry are important because the success of the industry is about <b>good teamwork and communication.</b> "	A2b A2f
R5	"... as long as the <b>passion</b> is there, when there's the will, there's the way."	A1b
R6	"The public's <b>perception of the industry</b> plays the important role."	A2a A2b
R7	"...main consideration for employers especially in construction industry to engage women is when women get pregnant and then give birth and thereafter <b>having their child to look after</b> . This may contribute towards more <b>sick leaves, maternity leave</b> , and even <b>childcare leave</b> . On this basis, women are at a disadvantage to men."	A2b A2d
R8	"... <b>raising awareness, training, and proficiency</b> . To be frank, gender discrimination is not necessarily true in construction industry."	A2a A2b
R9	"... <b>family structure support from employers</b> such as nursery."	A2b A2d
R10	" <b>Remuneration</b> should be enough to lure women into this industry."	A2b A2c
R11	"A way of promoting the industry to the women is by <b>sharing success stories</b> of such gender, and also <b>women empowerment.</b> "	A2a A2b A2c
R12	"...increase exposures to sites and the <b>human resource department</b> needs to look seriously into the harassment clause stipulated in contract to provide women the protection they should receive."	A2b
R13	"There are times where women are <b>taken for granted...</b> "	A2c

Analysis revealed that the predominant factor in career decision-making complied with one's personality and interest, which adopted to the principles of Holland's (1997) Theory of Vocational Personality and Work Environment, proving the correspondence of personality and preference with career interest. In pursuance of encouraging more women into the construction industry, the interviewees perceived – the probable factors – were highly valuable in deducing other considerations which could remedy the issues. Accordingly, governmental initiatives and organisational efforts were stressed on image formation of the construction industry. One of the interviewees, R3 also highlighted that it is important that women should focus on self-enhancement in the means of grasping psychological and emotional management before deciding to get involved with the construction industry. While overall, gender equality had always been fundamental in the discussion of women and the construction industry (Wong, 2019). The negative stigma and discrimination towards the gender needs to be banished for ensuring total inclusiveness within the struggles against participation. Nevertheless, a woman's decision to participate in the construction industry can be determined by her individuality, knowledgeability, and rationality, along with those vigorous attempts by the government and industry players (Ellis, 2019).

## Barriers and Challenges for Women’s Participation in The Construction Industry

Testimonies expressed by interviewees had identified the barriers and challenges that were encountered while participating in the construction industry. The subject matter focused mainly on the women, still the viewpoints of the men were considered to maintain objectivity. Data obtained are shown in Table 5 – Table 8.

**Table 5.** Coding Legend for Category B

Category	Theme	Sub-theme	Code
<b>B.</b> <b>Barriers and Challenges Encountered Relating to Women’s Participation</b>	1. Discriminatory ethics <i>(Bardsley, 1999; Powers, 2018; O’Connor, 2019; English &amp; Jeune, 2012)</i>	a. Biased recruitment practices and procedures	B1a
		b. Remuneration discrimination	B1b
		c. Hierarchy impediment	B1c
	2. Workplace harassment <i>(Rubin et al, 2018; Flavia, Lucia &amp; Liliana, 2010; Arnholz (2020)</i>	a. Discriminatory	B2a
		b. Personal	B2b
		c. Power	B2c
		d. Psychological	B2d
		e. Sexual	B2e
	3. Poor industry image and visualisation <i>(Miller, 2016; Donaldson, 2018; Buncio, 2019; Arnholz, 2020)</i>	a. Male-dominated industry	B3a
		b. Dirty and dangerous	B3b
		c. Stressful nature	B3c
	4. Societal roles and cultural beliefs <i>(WIBM, 2017; Guraj, 2017; Davey, 2019)</i>	a. Subordinate position	B4a
	5. Personal female attributes <i>(Wong; 2019; Hatipkarasulu, 2011; NAWIC, 2019)</i>	a. Physically weak	B5a
		b. Mentally weak	B5b

**Table 6.** Coding Matrix of Discriminatory Ethics Determined by Interviewees

<b>Category B: Barriers and Challenges Encountered Relating to Women’s Participation</b>													
<b>Theme 1: Discriminatory Ethics</b>													
	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13
B1a			✓		✓			✓	✓				
B1b	✓	✓				✓		✓	✓	✓	✓	✓	✓
B1c									✓				

**Table 7.** Coding Matrix of Workplace Harassment Determined by Interviewees

<b>Category B: Barriers and Challenges Encountered Relating to Women’s Participation</b>													
<b>Theme 2: Workplace Harassment</b>													
	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13
B2a			✓				✓			✓			
B2b		✓	✓	✓	✓		✓		✓	✓			
B2c			✓	✓									
B2d		✓	✓	✓	✓								
B2e									✓				

**Table 8.** Coding Matrix of Barriers and Challenges Expressed by Interviewee  
**Category B: Barriers and Challenges Encountered Relating to Women’s Participation**

Interviewee	Data Transcript	Code
R1	“Women in Malaysia have the perception that the <b>work environment</b> in the construction industry is <b>unsuitable</b> for them.”	B2a B2b
R2	“...the <b>safety and cleanliness issues</b> on site need to be improved.”	B3b
R3	“Most of the women are <b>driven by emotion</b> which ends up making irrational decisions.”	B5b
R4	“Women are indeed <b>weaker than men</b> in the consequence of <b>human biology</b> . Women are <b>emotional</b> when it comes to dealing with problems.”	B5a B5b
R5	“As a woman myself, I cannot deny that we tend to <b>express our emotions more intensely</b> compare to men, and I also agree that we <b>cannot do much physical work or tasks</b> .”	B5a B5b
R6	“If I have to <b>describe men and women</b> in such a way, I will classify them as either <b>hard or soft</b> . It is easily understandable when we have to judge the gender quickly.”	B5a B5b
R7	“ <b>Physical hard labour is not suitable</b> for the <b>female gender</b> .”	B5a
R8	“When women are working in a <b>male-dominated industry</b> , without fail there will be some kind of <b>unfair treatment</b> in terms of <b>wages</b> or when <b>hiring</b> .”	B1a B1b B3a
R9	“...women are <b>physically weak</b> , <b>hard labour</b> such as concreting is <b>unsuitable</b> that is why <b>most of the construction workers are men</b> . The <b>construction industry in general is difficult for women</b> ...”	B3a B3c B5a
R10	“ <b>Physically speaking women are much weaker than men</b> , therefore in my opinion the <b>construction industry is not that suitable for the females</b> considering it is largely <b>male dominated</b> , unless they can <b>prove themselves capable</b> than men and <b>earn their respect</b> . Further, women working in the industry may be viewed as <b>unfeminine</b> considering their attire and them mingling with the men on site.”	B3a B4a B5a
R11	“For sure there is a <b>gender gap</b> in the industry, although better than it has been, but it is still there. When the idea of women taking more time off because of maternity and paternity leave, it will essentially lead to a <b>pay gap</b> . It also relates to work ethics as expected of being dedicated and ambitious, which is why there are situations where women are <b>not given many opportunities</b> to deal with operations by themselves.”	B1b B1c
R12	“...they must be exposed into the <b>environment</b> requiring proficiency in social skills.”	B3c
R13	“The construction industry lifestyle is <b>challenging</b> and <b>stressful</b> ...”	B3c

Based on the Table 5 – Table 8, analysis revealed that the occurrence of remuneration discrimination is still prevalent. It had also been determined that biased recruitment procedures were practiced in a range of workplaces withal. Both the unethical behaviours demonstrated an overlap with the history where women suffered from mistreatment in the forms of wage disparity and debarment in the construction industry (O’Connors, 2019 and Ing, 2019). The results are also found to agree with Garner’s (2019) findings stating that construction industry is still among the sectors with the highest gender pay gap. Results also revealed that the qualities of men being able to work for longer hours, aggressive about negotiating for raises and committing labour-intensive jobs erode the conception of sex discrimination in pay gap contributed (Poole, 2018) as the barriers toward women’s participation in the construction industry. Certainly, the phenomenon was better than it had been, but it is still there. Further, personal harassment was greatly encountered by working individuals while sexual harassment was not of frequent case as contrasted in studies from previous literature. The basis of such workplace harassment took place as due in poor human relations among the employees. The results are also found to be aligned with the findings by (Miller, 2016; Donaldson, 2018; Buncio, 2019; Arnholz, 2020) that the notion of 3D – dirty, dangerous, difficult—used to describe the construction industry had worsened the level of interest of female workforces. As much as the construction companies should not trivialise the on-going problems within, women’s physical shortcomings placed a limit on career

opportunities in the industry. In a nutshell, construction employers are responsible for what is called barrier removal, while women need to work on personal development to be a more competent worker in the construction industry.

### Perceptions of Women Working in Construction Roles

This part of research was included deliberately to discover the impressions of women working in the construction sector, specifically in the attainment of leadership roles as well as employees in general. Data obtained are shown in Table 9 – Table 12.

**Table 9.** Coding Legend for Category C

Category	Theme	Sub-theme	Code
<b>C.</b> <b>Perceptions of Women Working in Construction Roles</b>	1. Gender dynamics in leadership <i>(Shanmugam, Amaratunga &amp; haigh, 2006; Ulger &amp; Morsunbul, 2016; Guraj, 2017; Ranstad, 2019)</i>	a. Women would do a better job	C1a
		b. Men would do a better job	C1b
		c. No difference/Depends	C1c
	2. Leadership qualities <i>(Shanmugam, Amaratunga &amp; haigh, 2006; Ulger &amp; Morsunbul, 2016; Guraj, 2017; Ranstad, 2019)</i>	a. Honest and ethical	C2a
		b. Compassionate and empathetic	C2b
		c. Persuasive	C2c
		d. Willing to take risks	C2d
		e. Working well under pressure	C2e
		f. Makes good decisions	C2f
	3. Peer impression <i>(Shanmugam, Amaratunga &amp; haigh, 2006; Ulger &amp; Morsunbul, 2016; Guraj, 2017; Ranstad, 2019)</i>	a. Polite and respecting	C3a
		b. Develop high quality work	C3b
		c. Collaborative/Cooperative	C3c
		d. Communicate transparently	C3d
		e. Behave ethically	C3e
		f. Provide assistance	C3f
		g. Appreciative	C3g
		h. Punctual and professional	C3h

**Table 10.** Coding Matrix of Gender Dynamics in Leadership Determined by Interviewees

Category C: Perceptions of Women Working in Construction Roles													
Theme 1: Gender Dynamics in Leadership													
	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13
C1a	✓												
C1b			✓										✓
C1c		✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	

The modernisation of societal roles and beliefs had significantly overturned the stereotypical thinking of women undertaking a career in the construction industry. The analysis revealed that the results agree with Ranstad’s (2019) findings, which femininity was reviewed to be derived individually rather than being influenced by external factor, such that women engaged in the construction industry are not condemned as unfeminine. In addition, peer impression conducted towards female employees in the construction industry received satisfactory feedback as an overall. Interviewees are viewing a non-gender specific appointment in leadership roles considering the patriarchal control practiced back in the late 14<sup>th</sup> century no longer effective in the current society, specifically within the construction industry context. Hence in general, it was discussed that women can be in the position of authority as well despite under a masculine environment of the industry.

**Table 11.** Coding Matrix of Leadership Qualities Determined by Interviewees

Category C: Perceptions of Women Working in Construction Roles													
Theme 2: Leadership Qualities													
	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13
C2a	Red	Red	Blue	Red									
C2b	Blue	Red	Blue	Red	Blue	Red	Red	Red	Blue	Red	Red	Red	Red
C2c	Blue	Red	Red	Red	Blue	Blue	Red	Red	Red	Red	Red	Blue	Red
C2d	Blue	Blue	Blue	Blue	Red	Blue							
C2e	Red	Blue	Blue	Red	Red	Blue	Red	Blue	Blue	Red	Red	Blue	Blue
C2f	Red	Red	Blue	Blue	Red	Blue							

	Women would do a better job
	Men would do a better job
	No difference/Depends

**Table 12.** Coding Matrix of Peer Impression Determined by Interviewees

Category C: Perceptions of Women Working in Construction Roles													
Theme 3: Peer Impression													
	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13
C3a	✓	✓		✓		✓	✓	✓		✓	✓	✓	✓
C3b	✓	✓	✓	✓	✓	✓		✓			✓	✓	✓
C3c	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
C3d				✓		✓	✓	✓	✓	✓	✓	✓	✓
C3e	✓	✓		✓		✓		✓		✓		✓	✓
C3f				✓		✓	✓	✓	✓	✓		✓	✓
C3g				✓		✓		✓		✓	✓	✓	✓
C3h	✓			✓		✓		✓		✓		✓	✓

### Evolutionary Change of Women’s Involvement in The Construction Industry

The data obtained was categorised into five main themes namely to identify the transformation took place within the construction industry, modernisation of social values, and future expectations reflected by industry insiders (refer to Table 13 – Table 15).

**Table 13.** Coding Legend for Category D

Category	Theme	Sub-theme	Code
D. Evolutionary Change of Women’s Involvement	1. Workplace involvement <i>(Zuska, 2009; Larson, 2017; NAWIC, 2019; O’Connor, 2019)</i>	a. An even mix of men and women	D1a
		b. More men than women	D1b
		c. More women than men	D1c
	2. Social change and modernisation <i>(Gurjao, 2017; Larson, 2017; NAWIC, 2019; O’Connor, 2019)</i>	a. Ambitious	D2a
		b. Freedom of choice	D2b
		c. Enhanced qualifications	D2c
		d. Promote gender equality	D2d
		e. Girl power	D2e
		f. Economics environment	D2f
	3. Personal female attributes <i>(Larson, 2017; NAWIC, 2019; O’Connor, 2019)</i>	a. Physically strong	D3a
		b. Mentally strong	D3b
	4. Improved industry image	a. Historical change over time	D4a
		b. Dominance of women	D4b
		c. Industry opportunities and needs	D4c

Category	Theme	Sub-theme	Code
	(Gurjao, 2017; Larson, 2017; WIBM, 2017; NAWIC, 2019; O'Connor, 2019)	d. Promote gender diversity	D4d
		a. Potential increment	D5a
	5. Future expectations	b. Ascending trend	D5b
	(Larson, 2017; WIBM, 2017; NAWIC, 2019; O'Connor, 2019)	c. Advancement of construction technology	D5c
		d. Unlikelihood	D5d
		e. Preservation of cultural beliefs	D5e

**Table 14.** Coding Matrix of Workplace Involvement Determined by Interviewees

Category D: Evolutionary Change of Women’s Involvement													
Theme 1: Workplace Involvement													
	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13
D1a										✓	✓		
D1b							✓		✓			✓	✓
D1c	✓	✓	✓	✓	✓	✓		✓					

Table 15 compiled the data transcript of interviewees with regards to subsequent themes concerning the evolutionary changes within the construction industry, in the context of women’s involvement. Transliteration of viewpoints expressed were personal disclaimer.

**Table 15.** Coding Matrix of Barriers and Challenges Expressed by Interviewees

Category B: Barriers and Challenges Encountered Relating to Women’s Participation		
Interviewee	Data Transcript	Code
R1	“Adapting to the <b>change of society</b> , most women today are not solely committed to the role of housewife and it is <b>not obligatory</b> . A <b>working wife</b> is <b>independent</b> and <b>less assertive</b> at home.”	D2c
		D2e
		D2f
	“As a whole, women can be <b>physically and mentally tougher</b> because they <b>never stopped challenging themselves</b> . They find any sorts of ways to constantly <b>improve themselves</b> to keep track with the society.”	D2a
		D2c
		D3a
		D3b
		D3c
	“It is only a <b>social stigma</b> that women cannot work at construction sites. There are <b>a lot of opportunities</b> in sub-functions and other profiles like contracts, billing, management. Women are also <b>gaining recognition as potential workforces</b> across the construction industry over the past years. The industry is <b>no longer dominated by male workers</b> and <b>female workers are equally capable</b> of performing their roles. But in general, women’s <b>negative perceptions</b> towards the working environment in the construction industry <b>still exists</b> .”	D2d
		D2e
D4a		
D4c		
D5a		
D5b		
D5d		
D5e		
R2	“It is the <b>individuality that defines femininity</b> , the change of character does not entirely lie on the construction industry itself.”	D2e
		D2b
	“Women can contribute their <b>talent and expertise</b> in the workplace as well, therefore <b>they can work too</b> instead of conforming to be only a housewife. It is a balance between these two roles to be achieved.”	D4a
		D4b
		D4c
R3	“The statement of construction being a male-dominated industry is the <b>history</b> in the past. Hence, the <b>ancient type of thinking</b> should be abolished today. In the present, <b>female is recognised</b> and <b>become dominant</b> especially in consultancy firms. I am <b>willing to engage</b> my daughter to a construction job in the future.”	D5a
		D5b
		D5c
	“ <b>Women can work like men</b> since they are also <b>qualified</b> . They are <b>equal to men</b> in terms of education level. Further, <b>inflation</b> is another threatening issue which requires both husband and wife to work to support the family.”	D2d
		D2e
		D2f
“The <b>construction industry needs female</b> especially for <b>desk jobs</b> in the office with lower technical skills required.”	D4c	
	D4d	

Category B: Barriers and Challenges Encountered Relating to Women's Participation		
Interviewee	Data Transcript	Code
	"I will <b>definitely encourage</b> my child to participate in the construction industry, because it does not only deal with cement and sand but also <b>requires documentation tasks where women are good at</b> . I am seeing <b>opportunities for more women</b> into the industry as well, especially with the <b>increase engagement of BIM</b> ."	D4c D5a D5c
R4	"In this new era, <b>women must have their own income</b> and be prepared for unpredictable things that might happen in the future."  "The thoughts of <b>female being unsuitable for the construction industry is irrelevant</b> . There are <b>opportunities and recognition provided</b> by organisations and government."  "I am <b>willing to engage</b> my kids into the construction industry to accept the challenges, but not for too long. I hope for them to gain practical experience and then move on to another sector such as academician or research industry."	D2f  D4a D4c D5a D5a
R5	" <b>Everyone deserves to pursue his or her own dreams</b> , women should not be confined to the traditional roles and stay at home only."  "Suitability of women in the construction industry depends on the type of work in discussion. There is <b>no problem for women to be part of the professional or technical team</b> . The life cycle of construction inclusive from inception to demolition of building itself. It involves a lot of phases that <b>requires multiple skills of professionals</b> including designing, costing, construction, managing and maintaining the building. <b>Women can do these tasks</b> . We cannot view construction as labour works only."  "As long as there is <b>passion</b> , it is <b>not a problem to engage</b> my child to pursue a career in the construction industry."	D2b  D4c  D5a
R6	" <b>Many women are capable</b> , and they also <b>want to have a career</b> now. Although the engagement as housewife and working wife cannot be equal, but it has to strike a balance somehow."  "Over the years I have been working in the construction industry, there are <b>more and more women getting involved</b> . If my kids show interest in the industry, certainly I <b>will encourage them</b> , otherwise I will just leave it to them."	D2a D2e  D4b D5a D5b
R7	"Every woman is different, so they <b>choose and decide what they want</b> to do with their life, either committing as a housewife or going out to work. As long as they do not infringe upon others' rights, they <b>can do anything they want</b> and are able to."  "On the contrary, science has proven that women are the <b>stronger gender both physically and mentally</b> ."  "The construction industry has traditionally been male-dominated but it <b>does not mean that it is only limited to men</b> . Both men and women have their own strengths and weaknesses, and so having a <b>mixture</b> is best as <b>diversity usually yields better results</b> ."  "Expectations are objective. Physical hard labour is unsuitable for the females, but once <b>most of the activities are automated</b> as well as the <b>wider use of IBS, more women can participate</b> not only in the area of management but also at the operatives level."	D2b  D3a D3b D2e D4a D4d D5a D5c
R8	"It <b>depends on individual interest</b> , but working wife is preferable."  " <b>Gender is not an issue</b> in the construction industry, whether they want to get involved, the <b>decision is based on them individually</b> ."  "The construction industry is a <b>good field and career choice</b> overall. It <b>provides a lot of job opportunities</b> . I <b>will not hesitate to encourage</b> my child to join the industry."	D2b D2b D4a D4c D5a
R9	"In the aspect of career, women should not limit themselves, they can <b>be whatever they want</b> . But working wife have <b>better insurance of themselves</b> . Women <b>should not depend</b> too much in their spouse financially."  " <b>Women can manoeuvre themselves among men</b> if they know where the rope is. They are <b>opportunities</b> for them in the <b>management level</b> , as <b>more women excel in academia</b> ."  " <b>No, I will not suggest</b> my kids to pursue a career in the construction industry. It is hard, very hard."	D2b D2e  D2e D4c D5a D5d
R10	" <b>Equality of gender</b> is in trend today, <b>men can be the househusband</b> as well instead of women traditionally. Some women are <b>stronger than men</b> in the aspects of <b>mental strength</b> that made them <b>capable to work</b> too. However in general, <b>women can commit as housewife</b> when their children are still little, only then they can return to work once the kids start attending schools."	D2d D3b D5e

Category B: Barriers and Challenges Encountered Relating to Women's Participation		
Interviewee	Data Transcript	Code
	"If my child is <b>capable and intelligent</b> , it is <b>not a problem</b> for them to <b>participate in the construction industry</b> . All careers are the same."	D5a
	"Indeed, <b>there is potential</b> for more women in the construction industry because of <b>equality of sexes</b> . <b>Women are getting tougher</b> and <b>can take care of themselves</b> in the construction industry."	D2c D2d D5a
R11	"Women <b>need to have career</b> . Strictly speaking, they can be <b>stronger than men</b> is the aspects of <b>physical and mental strength</b> . <b>Women can perform better</b> in <b>some professions</b> within the construction industry."	D2f D3a D3b D4c
	"If my <b>child is interested</b> , then <b>yes</b> , I am <b>willing to engage</b> them into the construction industry."	D5a
R12	"Women tend to <b>investigate problems meticulously</b> until it is solved, whereas men just let it go with the flow. Women are <b>serious competitor mentally</b> , and <b>physically they are fitter than men</b> . Men usually tends to suffer many sicknesses as they grow older because most men do not bother to maintain themselves compared to women who always want to look beautiful all the time. That is why women know how to <b>take care of themselves very well</b> ."	D2a D3a D3b
	"In the aspect of construction industry, <b>women tend to be better</b> because they have <b>less ego</b> compared to men. They <b>can communicate much better than men</b> on site. They can also <b>provide diverse opinions</b> because most men think alike. <b>Innovative opinions</b> are needed in the industry instead of depending on the men all this while."	D2c D2e D4c
	" <b>Working wife is better</b> , because they can <b>help to contribute extra income to the family</b> ."	D2e D2f
	" <b>Yes</b> , so that my kids can trained to be more outdoorsy and know how to communicate well, regardless as general workers or any kind of positions. They need to be exposed into this environment <b>to combat selective treatment in the future</b> ."	D2d D5a
R13	" <b>Women and men need each other</b> to achieve best results, for example in managing a project. Some things <b>need women's touch</b> , such as the <b>paper works</b> and also as <b>company representative</b> . You know how they say, "Behind every successful man there stands a woman."	D2e D4c D4d
	" <b>No</b> , I <b>will not encourage</b> my child to join the construction industry. It is <b>stressful</b> ."	D5d
	"If women are <b>willing to learn and take challenges</b> , then <b>there is a potential of increment</b> in the construction industry."	D2a D5a

This research umbrellaed the transitions took place within the construction industry from the late centuries to the modern era. The analysis revealed that expectancies for the time ahead was incorporated into the bargain to determine what the construction industry beholds for prospective workforces, particularly the females. The outcome was favourable considering that interviewees cited a potential increment of women participation in the construction industry (Gurjao, 2017). The satisfactory result was due to the enhanced qualifications and capabilities of women to work alongside men, the needs of innovative ideas to improve construction quality, as well as wide-ranging job opportunities awaiting women to engage in (Larson, 2017; NAWIC, 2019). Interviewees expressed that the current stride of women's involvement in the construction industry is proving an ascending trend. In addition, results revealed that the advancement of construction technology certainly will ease the primary concern of women's engagement in on-site occupations. Overall, the construction industry has changed for the better and its momentum needs to be maintained and conserved to create a workplace where women can thrive in.

## CONCLUSION AND RECOMMENDATION

By contrast, societal changes and modernisation of cultural beliefs had elevated women's status with the propaganda of "girl power". Perpetual strategies for self-improvement were undertaken which in turn enhanced their qualifications and being capable of working alongside men instead of adhering to the traditional role of a committed housewife. The construction industry established as exclusively male in the 14<sup>th</sup> century, and in the modern era, it recognises the values and positive effects upon women's contributions, consequently prophesying the need of such resources of great worth. Notwithstanding the realisation of advantages conceivably created by women and career opportunities said to be provided for them within the construction industry, unconscious bias in the forms of selective recruitment procedures and remuneration discrimination are still prevalent. Workplace harassment occurs withal, yet sexual harassment is not predominant. Apart from that, the average person can perceive a very stereotypical view of individuals working in construction industry due in the lack of understanding. In a nutshell, there is an overlapping of the historical and modern perception and practices within the industry which need to be addressed and scrutinised. The construction industry is unique in its characteristics of interdependency and requiring coordination of many parties which offers a wide spectrum of career opportunities. Certainly, it has changed for the better and more women can be found working in the industry, but there is still room for improvement and references can be made across countries. Besides increasing recruitment, construction companies as well need to exert effort in retaining female talent into full range of roles and at all levels. For good measure, it is critical to reach out the generality with enlightenment what a great industry construction is. Population of interest for this research was decided upon Registered Quantity Surveyors, which is classified among professional bodies in the construction industry. Comprehensive and impartial findings obtained, by and large, were in the opinions of construction employees of white-collar rather than those involved on-site or trade jobs. Critical issues such as discriminatory ethics and workplace harassment may differ in severity due to gender segregation as well as working environment. Therefore, further studies may need to canvas the opinions of the parties primarily excluded in this research.

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# CRITICAL RISK FACTORS IN CONSTRUCTION PROJECTS: A DEMATEL-BASED MODEL

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## Abstract

Construction projects are defenceless to more risks compared to the other industries due to their nature and complexities. These risks can lead to performance reductions, increased costs, scheduling delays, and even project failure. It is noted that the success of the project depends on identifying the most common risk factors and mitigate them effectively. Numerous studies have discussed the significance of investigating the critical risks in the construction projects but the complex causal relationships among the risk factors and their relative significance with respect to each other remain unexplored. The purpose of this paper is to identify the critical risk factors and investigate the interrelationship among the risk factors in the construction projects. Detailed literature review has been conducted and ten risk factors were identified. Decision Making Trial and Evaluation Laboratory (DEMATEL) is employed in the study to prioritize the risks and then analyse the causal relationship among the factors. Based on the interview data from thirteen experts, the results show design risks are the critical risk factors. The findings in this study can provide structural visualization of complex causal relationships among risk factors and also allow construction experts to prioritize the resource allocation to achieve project objectives.

**Keywords:** *Construction Industry; Critical Risks; Decision Making Trial & Evaluation Laboratory (DEMATEL).*

## INTRODUCTION

One of the main contributors to the economy of any country is the construction industry (Riazi et al., 2018). The jobs created, outputs generated and income provided by the industry contributes towards sustainable economic development. According to Durdyev and Ismail (2012); Kwabena A. Anaman (2007), the construction output has a positive relationship towards the economic growth, especially in developing countries. Based on Hasmori et al. (2018)), the construction industry in Malaysia contributes to the Gross Domestic Product (GDP) value. In 2019, the construction industry contributed 4.2% to the GDP value (Department of Statistics, 2019). Although the construction industry in Malaysia is developing at a rapid rate, delay of projects and cost overruns, unsatisfactory quality of performance, inadequate local labour workers and insufficient resources are classified as chronic issues that exist in the construction industry. According to Abdul Rahman et al. (2012); Vaardini, Karthiyayini, and Ezhilmathi (2016), 92% of construction projects faced delays and 89% of the projects were over budget.

There are many factors that may affect the quality, schedule and budget of the projects in which the risks involved in a project may also be considered a factor (Ibrahim & Esa, 2018). During the construction stage, the risks involved greatly affects a project's performance. Cakmak and Tezel (2019); Ehsan et al. (2010) revealed that the risks involved cannot be excluded in projects and the consequences of the risk varies according to the project type. Khan and Gul (2017) highlighted that the reason to projects being exposed to multiple risk

factors are due to the involvement of various stakeholders with multiple stages of work with prolonged work hours.

In the past decade, extensive studies of risk management in construction have been done, which according to Ghasemi et al. (2018); Hanna, Thomas, and Swanson (2013); Monat and Doremus (2018); Stosic, Isljamovic, and Mihic (2013) includes risk identification, risk assessment (Boulaid, Bahi, & Ouadif, 2018; Daniilidis, Doddema, & Herber, 2016; N. Li, Fang, & Sun, 2016; Monzer et al., 2019), and risk mitigation based on Dai, Wu, and Li (2017); Kirthika and Praveen Kumar (2015); Nishaant et al. (2019); Zuo and Zhang (2018). Although various construction risk factors have been identified, there has not been much attention given on the critical risk identification which consider the direct, indirect, and interdependencies among the risk attributes in the construction projects. Therefore, the research gap can be addressed by the present study.

This study is conducted to determine the critical risk in the construction projects and to investigate the causal relationship among the risk factors. This finding would provide useful information for the construction experts to prioritize the resource allocation and maximize the utilization of resources in order to improve the overall performance of construction projects. Besides, the management team can have better understanding on how the risks are generated and be aware of the critical risk factors in the future. Moreover, the findings allow construction practitioners to make proper decisions in mitigating the risk effectively.

## **LITERATURE REVIEW**

### **Risk Management in Construction Projects**

In the construction industry, risk management is a noteworthy field and in recent years, this field has gained worldwide attention as many studies have been conducted. In order to contribute significantly towards the construction industry, Iqbal et al. (2015) suggested that risk management should be focused in future studies. Risk management has to be properly performed at the initial stage of projects as if it is not performed properly, the project managers would find it more complex and difficult to handle the risks that occur in projects (Serpella et al., 2014; Srinivas, 2019). The description level, difficulty of tools, the sum of time and resources spent in risk management should correlate to the type of projects and the value that they can provide to the results when implementing risk management in the construction sector. For instance, based on Rehacek (2017), the larger the project, the resources, time and attention required to conduct risk management also increases. The implementation of risk management may not guarantee the achievement of success in projects, however, the likelihood of project failures may be reduced (Abazid & Harb, 2018). Risk management is noteworthy as it can contribute to a positive potential return on investment for the project.

### **Types of Risk in Construction Projects**

#### ***Technical Risk***

Technical risk may refer to an individual or a group of people who can possibly have an impact on a certain goal. Technical risk is often linked with various procedures or product design decisions and has potential to affect the outcomes. Furthermore, inaccurate

calculations and omission errors can be described as technical risks according to Khan and Gul (2017). Inefficient communication, lack of supervision, insufficient resources, equipment failures and poor material quality and work are examples of technical risks (Dey, 2001; J. Lee, Lee, & Kim, 2013; Mañelele & Muya, 2008; Reddy, 2015; W. Tang et al., 2007). Technical risks will end in many shortcomings and subsequently have an impact on the construction work as well as huge expenditures would be required to cover up the defects.

### *Financial Risks*

According to Sohrabinejad and Rahimi (2015); Ehrlich et al. (2008); Khan and Gul (2017) and Z. Wu et al. (2017), the most crucial risks in their research was mentioned as financial risks. Financial risks correlate with the funding system and implications on whether the initial cost can be recovered through the return on investment. According to Han et al. (2014), financial risks are variables related to the market that takes into consideration the external financial circumstances and contract particulars including exchange rates, interest rates, inflation rates and depreciation rates. Improper management of financial risk can cause the construction companies to result in failure of their business activities. Failure to address financial risks will result in projects falling behind schedule, contractors rejecting to correct defects, demanding for additional payments and declaring bankruptcy intentionally (H. Li, Arditi, & Wang, 2015).

### *Site Condition Risks*

According to Shahbodaghrou and Samani (2012) and Ferreira, Santos, and Silva (2019), the site condition should be a factor to be taken into consideration in risk assessment. The risks related to site condition include condition of roads, utility services and other structures and infrastructures on the construction sites. Unknown physical condition refers to site conditions that differ materially from what has been documented in contracts. Based on the findings of Amarasekara, Perera, and Rodrigo (2018), there is a high impact on design and build contracts when the site conditions are different. As a result of differing site conditions, projects may be delayed and cost overrun may occur. These consequences may happen as it is unexpected and unforeseeable by the contractor when bidding. The projects that undergo work stoppage on site can only resume when relevant decisions are made.

### *Human Capital Risks*

Previous studies identified manpower as the main factor that contributes to the success of projects (Khan & Gul, 2017; Mañelele & Muya, 2008; Park et al., 2019; Shahbodaghrou & Samani, 2012). Human capital risks refer to events that are associated to the workers or the operation of company influenced by the conduct of the workers (Shahbodaghrou & Samani, 2012). Employees with capabilities, knowledge and skills that vary are considered as human capital assets. These assets are important in the implementation of the policies, practices and technologies in construction projects (Yusof et al., 2018). The common human capital risks are lack of labour supply, insufficient professionals, inexperience administration or supervision and the over dependency of foreign workers. Human capital risks can reduce productivity, increasing the risk of delays, quality problems, and safety concerns.

### *Project Management Risks*

In order to achieve success in construction projects, the project management team plays an imperative part in contributing to the achievement. Therefore, the project management risks are considered as an important risk factors (Sohrabinejad & Rahimi, 2015). From initiation to the construction phase, many impacts can be resulted from improper project planning and budgeting. According to Banaitiene and Banaitis (2012); J. Lee et al. (2013); Sathishkumar, Ragunath, and Suguna (2015), estimation inaccuracy, unclear objectives of project, undefined scope of project, legally binding issues, delays, affected quality and insufficient period for bid preparations are risks associated with poor project management.

### *Political Risks*

When a threat towards the project income resulting from an impact from outside a project, usually regulatory actions, it can be considered as political risk (Alfraidi et al., 2020). Mubarak, Husin, and Oktaviati (2017) also mentioned that the attribute in political risks includes government law, political uncertainty and labour strikes. Political risks may cause organisations existing inside a particular nation to breach the rules and regulations, resulting in financial penalties (T. Chang, Hwang, et al., 2018; Shahbodaghlou & Samani, 2012). According to T. Chang, Deng, et al. (2018); Xiaopeng and Pheng (2013), the risks under this category are more complexed, unpredictable, and out of project scope in which affects projects before and during construction period. If there is inadequate legal vision of the criteria and changes to comply with government regulations, companies may be put at risk.

### *Health and Safety Risks*

Matters regarding safety and environment should be taken into consideration in construction projects (Cha & Shin, 2011; Shamsuddin et al., 2015; W. Tang et al., 2007). Risks that involve people such as fatalities and accidents are referred to as health and safety risks. The assurance of these risks depends on the physical conditions of any specific worker that develops a specific adverse reaction. During construction, the equipment with defects such as machineries, scaffold and ladder are the main cause of physical risk. Common hazards that are present on site include insufficient number of personal protective equipment (PPE), lacking security protection for machines, clutter of the floor and noise. Besides, if not properly controlled and managed, chemical and biological hazards can have an indirect impact on human beings. Other than that, insufficient systematic inspection of machineries, fire extinguishers and handrails may increase the possibility of mishaps when constructing a building (Gunduz & Laitinen, 2018).

### *Contract Risks*

Cha and Shin (2011), Mañelele and Muya (2008), and Park et al. (2019) stated that contract risks are considered a factor affecting the cost performance level in a project. It is not an easy task to incorporate everything into the contract agreement, since many things are unpredictable. Contract risks emerge from contractual activities. As the allocation of budget is more for procurement activities, it may have an adverse effect on the primary goal of the project. For example, unsatisfactory workmanship of the parties involved in the contract, bad contract management, early termination of contract, inexperienced contractors and legal

formalities. On the off chance that either one party comes up short to meet the terms and conditions agreed, legal disputes may arise.

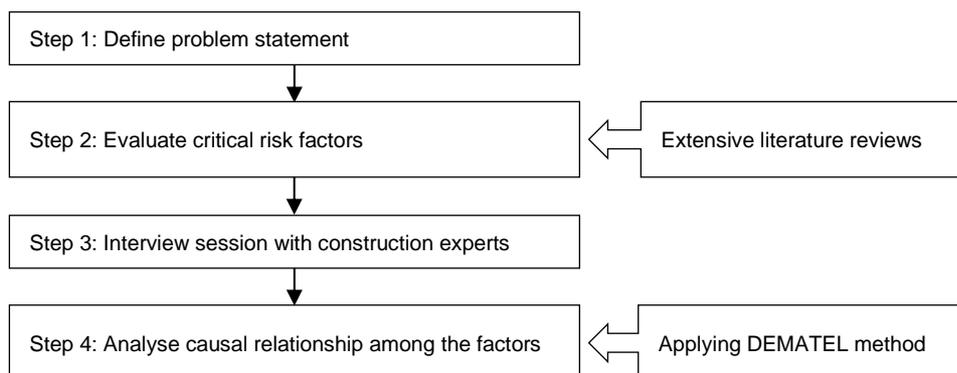
### *Design Risks*

Liu et al. (2017); Nieto-Morote and Ruz-Vila (2011) stated that design errors or unsatisfactory designs which do not achieve requirements of employers or relevant legislation are the factors that contribute to these problems. Design risks also include designs that do not correspond to the proposed timeline, unsuitable building design codes and standards, deficiency of management practices and experiences and inflexibility of designs (P. Wu et al., 2019). Furthermore, increasing design complexities raises challenges for contractors in sourcing, which results in the need to incorporate design expertise to ensure there are no issues during the project execution. Öztaş and Ökmen (2004) revealed that scope and quantity change, unexpected ground condition and delay in design are the major contributors of schedule delay.

### *Environmental and Force Majeure Risks*

Environmental risk is known as a threat to natural resources and to the environmental deterioration, which has an indirect impact on human health. Environmental risks are usually related specifically or by implication with the construction activities. The environmental risks in the construction industry are such as risk of land degradation, risk of air pollution and risk of water pollution. These risks may occur during stages of construction, operation or stages in the closing of operations and in unusual condition or contingency situation such as heavy rain or avalanches (Rahman & Esa, 2014). Natural calamities like earthquakes, volcano eruptions and external factors such as new environmental regulations can also be categorised as environmental risks. Environmental risks are not easy to mitigate and usually, the risks would need to be accepted by the stakeholders. For instance, extension of time for work delay will be given to contractors due to force majeure events (Al-Ashwal & Al-Sabahi, 2018).

## **METHODOLOGY**



**Figure 1.** Methodology Framework of Study

This paper was initiated with the definition of the problem statement. Next, extensive literature review had been performed to find relevant articles of construction risks. The risk factors in the construction project were determined by implementing systematic review to

filter the articles. After the questionnaires were established, interview sessions were conducted with professionals for data collection. This study applied the purposive sampling method in order to select the respondents to participant in the study. The target respondents in this study were experts with a minimum of 10 years of involvement in the construction industry. After receiving the completed questionnaires from experts, DEMATEL technique was used to analyse the causal relationship among the factors. In Figure 1, the overview of the proposed framework is depicted.

## Purposive Sampling Method

This study uses the purposive sampling method to select respondents for the study. This method is acquires the judgement of the researcher as to who will provide the best information to achieve the research objectives (Etikan & Bala, 2017). The researcher would be able to depend on the researcher's judgement to select the specific units for the study. According to Sharma (2017), the purposive sampling method is able to provide the researcher with justifications to make produce generalisations from the sample that being studied, whether it is theoretical, analytical or logical in nature.

## Systematic Review

Baird (2018) suggested that systematic review is aimed to resolve specific research questions by collecting, assessing and outline all verifiable evidence that fulfils the pre-established eligibility requirements. This procedure would help researchers identify and discuss the best evidence, confounding findings and research gaps in the literature (Gupta et al., 2018). The reliability of the research can be increased by using the systematic review process (Ke, Wang, & Chan, 2012; C. K. Lee, Yiu, & Cheung, 2016).

Through systematic review, research questions were established clearly and precisely. A thorough search was then conducted using the "Scopus" search function. In order to meet the requirements of this study, the search keywords with the specific term "project risk" or "construction risk" were inserted in the field "title/abstract/keywords." Based on this step, the results showed a total of 1973 articles related to construction risk and project risk. After narrowing down the subject area, the articles shown were reduced to 1591 articles. Then, a more thorough visual analysis of content was conducted to extract the articles that are closely related to the research topic and the results are presented in Table 1. Ultimately, 10 risk factors are identified from the articles as shown in Table 2.

**Table 1.** Segmentation of Articles According to Themes

Theme	Number of Articles	Percentage %
Risk modelling and analysis	151	27
Risk perception from third party	32	5.7
Risk assessment	59	10.6
Risk factors	36	6.4
Risk impact	24	4.3
Risk management	117	20.9
Risk mitigation	21	3.8
Risk management approach	119	21.3
<b>Total</b>	<b>559</b>	<b>100</b>

**Table 2.** Risk Factors in The Construction Projects

Factors	Author
C1: Design risks	Rostami and Oduoza (2017), Liu et al. (2017)
C2: Political risks	(Niazi & Painting, 2017), Mubarak et al. (2017)
C3: Financial risks	Park et al. (2019), Mubarak et al. (2017)
C4: Site condition risks	Forteza, Carretero-Gómez, and Sesé (2017), Jayasudha and Vidivelli (2016)
C5: Human capital risks	Windapo (2016), Khanizad and Montazer (2018)
C6: Project management risks	Abiodun, Ruben, and Julius (2018), R.Sakthiganesh, Dr.S.Suchithra, and S.Saravanakumar (2017)
C7: Health and safety risks	(Gunduz & Laitinen, 2018), Mashia, Subramaniama, and Joharia (2016)
C8: Contract risks	Dziadosz, Tomczyk, and Kapliński (2015), Sohrabinejad and Rahimi (2015)
C9: Technical risks	Khan and Gul (2017), Al-Ashwal and Al-Sabahi (2018)
C10: Environmental & Force majeure risks	Eskander (2018)

## DEMATEL Method

In order to resolve the complex relationship within the correlated factors, this study implemented the Multi-criteria decision making (MCDM) method. Among the MCDM tools that are available, this study adopted the Decision Making Trial and Evaluation Laboratory (DEMATEL) to carry out the analysis of multiple interrelated attributes. In the recent years, this method has been adopted in an increasing rate to address different matters including social, economic, or technical matters. The DEMATEL method has been commonly used in scientific discipline comprising of management, technology innovation and engineering sectors (Hsu & Lee, 2014). According to Gołabeska (2018); Gawlik (2016) and Mardani et al. (2015), the DEMATEL method was suggested in their studies as one of the best complex decision making tool as it comprises the mixture of qualitative and quantitative criteria. Moghaddam et al. (2011) highlighted that it is important to suggest a correct model for taking steps to obtain the most important factors in a precise direction. The final key factors obtained would be inaccurate or weak if the defining method lacks verification and integrity. Therefore, any strategies implemented to resolve the conflicts between the factors would be invalid. This technique includes the following basic steps (1) Gather expert's opinion and compute the average matrix, (2) Calculate the normalized initial direct-relation matrix D, (3) Derive the total relation matrix T, (4) Calculate the sum of rows and columns of matrix T, (5) Set a threshold value. (6) Build a cause-and-effect relationship diagram.

### Step 1: Gather Expert's Opinion and Compute the Average Matrix

A group of professionals were required to assess the level of direct influence among two variables listed in the pair-wise comparisons form. In order to view the pair-wise comparison form, a discrete scale range from 0 to 4 levels are used. According to the ascending order of the numbers, it symbolises the meaning of “no influence”, “low influence”, “medium influence” and “high influence”. The notation of  $x_{ij}$  is alluded as the degree to which the expert believes factor  $i$  influence factor  $j$ . For each expert, an  $n \times n$  non-negative matrix is formed as  $X^k = [x_{ij}^k]$ , where  $k$  is the number of experts with  $1 \leq k \leq m$ . Hence,  $X^1, X^2, X^3, \dots, X^m$  are the matrices from  $m$  experts (Sumrit & Anuntavoranich, 2013). The average matrix  $Z = [z_{ij}]$  is established as follows:

$$z_{ij} = \frac{1}{m} \sum_{k=1}^m x_{ij}^k \quad (1)$$

Step 2: Calculate the Normalized Initial Direct-Relation Matrix D.

Normalize initial direct -relation matrix D is obtained by dividing the average matrix (Z) by a scalar  $\lambda$  (Singhal, Tripathy, & Kumar Jena, 2018). It is calculated by using the following formula.

$$\lambda = \text{Min} \left[ \frac{1}{\max_{1 \leq i \leq n} \sum_{j=1}^n z_{ij}}, \frac{1}{\max_{1 \leq i \leq n} \sum_{j=1}^n z_{ij}} \right] \quad (2)$$

Step 3: Derive the total relation matrix T.

The total-influence matrix T is obtained by using Equation (3), where D is normalized matrix and I is an  $n \times n$  identity matrix.

$$T = D(I - D)^{-1} \quad (3)$$

Step 4: Calculate the sum of rows and columns of matrix T.

Characterise  $r$  and  $c$  be  $n \times 1$  and  $1 \times n$  vectors indicating the sum of rows and sum of columns of the total relation matrix T, respectively. Assume  $r_i$  be the sum of  $i$ th row in matrix T, then  $r_i$  summarizes both direct and indirect effects given by factor  $i$  to the other factors. If  $c_j$  represents the sum of  $j$ th column in matrix T, then  $c_j$  denotes both direct and indirect effects by factor  $j$  from the other attributes. When  $j=i$ , the sum  $(r_i + c_j)$  indicates the total effects given and received by factor  $i$ . That is  $(r_i + c_j)$  represents the degree of importance that factor  $i$  plays in the entire system. In contrast, the difference  $(r_i - c_j)$  shows the net effect that factor  $i$  contributes to the system. Factor  $i$  is a net cause if  $(r_i - c_j)$  is positive, while it is a net receiver if  $(r_i - c_j)$  is negative (Shieh, Wu, & Huang, 2010).

Step 5: Set a threshold value.

The elements in matrix T are averaged to calculate the threshold value ( $\alpha$ ). This computation aims to remove some negligible effects elements in matrix T. The factors with greater value than the threshold value would be chosen and then depicted in the cause-and-effect relationship diagram.

Step 6: Build a cause-and-effect relationship diagram.

The diagram can be obtained by mapping the dataset of  $(r_i + r_i, r_i - r_i)$ . The cause-and-effect relationship diagram is vital as it provides decision makers with information for judgement. The diagram shows the most significant factors and how the factors impact each other.

## RESULTS

Data were collected from 13 individuals who were professionals in the construction management position and with a minimum of 10 years of involvement in the construction sector. The experts were requested to determine the degree to which a factor influence or

being influenced by other factors. Since most of the respondents are unfamiliar in using the DEMATEL method for data collection, thus, explanation on the meaning of integer scores of 0-4 scale and the function of pairwise comparisons table were given to the respondents to ensure the accuracy of data. Besides that, the respondents were encouraged to give some explanation or justification to prove their claims during completion of questionnaire to increase the credibility of data. Each of the respondents took approximately 60 minutes to finish the survey. Snowball sampling method was implemented in this study in which the respondents would provide recommendation of other experts. This method can ease the difficulties of getting potential participants in this study.

Table 3 exhibits the profiles of the respondents. The experiences of respondents in this study are within the range of ten to more than twenty years. About 38.46% of the respondents hold a master's degree and the others 61.54% hold a bachelor's degree. The respondents hold the positions of project manager, senior project manager, consulting engineer, project engineer, contract manager, associate director and company director. This information shows that the respondents have a position in senior management level in which are considered an important role in the industry. Furthermore, some of the respondents are qualified as a professional engineer as they are entitled to the 'Ir' designation in front of their name. Hence, they have significant knowledge and profound understanding in the construction industry.

**Table 3.** Respondents' Profile

Measure	Item	Frequency	Percentage (%)
<b>Gender</b>	Male	8	61.54%
	Female	5	38.46%
<b>Age group</b>	31 - 35	2	15.38%
	36 - 40	6	46.15%
	41 - 45	2	15.38%
	46 - 50	-	-
	51 - 55	3	23.08%
<b>Education Level</b>	Degree	8	61.54%
	Master	5	38.46%
<b>Years of experience</b>	10 - 14	4	30.77%
	15 - 19	6	46.15%
	20 - 24	-	-
	25 - 29	3	23.08%
<b>Job titles/ Position</b>	Project Manager	1	7.69%
	Senior Project Manager	1	7.69%
	Contract Manager	1	7.69%
	Consulting Engineer	6	46.15%
	Project Engineer	2	15.38%
	Associate Director	1	7.69%
	Company Director	1	7.69%

According to the Equation (1), the average matrix ( $Z$ ) was constructed by using the inputs received from thirteen professionals after making the pairwise comparison. The results of average matrix ( $Z$ ) are exhibited in the Table 4. The normalized matrix shown in Table 5 is determined by dividing the scalar  $\lambda$ . The value of  $\lambda$  is equal to 22.8462 which is obtained using the Equation (2). Total relation matrix  $T$  which is calculated by utilizing Equation (3)

can be seen in Table 6. The average all elements of matrix T makes up the threshold value ( $\alpha$ ) which is 0.28498.

Following step 4 of DEMATEL,  $(r_i + c_j)$  indicates the importance of each factor in the overall analysis. Based on the Table 7, three factors such as financial risk ( $C_3$ ), design risk ( $C_1$ ) and project management risk ( $C_6$ ) contain the highest value of  $(r+c)$  in matrix T, which show their strongest dominance over other factors. According to  $(r+c)$  values, the overall ranking of the importance of ten risk groups was  $C_3 > C_1 > C_6 > C_7 > C_8 > C_4 > C_5 > C_9 > C_{10} > C_2$ .

The  $(r-c)$  value for each factor was further calculated to investigate the influence of each net cause and net receiver. Thus, the ten risk factors were divided into cause group and effect group based on the  $(r-c)$  value. If the value of  $(r-c)$  was positive, such factors were categorized in the cause group or net cause which directly impact on the others. The highest  $(r-c)$  factors had the largest influence on the others. In this finding, political risk ( $C_2$ ), environmental & force majeure risk ( $C_{10}$ ), site condition risk ( $C_4$ ), design risk ( $C_1$ ) and human capital risk ( $C_5$ ) were classified in the cause group, having the  $(r-c)$  values of 0.9608, 0.8444, 0.0684, 0.0656 and 0.3017 respectively. It also indicated that political risk ( $C_2$ ) was the most critical impact factor on the others.

If the value of  $(r-c)$  was negative, such factors were classified in the effect group or net receiver, and highly influenced by the others. In this findings, contract risk ( $C_8$ ), financial risk ( $C_3$ ), health & safety risk ( $C_7$ ), project management risk ( $C_6$ ), and technical risk ( $C_9$ ) were categorized in the effect group, with the  $(r-c)$  values of -0.7913, -0.5828, -0.4404, -0.2260 and -0.2003, respectively. Contract risk ( $C_8$ ) is the most impacted factor because it has the lowest  $(r-c)$  value.

According to the value listed in Table 7, cause and effect diagram is illustrated between a factor's importance  $r_i + c_j$  (x-axis) and the strength of its influence  $r_i - c_j$  (y-axis). The ten factors can be categorized into two groups of five through a line at  $r_i - c_j = 0$ . When  $r_i - c_j > 0$ , it indicates that the factors' influence is relatively strong compared with those factors for which  $r_i - c_j < 0$ . An impact relation map is drawn in Figure 3 to visualize the data and further understand the interrelationships between the factors. Only entries of greater value than the threshold value are considered in the causal relationship map. The dark boxes represent the top four strong influential factors while the light boxes are all the other factors. In Figure 3, the direction of the influence between two risk factors in construction projects is indicated by the arrow. The significant bi-directional relationship is illustrated by using a solid line while the significant uni-directional relationship is depicted by using broken lines. From Figure 3, it shows that design risk ( $C_1$ ) was the most critical factors because it directly influenced on the other six factors. Design risk ( $C_1$ ) had a mutual interaction on financial risks ( $C_3$ ), site condition risks ( $C_4$ ), project management risks ( $C_6$ ), health & safety risks ( $C_7$ ), contract risks ( $C_8$ ), technical risks ( $C_9$ ).

The other three top risk factors listed in the causal group include site condition risks ( $C_4$ ), human capital risk ( $C_5$ ) and environmental and force majeure risk ( $C_{10}$ ) based on the "R+C" values and these factors had a direct impact to the other six risk factors. For instance, site condition risk ( $C_4$ ) had directly affected contract risks ( $C_8$ ), technical risk ( $C_9$ ) and had a mutual interaction on design risks ( $C_1$ ), financial risks ( $C_3$ ), project management risks ( $C_6$ ),

health& safety risks (C<sub>7</sub>), contract risks (C<sub>8</sub>) and technical risks (C<sub>9</sub>). Besides that, human capital risks (C<sub>5</sub>) have direct influence on the design risk (C<sub>1</sub>), health and safety risks (C<sub>7</sub>), contract risks (C<sub>8</sub>), technical risks (C<sub>9</sub>) and had a mutual interaction on financial risks (C<sub>3</sub>), project management risks (C<sub>6</sub>). Meanwhile, Environmental risk and force majeure risks (C<sub>10</sub>) have direct influence on design risks, financial risks (C<sub>3</sub>), site condition risks (C<sub>4</sub>), project management risks (C<sub>6</sub>), health & safety risks (C<sub>7</sub>) and contract risks (C<sub>8</sub>).

**Table 4. Average Matrix**

	C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>	C <sub>4</sub>	C <sub>5</sub>	C <sub>6</sub>	C <sub>7</sub>	C <sub>8</sub>	C <sub>9</sub>	C <sub>10</sub>
C <sub>1</sub>	0	0.8462	3.1538	2.7692	1.2308	1.9231	2.0769	2.4615	2.7692	2.0000
C <sub>2</sub>	1.5385	0	2.4615	1.0000	1.5385	1.7692	1.4615	2.1538	0.9231	0.3077
C <sub>3</sub>	2.8462	1.0769	0	2.1538	2.0000	2.4615	2.3077	2.6923	2.1538	1.3077
C <sub>4</sub>	1.6154	1.0769	2.1538	0	1.3846	1.8462	3.0000	2.1538	2.0000	2.3077
C <sub>5</sub>	2.4615	0.6923	2.3846	0.8462	0	2.5385	2.3846	2.0769	2.1538	1.2308
C <sub>6</sub>	2.3077	0.6923	2.9231	2.0769	2.0000	0	2.3077	3.0000	1.6923	0.8462
C <sub>7</sub>	1.8462	0.5385	2.3846	2.2308	2.0769	2.4615	0	2.0000	1.5385	1.4615
C <sub>8</sub>	1.7692	1.1538	2.9231	1.3077	1.8462	2.2308	1.6923	0	1.5385	0.8462
C <sub>9</sub>	2.0000	0.3077	2.2308	1.9231	1.3077	2.2308	1.6923	2.0769	0	1.0769
C <sub>10</sub>	2.3846	1.0000	2.2308	2.4615	1.4615	1.8462	2.6154	1.6923	1.0769	0

**Table 5. Normalized Matrix**

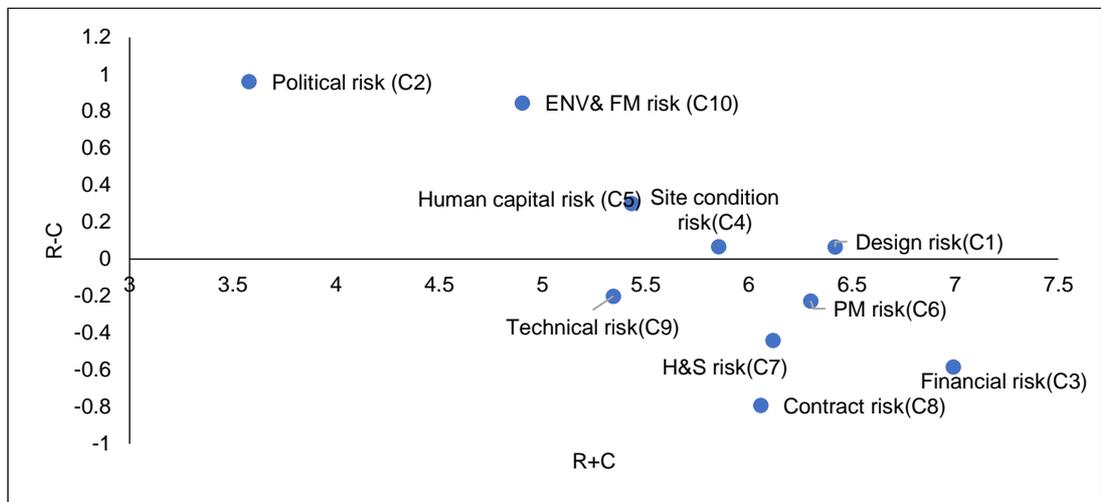
	C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>	C <sub>4</sub>	C <sub>5</sub>	C <sub>6</sub>	C <sub>7</sub>	C <sub>8</sub>	C <sub>9</sub>	C <sub>10</sub>
C <sub>1</sub>	0	0.0370	0.1380	0.1212	0.0539	0.0842	0.0909	0.1077	0.1212	0.0875
C <sub>2</sub>	0.0673	0	0.1077	0.0438	0.0673	0.0774	0.0640	0.0943	0.0404	0.0135
C <sub>3</sub>	0.1246	0.0471	0	0.0943	0.0875	0.1077	0.1010	0.1178	0.0943	0.0572
C <sub>4</sub>	0.0707	0.0471	0.0943	0	0.0606	0.0808	0.1313	0.0943	0.0875	0.1010
C <sub>5</sub>	0.1077	0.0303	0.1044	0.0370	0	0.1111	0.1044	0.0909	0.0943	0.0539
C <sub>6</sub>	0.1010	0.0303	0.1279	0.0909	0.0875	0	0.1010	0.1313	0.0741	0.0370
C <sub>7</sub>	0.0808	0.0236	0.1044	0.0976	0.0909	0.1077	0	0.0875	0.0673	0.0640
C <sub>8</sub>	0.0774	0.0505	0.1279	0.0572	0.0808	0.0976	0.0741	0	0.0673	0.0370
C <sub>9</sub>	0.0875	0.0135	0.0976	0.0842	0.0572	0.0976	0.0741	0.0909	0	0.0471
C <sub>10</sub>	0.1044	0.0438	0.0976	0.1077	0.0640	0.0808	0.1145	0.0741	0.0471	0

**Table 6. Total Relation Matrix T**

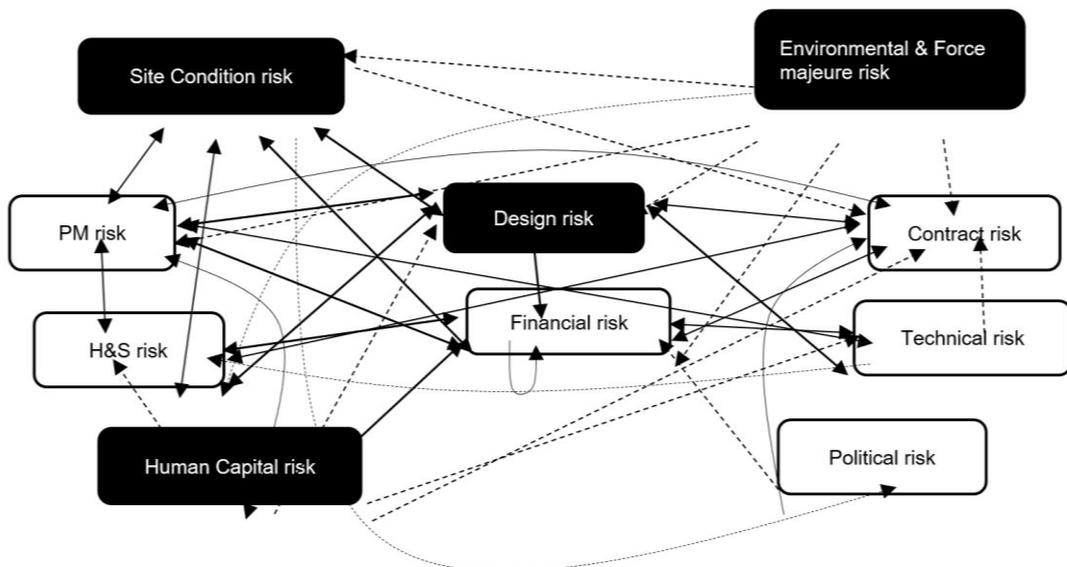
	C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>	C <sub>4</sub>	C <sub>5</sub>	C <sub>6</sub>	C <sub>7</sub>	C <sub>8</sub>	C <sub>9</sub>	C <sub>10</sub>
C <sub>1</sub>	0.2755	0.1493	<b>0.4494</b>	<b>0.3623</b>	0.2736	<b>0.3603</b>	<b>0.3682</b>	<b>0.3941</b>	<b>0.3507</b>	0.2588
C <sub>2</sub>	0.2562	0.0798	<b>0.3281</b>	0.2164	0.2200	0.2705	0.2572	<b>0.2956</b>	0.2090	0.1367
C <sub>3</sub>	<b>0.3832</b>	0.1564	<b>0.3251</b>	<b>0.3350</b>	<b>0.2999</b>	<b>0.3770</b>	<b>0.3721</b>	<b>0.3997</b>	<b>0.3260</b>	0.2294
C <sub>4</sub>	<b>0.3174</b>	0.1479	<b>0.3846</b>	0.2309	0.2609	<b>0.3332</b>	<b>0.3773</b>	<b>0.3560</b>	<b>0.2991</b>	0.2540
C <sub>5</sub>	<b>0.3424</b>	0.1289	<b>0.3857</b>	0.2610	0.1973	<b>0.3516</b>	<b>0.3448</b>	<b>0.3470</b>	<b>0.3012</b>	0.2068
C <sub>6</sub>	<b>0.3502</b>	0.1364	<b>0.4221</b>	<b>0.3185</b>	<b>0.2897</b>	0.2661	<b>0.3577</b>	<b>0.3963</b>	<b>0.2971</b>	0.2029
C <sub>7</sub>	<b>0.3168</b>	0.1231	0.3816	<b>0.3096</b>	0.2786	<b>0.3457</b>	0.2503	<b>0.3411</b>	0.2757	0.2159
C <sub>8</sub>	<b>0.2969</b>	0.1397	<b>0.3812</b>	0.2581	0.2564	<b>0.3197</b>	<b>0.2992</b>	0.2428	0.2603	0.1789
C <sub>9</sub>	<b>0.2995</b>	0.1046	<b>0.3496</b>	0.2786	0.2311	<b>0.3138</b>	<b>0.2951</b>	<b>0.3199</b>	0.1931	0.1868
C <sub>10</sub>	<b>0.3385</b>	0.1427	<b>0.3793</b>	<b>0.3228</b>	0.2574	<b>0.3250</b>	<b>0.3568</b>	<b>0.3319</b>	0.2602	0.1592

**Table 7.** The Causal Influence Table for The Ten Factors

Factors	R+C	R-C
C <sub>1</sub> Design risk	6.4188	0.0656
C <sub>2</sub> Political risk	3.5784	0.9608
C <sub>3</sub> Financial risk	6.9906	-0.5828
C <sub>4</sub> Site condition risk	5.8547	0.0684
C <sub>5</sub> Human capital risk	5.4315	0.3017
C <sub>6</sub> Project management risk	6.2999	-0.2260
C <sub>7</sub> Health & safety risk	6.1171	-0.4404
C <sub>8</sub> Contract risk	6.0578	-0.7913
C <sub>9</sub> Technical risk	5.3444	-0.2003
C <sub>10</sub> Environmental & Force majeure risk	4.9030	0.8444



**Figure 2.** Causal Diagram for Risk Factors in Construction Projects



**Figure 3.** The Impact Relations Map

## DISCUSSION

The interrelationships among the risk factors in construction projects depicted in IRM in Figure 3 illustrates that the design risk, site condition risk, human capital risk and environmental and force majeure risk have more influence over the other six risk factors. This finding shows that decision-makers should first consider these four risk factors during the implementing the risk measures.

The results indicate that design risks were the critical factors among other risks factors. Design risks ( $C_1$ ) have the highest “R+C” value in the cause group which play the greatest influence on others. This result corresponded with the findings from previous study where the design related risks among the 14 risk items were more likely to occur (P. Wu et al., 2019). Based on previous study, the experience of architects and engineers regarding the designs were considered the most serious factors. Design risks were critical due to its difficulty in acquiring and describing the user's requirements, difficulty in the time and resources estimation required to determine the design and difficulty of tracking performance during the design process. (Choudhry et al., 2017; Zou, Zhang, & Wang, 2007). Failure to respond to the design risks can lead to design rework which influences the subsequent work, schedules and finance of projects. Therefore, it is found that companies should have knowledgeable designs to tackle the risks in the design phase of the projects.

Site condition risks ( $C_4$ ) is the second most influential factors. Site condition risks exist when there is a huge number of labours, materials, equipment as well as unforeseeable situation. Besides, frequent rotations of work, changing environment and concurrent activities increase the difficulty for effective safety management and subsequently raise the accident rates (N. Tang et al., 2019). It is important that the overall construction activities should be prioritized to increase the likelihood of project success. Furthermore, the top management and employees are required to give their commitment to maintain a safe working environment. Safety policies and regulations should be revised timely and implemented by the authorities to maintain work safety in construction sites.

Based on the results of this study, human capital risks ( $C_5$ ) is another influential factor in construction projects. Human capital risks not only contribute to financial loss and resources, but the knowledge and experience of the employees are also affected in which hinders the performance of the company. It is essential to ensure that the employees stay in the company, otherwise, the employer has to cover the losses when an employee quits the company (Yusof et al., 2018). Jarkas and Younes (2014) mentioned that 30% to 50% of the overall project costs are contributed by labour costs. In other words, labour costs is regarded as a significant resource to the efficiency and success of construction projects. On top of that, Mohd-Rahim et al. (2016) pointed that project performance may most likely be affected by the risks of labour shortage. This would cause schedule delays and cost overruns. Therefore, the organization should focus on employee retention and labour management strategies in order to achieve project success. The government also needs to take initiatives to solve the problem of skilled labour shortage in the country to ensure the construction industry remains sustainable.

Furthermore, it is indicated that the environmental and force majeure risks ( $C_{10}$ ) have direct influence on the other six risk factors. Rahman and Esa (2014) described environmental risk as impending risk to the ecology with all sorts of influences. Environmental risks might occur during the mobilization, clearance of site and earthworks that require ground clearance for development. The risks to hazardous exposures is perhaps ten or even one thousand times higher than elsewhere in an unfavourable environmental condition (J.-H. Chang & Huynh, 2016). A number of construction development projects have reported schedule overrun or poor performance because of the explicit environmental concerns. It can be said that the project performance is also dependent on the project's environment (Malik et al., 2019). Thus, parties involved in the construction industry should give sufficient attention to ensure that fair and feasible approaches are taken to minimize the environmental and force majeure risks. Besides that, the government should be concerned on the environmental aspects to ensure that construction companies follow rules and regulations during operation in order to achieve sustainability development.

## CONCLUSION AND IMPLICATIONS

The present study reveals ten risk factors in construction projects. The factors include financial risk, design risk, project management risk, health & safety risk, contract risk, site condition risk, human capital risk, technical risk, force majeure and political risk. These factors are contributed by thirteen experts who have a minimum of ten years of involvement in the construction industry. To unveil the respondents' viewpoint, DEMATEL method has been employed. DEMATEL method has been utilized in this study to determine the critical risk factors in the construction project and investigate the interrelationships among the risk factors. In addition, causal diagram and impact relations map can be interpreted by project managers, engineers, contractors and the researchers easily. Results of the present study shows that design risks are the most influential factors in construction projects. Furthermore, site condition risks, human capital risks, environmental and force majeure risks are other key risk factors to be considered as they have a significant impact on the other factors. Despite the fact that financial risks and project management risks are important, they are affected by other risk factors, hence, their effect may be intervened by addressing the key causal factors.

The parties involved in the construction industry can benefit from this study by focusing on critical risk factors while planning for risk management in construction projects. It is also suggested that the project managers should develop better risks mitigation approaches that to ensure that the quality of construction projects are on par by emphasizing on rectifying the factors in the cause group, as they have significant impact on the other factors. To this extent, the quality as a whole can be strengthened from the initial stages to the completion stages of the projects. Besides that, collaborative work between government and private parties in construction sector are required to mitigate the risks in the construction projects. Ultimately, the limitations to the DEMATEL approach employed in the present study is that the study depends on the own view of respondents and their experience in the construction industry and subjective elements may be integrated inevitably within the research. Hence, statistical validation of results in this study can be conducted in the future studies. In order to validate the results found in this study, it is recommended to conduct a case study in the future. Moreover, empirical study of a large sample can be carried out further to substantiate the results of this study.

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# SURVIVAL STRATEGIES OF KLANG VALLEY MALAYSIAN SMALL AND MEDIUM BUILDING CONTRACTORS IN THE POST-COVID-19 ERA

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## Abstract

The post-COVID-19 era in Malaysia's busiest area, Klang Valley, necessitates an examination of the survival strategies used by small and medium building contractors in the construction industry, which are numerous in a developing country like Malaysia and contribute significantly to the country's economy. As a result, the purpose of this study was to investigate the survival strategies and perceived success of Klang Valley Malaysian small and medium building contractors in the post-COVID-19 era, to uncover the strategies that would ensure the small and medium building contractors' continuous survival. In this study, a survey approach was used, and building contractors in six grades ranging from G1 to G6 of CIDB Malaysia registered building contractors were sampled using a structured questionnaire. Mean ranking and factor analysis were used to analyse the data collected. The top five important survival strategies were as follows: (1) effective financial management, (2) upgrading of the skills of employees for productivity improvement, (3) improvement of service quality performance, (4) improvement of problem-solving capabilities, and (5) efficient marketing. The factor analysis method was used to identify the underlying factors of survival strategies such as diversification, networking, and innovation strategies; workforce management strategies; and financial management strategies. The effects of organisational survival on small and medium building contractors' perceived success in terms of business growth, profit growth, and employment growth were also investigated. This study raised awareness and deepened our understanding of the survival strategies used by Klang Valley Malaysian small and medium building contractors, as well as how their organisational survival was perceived.

**Keywords:** *Survival strategies; Klang Valley Malaysia; Small and medium building contractors; Post-COVID-19 era.*

## INTRODUCTION

The COVID-19 pandemic erupted in December 2019. It resulted in the deaths of many people. The COVID-19 pandemic has had a negative impact on many countries, particularly in the economic sector. The post-COVID-19 era saw the formation of a challenging economy.

The global financial crisis of 2007 was one of the most shocking economic events in world history. It had an impact on the industries and economies of many countries at the time. Construction firms in developing countries, such as Sri Lanka, have implemented several strategies in response to the challenging economy; however, many of these strategies can only address short-term issues. Many building contractor firms failed to implement appropriate survival strategies during the difficult economic times, resulting in insolvency or termination (Tansey et al., 2014).

Survival is defined as the act or fact of surviving, particularly in harsh or unusual conditions. On the other hand, survival is the most important aspect of any company's operations, and survival is the organisation's top priority before pursuing any other benefits (Adewale et al., 2011). Strategy can be defined as an all-encompassing plan devised by an organisation and its various components to achieve a desired end state in the future. Following that, strategy can be defined as the use and allocation of an organisation's limited resources to achieve its existing goals.

In Ireland, four of the top ten construction firms were unable to survive in the challenging economy, and the number of construction firm failures increased. Survival strategies were discovered in Singapore when most contractors decided to bid on jobs that were within their capabilities during the difficult economic times (Teck Heng Lim et al., 2010). In New Zealand, on the other hand, survival strategies included focusing on establishing relationships with main contractors, implementing strict financial management on a firm's cash flow, and implementing strict site management to reduce material and time waste. During a difficult economic period, building contractors in the United Kingdom, the United States, Hong Kong, and Japan implemented a variety of strategies such as advertising, technology or innovation, project management, and reorganisation (Tansey et al., 2014).

Ogbu (2017) conducted a study to determine the critical factors of construction industry survival strategies in a West African country, such as Nigeria. Human resource management, marketing, bid strategy, financial management, organisational culture, smart execution methods, and firm strategy were among the factors considered. According to the study, the marketing factor is the most important, while the organisational culture factor is the least important. The research assists indigenous construction firms in identifying the factors that contribute to their survival practises.

Aghimien et al. (2018) conducted a study on the survival strategies of Nigerian building contractors in a bad economy. Their research discovered that building contractors recognise the importance of effective management to operate in a challenging economy.

Throughout the years, many previous studies on the survival strategies of construction organisations around the world have demonstrated the significance of this issue. The post-COVID-19 era has brought about a new normal in all industries' work routines. There is no exception in the construction industry. The presence of COVID-19 introduces a new set of problems to the economic sectors, particularly since many people have been forced to work from home and businesses have been forced to close to prevent the disease from spreading, likely resulting in another economic downturn in no time.

Assessing the survival strategies used by small and medium building contractors is critical because these firms are numerous in developing countries such as Malaysia, and together they form the built environment that supports the nation's development. Unfortunately, these firms are vulnerable and easily influenced by economic conditions; they will either succeed and grow into large corporations, or they will decline and disappear from the industry. Studies on construction firm survival strategies will help provide evidence on how firm survival occurs in the country. This study investigated the survival strategies and perceived success of Klang Valley Malaysian small and medium building contractors in the post-COVID-19 era. This study's findings are expected to serve as a guide for small and medium building construction

business owners in developing effective and efficient survival strategies to sustain and remain active in the industry.

## LITERATURE REVIEW

After manufacturing and agriculture, Malaysia's construction industry is the third largest in terms of output. The construction industry is defined as a sector of the country's economy that is involved in land planning and construction, as well as the modification and renovation of property, structures, and other real estate. This industry is critical to any country's economy (Awolele et al., 2019). It is one of the economic sectors that used resources to build economic and social infrastructure.

**Table 1.** List of Survival Strategies and Sources

Ref	Survival Strategy	Source
SS01	Diversification into other companies related to construction	Ogbu (2017), Ye et al. (2017), Aghimien et al. (2018), Ulubeyli et al. (2018)
SS02	Effective financial management	Ho (2016), Ogbu (2017), Ojera (2018), Sabug and Pheng (2018)
SS03	Diversification into related practices based on professional expertise	Ling and Li (2016), Sabug and Pheng (2018)
SS04	Upgrading of the skills of employees for productivity improvement	Mishra and Smyth (2015), Panda (2015), Ogbu (2017), Roshchin and Travkin (2017)
SS05	Reduction in fees for services	Ogbu (2017), Aghimien et al. (2018)
SS06	Efficient marketing	Hsu (2016), Ogbu (2017), Aghimien et al. (2018), Hammerschlag et al. (2020)
SS07	Improvement of service quality performance	Dauda and Lee (2016), Pattanayak et al. (2017), Aghimien et al. (2018)
SS08	Layoff and reduction of employment	Ogbu (2017), Aghimien et al. (2018), Abbaspour and Dabirian (2019)
SS09	Changing of geographical location	Aghimien et al. (2018), Silva and Moreira (2019), Viswanathan and Jha (2019)
SS10	Cooperation partnerships	Colavitti and Usai (2015), Aghimien et al. (2018), Freytag (2019)
SS11	Improvement of corporate culture through activities that prioritise goals and responsibilities	Naqshbandi et al. (2015), Belak (2016), Kumar and Sharma (2018)
SS12	Improvement of problem-solving capabilities	Worley and Doolen (2015), Hämäläinen et al. (2017), Lee-Post (2019)
SS13	Use of emerging technologies or innovations	Oly Ndubisi and Agarwal (2014), Tsou et al. (2014), Batra et al. (2015), Valmohammadi (2017)
SS14	Purchase of resources	Sánchez-Rodríguez et al. (2019), Lafuente et al. (2020)
SS15	Improvement of the organisational framework	Bonanomi et al. (2019)
SS16	Effective networking to enhance reach	Sullivan and Ford (2014), Leung et al. (2019), Sharafizad and Brown (2020)
SS17	Investment in various businesses	Sort and Nielsen (2018), Nguyen (2019)
SS18	Contract conflict risk mitigation by contract management	Cheung and Pang (2013), Treacy et al. (2016), Besaiso et al. (2018)

Small and medium building construction enterprises in Malaysia are generally classified based on their CIDB Malaysia registration grades. Building contractors are classified by CIDB Malaysia into seven grades, ranging from G1 to G7. Building contractors in grades G1 to G3 are considered small building contractors, while those in grades G4 to G6 are considered

medium building contractors. Grade G7 building contractors are considered large building contractors because they are the only group that can participate in construction projects of any value without restriction (Mustafa Kamal and Flanagan, 2012).

Building contractors can benefit from a survival strategy to gain a better understanding of the company. It has the potential to improve employee leadership and capability. It can also help building contractors identify and address flaws, as well as mitigate risks (Mahmood et al., 2017). A building contractor firm cannot move forward or determine its market position in comparison to its competitors without a survival strategy. The survival strategies identified in the review of literature are shown in Table 1.

Survival strategies implemented by Klang Valley Malaysian small and medium building contractors may result in perceived success for the firms, such as business growth, profit growth, and employment growth.

Business growth was one of the most important aspects of any organisation because it reflected a company's success. Business expansion denotes an increase in the firm's size (Hanifzadeh et al., 2018). Historically, the success of an organisation was linked to business growth. Business growth boosted the competitiveness of small and medium-sized businesses (Ahonen, 2019). The firm's strategies were a factor that influenced the growth of a business in a difficult economy. A significant benefit that resulted from the expansion of the company was the addition of new employment opportunities.

Profit, according to Sitorus and Christian (2019), can be defined as a reward for firms' efforts to produce goods and services. Profit can also be defined as an excess of income over the total costs of producing and delivering goods or services (Sitorus and Elinarty, 2017). Profit growth was defined as an increase in profits earned by the firm expressed as a percentage. Profit growth indicated that the firm's finances were sound, which increased the firm's value.

According to a study conducted by Rafiki (2020), observed firm growth can be measured in a variety of ways, including employment, resources, and sales. Employment growth is linked to a company's success, and employment growth is a process that increases the rate of employment. More employees were needed by a company to complete heavy work that would generate revenue for the company's operations. The goal of job creation was to improve a company's ability to accept and complete projects. Torkkeli et al. (2016) discovered that employment growth can influence a firm's networking and thus lead to firm success.

## RESEARCH METHODOLOGY

This study was carried out to investigate the survival strategies and perceived success of Klang Valley Malaysian small and medium building contractors in the post-COVID-19 era. The findings of this study will assist Klang Valley Malaysian small and medium building contractors in surviving in the post-COVID-19 era. This study used a questionnaire survey approach to collect quantitative data from Klang Valley Malaysian small and medium building contractors, as Ogbu (2017) did. Small building contractors ranging from CIDB grade G1 to CIDB grade G3 and medium building contractors ranging from CIDB grade G4 to CIDB grade G6 operating in Klang Valley, Malaysia were the study's targeted respondents.

Questionnaire surveys are one of the most widely used social research methods for collecting data for research studies (Blaxter et al., 2013). A questionnaire survey is a method of gathering data based on a sample size (Keong, 2012). It can accommodate a broader range of research participants and is simple to implement. Because the respondents for this study were spread across Klang Valley, Malaysia, a questionnaire was deemed the best tool for data collection.

The questionnaire used was divided into three sections. Section A asked questions about demographic information such as the CIDB grade of contractor, category of work, position in the firm, and years of working experience. In Section B, the literature review was used to summarise a total of 18 survival strategies that can assist Klang Valley Malaysian small and medium building contractors. The respondents were asked to rate the effectiveness of all 18 survival strategies used to ensure the continuous survival of small and medium building contractors in Klang Valley, Malaysia, on a 5-point Likert scale, where 1 point indicates 'strongly disagree', 2 points indicate 'disagree', 3 points indicate 'neither agree nor disagree', 4 points indicate 'agree', and 5 points indicate 'strongly agree'. Section C included questions about three indicators of perceived success, which included statements from the literature review summarising business growth, profit growth, and employment growth. Similarly, respondents were asked to rate their perceived success in terms of business growth, profit growth, and employment growth because of organisational survival on a 5-point Likert scale, where 1 point indicates 'strongly disagree', 2 points indicate 'disagree', 3 points indicate 'neither agree nor disagree', 4 points indicate 'agree', and 5 points indicate 'strongly agree'. On the collected data, mean ranking and factor analysis were performed to identify the significant survival strategies and underlying survival strategies for Klang Valley Malaysian small and medium building contractors to survive in the post-COVID-19 era.

Minimum sample sizes for factor analyses range from 3 to 20 times the number of variables, with absolute sample sizes ranging from 100 to over 1,000 (Mundfrom et al., 2005). To meet the requirements, the average times  $[(20 \text{ times} - 3 \text{ times})/2 + 3 \text{ times} = 11.5 \text{ times}]$  were calculated and multiplied by 21 variables (the number of variables investigated in this study). According to the calculations, this study would require at least 242 responses. A total of 625 sets of questionnaires were distributed after considering the response rate of a previous questionnaire survey conducted to determine the response rate of construction professions, which revealed a 40% response rate (Boschman et al., 2012). At the end of the data collection period, 260 responses were collected, indicating a response rate of 41.60 per cent. However, only 250 valid responses were used in the data analysis.

## RESULTS AND DISCUSSIONS

### Background Information of Respondents

Table 2 depicts the demographic profile of respondents. Overall, the findings of this study were derived from the perceptions of construction practitioners from various backgrounds and levels of experience. In terms of sample size, this study collected a comparable number of responses from small building contractors ranging from CIDB G1 to CIDB G3, accounting for 49.6 per cent; and medium building contractors ranging from CIDB G4 to CIDB G6, accounting for 50.4 per cent. As evidenced by the contractors' registration database system, it is common in Malaysia for building contractors to hold both building and non-building licences, allowing them to engage in non-building work. Construction practitioners who

participated in this study majored in both building work (122 respondents, 48.8 per cent) and non-building works (128 respondents, 51.2 per cent), such as civil engineering, mechanical and electrical engineering, and facility management. The findings of this study were based on the perspectives of both managerial staffs (40 respondents, 16.0 per cent) made up of managing directors, directors, senior managers, managers, and assistant managers; and executive staffs (210 respondents, 84.0 per cent) made up of executives, engineers, quantity surveyors, and supervisors. Most construction practitioners (159 respondents, 63.6 per cent) had five or more years of experience, while others (91 respondents, 36.4 per cent) had less than five years of experience.

**Table 2.** Demographic Profile of Respondents

Category	Classification	Frequency	Percentage
Grade of contractor	CIDB G1	41	16.4
	CIDB G2	41	16.4
	CIDB G3	42	16.8
	CIDB G4	42	16.8
	CIDB G5	41	16.4
	CIDB G6	43	17.2
	Total	250	100.0
Category of work	Building	122	48.8
	Civil engineering	54	21.6
	Mechanical and electrical engineering	39	15.6
	Facility management	35	14.0
	Total	250	100.0
Position in the firm	Managing Director	1	.4
	Director	1	.4
	Senior Manager	2	.8
	Manager	26	10.4
	Assistant Manager	10	4.0
	Executive	21	8.4
	Engineer	54	21.6
	Quantity Surveyor	110	44.0
	Supervisor	25	10.0
Total	250	100.0	
Years of working experience	Less than 5 years	91	36.4
	5 years to 10 years	66	26.4
	10 years to 15 years	44	17.6
	15 years to 20 years	29	11.6
	20 years to 25 years	16	6.4
	25 years to 30 years	3	1.2
	30 years to 35 years	1	.4
Total	250	100.0	

## Survival Strategies of Klang Valley Malaysian Small and Medium Building Contractors

### Mean Ranking

Any mean score value less than 3.0 was deemed insignificant for the research because it fell below the neutral rating of 3.0. Simultaneously, standard deviation values less than 1.0 indicated that respondents were consistent in their agreement on the reported level of results. When two or more factors had similar mean scores, the one with the lowest standard deviation was given the highest importance ranking to properly rank the factors. Table 3 displays the mean ranking of the 18 survival strategies used by Klang Valley Malaysian small and medium building contractors in the post-COVID-19 era. According to the results of the mean ranking analysis, the top three significant survival strategies perceived by respondents in the post-COVID-19 era were: (SS02) effective financial management, (SS04) upgrading of the skills of employees for productivity improvement, and (SS07) improvement of service quality performance. On the contrary, (SS17) investment in various businesses, (SS14) purchase of resources, and (SS09) changing of geographical location were the bottom three significant survival strategies for Klang Valley Malaysian small and medium building contractors in the post-COVID-19 era.

**Table 3.** Mean Ranking of Survival Strategies

Ref	Survival Strategy	Mean	Std. Deviation	Rank
SS02	Effective financial management	4.23	.659	1
SS04	Upgrading of the skills of employees for productivity improvement	4.07	.604	2
SS07	Improvement of service quality performance	4.02	.688	3
SS12	Improvement of problem-solving capabilities	3.94	.638	4
SS06	Efficient marketing	3.80	.700	5
SS16	Effective networking to enhance reach	3.79	.731	6
SS05	Reduction in fees for services	3.78	.756	7
SS03	Diversification into related practices based on professional expertise	3.60	.812	8
SS18	Contract conflict risk mitigation by contract management	3.59	.702	9
SS13	Use of emerging technologies or innovations	3.56	.721	10
SS01	Diversification into other companies related to construction	3.56	.738	11
SS11	Improvement of corporate culture through activities that prioritise goals and responsibilities	3.55	.755	12
SS08	Layoff and reduction of employment	3.53	.729	13
SS15	Improvement of the organisational framework	3.50	.724	14
SS10	Cooperation partnerships	3.48	.756	15
SS17	Investment in various businesses	3.42	.708	16
SS14	Purchase of resources	3.35	.661	17
SS09	Changing of geographical location	3.01	.867	18

### Result of FA

The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity were used to ensure the suitability of the research data prior to factor analysis using principal components analysis (PCA) with varimax rotation. The survey data for survival

strategies were appropriate for factor analysis, according to Table 4, because the KMO value was 0.914 (greater than the threshold value of 0.6) and the level of significance (p-value) of the Bartlett's test of sphericity was  $< 0.001$  (lesser than the threshold value of 0.05).

**Table 4.** Kaiser-Meyer-Olkin Measure of Sampling Adequacy and Bartlett's Test of Sphericity for Survival Strategies

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.914
Bartlett's Test of Sphericity	Approx. Chi-Square	1676.515
	df	153
	Sig.	.000

Table 5 shows that with a factor loading of 0.40 as the cut-off point, three components with eigenvalues greater than one were extracted. Component 1 explained 37 per cent of variance, component 2 explained 9.3 per cent, and component 3 explained 6.8 per cent. The final PCA statistics and extracted components accounted for approximately 53.2 per cent of the total cumulative variance (greater than the threshold value of 50 per cent).

**Table 5.** Total Variance Explained for Survival Strategies

Component	Initial Eigenvalues		
	Total	% of Variance	Cumulative %
1	6.665	37.026	37.026
2	1.683	9.349	46.374
3	1.230	6.835	53.209

## Discussion of Findings

**Table 6.** Rotated Component Matrix of Survival Strategies

Ref	Survival Strategy	Component		
		1	2	3
SS11	Improvement of corporate culture through activities that prioritise goals and responsibilities	.788		
SS17	Investment in various businesses	.756		
SS14	Purchase of resources	.696		
SS10	Cooperation partnerships	.694		
SS09	Changing of geographical location	.686		
SS13	Use of emerging technologies or innovations	.614		
SS15	Improvement of the organisational framework	.585	.481	
SS16	Effective networking to enhance reach	.563	.479	
SS01	Diversification into other companies related to construction	.557		
SS18	Contract conflict risk mitigation by contract management	.543	.419	
SS03	Diversification into related practices based on professional expertise	.540	.522	
SS06	Efficient marketing	.441		
SS04	Upgrading of the skills of employees for productivity improvement		.767	
SS07	Improvement of service quality performance		.753	
SS12	Improvement of problem-solving capabilities		.582	
SS02	Effective financial management		.504	
SS05	Reduction in fees for services			.803
SS08	Layoff and reduction of employment			.701

The factor loadings for each of the three components are shown in Table 6. After a thorough examination of the components' survival strategies, the subsequent interpretation was deduced to represent the underlying survival strategies. Component 1 (diversification, networking, and innovation strategies), component 2 (workforce management strategies), and component 3 (financial management strategies).

### *Diversification, Networking, and Innovation Strategies*

The first component consisted of the following survival strategies: (SS11) improvement of corporate culture through activities that prioritise goals and responsibilities, (SS17) investment in various businesses, (SS14) purchase of resources, (SS10) cooperation partnerships, (SS09) changing of geographical location, (SS13) use of emerging technologies or innovations, (SS15) improvement of the organisational framework, (SS16) effective networking to enhance reach, (SS01) diversification into other companies related to construction, (SS18) contract conflict risk mitigation by contract management, (SS03) diversification into related practices based on professional expertise, and (SS06) efficient marketing as shown in Table 6. According to Table 5, it accounted for a variance of 37.026% (the highest among all the three components). It was named 'diversification, networking, and innovation strategies' after an examination of the characteristics of the survival strategies.

Belak (2016) observed that corporate culture was one of the factors that contributed to long-term firm success. Improved corporate culture was a key success factor in firms seeking potential partnerships to help with business diversification. Diversification-related strategies, according to Ogbu (2017), can aid a construction firm in mitigating the effects of an economic downturn. Building contractors could diversify their businesses by selling materials, leasing equipment, and expanding into areas where their competencies allow, according to Aghimien et al. (2018). Ling and Li (2016) discovered that a construction firm can achieve service diversification through a 'one-stop shop' approach, which allows the firm to offer a complete package of services to clients, including project management, construction, and maintenance. Investing in various businesses required relevant experience to evaluate and comprehend the new business opportunity. Nguyen (2019) discovered that investment is critical to the survival and growth of small businesses. Strategic resource procurement can help a company develop close relationships with suppliers, according to Sánchez-Rodríguez et al. (2019). Aghimien et al. (2018) realised that international construction firms prefer to use partnership as a survival strategy when entering new market areas. According to Viswanathan and Jha (2019), geographical location is an important factor for firms to consider when entering a new market because it can affect firm sustainability and profit growth. When making decisions to improve performance, it was critical for a company to use technology and innovation (Oly Ndubisi and Agarwal, 2014). Improvements to the organisational framework should make it easier to achieve goals, which are an important component of firm strategies. A network provides a critical opportunity for a company to identify critical stakeholders who can assist a company, particularly a small company, in gaining a competitive advantage in a challenging economy (Sharafizad and Brown, 2020). According to Treacy et al. (2016), building contractors must avoid potential conflict in ensuring firm survival during a recession period. Understanding the terms and clauses in a contract can help businesses avoid contract disputes. According to Ogbu (2017), many construction firms did not initially regard marketing as a critical survival strategy; however, some construction firms implemented marketing strategies and achieved

firm success. Contractors can benefit from effective marketing by promoting their services and attracting potential clients to hire them.

### *Workforce Management Strategies*

The second component consisted of the following survival strategies: (SS04) upgrading of the skills of employees for productivity improvement, (SS07) improvement of service quality performance, (SS12) improvement of problem-solving capabilities, and (SS02) effective financial management as shown in Table 6. Workforce management practices have a direct impact on a firm in the long run. Table 5 shows that it accounted for a variance of 9.349% (the second highest among all the three components). It was named 'workforce management strategies' after an examination of the characteristics of the survival strategies.

According to Tabassi et al. (2012), improving a firm's human resources is a critical strategy for any construction-related organisation. Ogbu (2017) discovered a way for construction firms to survive in a difficult economy in the upgrading of employee skills for productivity improvement. This revealed that a company can survive by properly managing its workforce and training its employees to improve their capabilities. Service quality can be improved by fully understanding the needs of the clients and satisfying and exceeding their expectations (Pattanayak et al., 2017). Employees with a high level of problem-solving abilities were more likely to be able to manage a company successfully (Lee-Post, 2019). When the economy was shaky, many building contractors in Singapore implemented strict financial management to maintain their cash flow. Most construction companies delayed paying their employees and terminated employment (Teck Heng Lim et al., 2010).

### *Financial Management Strategies*

The third component was made up of the following survival strategies: (SS05) reduction in fees for services and (SS08) layoff and reduction of employment as shown in Table 6. According to Table 5, it accounted for a variance of 6.835% (the lowest among all the three components). Following an examination of the characteristics of the survival strategies, it was named 'financial management strategies'.

Aghimien et al. (2018) discovered that lowering service charge fees can help a company retain old clients while also attracting new ones during a difficult economic period. Because the anticipated income would be reduced due to the implementation of the reduction in service fees, this survival strategy was appropriate when adequate measures were in place to manage the revenue and expenses that the firm was responsible for. Effective financial management of a company can assist the company in lessening the impact of a reduction in service fees. Layoffs and reductions in employment may be beneficial for businesses seeking to manage their available financial resources during a recessionary period. This is because layoffs and reductions in employment may be able to reduce the financial burden placed on the financial management of the businesses (Aghimien et al., 2018).

## Perceived Success of Klang Valley Malaysian Small and Medium Building Contractors

### Mean Ranking

Table 7 illustrates the perceived success of Klang Valley Malaysian small and medium-sized building contractors ranging from CIDB G1 to CIDB G6, as measured by organisational survival. All the small and medium-sized Klang Valley Malaysian building contractors who took part in this study considered that organisational survival resulted in firm (PS20) profit growth, followed by (PS19) business growth, and finally (PS21) employment growth.

**Table 7.** Mean Ranking of Perceived Success

Ref	Perceived Success	Mean	Std. Deviation	Rank
PS20	Profit growth	3.98	.515	1
PS19	Business growth	3.89	.597	2
PS21	Employment growth	3.67	.727	3

### Result of FA

The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity were used to ensure the suitability of the research data prior to factor analysis using principal components analysis (PCA) with varimax rotation. The survey data for perceived success were appropriate for factor analysis, according to Table 8, because the KMO value was 0.673 (greater than the threshold value of 0.6) and the level of significance (p-value) of the Bartlett's test of sphericity was  $< 0.001$  (lesser than the threshold value of 0.05).

**Table 8.** Kaiser-Meyer-Olkin Measure of Sampling Adequacy and Bartlett's Test of Sphericity for Perceived Success

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.673
Bartlett's Test of Sphericity	Approx. Chi-Square	133.468
	df	3
	Sig.	.000

Table 9 shows that with a factor loading of 0.40 as the cut-off point, only one component with an eigenvalue greater than one was extracted. This component explained 62.9 per cent of variance. The final PCA statistics and extracted component accounted for approximately 62.9 per cent of the total cumulative variance (greater than the threshold value of 50 per cent).

**Table 9.** Total Variance Explained for Perceived Success

Component	Initial Eigenvalues		
	Total	% of Variance	Cumulative %
1	1.886	62.880	62.880

### Discussion of Findings

The factor loadings for the component are displayed in Table 10. Considering that all three of the initial three indicators of perceived success for small and medium-sized building contractors used in this study, as discovered through a review of the literature, were grouped together under this component, the name perceived success was retained for the component.

**Table 10.** Component Matrix of Perceived Success

Ref	Perceived Success	Component 1
PS21	Employment growth	.811
PS19	Business growth	.791
PS20	Profit growth	.777

### *Perceived Success*

The component consisted of the following indicators resulting from organisational survival in this sequence based on factor loadings: (PS21) employment growth, (PS19) business growth, and (PS20) profit growth as shown in Table 10. According to Table 9, it accounted for a variance of 62.880%.

The success of a company can be measured in a variety of ways, including in terms of business, employment, profit, and resources (Hanifzadeh et al., 2018). Firm survival will lead to the achievement of firm success. Employment growth can assist a company in expanding its network, which can ultimately result in the success of the company (Torkkeli et al., 2016). Historically, the success of an organisation was linked to business growth (Hanifzadeh et al., 2018). Increasing returns on the efforts of businesses to produce goods and services is what profit growth is defined as (Sitorus and Christian, 2019).

## **CONCLUSION**

Companies in the construction industry will face an uphill battle to remain viable in the post-COVID-19 environment if they do not put in place sound strategies. The recent COVID-19 pandemic has posed numerous new and long-term challenges to businesses across all sectors, particularly in the construction industry, and it is imperative that swift action be taken to prevent businesses from failing and to operate in a new business environment with new business models. The goal of this study was to improve firm survival chances by investigating the survival strategies and perceived success of Klang Valley Malaysian small and medium building contractors in the post-COVID-19 era.

The findings of this research suggested that diversification, networking, and innovation strategies, as well as workforce management strategies and financial management strategies, all contribute to the survival of organisations. These underlying dimensions corresponded to the domains of survival strategies used by small and medium-sized building contractors in Klang Valley, Malaysia, to combat the COVID-19 pandemic. Firm policies and strategies that encompass these areas should be developed and implemented so that businesses can prosper and succeed in terms of employment, business, and profit growth on an ongoing basis. Despite lower project profit margins due to the downturn in the economy, small and medium-sized building contractors must continue to build high-quality structures and provide high-quality services to remain competitive.

With the assistance of this study, small and medium-sized building contractors in Klang Valley, Malaysia, were able to adopt and implement effective and efficient survival strategies that allowed their businesses to survive and thrive while operating in the construction sector.

Construction practitioners and academics should be aware of the survival strategies that have been highlighted, and efforts should be made to discover additional useful survival strategies.

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# SURVIVAL PRACTICES OF KLANG VALLEY MALAYSIAN INDIGENOUS CONSTRUCTION FIRMS IN THE POST-COVID-19 ERA

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## Abstract

In Malaysia, indigenous construction firms face significant challenges in staying in business. The outbreak of the COVID-19 pandemic has exacerbated the situation and made it difficult for indigenous construction firms to continue their operations and projects. Furthermore, firm-level practices to support indigenous construction firms have been scarcely determined in the Malaysian context when compared to non-indigenous construction firms. The goal of this study was to investigate the survival practices and perceived success of indigenous construction firms to increase the likelihood of firm survival. A total of 18 survival practices were discovered through a review of the literature. A structured questionnaire administered to 200 CIDB registered Grade G1 to Grade G7 Malaysian indigenous construction firms in the Klang Valley area provided data for mean ranking and factor analysis. The top five significant survival practices were (1) upgrading of employee skills to improve productivity, (2) elimination of bad performers, (3) improvements in health and protection at work, (4) promotion of the good image of the company, and (5) practice of quality assurance methods and enhancement of quality. The underlying factors of survival practices were identified using factor analysis, which are as follows: tendering strategy, human resource management, organisational culture, finance management, and marketing. The effects of organisational survival on the perceived success of indigenous construction firms in terms of business growth, profit growth, and employment growth were also investigated. This study raised awareness and deepened our understanding of the survival practices of Malaysian indigenous construction firms in Klang Valley, as well as how their organisational survival was perceived.

**Keywords:** *Survival practices; Klang Valley Malaysia; Indigenous construction firms; Post-COVID-19 era.*

## INTRODUCTION

Malaysian indigenous construction firms, also known as ‘Bumiputera’ contractors, face significant challenges in maintaining their businesses when compared to non-indigenous construction firms. Chester Tay (2019) discovered that the younger generation of indigenous contractors is having difficulty surviving in the construction industry due to the high population of existing indigenous contractor firms.

Furthermore, the COVID-19 outbreak has caused widespread concern and economic hardship for construction professionals, particularly contractors. These outcomes have a negative impact on the long-term viability of Malaysian construction companies. The presence of COVID-19, according to Datuk Azman Yusoff, president of the Malaysian Bumiputera Contractors Association, caused the bankruptcy of 10% of 40,000 G1 and G2 indigenous contractors, as well as many other G3, G4, and G5 indigenous contractors (Povera, 2020). Despite Malaysia’s Prime Minister implementing the Prihatin Rakyat Economic

Stimulus Package, the economic crisis caused by COVID-19 has increased not only the unemployment rate but also the number of business failures among indigenous construction firms. Also, due to a lack of resources in the post-COVID-19 era, financial institutions are hesitant to lend to Malaysian indigenous construction firms (Jumain, 2020).

The severe consequences of COVID-19 have harmed Malaysian indigenous construction firms, forcing them to make difficult decisions about continuing their operations and obtaining projects. The reason for this is that they are most concerned about the financial impact of the COVID-19 pandemic on operations and future periods, liquidity and capital resources, a potential global recession, a decrease in productivity, a decrease in client confidence, and a variety of other considerations.

There have been few studies conducted on the survival practices of Malaysian indigenous construction firms, which are critical to the development of the country. The effectiveness of various government-implemented programmes for indigenous construction firms is rarely studied. To avoid business failure, the current situation appears to necessitate determining the best survival practices for Malaysian indigenous construction firms. Therefore, this study investigated the survival practices and perceived success of Klang Valley Malaysian indigenous construction firms in the post-COVID-19 era. The findings of this study will help us understand how Klang Valley Malaysian indigenous construction firms can survive the pandemic and ensure the long-term viability of their companies.

## **LITERATURE REVIEW**

### **Definition of Indigenous Construction Firms in Malaysia**

The term 'indigenous' refers to the legal status of natives within a country's borders. The term 'indigenoussness' is interpreted differently in different countries. Some countries believe that the term refers to the presence of an indigenous group in a specific country. 'Bumiputra' or 'bumiputera' is the term used in Malaysia to refer to indigenous people, which is translated as 'indigenous people' by the rest of the world. The World Bank says that in the construction industry, the Malaysian government places a high priority on and strengthens the participation of bumiputera contractors in government projects. This helps to reduce racial income disparities while also improving the economy of the country (Chester Tay, 2019).

### **Reviews of Survival Practices for Indigenous Construction Firms**

Survival practices are critical for indigenous construction firms during a pandemic outbreak. These businesses are taking steps to ensure their long-term viability. Firm survival can be regarded as the ultimate indicator of firm performance (Backman and Karlsson, 2020). Survival practices are also considered to be a firm's efficiency in terms of industry sustainability. According to Chen et al. (2013), 'survival practice' refers to proper planning and management characteristics that influence a firm's competitive advantage. Survival practices were defined by Okwo et al. (2019) as a firm's ongoing presence in the industry. Survival experience is the most direct result of a company's effective market process management and regulation, as well as ownership, financing, and organisational management. Dobson et al. (2013) discovered that survival practice in a competitive environment is a continuous process of knowledge exploration, whereas Chen et al. (2016) asserted that there

is a survival practice link between environmental management practices and construction firm performance. The survival practices identified in the literature review are shown in Table 1.

**Table 1.** List of Survival Practices and Sources

Ref	Survival Practice	Source
SP01	Elimination of bad performers	Bloom et al. (2015), Ogbu (2017)
SP02	Employment of internship students	Holyoak (2013), P. Maertz Jr et al. (2014)
SP03	Upgrading of employee skills to improve productivity	Lill (2009), Teck Heng Lim et al. (2010), Ogbu (2017)
SP04	Rewarding of employees fairly and effectively	Ogbu (2017)
SP05	Improvements in health and protection at work	Teck Heng Lim et al. (2010), Schneider et al. (2013), Povera (2020)
SP06	Entry into forward arrangements with manufacturers and subcontractors to shield the company from cost escalation	Ogbu (2017), Aghimien et al. (2018)
SP07	Joining of social clubs with potential clients	Ogbu (2017)
SP08	Allocation of appropriate funding for marketing	Jung et al. (2018)
SP09	Expanding of business to new locations	Ogbu (2017)
SP10	Promotion of the good image of the company	Awang and Jusoff (2009), Ogbu (2017)
SP11	Diversification into other construction and non-construction related businesses	Lan Oo et al. (2007), Teck Heng Lim et al. (2010), Nafday (2011)
SP12	Practice of quality assurance methods and enhancement of quality	Ogbu (2017), Aghimien et al. (2018)
SP13	Use of electronic platform to achieve effectiveness and efficiency	Onyegiri and Nwachukwu (2011), Fulford and Standing (2014), Norailis and Asiah (2015), Aghimien et al. (2018)
SP14	Downsizing and restructuring of the company	Teck Heng Lim et al. (2010), Ogbu (2017)
SP15	Capability in identifying bidding opportunities	Teck Heng Lim et al. (2010), Jarkas (2013), Ogbu (2017), Alsaedi et al. (2019)
SP16	Outsourcing of specialist works to subcontractors	Teck Heng Lim et al. (2010), Ogbu (2017), Osuizugbo et al. (2020)
SP17	Benchmarking of business performance against best practices in the industry	McKay and Chung (2005), Markovic et al. (2011), Norailis and Asiah (2015), Ogbu (2017)
SP18	Emphasising of goals achievement and tasks accomplishment	Naidoo (2010), Teck Heng Lim et al. (2010), Lechner and Gudmundsson (2012), Dobson et al. (2013), Schein and Schein (2017)

## Indicators of Perceived Success for Indigenous Construction Firms

Firm owners and employees struggle to measure organisational survival and success through survival practices. This study conceptualises indigenous construction firms' organisational survival by referring to the research of Ogbu (2017) in defining the success of indigenous contractors as measured by company growth indicators (Costanza et al., 2015). In the construction industry, 'business growth' is defined as the number of company sales or the number of projects undertaken by the firm, which is reflected in the attribute of business measure (Tajnikar et al., 2016). As clients place a premium on contractor firms' business growth, organisational survival is a critical factor in sustaining firm performance on client projects. Construction firms' business growth should be evaluated as an indicator of the effectiveness of firm performance and productivity (Bravo-Biosca et al., 2016).

The term ‘profit growth’ refers to the firm’s ability to generate profit as a measure of organisational success. This is significant because the organisation’s mission is to satisfy the financial needs of the company’s investors and shareholders. The increasing number of contracts defines more competitive strategies and stable firm survival positioning in the construction industry, resulting in higher profitability and market value to counter each other. When a company achieves organisational success, it experiences an increase in its market value, which indicates positive profit growth.

Tajnikar et al. (2016) defined ‘employment growth’ as a growth variable. The survival of an organisation may lead to the expansion of more projects, resulting in an increase in capital and workforce employment. Because of the company’s larger size, there is a higher volume of activity (Tajnikar et al., 2016). The presence of an increasing number of employees over time indicates that the firm’s employment is expanding due to organisational survival.

## RESEARCH METHODOLOGY

This study aimed at investigating the survival practices and perceived success of Klang Valley Malaysian indigenous construction firms in the post-COVID-19 era. This study’s findings will assist Klang Valley Malaysian indigenous construction firms in surviving in the post-COVID-19 era. During the literature review, a total of 18 survival practices that can assist Klang Valley Malaysian indigenous contractors were identified. This study employed a questionnaire survey approach to reach out to Malaysian indigenous contractors in Klang Valley. This study’s targeted respondents were indigenous contractors ranging from CIDB Grade G1 to Grade G7. Quantitative research can collect a large amount of data to improve data reliability. Through this survey method, large amounts of data can be used to calculate the means and standard deviations of the variables (Creswell and Creswell, 2018). As a result, it is used to collect data from the targeted respondents in Klang Valley for this study. A total of 200 responses were collected and analysed for mean ranking and factor analysis.

Closed-ended questions were used for respondents to respond in this study so that they can answer the questions in less time and the data gathered were easier to interpret. Respondents completed the questionnaire by selecting only the most suitable answers for all the questions. This questionnaire was divided into three sections. Section A was designed to collect demographic information from respondents. The CIDB grade of contractor, category of work, position in the firm, and years of working experience were included in the demographic information section of the questionnaire. Section B allowed the Klang Valley Malaysian indigenous construction practitioners to rate the variables for the purpose of assessing the importance of the 18 survival practices identified earlier. Each variable of survival practices was evaluated using the Likert scale. Section C asked the respondents to rate their perceived success in terms of business growth, profit growth, and employment growth because of organisational survival.

## RESULTS AND DISCUSSIONS

### Background Information of Respondents

The demographic profile of respondents is shown in Table 2. Overall, the findings of this study were derived from the perceptions of construction practitioners with a variety of

backgrounds and levels of experience. This study evenly collected responses from small-sized contractors (CIDB G1 to CIDB G3, 33.0%), medium-sized contractors (CIDB G4 to CIDB G6, 33.0%), and large-sized contractors (CIDB G7, 34.0%). Most construction practitioners (140 respondents, 70.0%) in this study majored in building work, while the remaining construction practitioners (60 respondents, 30.0%) in this study majored in non-building works, such as civil engineering, mechanical and electrical engineering, and facility management. This study's findings were based on the perspectives of both managerial staffs (47 respondents, 23.5 per cent) made up of managing directors, directors, senior managers, managers, and assistant managers; and executive staffs (153 respondents, 76.5 per cent) made up of executives, architects, engineers, quantity surveyors, and supervisors. Most construction practitioners (135 respondents, 67.5 per cent) had five or more years of experience, while others (65 respondents, 32.5 per cent) had less than five years of experience.

**Table 2.** Demographic Profile of Respondents

Category	Classification	Frequency	Percentage
Grade of contractor	CIDB G1	30	15.0
	CIDB G2	11	5.5
	CIDB G3	25	12.5
	CIDB G4	24	12.0
	CIDB G5	22	11.0
	CIDB G6	20	10.0
	CIDB G7	68	34.0
	Total	200	100.0
Category of work	Building	140	70.0
	Civil engineering	28	14.0
	Mechanical and electrical engineering	16	8.0
	Facility management	16	8.0
	Total	200	100.0
Position in the firm	Managing Director	3	1.5
	Director	6	3.0
	Senior Manager	8	4.0
	Manager	21	10.5
	Assistant Manager	9	4.5
	Executive	41	20.5
	Architect	6	3.0
	Engineer	38	19.0
	Quantity Surveyor	47	23.5
	Supervisor	21	10.5
Total	200	100.0	
Years of working experience	Less than 5 years	65	32.5
	5 years to 10 years	80	40.0
	10 years to 15 years	35	17.5
	15 years to 20 years	11	5.5
	20 years to 25 years	3	1.5
	25 years to 30 years	2	1.0
	30 years to 35 years	2	1.0
	35 years to 40 years	1	.5
	More than 40 years	1	.5
Total	200	100.0	

## Survival Practices of Klang Valley Malaysian Indigenous Construction Firms

### Mean Ranking

The study concentrated on Malaysian indigenous construction firms in Klang Valley, which were in urban areas. Table 3 displays the mean ranking of the 18 survival practices of Klang Valley Malaysian indigenous construction firms in the post-COVID-19 era. Overall, the top five critical survival practices in the views of Klang Valley Malaysian indigenous construction firm respondents from all grades (CIDB G1 to CIDB G7) were: (1) upgrading of employee skills to improve productivity; (2) elimination of bad performers; (3) improvements in health and protection at work; (4) promotion of the good image of the company; and (5) practice of quality assurance methods and enhancement of quality.

**Table 3.** Mean Ranking of Survival Practices

Ref	Survival Practice	Mean	Std. Deviation	Rank
SP03	Upgrading of employee skills to improve productivity	4.25	.693	1
SP01	Elimination of bad performers	4.19	.594	2
SP05	Improvements in health and protection at work	4.18	.726	3
SP10	Promotion of the good image of the company	4.15	.690	4
SP12	Practice of quality assurance methods and enhancement of quality	4.12	.720	5
SP15	Capability in identifying bidding opportunities	4.09	.671	6
SP04	Rewarding of employees fairly and effectively	4.04	.736	7
SP18	Emphasising of goals achievement and tasks accomplishment	3.97	.668	8
SP06	Entry into forward arrangements with manufacturers and subcontractors to shield the company from cost escalation	3.91	.741	9
SP13	Use of electronic platform to achieve effectiveness and efficiency	3.89	.731	10
SP17	Benchmarking of business performance against best practices in the industry	3.86	.680	11
SP08	Allocation of appropriate funding for marketing	3.83	.681	12
SP11	Diversification into other construction and non-construction related businesses	3.76	.767	13
SP16	Outsourcing of specialist works to subcontractors	3.74	.740	14
SP07	Joining of social clubs with potential clients	3.69	.804	15
SP14	Downsizing and restructuring of the company	3.59	.876	16
SP09	Expanding of business to new locations	3.51	.814	17
SP02	Employment of internship students	3.49	.770	18

The most recognised survival practice among all other survival practices, according to respondents from all grades of Klang Valley Malaysian indigenous construction firms, was the (SP03) upgrading of employee skills to improve productivity. This finding was supported by Teck Heng Lim et al. (2010), who stated that training employees can increase their productivity levels, especially when applying high levels of technical knowledge in various projects, increasing the chances of survival in the post-COVID-19 era. The second survival practice ranked by Klang Valley Malaysian indigenous construction firms was (SP01) elimination of bad performers. According to Ogbu (2017), elimination of bad performers reduces disruptive and negative behaviour to the company's productivity and reputation, allowing firms to survive in the post-COVID-19 era. (SP05) improvements in health and protection at work was ranked third among all other survival practices. Teck Heng Lim et al.

(2010) defended this survival practice as critical because it prevents diseases, injuries, and deaths caused by working conditions, all of which have a negative impact on the reputation and survival of construction firms. (SP10) promotion of the good image of the company came in fourth place on the list of survival practices. Ogbu (2017) discovered that developing a positive image in terms of quality, ethics, reputation, and corporate social responsibility is beneficial in bringing a steady stream of new and existing projects to survive in the construction industry. The fifth survival practice was (SP12) practice of quality assurance methods and enhancement of quality. Ogbu (2017) and Aghimien et al. (2018) discovered that an evidence or certificate to qualify the workmanship may increase productivity and value-added operations, which increase firm survival performance in the post-COVID-19 era.

### Result of FA

Prior to factor analysis using principal components analysis (PCA) with varimax rotation, the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity were used to ensure the suitability of the research data. Table 4 shows that the survey data for survival practices were appropriate for factor analysis because the KMO value was 0.830 (greater than the threshold value of 0.6) and the level of significance (p-value) of the Bartlett's test of sphericity was  $< 0.001$  (lesser than the threshold value of 0.05).

**Table 4.** Kaiser-Meyer-Olkin Measure of Sampling Adequacy and Bartlett's Test of Sphericity for Survival Practices

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.830
Bartlett's Test of Sphericity	Approx. Chi-Square	690.811
	df	153
	Sig.	.000

Table 5 shows that five components with eigenvalues greater than one were extracted with a factor loading of 0.30 as the cut-off point. Component 1 explained 25% of variance, component 2 explained 8.8%, component 3 explained 6.4 per cent, component 4 explained 6%, and component 5 explained 5.8 per cent. The final PCA statistics and extracted components accounted for approximately 52% of the total cumulative variance (greater than the threshold value of 50 per cent).

**Table 5.** Total Variance Explained for Survival Practices

Component	Initial Eigenvalues		
	Total	% of Variance	Cumulative %
1	4.505	25.028	25.028
2	1.576	8.755	33.783
3	1.152	6.400	40.183
4	1.080	5.998	46.181
5	1.052	5.844	52.024

### Discussion of Findings

The factor loadings for the five components are shown in Table 6. Following a careful examination of the components' survival practices, the subsequent interpretation was deduced to represent the underlying survival practices. Component 1 (tendering strategy), component

2 (human resource management), component 3 (organisational culture), component 4 (finance management), and component 5 (marketing).

**Table 6.** Rotated Component Matrix of Survival Practices

Ref	Survival Practice	Component				
		1	2	3	4	5
SP12	Practice of quality assurance methods and enhancement of quality	.760				
SP17	Benchmarking of business performance against best practices in the industry	.631				
SP16	Outsourcing of specialist works to subcontractors	.571				
SP15	Capability in identifying bidding opportunities	.486	.400			
SP06	Entry into forward arrangements with manufacturers and subcontractors to shield the company from cost escalation	.395				.388
SP03	Upgrading of employee skills to improve productivity		.691			
SP05	Improvements in health and protection at work		.573			
SP08	Allocation of appropriate funding for marketing		.544			
SP10	Promotion of the good image of the company	.397	.447		.399	
SP13	Use of electronic platform to achieve effectiveness and efficiency			.668		
SP18	Emphasising of goals achievement and tasks accomplishment	.372		.582		
SP04	Rewarding of employees fairly and effectively		.448	.496		
SP11	Diversification into other construction and non-construction related businesses				.740	
SP01	Elimination of bad performers				.645	
SP07	Joining of social clubs with potential clients					.752
SP14	Downsizing and restructuring of the company				.420	.576
SP02	Employment of internship students			.426	.370	.473
SP09	Expanding of business to new locations			.392		.422

### *Tendering Strategy*

The first component was made up of the following survival practices: (SP12) practice of quality assurance methods and enhancement of quality, (SP17) benchmarking of business performance against best practices in the industry, (SP16) outsourcing of specialist works to subcontractors, (SP15) capability in identifying bidding opportunities, and (SP06) entry into forward arrangements with manufacturers and subcontractors to shield the company from cost escalation as shown in Table 6. According to Table 5, it accounted for a variance of 25.028% (the highest among all the five components). Following an examination of the characteristics of the survival practices, it was named ‘tendering strategy’.

Reviewing an effective bid strategy by firms to clients ostensibly aids the survival of Klang Valley Malaysian indigenous construction firms in the post-COVID-19 era. Clients appear to be becoming more price-sensitive to contractor bids, making it more difficult for indigenous construction firms to compete with lower mark-ups. However, in the case of COVID-19, the study found that clients prefer performance over lower mark-up bidding. Such performance shall be evaluated by employing various quality assurance methods in demonstrating the quality of workmanship to be reviewed during the bidding stage as the most beneficial outcome of interest for clients (Ogbu, 2017; Aghimien et al., 2018). Benchmarking business performance against best practices in the construction industry indicates that

indigenous contractor firms should learn how to obtain higher profit margins in terms of firm survival through bidding strategy from other construction firms. Contractors' bidding behaviours should be adjusted if clients are unable to pay contractors on time, as this will affect the contractor's cash flow and financial status. Because the contractor firm's resources are linked to the firm's capabilities and performance, it can affect the chances of winning bids. Outsourcing specialist work to subcontractors and entering into forward agreements with manufacturers and subcontractors to protect the company from cost escalation could demonstrate indigenous construction firms' qualified capability in bidding opportunities (Teck Heng Lim et al., 2010; Ogbu, 2017). During the tender stage, contractor capabilities are related to: (1) owner characteristics, (2) project characteristics, (3) economic environment, (4) contract terms and conditions, and (5) contractor characteristics (Jarkas, 2013). This indicates that many clients would select potential bidders for construction work based on performance, as it represents net profit to sales and liquidity (Dobson et al., 2013). As a result, to survive in the construction industry, indigenous construction firms should develop a tendering strategy based on potential qualified personnel and contractor firm characteristics that clients prefer. This demonstrates that there is a strong relationship between the bidding strategy of contractors and the state of the economy, particularly in the post-COVID-19 era.

### *Human Resource Management*

The second component consisted of the following survival practices: (SP03) upgrading of employee skills to improve productivity, (SP05) improvements in health and protection at work, (SP08) allocation of appropriate funding for marketing, and (SP10) promotion of the good image of the company as shown in Table 6. Survival practices in this component frequently reflect the initial responses of Klang Valley Malaysian indigenous construction firms to threats to their survival. Table 5 shows that it accounted for a variance of 8.755% (the second highest among all the five components). Following an examination of the characteristics of the survival practices, it was named 'human resource management'.

In response to the economic downturn caused by COVID-19, Klang Valley Malaysian indigenous construction firms may wish to reduce recurring overhead costs, of which employee welfare would be a significant portion. A common risk in this regard is that fundamental workforce may be lost over time, jeopardising the company's chances of winning future contracts, or completing current projects at a reasonable cost. Contractors who have been awarded projects are sometimes chosen based on the abilities of individuals within the construction firm. As a result, to achieve the long-term survival goals of the company, indigenous construction firms require useful employees who can run the organisation in a systematic manner. Failure to manage such a vital workforce can be fatal to the company's survival. According to Teck Heng Lim et al. (2010), upgrading employees with multi-skills or multi-tasking is beneficial for organisations in terms of lowering the cost of hiring new employees, training them, and increasing productivity for various projects. Keeping reported injuries to a minimum benefits Klang Valley Malaysian indigenous construction firms' long-term performance and reputation in ensuring their businesses' survival. Adequate marketing expenditure positively contributes to efforts to break into new sources of work, resulting in increased chances of obtaining new contracts. Improving the professional services and behaviour of employees may benefit the company's image. This component demonstrated that human resources are the driving force behind the firm's other assets.

### *Organisational Culture*

The third component was made up of the following survival practices: (SP13) use of electronic platform to achieve effectiveness and efficiency, (SP18) emphasising of goals achievement and tasks accomplishment, and (SP04) rewarding of employees fairly and effectively as shown in Table 6. According to Table 5, it accounted for a variance of 6.400% (the third highest among all the five components). Following an examination of the characteristics of the survival practices, it was named ‘organisational culture’.

Organisational culture refers to an adaptive mechanism that establishes the philosophy and operational styles of various indigenous construction firms (Costanza et al., 2015). Klang Valley Malaysian indigenous construction firms implied that the importance of the firm’s operational philosophy and patterns on firm survival in the post-COVID-19 period was acknowledged. The organisational culture of indigenous construction firms may stem from a desire to emulate other better construction firms in which project stakeholders may be interested. In that case, they become more organised in their construction business approach. According to Schein and Schein (2017), organisational culture is widely regarded as a long-standing and relatively stable trait that can serve as a foundation for indigenous construction firms to make changes to meet market demands. As a result of this component, owners of indigenous construction firms should be diligent in recruiting and encouraging workers who demonstrate adaptive efficiency for firm survival in the post-COVID-19 period to create and sustain an adaptation culture.

### *Finance Management*

The fourth component comprised the following survival practices: (SP11) diversification into other construction and non-construction related businesses and (SP01) elimination of bad performers as shown in Table 6. According to Table 5, it accounted for a variance of 5.998% (the second lowest among all the five components). Following an examination of the characteristics of the survival practices, it was named ‘finance management’.

One of the most significant challenges that Klang Valley Malaysian indigenous construction firms face is financing. It is due to their frequent failure to maintain adequate financial records and vulnerable financial projections for future firm uses. The findings indicated that Klang Valley Malaysian indigenous construction firms should prioritise finance management as a factor in their survival practices. The firm’s general ways of deploying its resources, including cost implications in dealing with COVID-19 pandemic threats, should be identified. It describes how a company intends to achieve its goals and examines the underlying structure of a series of company decisions. The findings also implied that strategic diversification could mitigate the negative effects of operating costs during economic downturns. Furthermore, the act of dismissal due to employee misconduct or poor performance outweighs the financial cost in affecting the company’s survival. Obviously, Klang Valley Malaysian indigenous construction firms would develop a bold and structured approach to finance management in challenging times.

### Marketing

The fifth component comprised the following survival practices: (SP07) joining of social clubs with potential clients, (SP14) downsizing and restructuring of the company, (SP02) employment of internship students, and (SP09) expanding of business to new locations as shown in Table 6. According to Table 5, it accounted for a variance of 5.844% (the lowest among all the five components). Following an examination of the characteristics of the survival practices, it was named ‘marketing’.

Growing marketing interest in Klang Valley Malaysian indigenous construction firms could have led to the emergence of a marketing component. Marketing expenditures were discovered to have been maintained in the post-COVID-19 era to promote company operations. Marketing is unquestionably important to firm performance, regardless of the time. In this difficult economic climate, indigenous construction firms should continue to market themselves. Marketing was the final extracted component of this study. This demonstrated that effective and efficient marketing has the potential to significantly assist Klang Valley Malaysian indigenous construction firms in surviving the COVID-19 pandemic.

### Perceived Success of Klang Valley Malaysian Indigenous Construction Firms

#### Mean Ranking

Table 7 depicts the perceived success of Klang Valley Malaysian indigenous construction firms of all grades (CIDB G1 to CIDB G7), as measured by organisational survival. All the small, medium, and large-sized Klang Valley Malaysian indigenous construction firms that participated in this study believed that organisational survival resulted in firm (PS19) business growth, followed by (PS21) employment growth, and finally (PS20) profit growth.

**Table 7.** Mean Ranking of Perceived Success

Ref	Perceived Success	Mean	Std. Deviation	Rank
PS19	Business growth	4.14	.647	1
PS21	Employment growth	3.99	.709	2
PS20	Profit growth	3.81	.728	3

#### Result of FA

Prior to factor analysis using principal components analysis (PCA) with varimax rotation, the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett’s test of sphericity were used to ensure the suitability of the research data. Table 8 shows that the survey data for perceived success were appropriate for factor analysis because the KMO value was 0.620 (greater than the threshold value of 0.6) and the level of significance (p-value) of the Bartlett’s test of sphericity was < 0.001 (lesser than the threshold value of 0.05).

**Table 8.** Kaiser-Meyer-Olkin Measure of Sampling Adequacy and Bartlett’s Test of Sphericity for Perceived Success

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.620
Bartlett’s Test of Sphericity	Approx. Chi-Square	49.004
	df	3
	Sig.	.000

Table 9 shows that only one component with an eigenvalue greater than one was extracted with a factor loading of 0.30 as the cut-off point. This component explained 53.3 per cent of variance. The final PCA statistics and extracted component accounted for approximately 53.3 per cent of the total cumulative variance (greater than the threshold value of 50 per cent).

**Table 9.** Total Variance Explained for Perceived Success

Initial Eigenvalues			
Component	Total	% of Variance	Cumulative %
1	1.600	53.324	53.324

### *Discussion of Findings*

The factor loadings for the component are shown in Table 10. The component's name was retained as perceived success because all three of the original three indicators of perceived success for indigenous construction firms used in this study, as identified in the literature review, were grouped under the component.

**Table 10.** Component Matrix of Perceived Success

Ref	Perceived Success	Component
		1
PS20	Profit growth	.764
PS19	Business growth	.733
PS21	Employment growth	.692

### *Perceived Success*

The component consisted of the following indicators resulting from organisational survival in this sequence based on factor loadings: (PS20) profit growth, (PS19) business growth, and (PS21) employment growth as shown in Table 10. According to Table 9, it accounted for a variance of 53.324%.

Profit growth is a measure of organisational survival in terms of generating profit to satisfy the company's investors and shareholders. As a corporate measure, business growth is defined as the number of company sales or projects undertaken by the firm (Tajnikar et al., 2016). A higher volume of activity results from the company's larger size, and thus an increasing number of employees over time indicates positive employment growth of the firm due to organisational survival.

## **CONCLUSION**

Construction practitioners seeking useful survival practices face a difficult task that may result in the implementation of ineffective survival practices that jeopardise the survival of their organisations. There is no room for experimentation as the COVID-19 pandemic had serious and massive consequences, particularly for the economy and the construction industry, which can lead to high business failure rates. The purpose of this study was to increase the likelihood of firm survival by investigating the survival practices and perceived success of Klang Valley Malaysian indigenous construction firms in the post-COVID-19 era.

This study found that tendering strategy, human resource management, organisational culture, finance management, and marketing all play a role in organisational survival. These underlying factors were the realms of survival practices of indigenous Malaysian construction firms in Klang Valley to survive the COVID-19 pandemic. New company policies covering these areas must be developed for firms to continue to succeed in terms of profit, business, and employment growth in the future. Indigenous construction firms should continue to strive to build quality buildings and provide quality services as clients seek performance even when project prices are reduced.

This study assisted Klang Valley Malaysian indigenous contractors in adopting effective survival practices for their businesses to remain viable in the construction industry. Educators and construction professionals should recognise these highlighted survival practices, and efforts to discover more useful survival practices should continue.

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# BENEFITS OF THE POTENTIAL IMPLEMENTATION OF AUGMENTED REALITY TO THE CONSTRUCTION PROFESSION

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## Abstract

The nature of construction revolves around the level of drawing details (LOD) as a platform of communication which supports the levels of decision-making between different stakeholders in a project. This affects different areas within a project – Design, Engineering, Commercial (Cost and Change Management), Health and Safety and Programme. Recently, Building Information Modelling/Management has evolved to Virtual Design in Construction (VDC) to cater for the constraints in 2D drawings. An example of a VDC interactive technology is Augmented Reality (AR), a partially immersive technology which is in this period, known to be already ubiquitous. However, its implementation is not fully adopted with the lack of studies about exploring a BIM Powered AR User Interface (UI) /User Experience (UX). Deliberately, this paper aims to introduce how the AR functionalities will be able to aid Quantity Surveying (QS) students with their issues in Quantity Take-off tasks from drawings. Due to time constraints and the complexity of developing a prototype the study is limited to the responsiveness, visualisation and communication between QS students and QS lecturers. A prototype was intentionally developed to highlight the relevant features for an AR mobile application which can be suitable for understanding Quantity Take-off considering Standards, Construction Technology, and Materials. An overview of the findings was formulated from related studies and from perspectives of a chosen semester of QS students from a private university using formative usability testing. Therefore, serving as a guide for future research to consider the benefits and usability of AR specifically for Construction Professionals.

**Keywords:** *Augmented Reality; Measurements; Usability; UI/UX.*

## INTRODUCTION

Due to the vitality of the BOQ, Measurement is known to be the core subject for quantity surveying students. Nani et al. (2007) illustrated two types of information can be found in the BOQ document: 1) descriptive information, which includes identifying the identity of an item and its respective material, quality, precision, dimension as well as the location on the building, and 2) Numeric information, which involves observing the building's dimensions and gathering the quantities with the unit of measurement - Length (m), Area (m<sup>2</sup>), Volume (m<sup>3</sup>), Weight (ton) and Number (No.) - rationalized into a fiscal value. BOQ is prepared through the process of "measuring" or theoretically termed as "taking-off" each item's quantity from design drawings prepared by an architect or engineer. The process of taking-off is done in correlation with a set of rules defined under a specified Method of Measurement. McDonnell (2019) have asserted that students are struggling in grasping the principles of Measurement. This was due to several issues in the teaching and learning of Measurement subject encountered, such as errors in the bills of quantities, difficulties in measuring, and restrictions of the software used for measurement. One main reason for these issues is the lack of experiential learning e.g., provision of site visits.

Lee (2013) have found the currently technological tools – PowerPoint and online videos (e.g., YouTube) – to be sufficiently useful but still have their constraints. 2D images and videos lack the benefit of offering a partially immersive experience where students can self-manipulate or self-navigate around a context. Thus, the limit of illustrating various perspective, elevational or sectional views. As for Building Information Modelling software (BIM), it has an enhanced spatial feature but has a set-back of having a complex interface and an expensive licensing attainability.

AR is a ubiquitous product that allows comparability of a digital object (such as 3D models created from BIM software) against details from the real world. With the incorporation of self-navigation, instructional method, and the ability to target images characteristics visualizing BIM via AR will give more realistic sense of materials for understanding measurements contexts. Deliberately, AR applications being digital products which are reliant on the quality of conveying information contains the characteristics of Usability.

## LITERATURE REVIEW

Ubiquitous is defined as appearing everywhere. Mobile device is one example of being ubiquitous. Alexander (2004) predicted that mobile devices will be the powerhouse of information and communication connected to the internet, which is available anywhere or anytime.

Augmented Reality has been applied in product development as a tool to facilitate interactive modification of design concepts with “users” (Santos et al., 2003). Users are a focus group of people that are going to interact with a specific product or are interacting with a specific product. Choi (2019) have elaborated that augmented reality is a mixed immersion technology affecting the sense of user feeling, this is a product wherein its “level of potential” is assessed through simulation and evaluation. This eventually consumes the factors of Usability. Reiss et al. (2012) opined usability as the provided factors that can lead to the ease of use of a product. They elaborated that usability of a product revolves around the following characteristics: Functional, Responsive, Ergonomic, Convenient and Fool proof. Groot (2015), defined usability as the principle of the users’ perception on how they can effectively, efficiently, and satisfactorily accomplish a task when a product or application. Usability is incorporated within two aspects of a product as justified by UX Planet (2019): (A) User Interface (UI) refers to the graphics design of an application which is composed of: (A.1) buttons clicked by the users, (A.2) tests read by the users, (A.3) images, (A.4) scrolling features, (A.5) text entry fields, (A.6) screen layout, (A.7) transitions, and (A.8) animations. Primarily this is any kind of visual elements and anything that happens or flashes on screen once the users have instigated any form of interactions. (B) User Experience (UX) is affected by the designer’s UI arrangement. This determines how the users interact with the UI elements. It answers the questions: (B.1) Is the experience smooth? (B.2) Is it intuitive? (B.3) Is it lagging? (B.4) Is navigation confusing (too random) or straightforward (logical)? (B.5) Does it provide a sense of efficiency to the users? (B.6) Is it a struggle overall? In short, UX covers the entire experience of users on a specific product. Jo et al. (2019) signified that AR garners attentions through its interactive medium enabling a view of the actual world which is spatially augments computer-generated information. They further explained that it aids in the amplification of people’s intelligence for problem-solving and carrying out actual tasks.

To summarize, there is an interconnection with AR, usability (UI/UX) and mobile devices. AR retains a user interface that blends the realistic environment with a digital object overlaid over it using various systems or devices. This form of user interface then creates an environment for users which enhances their user experiences with attaining information through amplified visual context that are now conventionally installed on smartphones as a form of application.

## Potential Use of Augmented Reality in Quantity Surveying Education

Measurements is a core competency of a QS profession that encompasses a learning outcome for students to achieve. To accomplish this learning outcome, the students are required to attain a well experiential learning environment. Various researchers that tackled the learning-teaching outcomes in Quantity Surveying and the use of AR in education utilized the theories of Kolb and Piaget (Chi et al., 1998; Loewe et al., 1994; Lee 2013) where the factors of experiential learning are elaborated: (1) Active Experimentation – willingness to be active and be initiative; (2) Reflective Observation – ability to distinguish a misunderstanding or errors and be open to correcting them; (3) Concrete Experience – adapt and integrate observation into complex but logical theory; (4) and Abstract Conceptualization – critical thinking of problems. For students to be effective learners they should apply these four factors in the form of assimilation and accommodation. Application of knowledge and adaptation with circumstance. However, many students still have issues with accomplishing these in learning measurements. The following are found to be the main problems in students towards achieving an effective learning outcome in measurements based on the findings of both Tunji-Olaveni et al. (2016) and Badu et al. (2004): (1) Teaching method and communication; (2) Difficulty in visualizing; (3) Lack of resource materials; (4) Lack of practical experience; (5) Lack of excitement. Textbook may not be suitable to teach the experience (Qaswari, 2018). Maton et al. (1976) found that the more life experience occurs in a student, rather than perceiving learning as an external process, they perceive learning as an internal process. Students at a developmental stage learn concrete concepts that they can recognize through their sensory organs more comfortably (Sirakaya et al., 2018). Hence, learning tools that will facilitate to concretize abstract concepts are needed in this period. Aigbavboa et al. (2018); Sirakaya et al. (2018); and Cabero-Almenara et al. (2019) observed that there are a variety of solutions that AR can offer to students for them to achieve a metacognitive learning outcome through a half-digitalized class environment experience. These solutions are mapped extensively by Diegmann et al. (2015) (see Table 1). AR's usability can affect the students' learning environment and promote a different behavioural pattern as compared to manual learning environment: AR ensures teaching abstract concepts by making them concrete in an engaging and fun manner.

**Table 1.** Benefits of AR to The Learning Experience of Students

Category	Benefits to Students Learning Experience
State of Mind	Increased Motivation, Increased Attention, Increased Concentration Increased Satisfaction
Teaching Concepts	Increased Student-centred Learning, Improved Collaborative Learning
Presentation	Increased Detailing, Increased Information Accessibility Increased Interactivity
Learning Type	Improved Learning Curve, Increased Creativity
Content Understanding	Improved Development of Spatial Activities, Improved Memory

(Source: Diegmann et al., 2015)

Seeing, that researchers have found BIM to be one of the solutions to the problems, the setback with BIM is its inability to be ubiquitous and its interface is not deemed to be simple to use by novice learners (Migilinskas et al., 2013). Arashpour et al. (2017), explained the empowerment of AR in BIM through the streamlining the ergonomic interface thus enhancing the convenience for individuals who only need to observe the actual motion picture of a component or of a building. Visualizing BIM via AR gives a more realistic sense of materials, facilitates recognition of problems and allows decision-making processes adoption. Similarly, Suk et. Al (2017) have observed the effectiveness of AR in the taking-off performance of Construction Management students. Whereas Fauzi et al. (2019) assessed the acceptance, expectations, and readiness of students with AR in learning Construction Technology.

## Usability Testing

AR is designed for a specific function it is developed for which consists of a unique user interface that projects a respective user experience. In this study AR's function to be able to deliver the following theories and practical experience within the subject (Lee, 2013): Construction Technology, Measurement Principles and Mathematics, Skills in Taking-off Quantities, Preparing and Presenting Bills of Quantities. Lee's elaboration was found to be a summarized version having similar skills factors with Mcdonell (2019), Qasrawi (2018), Almunifi et al. (2019) and Shafiei et al.'s (2013). Where all these studies elaborated skills for a mathematical oriented field with the cooperation of critical thinking. Thus, the following technical skill factors relative to measurements module are extracted: (1) Theoretical knowledge in Construction Technology; (2) Being able to understand SMM2 clauses; (3) Abstract Thinking; (4) and Mathematical skills. Relatively, Lewis (2006) claimed that Usability Testing is a widely used and a vital technique for evaluating product design. For applications, the important essence is not to wait for perfection when creating something new, but it is important to first create and test a minimum version and quickly improve the product based on the feedback until it is exactly what the users need. Many AR researchers who tackled this topic and applied it to educational context, used Usability Testing to identify whether it will meet the expectations, acceptance and satisfactions of students as users. These researchers attempted and tested AR applications as an initial proposal as an educational tool to students. According to Pribeanu et al. (2008), they used the Technology Acceptance Model (TAM) as source for their usability Likert scaled based questionnaire. to have a broader view on the usability evaluation from students taking Biology. The TAM developed by Davis et al. (1989) aims to acquire information from four main factors: perceived usefulness, perceived ease-of-use, perceived enjoyment, attitude towards use and intent to use. The principle of TAM indicates that "usability (usefulness & ease of use)" is influenced by "users' attitude" regarding the technology. TAM presents an early and useful context on whether users will or will not accept a new technology (Dillon et al., 1996). Martín-Gutiérrez et al. (2018) & Pribeanu et al. (2008) methodologies, used a Usability Questionnaire that follows the outline of the Technology Acceptance Model by Davis et al. which incorporates questions to understand the students' perception on the (1) Learnability, (2) Efficiency in Learning, (3) Efficiency in Familiarization, (4) and Satisfaction to the specific AR application designed to function as a digital measurement learning guide. Learning strategy, learning motivation and teaching strategy are a domino effect to one another. Biggs et al. (2001) stated that in a learning model, student factors, teaching context, on-task approaches to learning, and the learning outcomes, mutually intermingle, thus establishing a dynamic system. This is then adopted by Leung et al.'s (2008) Quantity Surveying students' learning model. Ergo, student

learning approaches are observed to be a forming part of the entire educational system. What the student does is as important than what the teacher does (Biggs et al., 2001).

## RESEARCH METHODOLOGY

### Design

An AR application (see Figure 1) was developed using three different software. Google Sketch-up and Autodesk Revit were used to model and render the digital object. Whereas Photoshop and Unity with Vuforia plug-in were where the UI was formatted and where the digital object was augmented. The UI of the prototype was designed and arranged based on suitable functions gathered from Reiss et al. (2012) and UX Planet (2019) in consideration of the aimed overall user experience with factors from Diegmann et al. (2015). Information Simplification and Arrangement, Tool tips, Buttons, Color-coding, Page Scrolling, Transitions and 3D Objects were all integrated for QS students to navigate with. A Zoom Meeting discussion implicated an observation of users of the proposed application infused with an AR feature. These observations are associated with the variables revolving on the usability level rated by the students who were considered as the users within this study.

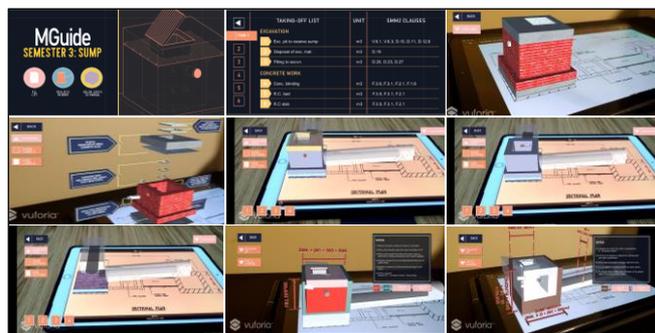


Figure 1. Developed UI of the AR Application Prototype Used During Zoom Meeting Discussion

Quantitative Data was used to collect the findings which consist of close-ended questions asking the respondents about their ratings and responses attaining a usability metrics for AR in measurements which was based on Martín et al. (2018) framework. Another section of the questionnaire queried students on their issues founded by Tunji-Olaveni et al. (2016) and Badu et al. (2004), to be able to relate how each of AR’s usability can be able to solve these issues based on its experiential benefits as mapped by Diegmann et al.’s (2015). These benefits are also related to the skills that the students require to attain with the learning outcome of the measurement module. This study is limited to the creation of the framework to illustrate how augmented reality can be inserted into the measurement’s module which can be proven based on AR benefits, QS student’s issues and a class of QS student’s perception ratings. In the analysis and interpretation of the surveyed data, scale of means was used in determining the experiences and the usability feedbacks of the respondents. Table 2 indicates the Likert-scale and their descriptive equivalents which are labelled as DR for the questionnaires disseminated to the students.

Table 2. Descriptive Equivalents Used for Each Scale of Means

Derivations (DR):	High	Strongly Agree	Agree	Disagree	Low
Scale of Means:	4.20 – 5.00	4.19 – 3.40	2.50 – 3.24	1.75 – 2.49	1.00 – 1.74

## Locale of Study

When dealing with an initial prototype, in a design process it is tested (usually with a few) users to see how usable it is. This is called a formulative usability testing which is meant to steer a design in the right path (Joyce, 2019). This pertains to asking the users about any confusion, interface’s simplicity, intuitive navigation, perception on clarity and their thought process while interacting with the screen. Due to time constriction and the thorough process of developing the prototype, convenience sampling was utilized for this study. The target population were quantity surveying students in Semester 4 within Taylor’s University. There was a total of 33 students in the target class. The content of the proposed application (Drainage: Sump) was only taught in this specific semester. Sump was a newly introduced construction structure for the students however the process within this structure included Excavation Works and Concrete Works which were taught during their semester 2. It also included Brick Wall and Finishing Works which were taught during their semester 3. Deliberately, since the content created is prototyped to function for this semester’s topic, the convenience sampling is limited to this batch of quantity surveying students’ number within the class.

## CONCEPTUAL FRAMEWORK

From the sets of related studies, the conceptual framework on Figure 2 was formulated and followed on the succeeding portions of this study. For ease of reference, Table 3 shows the codes used in the overview map formulated following the findings in section 5.

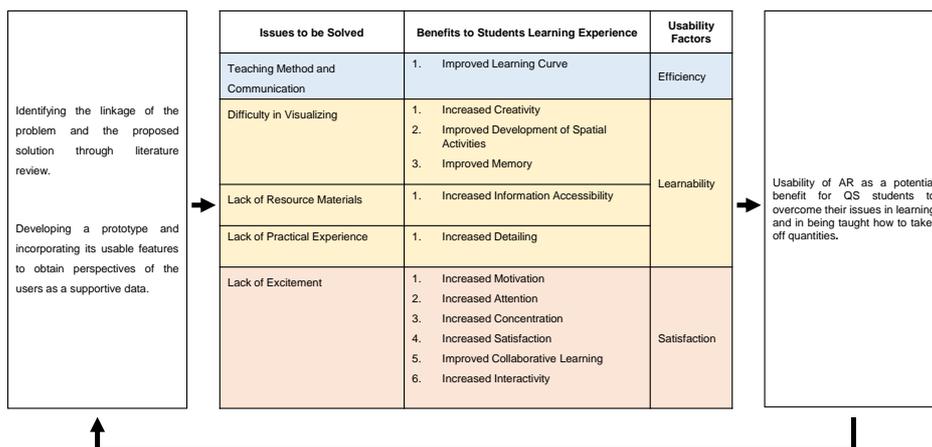


Figure 2. Conceptual Framework

Table 3. Coding of Factors

Issues	Coding	Usability Factors	Coding	Skill Benefits	Coding
Teaching Method and Communication	I1	Efficiency in Learning	EL	Theoretical Knowledge in Construction Technology	B1
Difficulty in Visualizing	I2	Learnability	L	Being able to understand SMM2 Clauses	B2
Lack of Resource Materials	I3	Satisfaction	S	Abstract Thinking	B3
Lack of Practical Experience	I4	Efficiency in Familiarization with the Device	EF	Mathematical Skills	B4
Lack of Excitement	I5				

## RESEARCH FINDINGS

### Issues Faced by Students with Studying Measurements Module

On Figure 3 evidently the main issues of the students are being able to explore the conventional context and apply the knowledge in construction technology seeing that it is the highest rated issue having 87% of students acquiring this problem (I4). Relatively, Gurmu & Mahmood (2020) found that the students struggle with keeping up with lectures due to the insufficient exercises or examples, the adoption of non-interactive lectures and lack of exposure to software which resulted to their difficulty in learning measurements. These observations are seen to be occurring in the class where 66% of the students answered yes to I1 which referred to the teaching method and communication. Students prefer to be taught step-by-step and for lecturers to not assume that they can understand topics right away (Tunji-Olayeni et al., 2016). When talking about context, this means course materials. Gurmu & Mahmood (2020) opined that “there is insufficient country-specific textbooks on building measurement”. This is proven by the findings where lack of resource materials (I3) is the second highest rating of being an issue to the students, this occurs to 81% of the class. After, the issue with relating construction technology principles and the issue with the lack of resources, the issue with memorizing (I6) comes into third place of being an issue for 75% of the students. Another issue found was that some students also lack interest (I5) with the module comprising 58% of the class. Students who are considered novice to the construction field and the inevitable case of not being able to provide them site visit experience they can only depend on their visual attributes. Moreover, due to the extensivity of information of learning standards, applying mathematical concepts with costing, and understanding construction principles, students have a hard time filtering important details. Not being able to filter the important details affects their ability to memorize where they have limited time Bather (2013) to study with the thought of memorizing too many details. This complex information being thrown to the students at a fast pace and only through verbal/2D communication prevents the interest of the students to emerge. Since building measurement is calculation based it is perceived to be hard for many students as it consists of various components like geometry, symmetry, a lot of thinking and interpretation of components (Tunji-Olayeni et al., 2016). As for the benefits of AR on Figure 3, 100% of the students consisting of the entire class, agree AR can aid them in with their theoretical knowledge in Construction Technology (B1). Consequently, majority of the students comprising 97% of the class, approve that AR offers a benefit with their abstract thinking skills (B3). Thirdly, most of the students involving 90% of the class think that AR can also help them with their mathematical skills. Lastly, although being able to understand SMM2 clauses was the least agreed upon by students, it still is considered a benefit by more than half of the class showing that there are 71% agreed students. To summarize, the benefits of AR can be extended to QS students who aim to acquire the skills necessary to obtain a positive learning outcome in measurements module. *“Overall, the application work well and it cover most details about sump (B1) that explain in the class. It helps me visualise (B3) and know how to measure (B2 & B4) the sump faster. Hopefully can extend to other topic.”* (Respondent No. 18).

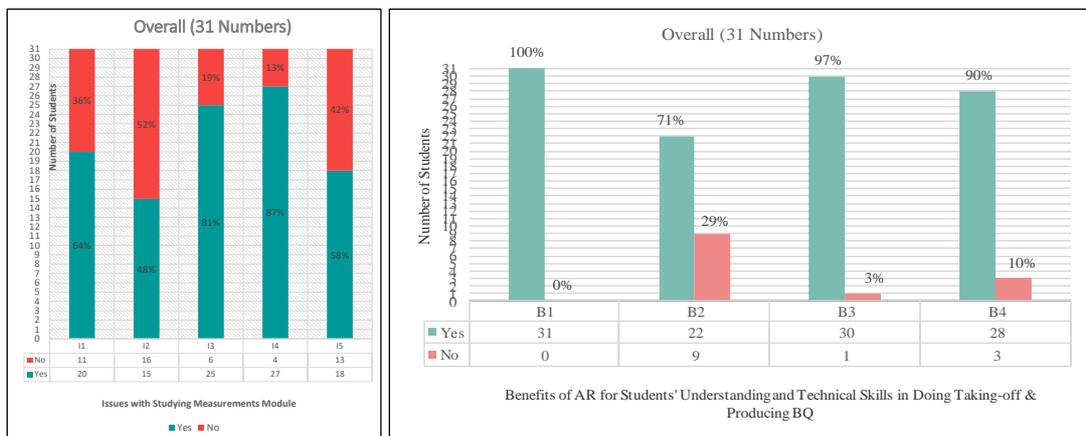


Figure 3. Issues with Studying Measurements Module Bar Chart and Benefits of AR for QS Students Bar Chart

### Usability Level of the AR Application Based on the Students' Perceptions

Summarizing the means of each factor, the students' rating on their perceived usefulness, perceived ease-of-use, perceived enjoyment, attitude towards use and intent to use of the proposed AR application was positive seeing that all the usability factors were rated above average and high (see Figure 4). Learnability has a mean of 4.1 (above average), Learning Efficiency has a mean of 4.35 (high), Efficiency in Familiarization (above average) and Satisfaction (high). These factors were derived from the ratings breakdown as shown on subsection 5.3 where their implications are further explained. With this summary it can be seen that the chosen group of students perceive AR to be suitable for their needs and found it to be easy to use despite a few programming errors.

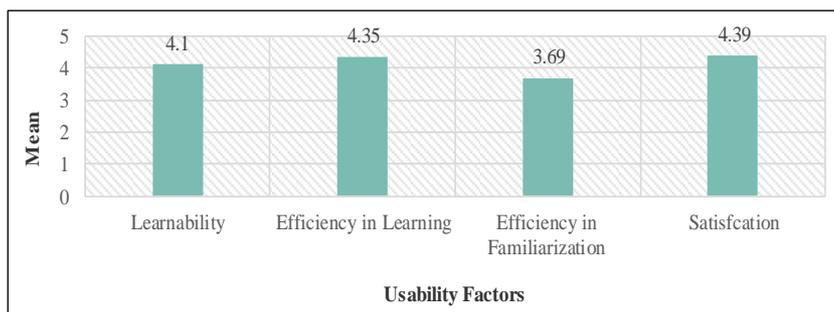


Figure 4. Usability Ratings Based on Students' Perceptions Bar Chart

### Overview

Through the overview map (see Figure 5), the benefits of AR with the students' measurement skills were linked through assessing the usability factors that can enhance the QS students learning experience which will eliminate their founded issues in studying measurements. Thus, narrowing the general usability of an AR product into the QS students' essential usability of the proposed AR product for the module.

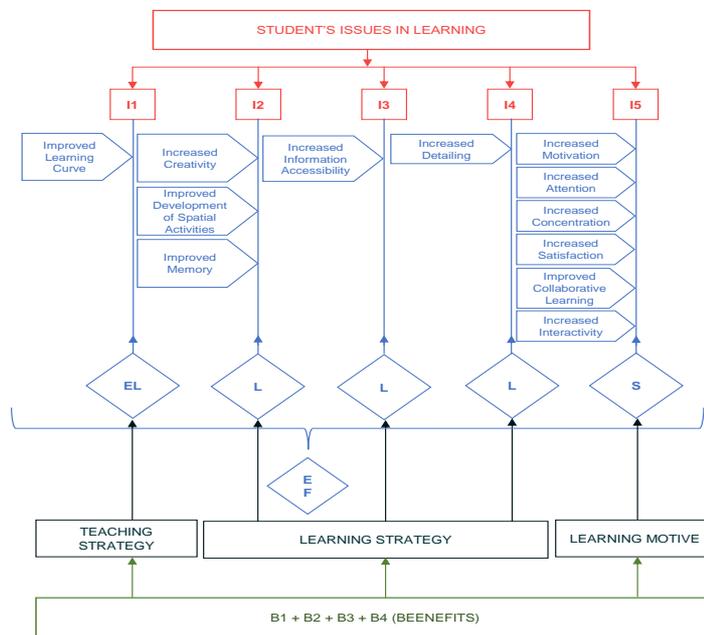


Figure 5. Overview of Findings

**Learnability:** Arashpour et al. (2017) stated, AR-powered BIM can accommodate for all learning measures of remembering, understanding, applying, analysing, evaluation and creating. This then caused the above average rating of learnability. As defined by Reiss (2019) a usable product is fool proof – the designer helps the users to prevent mistakes. The AR application has a great potential in minimizing errors while doing the taking off. As commented by a student, “it is easier to understand rather than looking at the drawings and running self-visualisation inside my head” (Respondent no. 17). “It helped me to have a clearer picture and better understanding of the structure of sump” (Respondent no. 4). It was established that the application of abstracting the process of construction elements is one of the main difficulties that the QS students encounter. As founded from the Figure 4, at the current period, it is still a common issue. Students having lack of practical experience (I4) and lack of resource materials (I5) are the sources of the stated difficulty (Suk et al., 2017 and Tunji-Olayeni et al., 2016). Seeing the low agreement from Figure 2, although most students are capable of interpreting drawings (I2) as a task and are capable of visualization (I6), these capabilities are not enough to cater for the complexity of the dynamic details of construction principles (I4). That said, if the AR 3D content is modelled to be presented in detail and accurately (L), this will enable the students to manipulate and navigate (EF) how the components of the elements are connected (B1). Thereby, in this study the students were able to see the Sumps detail in different perspectives, different rendering styles and different sections. They were also able to see how the Sump is connected to other drainage elements – Sewage Water Drainage and Pipe Culvert. Moreover, with the supplement of digital notes that include SMM2 clauses with explanation (B3) and dimension indicators (B4), the students can abstract (B1) the necessary measurements of each component of the topic. Reiss (2019) also indicated that a usable product is ergonomic – the designer allows users to easily see, click, poke and turn stuff. With the use of AR on smartphones, this would permit the students to see the BIM model of buildings’ structures and other components that pops up on the phone screen (Blinn et. al., 2015). The proposed AR application was created using a BIM software called SketchUp, thereby the layering feature that students learn complexly in Revit was

applied and simplified into categorizing instructional scenes into the relevant elements of the topic. This then constitutes an additional technological learning tool (L) for them to experience the accommodation of spatial information combined with context information and assimilation of these information into descriptively quantified documents for costing. Thus, highlighting the above average usability level of Learnability (Table 4).

**Table 4.** Learnability Breakdown

Content	Mean	sd	DR
The material is clearly presented (e.g., Sump components, materials and process).	4.35	0.88	High
The content of the AR application has sufficient information I need therefore minimizes any confusions.	4.39	0.76	High
The text contents were easy to read and offer helpful instructions.	4.23	0.85	High
AR with a separate printed drawing, SMM2 book and other notes on my desk while listening to lecture is not a hindrance.	3.94	1.06	Above Average
There are no unnecessary contents.	4.03	0.95	Above Average
I feel more confident to measure sump without the need to follow tutorial answer.	3.90	1.01	Above Average
I was able to visualize sump better as compared to being taught without AR.	3.77	1.18	Above Average
I feel like it is easier to know how to calculate the measurements.	4.16	0.86	Above Average
<b>OVERALL</b>	<b>4.10</b>	<b>0.72</b>	<b>Above Average</b>

Efficiency in Learning: Diegmann et al. (2015) described in their AR benefit map that AR provides an improved learning curve which is the effect that refers to students learning faster and easier. Correlating with learnability of improved memory point in their map, they explained that AR contributes to memory vividness. This can be justified using Sirakaya et al.'s opinionment that AR concretizes abstract concepts thus facilitating the ability to perceive these concepts through sensory organs more comfortably. As explained by Jo et al. (2019) AR's content amplification aids in problem-solving and carrying out actual tasks. Relating this to the measurement module, AR enhances the understanding of construction drawings eliminating the need for redrawing during self-study process of the students (Suk et al., 2017 & Fauzi et al., 2019). This finding is then supported by another student's comment, "*it is useful because in last 2 semesters I have to draw the element out to clearly understand how it is to be*" (Respondent no. 15). Another difficulty the QS students encounter is being able to keep up with the lecturers. As explained by Reiss (2019), a usable product is convenient – everything is where the users need it to be. This is due to the fast method of conveying verbal and 2D images in a time-limited class session (I1). One usable factor that AR can enhance this constraint for students is through the learning curve (EL). This means that lecturers can use the proposed AR application as a form of teaching strategy to relate verbal theoretical principles with the 3D images that they themselves can navigate (EF) during class while students can follow along on their phones. The interface provided dimensions and instructional methods, along with the play on opacity to highlight the volumes to deduct or add, for example during the excavation process where excavate, fill and disposal are to be considered. Ergo, the high rating as seen on Table 5. Although there has been a trend of BIM, is has the inability to be ubiquitous and its interface is not deemed to be simple to use by novice learners (Migilinskas et al., 2013). For face-to-face sessions, phones of the lecturers can be connected to their laptops where their laptops can be connected to a project. As for online learning cases, lecturers can project their phone screens using screen sharing of video call applications. This was demonstrated through the Zoom Meeting session with the

respondents. This finding is in line with Tunji-Olayeni et al's (2016) finding where teaching strategy is one factor that affects student learning experience in measurements.

**Table 5.** Efficiency in Learning Breakdown

Content	Mean	sd	DR
The AR application with in-class explanation, will saves time for self-study.	4.35	0.84	High
The AR application is a faster method to teach in-class discussion.	4.45	0.93	High
I feel like AR learning will save me time from redundant memorizing tasks.	4.26	0.89	High
<b>OVERALL</b>	<b>4.35</b>	<b>0.78</b>	<b>High</b>

**Efficiency in Familiarization with the Device:** The quality of the interface's simplicity is distinct to how it is designed and developed. According to Reiss (2019), a usable product is also functional and responsive – the users know the product is working and expects the features to work as they are functioned. Although the feedback from students was above average, the reason for not scoring high was due to some problems the students encountered with the current state of the proposed AR application. For applications, the important essence is not to wait for perfection when creating something new, but it is important to first create and test a minimum version and quickly improve the product based on the feedback until it is exactly what the users need (Lewis, 2006). As commented by another student, *“The application works well, but sometimes there are slight framerate issues and slightly laggy. Fixing this problem will be very nice”* (Respondent no. 27). The 3D model depends on the sensor of the camera against the marked 2D drawings. Some students encountered a frame rate issue: *“allow camera focus techniques will make the apps better”* (Respondent no. 30). Also, one student encountered a purple screen blocking the entire screen thus require her to keep on refreshing the application, *“got problem on my android phone, just a purple screen came out”* (Respondent no. 8). Hence, the slight issue with the navigation, manipulation, and transition. The proposed AR application is marker-based. In this type of AR design, it is best to consider the Efficiency in Familiarization of the users with the product. This factor affects the quality of the UI due to the fact that it refers to the adaptive level of new users with the technology. Framerate refers to the smoothness of the models to show up on the screen on top of the 2D drawing details after pressing the buttons. Some students faced an issue where the model did not appear as fast as they expected. There were also instances where the screen was lagging. Thus, it the students did not rated EF as above average as seen on Table 6.

**Table 6.** Efficiency in familiarization with the device breakdown.

Content	Mean	sd	DR
It was easy to navigate and manipulate the entire AR interface right away.	3.84	0.9	Above Average
I feel like I can use the application without an instructor.	3.71	1.07	Above Average
Transitions and animations went smooth after pressing the buttons.	3.52	1.03	Above Average
<b>OVERALL</b>	<b>3.69</b>	<b>0.86</b>	<b>Above Average</b>

**Satisfaction:** Similar with Bather's (2013) and Shaaban (2013) studies, having lack of engagement is a learning barrier that need to be managed, as it results to students' having self-defeating behaviour to produce a contextual knowing – learning to develop critical thinking skills. Satisfaction is the perceived successfulness of a product to maintain users' motivation. Table 7 illustrated that the students' satisfaction level with the proposed AR application was high. This level of satisfaction finding is similar to the QS students' acceptance with AR learning in construction technology finding of Fauzi, Ali and Amirudin's (2019). They were able to evaluate that student at first introduction, AR automatically attracted the students'

attention. They found that students perceived that “AR will make group works more interesting”. In this study, this attraction was also observed as commented by a student: *“Interesting and fun”* (Respondent no. 5). This is aligned with Baccas et. Al.’s (2014) conclusion that the main benefit of AR is its ability to provide better motivation, interaction and collaboration. Due to the way of presenting the course material the students were able to find the AR environment interesting. Learning approaches of the respondents are characterized by both strategy and motive. Learning motive indicates their motivational level (Biggs et al., 2001). Where in Figure 2, it was founded that the students are not interested with this core module and found it boring having lack of interactivity (I6). During the tutorial session, one student asked about the weephole, the facilitator was able to communicate how the weephole looks like while the student and his classmates can follow by manipulating their own phones or watching the screen sharing. Deliberately, the students gave a high rating to the satisfaction of using AR. Satisfaction refers to attaining their attention, concentration and motivation while navigating (EF) along with AR’s interactive feature (S). Satisfaction is also connected to learnability which one student implied that *“very good presentation and easy to understand. If there is AR application for other measurement topic. This will definitely make the learning more interesting and easier to understand.”* (Respondent no. 5). Learning strategy refers to the students’ method of study. This relates to the visualizing skills and memorizing skills they apply. Visualizing the construction process when self-studying. Memorizing the taking-off list of elements, the materials, basic mathematical formulas and SMM2 clauses.

**Table 7. Satisfaction Breakdown**

Content	Mean	sd	DR
AR Technology is interesting that makes me motivated to study the topic.	4.35	0.70	High
AR makes class session fun.	4.55	0.57	High
AR makes me want to be attentive in class.	4.45	0.62	High
AR makes me want to join class discussions.	4.26	0.77	High
AR provided a fun class session.	4.42	0.62	High
I was able to be more attentive in class with AR.	4.29	0.69	High
<b>OVERALL</b>	<b>4.39</b>	<b>0.56</b>	<b>High</b>

All in all, AR is able to intermingle both student factors and teaching concept (Biggs, Kember & Leung, 2001) through providing an engaging class from lecturers to students which can result to a positive learning outcome. By enhancing the experiential learning, it encourages students to have a sense of responsibility (Aigbavboa, Oladokun & Kgoadi, 2018). AR can supplement the experiential learning which site visits can provide in a digital manner (Suk et al., 2017 and Fauzi et al., 2019). This then achieves Kolb’s (1984) experiential learning requirements for the students of willingness to be active, able to reflect on experience, able to conceptualize analytically and able to apply problem-solving with decision making skills.

## CONCLUSION

As founded in the results, manipulating and navigating (EF) AR can be used for guiding the users in terms of concentration (S), visualizing (L) and filtering information where they will be able to process the taking-off procedure easier (EL). Relating this to the measurement module, AR enhances the understanding of construction drawings. Moreover, with various

perspectives and instructional methods, it is easier to show are needed to take-off. Students can interact with the application while being guided which improves engagement. However, designers need to be wary of the application's functionality and responsiveness of the application, how topics/concepts are 3D modelled and how information are arranged to prevent users confusion and inefficiency to see what they need to see. Similarly with other researches, QS students' lack practical experience and having less site visits does not help in terms of visualizing, thus with AR this can substitute for students' experiential learning in-class. Dissimilarly, this study did not only give a view on the visual benefit of AR but also provided a view on how user interface features are relative to the learning-teaching experience with measurement. AR can be used to guide the users to conveniently see the components while taking in consideration the quantities and standard method of measurement through tool tips/color coding features and satisfies engagement through AR's navigation/interactive feature. Due to the impact of the Covid-19 situation a face-to-face experimentation was unable to be conducted preventing an experimental method of pre-test and post-test. Hence the limitations impacted the results of this study as the data analysed from respondents were subject to opinions of the students only. With the scarcity of research in AR for QS and the construction industry, it is recommended to provide more in-depth analysis through observation of the users' usage of the application over a period of time to have a more credible support of its effectiveness as a whole application. This study focused on QS students as users, hence for future research, students, lecturers and other professionals within the construction industry are a viable target population. Thereby the implication of this study is to promote the development of an AR interfaces for construction which can open for more case studies of this technology's implementation. Concluding, with this study, it showed how an AR application can specifically function as a portable, simple, interactive visual communication tool and it serves as an initial guide which illustrates how AR itself can be suitably optimized to be implemented for the field.

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# SUSTAINABLE DEVELOPMENT FROM THE PERSPECTIVE OF EDUCATION GOALS

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## Abstract

Various initiatives and tools have been undertaken by universities abroad to ensure that they meet the sustainability practices. Yet, it seems that the practices still divergent and not well-ordered applied across the Higher Education Institutions especially in Malaysia Private Higher Education Institutions. The research objectives it's to measure awareness among Private Higher Education Institutions academician towards the element sustainable education criteria in Higher Education Institutions in Malaysia. The research involves a quantitative approach using structured questionnaire survey which was designed based on items obtained from literature review. The questionnaire further distributing to 29 Private Universities in Malaysia with 75 respondents responded. Furthermore, Rasch Model analysis has been used to analyse the data gathered. This study finds that optional course on sustainable development in the curriculum, course on sustainable development for all students and pedagogical approaches used to teach sustainable development issues contributing to favor findings. The findings are able to significantly highlight the specific element for an academician and management at Private Higher Education Institutions to further considering to implementing the sustainable concept in a further better way.

**Keywords:** *Sustainable education criteria; Rasch Model analysis; Private Higher Education institution*

## BACKGROUND OF STUDY

Sustainable development, which is prominent in these few decades has been implemented worldwide due to its essential role in society. Besides, Higher Education Institutions are also actively working closer to sustainability implementation by imposing sustainability practices within the establishments themselves (Law, 2015). The motives of imposing sustainable development inside the Higher Education Institutions are, broadly speaking, to tackle the challenges of Higher Education Institutions thus they are in parallel with the Sustainable Development Goals (SDG) Number 4 on improving the quality of education.

Higher Education Institutions ought to play a vital role in turning society to emerge as sustainable via their strength in producing and educating the heirs' generations. The functionality of a research core must be superior regarding the sustainability agenda. The conceptual and philosophy of sustainability ought to be taught to the scholar to embody their understanding as soon as they enter their professional life. Besides, from an organisational perspective, the sustainability idea has to be embraced inside day-by-day routine organisational management tasks. Furthermore, it was once viewed that as sustainable Higher Education Institutions have to refer to a four-dimension system – education, research, community outreach and campus operation. Therefore, all dimensions of sustainable Higher Education Institutions ought to be utterly adopted, which include the fifth dimension

advocated by way of Lozano (2003), where overall sustainability implementation performance has to be assessed and reported.

Sustainable development has been a much-debated subject in recent years, especially in developing countries, including Malaysia, due to rapid urbanisation with increased population and rapid economic growth. Every developing country is now moving forward in implementing this concept (Ibrahim et al., 2015). The Malaysian government has expressed its concern in achieving sustainability through several strategies formulated in its five-year national development plans (Yakob et al., 2012). Observing from this as a jump start, the Malaysian government has come out with 11th Malaysia Plan (11MP), and upgrading formula from the previous plan, which has been launched since the year 1991 to support in realising the highlighted Vision 2020 to be a fully developed country including economic, politic, social, spiritual, psychological and cultural dimension by the year 2020 (Eleventh Malaysia Plan, 2016).

The main concern in the 11MP regarding education strategy is to improve the quality of education for better student outcomes and institutional excellence and foster sustainable practices. The 11MP not only marks the culmination of a 30-year journey towards Vision 2020, where it also sets the stage for the next horizon of growth. In 2020, the challenge is to raise the bar even higher on its growth prospects along three dimensions: economy, people and environment. These stated three dimensions reflect on the sustainability concept in sustainable development clearly announced during the World Summit on Social Development, where sustainable development requires three main reconciliations, namely environmental, social equity and economic sustainability (Tanguay et al., 2010). Thus, by identifying the elements of education criteria of the sustainability implementation assessment for Private Higher Education Institutions in Malaysia may showing a further commitment to the vision in parallel with sustainable development concept.

## **SUSTAINABLE EDUCATION CRITERIA**

In general, sustainable implementation assessment in Higher Education Institutions starts from the assumption that if sustainability cannot be measured, it can neither managed nor improved (Christian et al., 2015). However, the principle understanding of sustainability implementation, which shall be implemented by Higher Education Institutions, should largely determine the process, direction, and outcomes in the sustainability implementation assessment. Despite the growing concept of sustainability implementation facing a wide range of conflicting ideological, conceptual and terminology aspect has already been discussed in abroad scale before (Christian et al., 2015; Sneddon et al., 2006; Vettori et al., 2014; Folke et al., 2002). To highlight one among many definitions, Velazquez et al. (2006) define sustainable Higher Education Institutions as a whole or as a part, that addresses involves and promotes on a regional or global level, the minimisation of environmental, economics, societal and health negative effects in the use of their resources to fulfil its main functions of teaching, research, outreach and partnership as well as stewardship among others as a way to help society make the transition to sustainable lifestyles. Table 1 explains the conceptual definition of sustainability in Higher Education Institutions.

**Table 1.** Conceptual Definitions of Sustainability Implementation in Higher Education Institutions (Velequez et al., 2006; Cole, 2003; Alshuwaikhat et al., 2008; Cortese, 2003; Lozano, 2003)

Definition	Authors
Higher Education Institutions should minimise the negative environmental, economic, and social and health effects generated in the use of their resources.	Velequez et al. (2006)
The effort of energy and resources conservation, waste reduction, promotion of social justice, and the notion of equity need to be transferred to society.	Alshuwaikhat et al. (2008)
Higher Education Institutions have the responsibility of protecting the health and well-being of humans and the ecosystem and using the knowledge produced on the Higher Education Institutions to address the ecological and social challenges that the world faced now and in the future.	Cole (2003)
Higher Education Institutions are a four-dimensional system – education, research, campus operation, and community outreach.	Cortese (2003)
Beside four-dimensional, as stated by Cortese (2003), the fifth dimension had been added claiming that the four-dimensional system needed to be assessed and reported.	Lozano (2003)

According to Lozano et al. (2014), the criteria of sustainability implementation assessment, particularly in the education, can be discussed from many perspectives that directly affected the overall course syllabus on sustainable development. The development of course content, syllabus and pedagogical approach, including the assessment regardless of the undergraduate or postgraduate level of studies, as the content should in line with sustainability (Lozano et al., 2014; Lozano and Yang, 2013). Other than the syllabus and course content, another angle that should be considered as sustainability implementation assessment criteria for education is the number and percentage of sustainable development and corporate social responsibility (CSR) programmes or specialisations (Yarine et al., 2012; Ceulemans et al., 2011; Monno et al., 2011).

Table 2 shows the sustainability implementation assessment of education criteria. There are 25 elements critically discussed accordingly. According to Lozano et al. (2014), the champion of sustainability implementation for Higher Education Institutions, the success of sustainability implementation in education should start from the teaching staff regardless of lecturer or professor. According to Lozano et al. (2014), the holistic and creative way of delivery, the principles knowledge toward sustainable development and the cross teaching inter-faculties may impact the syllabus and course of sustainability implementation to the student.

According to Ceulemans et al. (2011), Moon and Orlitzky (2011), Seto-Pamies (2011), Wring and Bennet (2011) and Bennett (2011), the distinction between regular course and stand-alone sustainable development course as well as the distinction between compulsory and elective course may be leading to better sustainability implementation for education criteria. The presence of sustainable development issues within course competencies and pedagogical approaches used to teach sustainable development issues may be contributing to the success of sustainability implementation in Higher Education Institutions (Lozano et al., 2014; Ceulemans, 2011).



**Table 2. Elements of Sustainability Implementation Assessment in Education Criteria for Higher Education Institutions (con' d)**

No	Element	Author	Ceulemans et al. (2015)	Lozano et al. (2014)	Shi and Lai (2013)	Yuan and Zuo (2013)	Koehn and Utito, 2013	Dlouha et al. (2013)	Lozano and Yong (2013)	Yarime and Tanaka (2012)	White and Koester (2012)	Ceulemans et al. (2011)	Moon and Orlitzky (2011)	Seto-Pamies (2011)	Wing and Bennet (2011)	Bennett (2011)	Glover et al. (2011)	Lozano (2011)	Madeira et al. (2011)	Wahed et al. (2011a)	Wahed et al. (2011b)	Lukman et al. (2010)	Lozano (2010)	Bernger (2007)	Total Referred
12	Continuing education to the public on sustainable development		✓																						1
13	Number and percentage of sustainable development and corporate social responsibility programmes or specialisations		✓						✓			✓	✓												4
14	Proportion of multi/inter/intra-disciplinary programme		✓																	✓					2
15	Proportion of programmes involving community and Higher Education Institutions		✓																	✓					2
16	Importance of course credits of sustainable development course as compared to total number of credits		✓								✓	✓		✓											5
17	Distinction between regular course and stand-alone sustainable development course		✓									✓	✓	✓	✓	✓					✓				8
18	Distinction between compulsory and elective course		✓									✓	✓	✓	✓	✓					✓				8
19	Presence of sustainable development within curriculum		✓								✓														2
20	Students/staff feedback of sustainable development course		✓														✓			✓					3

**Table 2. Elements of Sustainability Implementation Assessment in Education Criteria for Higher Education Institutions (con' d)**

No	Element	Author	Ceulemans et al. (2015)	Lozano et al. (2014)	Shi and Lai (2013)	Yuan and Zuo (2013)	Koehn and Uitto, 2013	Douha et al. (2013)	Lozano and Yong (2013)	Yarime and Tanaka (2012)	White and Koester (2012)	Ceulemans et al. (2011)	Moon and Orlitzky (2011)	Seto-Pantries (2011)	Wing and Bennet (2011)	Bennet (2011)	Glover et al. (2011)	Lozano (2011)	Madeira et al. (2011)	Wahed et al. (2011a)	Wahed et al. (2011b)	Lukman et al. (2010)	Lozano (2010)	Beringer (2007)	Total Referred
21	Presence of sustainable development issues within course competencies	Author	✓									✓								✓					3
22	Pedagogical approaches used to teach sustainable development issues	Author	✓						✓			✓						✓							5
23	Doctoral studies on sustainable development	Author	✓																						2
24	Presence of extracurricular activities within Higher Education Institutions	Author	✓		✓													✓							4
25	Presence of continuing education on sustainable development	Author	✓																✓						2

Besides the syllabus and pedagogical, the external curricular may contribute to the discussion criteria of sustainability implementation for the education criteria. According to Glover et al. (2011), Ceulemans et al. (2015), Lozano et al. (2014), Shi and Lai (2013), Yuan and Zuo (2013) and Lozano (2011), the presence of extracurricular activities within Higher Education Institution may diversify the approach in letting the student have a better understanding on the sustainability implementation assessment and this may lead to the presence of continuing education on sustainable development.

## **METHODOLOGY**

Data collection is divided into two, namely primary data and secondary data. Literature review falls under secondary data, whilst questionnaire survey is under primary data, which are therefore discussed in this section. The literature review is conducted to gather a sematic analysis from the previous studies on commitment towards sustainability implementation in Higher Education Institution. The questionnaire survey is basically designed to collect the same data via literature review yet from the primary sources in a sustainability implementation assessment framework in Private Higher Education Institutions in Malaysia. Items in the questionnaire have been developed based on the input gathered through rigorous literature review, thus they are in-line with the listed objectives of this study.

Likert scale is a psychometric scale commonly used in research that adopts questionnaires survey. The psychometric scale means that the respondents specify their level of agreement on a symmetric agree-disagree scale for a series of statements while responding to a particular Likert questionnaire item. The range of Likert scale captures the concentration of their approaches for a given item (Barua, 2013). This study uses five-point Likert scales of agreement and importance, which are commonly used for scales (Likert, 1932).

For this questionnaire survey sampling design used a purposive sample, where non-probability sample is selected based on characteristics of a population and the research objectives of this study. This study is conducted in Private Higher Education Institutions in Malaysia with University status. The Private Higher Education Institutions are identified based on the list from Malaysia Association of Private Colleges and Universities (MAPCU).

According to MAPCU (2018), there are 69 Private Higher Education Institutions being the member and 29 from them are Private Higher Education Institutions with university status. These Higher Education Institutions are also accredited by Malaysian Qualification Agency (MQA), recognised by Ministry of Education Malaysia (MOE) and operationally complied with IPTS Guidelines Act 555.

The method analysis to be use are factors analysis for categorising the elements of education criteria of sustainability implementation assessment in Private Higher Education Institutions. All the data gathered from the questionnaire survey is analysed via the Rasch model using WINSTEPS version 3.69.1.16 software. There are five analysis in the Rasch model, which are reliability and validity analysis, organisation misfit analysis, unidimensionality analysis, item misfit analysis and Person-Item distribution map analysis. Rasch model analysis is used because it changes the concept of reliability from creating a fit of the data into constructing a reliable measurement instrument (Said, 2016). Baghaei (2008) states one of the advantages of the Rasch model is that it builds a hypothetical unidimensional

line along which items and persons identified according to their difficulty and ability measures are shown in the Person Item Distribution Map (PIDM). As Bond and Fox (2001) mentioned, the Rasch model is a prescriptive model in which how the data fit the model is investigated instead of the more classical statistical problem of how the model fits the data. Scholten (2011) further explained that the data are required to fit the model, and when they do not, items that show misfits discarded until a satisfactory fit obtained.

Thus, the Rasch model analysis is done in this study following Bond and Fox (2007), who explain that the Rasch model's logit value is the unit of measurement at an interval level instead of the ordinary number. In the Rasch model analysis, this study adopts summary statistics, item characteristic curve scalogram, PIDM, and person and item measure order used. The analysis shows both person and item measures to indicate that the respondent is completing the survey. At the same time, the respondent understands the questions given, while the item in the survey is understood and answered.

## **DATA ANALYSIS AND FINDINGS**

### **Demographic Data Analysis**

This study population is 169 respondents based on the database obtained from organisational chart of the Private Higher Education Institutions, namely 47 Deputy Vice-Chancellors and 122 Deans, who are expecting to respond to the questionnaire from 29 Private Higher Education Institutions in Malaysia. Invitation to the respondents to participate in this questionnaire survey was sent via an online questionnaire survey. The data collection starts from 2 May 2019 until 30 June 2019 via online questionnaire survey. As Krejcie and Morgan (1970) mentioned, 118 respondents should respond from the total population of 170. The total valid responses from the survey are 75 at the response rate of 63.6 percent as shown in Table 3, where in terms of adequacy of analysis and reporting as shown in Table 4, the response is considered good. The survey was developed to be comprehensive and cover many issues; however, it may be difficult for a respondent to have adequate knowledge about all topics and issues addressed in the survey. According to Lozano et al. (2014), top management officials might be aware of all the courses pertaining to sustainable development issues, hence merely Deputy Vice-Chancellors and Deans of Private Higher Education Institutions are selected.

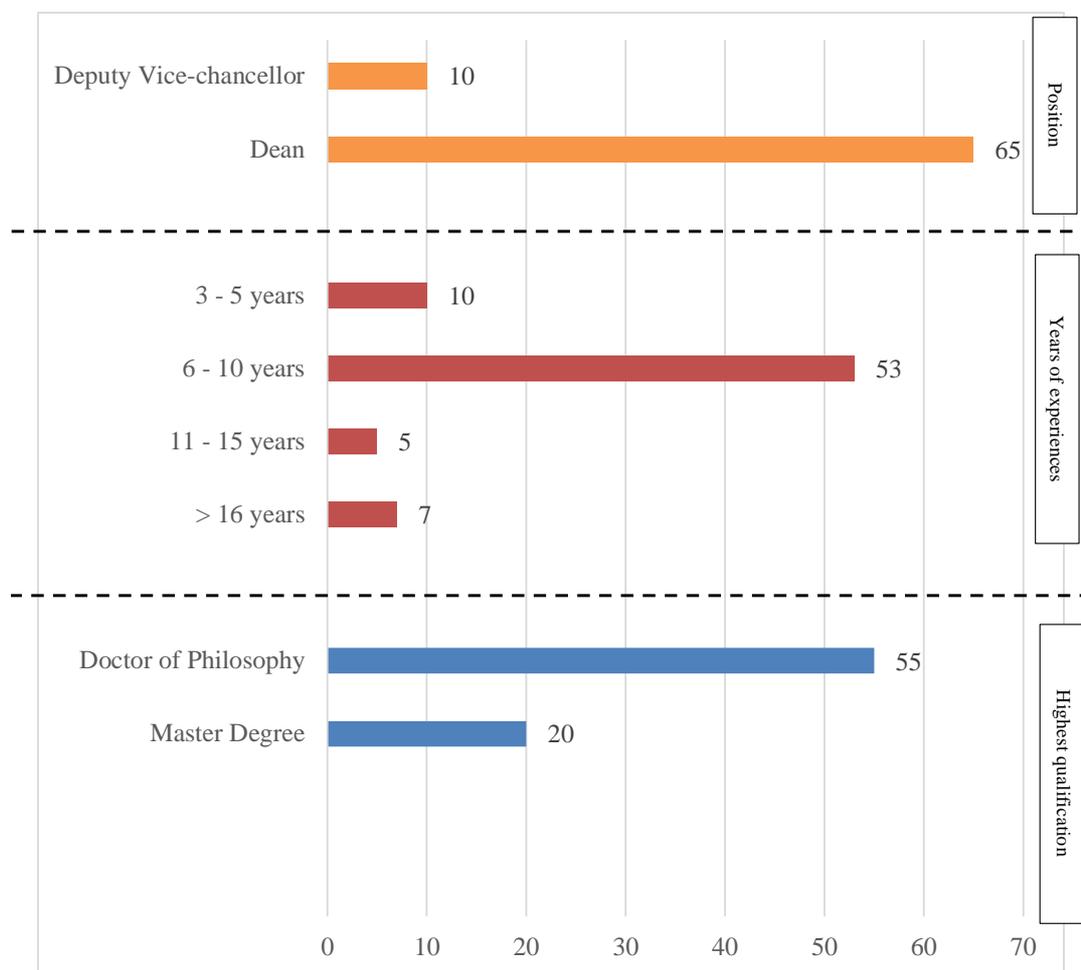
The demographic analysis consists of university name, position, department, years of working with the institutions and the highest education level as shown in Figure 1. There are ten Deputy Vice-Chancellors (13.33 percent) and 65 Deans (86.67 percent). Figure 1 also shows the year of respondents' experience. Most of the respondents had 6 to 10 years of experience in the education industry particularly working with the current institution, with 53 (70.67 percent) respondents. This is followed by 10 respondents (13.33 percent) having 3 to 5 years of experience, 7 respondents (9.33 percent) with more than 16 years of experience, and 5 respondents (6.67 percent) who are having 11 to 15 years of experience. In addition, there are also 39 respondents (52 percent) having Master's Degree qualification, 34 respondents (45 percent) having Doctor of Philosophy and 2 respondents (3 percent) having Bachelor's Degree.

**Table 3.** Response Rate

Categories	Respondent	Percentage (%)
Questionnaires distribute	118	100
Total respondent	75	63.6
Incomplete respondent	0	0
Total usable respondent	75	63.6

**Table 4.** Adequacy of Valid Response Rate for Analysis and Reporting (Miller, 1991)

Valid Response Rate (%)	Adequacy for Analysis and Reporting
< 50	Not adequate
50- 59	Adequate
60 – 69	Good
70 – 100	Very good



**Figure 1.** Demographic Data

## Reliability and Validity Analysis

**Table 5.** Summary of 25 Constructs (Non-Extreme) Person to Identify the Elements of Education Criteria in Sustainability Implementation Assessment at Private Higher Education Institutions in Malaysia

	TOTAL SCORE	COUNT	MEASURE	MODEL ERROR	INFIT		OUTFIT	
					OMNSQ	OZSTD	OMNSQ	OZSTD
MEAN	317.4	75.0	.00	.94	0.46	-1.03	0.16	-3.24
S.D	45.8	.0	32.37	.37	.51	1.13	.38	1.86
MAX.	370.0	75.0	53.12	.49	2.47	2.74	1.84	1.09
MIN.	227.0	75.0	-40.84	.32	.10	-2.21	.01	-6.98
Real SMSE 1.02		TRUE S.D	31.70	SEPARATION	31.01	CONSTRUCT RELIABILITY 1.00		
Model S.E. 1.01		TRUE S.D	31.70	SEPARATION	31.43	CONSTRUCT RELIABILITY 1.00		
S. E. of constructs MEAN = 6.47								

The input for research objective is with 25 constructs measured. Table 5 shows 25 constructs (non-extreme) are reporting the value of person reliability is  $\beta = 1.00$  with 0.20 Standard Error (SE), suggesting that the respondents were competent to answer the questionnaire survey (Fisher, 2007). This indicates that the 25 constructs in identifying the element of education criteria in the sustainability implementation assessment in Private Higher Education Institutions in Malaysia have an excellent range of difficulties in measuring the organisation ability. Organisation fit statistics investigation on outfit on Mean Square (OMNSQ) and z-score (OZSTD) show that the OMNSQ is 0.16 and OZSTD is -3.24, which is near to expectation 1 and 0. This reveals that 25 constructs are targeting the right type of respondents in measuring the latent traits and produced data is at a reasonable prediction level of the responses to the constructs. The maximum organisation ability is  $\beta_{\max} = +53.12$  logit and the minimum measure is  $\beta_{\min} = -40.84$  logit. The organisation mean  $\beta_{\text{mean}} = 0.00$  logit reveals that the majority of the respondents find the importance to understand the element of education criteria in sustainability implementation assessment at Private Higher Education Institutions in Malaysia.

## Unidimensionality Analysis

The principal component analysis (PCA) shows that the raw variance explained by measures was approximately 98.0 percent lower compared to the expected target of 97.1 percent as shown in Table 6, which shows good quality criteria of variance in data explained by measures as stated by Fisher (2007). In addition, the unexplained variance in the 1 contrast is also in good quality criteria (Fisher, 2007), which is 0.7 percent. This can be concluded that the 25 constructs in identifying the element of education criteria in sustainability implementation assessment at Private Higher Education Institutions in Malaysia have one single overarching dimension.

**Table 6.** Standardised Residual Variance (in Eigenvalue units) to Identify the Elements of Education Criteria of Sustainability Implementation Assessment in Private Higher Education Institutions in Malaysia

		Empirical		Modelled
Total raw variance in observation	122.1%	100.0%		100.0%
Raw variance explained by measurer	119.6%	98.0%		97.1%
Raw variance explained by persons	37.0%	30.4%		30.1%
Raw variance explained by item	82.5%	67.6%		67.0%
Raw unexplained variance (total)	2.5%	2.0%	100.0%	2.9%
Unexplained variance in 1 <sup>st</sup> contrast	0.8%	0.7%	32.5%	

### Construct Misfit Analysis

Table 7 shows the misfit order of construct to identify the elements if sustainability education criteria of sustainability implementation in Private Higher Education Institutions in Malaysia is based on the three criteria, known as Outfit MNSQ, Outfit ZSTD and point measure correlation (PMC). Out of the three criteria, there are 23 constructs with minor misfit, which are construct B24 (presence of extra- curricular activities within Higher Education Institutions), B11 (teaching across the natural sciences and social sciences faculties), B7 (possibility for students to take classes in other faculties), B17 (distinction between regular course and stand-alone sustainable development course), B21 (presence of sustainable development issues within course competencies), B18 (distinction between compulsory and elective course), B12 (continuing education to the public on sustainable development), B9 (invited lecturers/professors in sustainable development), B14 (proportion of multi/inter/intra-disciplinary programme), B2 (optional course on sustainable development in the curriculum) and B16 (importance of course credits of sustainable development course as compared to total number of credits).

Other constructs are B3 (sustainable development major at undergraduate level), B15 (proportion of programmes involving community and university), B6 (promotion of system thinking in teaching), B19 (presence of sustainable development within curriculum), B4 (sustainable development major at postgraduate level), B8 (integrated sustainability course in some curricula), B25 (presence of continuing education on sustainable development), B22 (pedagogical approaches used to teach sustainable development issues), B1(course on sustainable development for all students), B5 (promotion of holistic thinking in teaching), B10 (sustainable development education for lecturers) and B23 (doctoral studies on sustainable development). All constructs with minor misfit are not within the accepted range of Outfit MNSQ ( $0.5 < \text{MNSQ} < 1.5$ ), Outfit ZSTD ( $-2 < \text{ZSTD} < +2$ ) as mentioned by Linacre (2002), nevertheless all the PMC values are still in positive value that verify all constructs are measured in the same direction. Thus, all constructs are remained for further analysis.

### Person-Construct Distribution Map Analysis

Table 8 shows the measure order of 25 constructs to identify the element of sustainability education criteria implementation assessment in Private Higher Education Institutions in Malaysia. The items are sorted based on their measured value, which the positive value is less importance items while for negative value is the aware items, based on Item mean  $\mu_{\text{mean}} = 0.00$  logit as the cut-off point. The location of the organisation mean is  $\beta_{\text{mean}} = 0.00$  logit as in Table 9, which shows that the respondents have the ability to endorse all 25 constructs. The

organisations can be separated into three groups, which are extremely important, moderately important, and not important as shown in Table 9 although the separation of organisation is - 20.73, which have separated the organisations into five groups.

**Table 7.** Misfit Order of Construct to Identify the Elements of Education Criteria of Sustainability Implementation Assessment in Private Higher Education Institutions in Malaysia

Item	Total score	Total count	Measure	Model S. E	Outfit		PMC	Remarks
					MNSQ	ZSTD		
B24	227	75	53.12	0.87	0.03	-3.78	0.95	Minor misfit
B11	243	75	45.32	0.93	0.03	-1.49	0.96	Minor misfit
B7	260	75	38.94	0.46	0.29	-1.10	0.93	Minor misfit
B13	262	75	38.51	0.47	0.63	-0.40	0.95	Normal
B17	260	75	38.94	0.46	0.29	-1.10	0.93	Minor misfit
B20	273	75	35.26	0.63	1.84	1.09	0.92	Normal
B21	263	75	38.29	0.47	0.22	-1.54	0.91	Minor misfit
B18	281	75	31.48	0.79	0.03	-2.05	0.93	Minor misfit
B12	288	75	26.95	0.85	0.04	-2.08	0.94	Minor misfit
B9	323	75	4.96	1.40	0.01	-4.22	0.91	Minor misfit
B14	323	75	4.96	1.40	0.01	-4.22	0.91	Minor misfit
B2	330	75	-3.47	1.65	0.01	-5.10	0.89	Minor misfit
B16	330	75	-3.47	1.65	0.01	-5.10	0.89	Minor misfit
B3	340	75	-13.75	1.14	0.02	-3.97	0.81	Minor misfit
B15	345	75	-20.73	1.52	0.01	-5.43	0.76	Minor misfit
B6	335	75	-9.97	0.88	0.04	-6.98	0.85	Minor misfit
B19	365	75	-35.55	0.98	0.04	-2.58	0.45	Minor misfit
B4	362	75	-33.41	0.76	0.06	-2.89	0.51	Minor misfit
B8	359	75	-31.82	0.70	0.06	-3.63	0.56	Minor misfit
B25	363	75	-34.02	0.80	0.05	-3.24	0.49	Minor misfit
B22	360	75	-32.33	0.72	0.06	-3.11	0.54	Minor misfit
B1	356	75	-30.48	0.64	0.08	-4.00	0.60	Minor misfit
B5	370	75	-40.84	1.20	0.01	-5.26	0.34	Minor misfit
B10	348	75	-26.02	0.99	0.03	-3.64	0.72	Minor misfit
B23	370	75	-40.84	1.20	0.01	-5.26	0.34	Minor misfit

**Table 8.** Measure order of the constructs to identify the elements of education criteria in sustainability implementation assessment at Private Higher Education Institutions in Malaysia

Item	Measure	Model SE	Remarks
B24_CSPHEI_24	53.12	0.87	Less Important
B11_CSPHEI_11	45.32	0.93	Less Important
B7_CSPHEI_7	38.94	0.46	Less Important
B17_CSPHEI_17	38.94	0.46	Less Important
B13_CSPHEI_13	38.51	0.47	Less Important
B21_CSPHEI_21	38.29	0.47	Less Important
B20_CSPHEI_20	35.26	0.63	Less Important
B18_CSPHEI_18	31.48	0.79	Less Important
B12_CSPHEI_12	26.95	0.85	Less Important
B9_CSPHEI_9	4.96	1.4	Moderately Important
B14_CSPHEI_14	4.96	1.4	Moderately Important
B2_CSPHEI_2	-3.47	1.65	Moderately Important
B16_CSPHEI_16	-3.47	1.65	Moderately Important
B6_CSPHEI_6	-9.97	0.88	Moderately Important
B3_CSPHEI_3	-13.75	1.14	Moderately Important
B15_CSPHEI_15	-20.73	1.52	Extremely Important
B10_CSPHEI_10	-26.02	0.99	Extremely Important
B1_CSPHEI_1	-30.48	0.64	Extremely Important
B8_CSPHEI_8	-31.82	0.7	Extremely Important
B22_CSPHEI_22	-32.33	0.72	Extremely Important
B4_CSPHEI_4	-33.41	0.76	Extremely Important
B25_CSPHEI_25	-34.02	0.8	Extremely Important
B19_CSPHEI_19	-35.55	0.98	Extremely Important
B5_CSPHEI_5	-40.84	1.2	Extremely Important
B23_CSPHEI_23	-40.84	1.2	Extremely Important

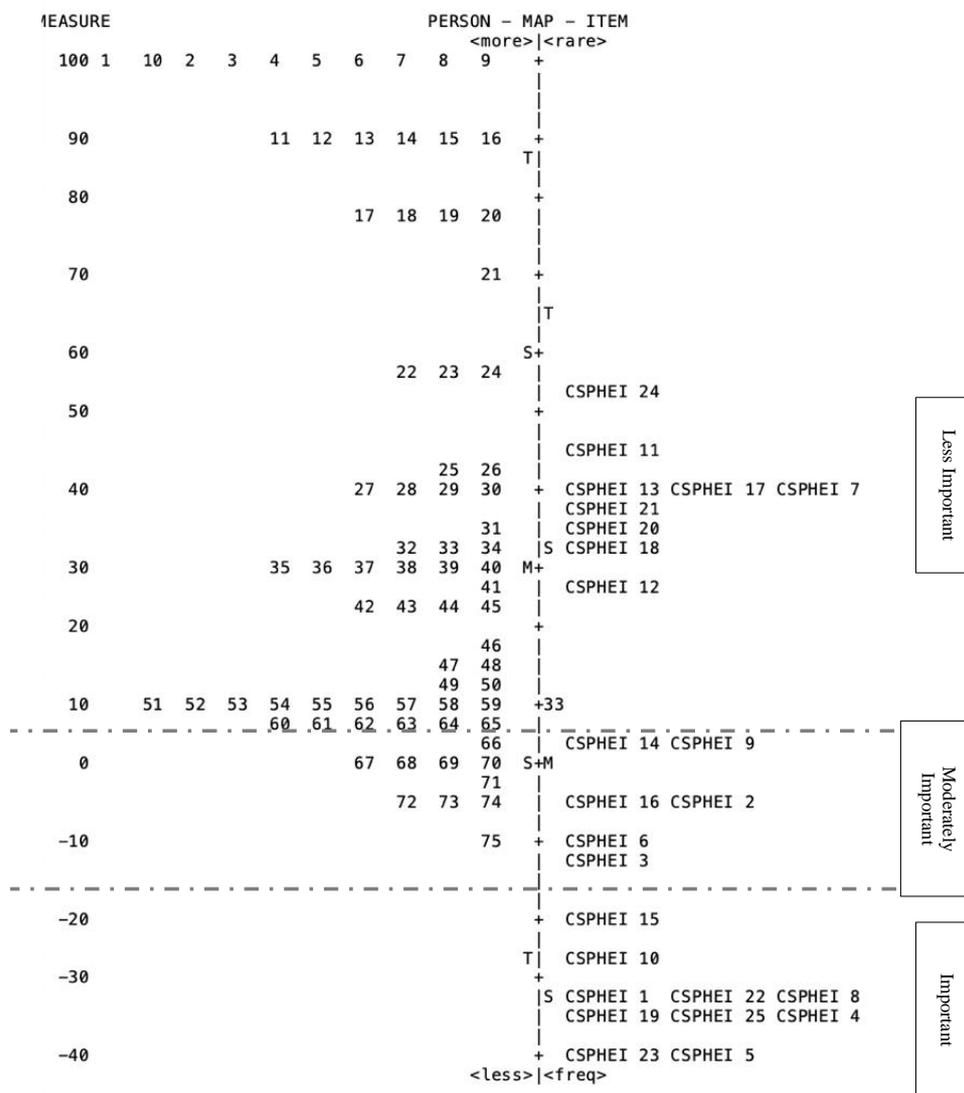
**Table 9.** Matrix of Categorization to Identify the Elements of Education Criteria in Sustainability Implementation Assessment at Private Higher Education Institutions in Malaysia

Awareness Categories	Logit	n	%
Extremely important	$\infty$ to -20.73 logit	35	46.67
Moderately important	-20.73 logit to 4.96 logit	26	36
Less important	4.96 logit to $\infty$	14	18.67

Figure 2 to reflect on the measure order Person-Construct Distribution Map Analysis. The distribution it's based on the data gathered and analysis in Table 9.

## CONCLUSION

The finding of research objective of this study is to identify the elements of education criteria of sustainability implementation assessment in Private Higher Education Institutions in Malaysia. From the total 25 constructs, only 10 constructs are accepted to be included in the framework of sustainability implementation assessment at Higher Education Institutions in Malaysia. Out of these, three constructs received the highest response: integrated sustainability course in some curricula (B8), sustainable development education knowledge to the academician (B10) and proportion of programme involving community and Private Higher Education Institutions (B15).



**Figure 2.** Person-Construct Distribution Map to Identify the Elements of Education Criteria in Sustainability Implementation Assessment at Private Higher Education Institutions in Malaysia

Integrating sustainability concepts into the syllabus and curriculum may lead to a better understanding of the sustainability implementation concept at Private Higher Education Institutions. According to Lozano (2013), integration into the courses and programmes give as example of focus on the environment. Lozano (2013) mentioned that certification attempts to include in accreditation will be great; however, these are still limited.

Sustainable education knowledge to the academician, in which the emerging academic field focused on sustainability, aims to address complex anthropogenic challenges via various research and teaching approaches. According to Talwar et al. (2011) and Baartman et al. (2007), who integrate the links, use-inspired knowledge to transformational action in participatory, as well as deliberative and adaptive settings increase prominence-specific learning outcomes in order to design the teaching delivery in academic programmes successfully.

The proportion of programmes involving the community may include the sustainable implementation assessment as Private Higher Education Institutions play a vital role in turning society to become sustainable through their power to produce and educate the young generation (Lozano, 2016). Apart from that, the sustainability conceptual learned in a class can be practised via communication with the community. Other essential elements of education criteria are course on sustainable development for all students (B1), presence of sustainable development within the curriculum (B19) and pedagogical approaches used to teach sustainable development issues (B22). Thus, the sustainability education criteria implementation in Private Higher Education Institutions can be improved by having the most comprehensive coverage on the curriculum, pedagogical approach and teaching delivery.

This study has a significant contribution to understanding the sustainability implementation assessment in Private Higher Education Institutions in Malaysia. The study expands the contribution to the body of knowledge in theoretical knowledge, practical knowledge and methodology. This study eventually may improve the sustainability implementation assessment in Private Higher Education Institutions in Malaysia. It can raise the level of awareness on sustainability implementation assessment concepts. Previously, the study related to sustainability implementation assessment is more towards Public Higher Education Institutions and almost none for Private Higher Education Institutions. From this study, all levels in Private Higher Education Institutions can be alarmed toward the sustainability implementation assessment by understanding the education criteria of sustainable implementation.

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# DEMOLISH AND DISCARD OR REPAIR AND RENEW: A GREEN INNOVATION CHALLENGE

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## Abstract

This paper is predicated on the observations that, over human history, people have endeavoured to maintain and repair their possessions but that, today, possessions become obsolete rapidly, are designed against maintenance and repair and so, are discarded and replaced. That is hugely wasteful at an extent that this planet cannot sustain. Not only are scarce resources being depleted quickly, but humans are polluting and warming the Earth very rapidly, destroying the natural environment and many life forms and moving towards an uninhabitable world. Pursuit of true, scientific sustainability is essential, with attention to Einstein's equation and conservation of energy. The means changing behaviour fundamentally, and doing so now, to maintain and repair, re-cycle, conserve and preserve. Innovation and learning are examined as important vehicles to move away from short-term self-centrism in order to foster and promote sustainable survival. We should reduce reliance on financial techniques and, instead, use direct metrics for evaluating (construction projects), and reverse discounting of the future to enhancing the future. Education and regulation must embrace sustainability requirements – with much greater emphasis in maintenance, repair, and recycling at disposal – such that only proposals that are clearly sustainable will be allowed to be implemented.

**Keywords:** *Discounting; Disposal; Learning; Natural Environment; Quintuple helix; Sustainability*

## INTRODUCTION

My Dad saved things – nuts and bolts, screws, pieces of metal, pipe, wood – he'd pick up items he found on the street and add them to his store – 'they might come in handy one day'. Many people did as he did. He had (almost) a mania to fix things that went wrong, or just wore out, and he was good at fixing things. He epitomized a spirit of his generation to 'keep, mend and, often, 'make do' rather than discard and replace' – deprivations of two 'World Wars' instilled that sentiment, nay, requirement, deep in his psyche. I have inherited much of that – probably due to nurture rather than nature. I do not like to throw things away – 'they may be useful in the future'! Rather unlikely due to modifications and advances in technologies.

Things change. The Chinese proverb that 'the only thing that is constant is change' seems ever more relevant. As a student, my friends and I repaired cars ourselves – perhaps not very well but we kept mobile (and occupied productively). Today, that is hardly possible. Most cars, computers, mobile phones, household appliances, etc. have (very obviously) built-in obsolescence – often, for both hardware and, certainly, software. My two-year-old MacBook has started to give me problems while my fifteen-year-old PC still works, if rather slowly! Nowadays, we do not retain and repair, we discard and replace.

During the latter half of the twentieth century, people seemed to be striving for quality improvements – as measured by reliability and longevity. Although reliability and longevity may command higher purchase prices, there is a consequent reduction in servicing, repairs and upgrading/updating replacement purchases. In the twenty-first century, difficulty of

repair has extended, including computer-based diagnostics and ‘sealed’ conglomerate components (e.g., computer motherboards), and obsolescence is built-in (e.g., IT operating systems and support for those; batteries for mobile phones).

My wife reminds me ‘things have a life’ – but why should lives of things be ever-shorter? The easy answer is greed – by consumers (at least, in ‘developed’ economies) to have the latest gadgets and so, to be seen to be at the forefront and up to date; by suppliers, to enlarge sales and monetary profit – their (financial) capital.

Built-in obsolescence is hard to resist. But it is extremely wasteful through unnecessary consumption of increasingly scarce, and, often, rare, resources. Sustainability has become a word that is used inordinately extensively but, frequently, it is abused. Green is no longer (just) a colour at about 500-550nm on the visible spectrum but is a sustainability-related concept – along with conservation, preservation, renewables, and a whole gamut of other terms.

So, what do the terms mean? What are (some) people trying to achieve? Definitions are important – research requires us to be strict and precise; elastic definitions (Piercey, 2009) will not do!

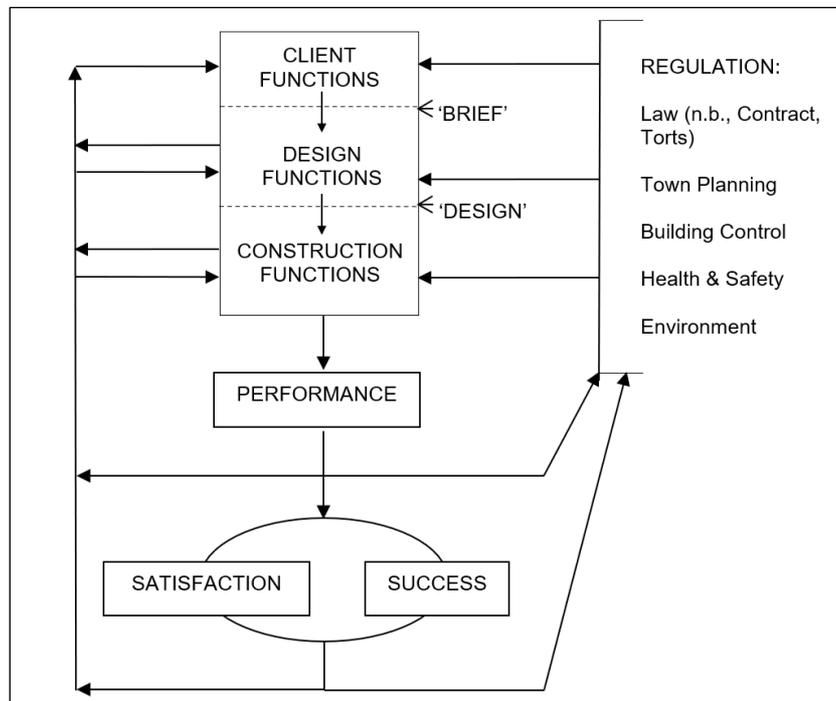
Sustainability is “The ability to be maintained at a certain rate or level”; “Avoidance of the depletion of natural resources in order to maintain an ecological balance” (OED, 2020). The definitions imply forever, in perpetuity. However, in common parlance and so, in practice, that temporal imperative is relaxed almost invariably and, I submit, hugely detrimentally. So, practice uses ‘sustainability’ loosely with the applicable time horizon becoming ‘for a long time’ – which is of course, is as long as a piece of elastic!

In the built environment, a variety of sustainability concepts operate – including consumption of finite resources, consumption of energy, ‘production’ (harvesting) of energy – in the production, use, and disposal of the products. Traditionally, financial accounting has been the surrogate, universal measure used. Today people are increasingly aware of some of the failings of surrogate metrics – especially, the monetary units of financial accounting (which, even if audited rigorously, financial accounting is not very accurate – issues of depreciation form the tip of an iceberg).

Further, application contexts of sustainability are segregated – ‘sustainable development’, ‘sustainable cities’, ‘sustainable economy’, ‘sustainable society’, etc. It is rare for any of those individual applications to address the fundamentals of sustainability and so, once the individual applications are brought together in a political arena, they not only compete with each other according to the political objectives prevailing but also conflict with the fundamentals of sustainability – to yield unsustainable end results.

Moreover, the built environment is notoriously conflictual – usually caused by the pervading business objectives of revenue growth and profit maximization within a zero-sum game (Fellows and Liu, 2000). The conflicts arise not from the built environment itself, nor from the matter and energy that are embodied and used in it; conflicts arise from the humans involved and their (usual) pursuit of self-interest.

## PARTIES TO CONSTRUCTION PROJECTS



**Figure 1.** The Project Realisation Process (Developed from Fellows, 2009)

### Notes:

- 1) Adopting a co-creational perspective, the boundaries between client, design, and construction functions are fuzzed (broken down) increasingly with recognition of the emergence and integration of client requirements, design possibilities and construction practicalities.
- 2) Performance of project realisation leads to success and, thence, satisfaction of participants (or otherwise if performance is 'poor') and, hence, further perspectives of overall success.
- 3) Performance – Success – Satisfaction also produces feedforward in the 'cycling' of project data and information to aid realisations of future projects through participants' perception-memory-recall filtering ('experiences').
- 4) A similar model applies to projects in use (beneficial occupation) but with 'Facilities Management' and 'Maintenance and Adaptation' replacing 'Design' and 'Construction' as major functionary groups.

Accepting that “all models are wrong, but some are useful” (Box, 1976), a systems model of a construction project, Figure 1, helps to identify the primary parties and their associations – i.e., the members of the temporary multi-organisation (TMO) which is undertaking the realisation of the project.

Overtly, the ‘primary task’ is to produce a product effectively and efficiently that performs best – but what does that strategic, grandiose statement mean; and how should such strategy be operationalized? Additionally, from whose perspective should the primary task be addressed? The obvious, rather glib, answer is ‘The Client’ – but who is that? A functional analysis of the client readily identifies the commissioner, the owner, the occupier, the user, the visitor, ..., anyone who is impacted by the project – during realisation (initiation, design and construction), product existence (including adaptations), and disposal (Fellows, 2014). Clearly, such client functionaries are numerous, even if categorised and so, focus tends to fall on the few, most powerful functionaries – usually, the paymaster (Fellows, Liu and Storey, 2013).

Whilst identifying the parties to a construction contract is straightforward – the ‘Employer’ (commissioning client) and the (main) ‘Contractor’ (constructor), extensive agency is apparent also – Architect, Resident Engineer, Quantity Surveyor, Clerk of Works, Supervising Officer, Subcontractors (Nominated, Named, Domestic), Suppliers (Nominated, Named, Domestic), Statutory Undertakers ....Hence, it is more usual to consider project stakeholders – again, a functional perspective is helpful.

As with most systems, a vital consideration is the boundary – for the project, product or process, and for each constituent. Relationships, largely, are determined by functions but the problem that becomes evident is the almost exclusive focus on the technical function of each stakeholder rather than on what they are trying to secure through association with the project (and, consequentially, each other) from a ‘business’ or/and personal perspective. While the technical factors may drive success, the business/personal one’s drive satisfaction.

Stakeholders’ technical goals and objectives differ, as do the constraints and parameters, but the main ones can be identified quite readily (e.g., Engineer – structural integrity; Architect – aesthetics). Business goals, in the current context of global capitalism, focus on revenue (managers) and profit (owners) (Friedman, 1970) – such that the purpose is to maximise revenue, subject to a minimum profit constraint (Baumol, 1959). Personal goals are rather more obscure and diverse but may be summarized as ‘personal well-being’ for self and close associates, perhaps tempered by some moral/ethical considerations (e.g., not harming others; environmental preservation). Notoriously, pursuit of goals tends to promote extensive opportunistic behaviour (Cox, 1999; Ireland, 2004).

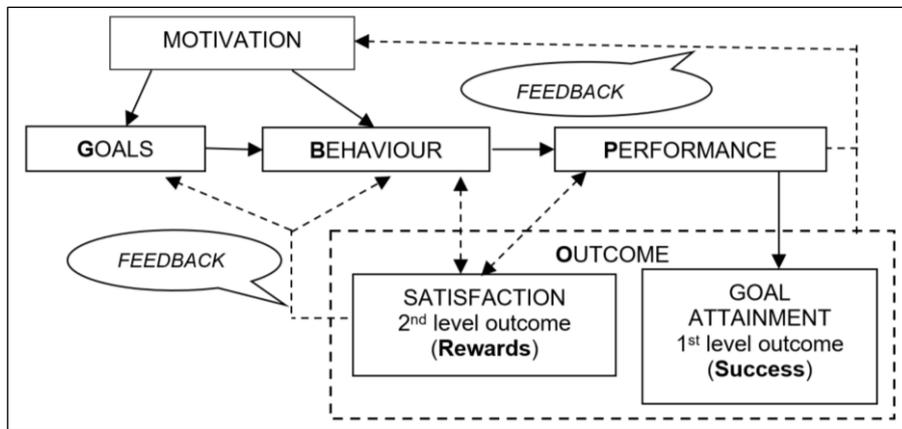
In welfare analyses, the strict Pareto criterion (no detriment to anyone) can be applied very rarely; the lesser, but pragmatic, Hicks-Kaldor criterion (net benefit) is much more common, although valuation debates are extensive. Indeed, such teleological approaches are almost universal. Technical goals are interdependent through diverse relationships of compatibility (is time-cost always a trade-off?); normally, each is acknowledged to be desirable, if not imperative, thereby prompting satisficing (Simon, 1956). Business goals are, almost, ubiquitous and so, common to each stakeholder – thereby fostering conflict in zero-sum games.

Further, constraints and parameters apply to limit what can be constructed (the physical site, weather, finance, human skills, market behaviour, regulations, etc.) and do so with varying flexibility. The site boundary is quite fixed – legally and physically – planning parameters may be ‘negotiated somewhat’ – plot ratio; site coverage – and the finance ceiling may be changed (such as through additional bank loans).

## **CONSTRUCTION PROJECT EVALUATION**

Evaluation is a judgement that, inevitably, involves a degree of subjectivity – about what is valued (often relatively) and what has been obtained against the value criteria. The classic ‘iron triangle’ of cost, time and quality seems to comprise two objective and one subjective constituent but that is questionable. What metrics should be employed; how accurate are the measurements made; what are the relative importance’s of the constituents and their components...? It is the same process as analysing a construct into its component variables.

What is the objective of the evaluation and to whom? Those, over-arching considerations require similar analysis and are likely to be unstable temporally.



**Figure 2.** Goal – Behaviour – Performance – Outcome (GBPO) Cycle with First and Second Levels of Outcome (Derived from Liu and Walker, 1998)

The second level outcome depends on the first level outcome achieved and its valence.

Focussing on the survival imperative, a business must meet its own performance criteria and provide adequate satisfaction to those who comprise, and influence, its market.

What is wanted is performance – what the project in use facilitates over and above the next best alternative (the opportunity cost of the project). But, of course, performance requirements depend on the perspective of the evaluation. Figure 2, the generic Goal(s) Behaviour, Performance, Outcome cycle, depicts the main issues involved.

Motivation is important to both goal setting and behaviour that impacts the achievement of the goals and is influenced by past outcomes, expectations, and environmental variables. Beyond classical motivation theory, the perspective of motivated reasoning (Fellows and Liu, 2018) is important for both setting goals and for performance evaluation (i.e., examining success and satisfaction – outcome – and their consequences) as bias may be introduced. Further, Winch and Maytorena (2009) consider the usual approach of forensic analyses of project performance against criteria that were determined before realisation processes were performed rather than against performance criteria that emerged during the realisation trajectory of the project to be inappropriate from a sensemaking perspective, as examined in Fellows and Liu (2016; 2017). Participating organisations and their representative personnel change throughout a project’s life – that warrants examination of involvements to ensure that the appropriate and up-to-date viewpoint is being adopted, along with the appropriate criteria and metrics for evaluation.

It is well-known that the earliest phases of a project are hugely important in determining what the project is and how it performs – in both realisation (design and construction – project management performance) and in use (project performance) (n.b., Morris, 2011; 2013). However, to the realisation and use, should be added ‘disposal’; as well as affording greater focus to servicing, maintenance, replacement and renovation during the life of the project in use.

Traditionally, focus rests on the ‘glamorous’ phase of realisation, with attention on the capital cost (in money to the commissioning client) and duration of the realisation – especially, the construction period. But that is a small, partial analysis only. Even from a financial cost perspective, and discounting future expenditures, the capital cost of a construction project is only a small fraction of the total, project-related expenditure over the project’s total life.

Given the vagaries and distortions of representing all forms of resources used in monetary terms (due to taxation, valuations, timing, etc.), many projects financial analyses are little more than random monetary approximations. In the field of cost benefit analysis (CBA), the fundamental issues of monetary valuation (often, using ‘shadow prices’) and discounting analyses are acknowledged – all constituents are reduced to (discounted) monetary quantities (the imaginary net present value – NPV); whilst in analyses using the planning balance sheet (PBS) approach (Lichfield, 2005) (which adopts multiple goal criteria for the various, primary stakeholders), resources consumed are measured in units appropriate to those resources. Of course, CBA analysis yields a single figure result (which, often, is viewed as the ‘answer’ and so, ‘makes the decision’ of whether and how to proceed), while the PBS yields arrays of multiple criteria and multiple metrics of diverse resources which render decision-making complex and problematic. In practice, people prefer ‘simple solutions’ – those may be politically useful models but with what consequences?

The framing of the question (or brief) for the project analysis is of fundamental importance to not only the nature of the answer/outcome but also the scope of the investigation – the brief of the Roskill Commission for (CBA) evaluation of the location of the third airport for London stipulated the sites to be considered, thereby restricting the scope of study and influencing, if not dictating, the outcome.

## **GREEN IS NOT SUSTAINABLE**

From a perspective of the natural environment (rather than the environment produced by homo sapiens), ‘sustainability’ incorporates ‘green’. Left on its own, this world’s environment evolves in a sustainable way – at least, from a Darwinian perspective. Granted, shocks do occur to and within that system – the meteor strike that eliminated many dinosaurs; major volcanic eruptions; occasional ice-ages – but, given evolutionary time, (new) dynamic environmental equilibria occurred.

Over the last few thousand years (since the agricultural revolution), especially the last two hundred (since the industrial revolution), things have changed radically; and as is well-known, change is ever faster. Information technology (IT) has brought an information revolution; although not all the ‘information’ available is correct!

Industrialisation, including agriculture, continues to occasion severe threats to our planet and survival of life on it. Indeed, much life (many species) has been extinguished already and much more extinguishment is threatened imminently. Despite the wealth and weight of scientific evidence, many people, including hugely influential and powerful ones, ignore it.

A major problem with initiatives for preservation of a habitable natural environment is terminology – which causes confusion and lack of awareness of simple fundamentals. The

problems are exacerbated by popularisation of the convenient notion that ‘(advances in) science and technology will solve (all) the problems.

The World Commission on Environment and Development (1987) (the Brundtland Report) produced what is, probably, the most widely adopted description of sustainable development, “...development that meets the needs of the present without compromising the ability of future generations to meet their own needs”. That seems fine as a statement of vision/mission but how should it be (and is it) operationalised? It is replete with subjective, elastic terms. Even adoption by the United Nations (Unesco, 2021) has only exacerbated the difficulties by expressly relating sustainable development to social, environmental, cultural, and economic dimensions.

Sustainability is a stringent criterion – enduring for ever; green is a pragmatic criterion regarding not harming the natural environment – an elastic concept that may range from (slight) reduction in resource consumption, or/and pollution (perhaps only as forecast), to approximation to anticipated sustainability.

Science indicates that the world comprises matter and energy as fundamental, interchangeable constituents ( $E = mc^2$ ). Clearly, given global warming, our world is not a closed system and, with our current knowledge of ‘black holes’, is not truly sustainable. For more practical purposes, it is helpful to consider the matter and energy of the planet in terms of forms and quantities of each form, coupled with a perspective of changes over time. Further, it is appropriate to endeavour to identify influences on those quantities and changes and to determine what may lie within the control of humans.

A major problem is that, often, ‘sustainability’ is no more than a label used in discussion – what is really being debated is not sustainability but a related and much less demanding topic – ‘greening’. Cole (1999) classifies ‘green’ performance of buildings as being assessed in relative/comparative terms, perhaps including benchmarking, but ‘sustainability’ performance assessments use absolute measurements (of energy embodiment, consumption, etc.). Whilst ‘greening’ is worthwhile, it is only a move towards the potential achievement of sustainability and, on many occasions, only a very small step!

The Law of the Conservation of Energy, formulated by Maxwell, states that within a closed system, whatever changes or transformations occur between the energies within that system, the total amount of energy remains constant. That law also concerns the quantitative equivalence across different forms of energy – kinetic and potential. The law of conservation of energy relates to three further laws – transformation, constancy and dissipation. Transformation asserts that all forms of energy are inter-convertible; and conversions are reversible. Constancy concerns conservation of the total quantum of energy in a (closed) system, irrespective of the forms assumed by the energy. Dissipation concerns instability introduced by changes in energy forms which are, then, spread evenly through the system over time.

An essential component of the laws of energy is that the system must be closed, implying both a fixed and impervious boundary. In the broadest context, we do not know where the system boundary lies or its nature (including permeability). However, for pragmatics, system boundaries are determined somewhat arbitrarily – as for planets (earth), geographical regions (a city), functions (society, economy), etc.

## **INNOVATION: ‘BELT AND ROAD OR BELT AND BRACES’**

Innovation is related to both discovery and invention closely – a consequence is that those processes are, often, conflated. Discovery is the process of finding, finding out, or becoming aware of something; invention is creating by thought, devising, originating something; innovation is bringing in new methods, ideas, etc. (OED, 1995). Thus, discovery concerns finding something that exists while invention concerns creating something new. Innovation, usually, is about application – changing a process or using something in a different (new) way or for a different purpose. Discovery is not creative but invention is.

The concepts of invention and innovation are related to learning. Educational studies have drawn on biology to develop double helix learning – in which students learn from integration of academic education and work to foster the ‘knowledge economy’ through lifelong learning (which compliments continuing professional development – CPD, etc.). Universities and other research institutions have long wrangled with issue over securing funding and with industrial/practical applications of research (outputs); in many disciplines the differences between academia and practice are extensive – often, ‘research and industry speak different languages’ (and government speaks another).

Since the 1990’s, multiple helix relationships for innovation have been advanced – the triple helix (Etzkowitz and Leydesdorff, 1995) of academia, industry and government is known most widely (and evidenced in the development of science parks, university research spin-off companies, etc.) but quadruple (including the public – notably, the institutions of civil society and the media) (Carayannis and Campbell, 2009) and quintuple helixes (adding the natural environment) (Carayannis, Barth and Campbell, 2012) have been added. The questions of representation are apparent immediately, accompanied by concerns of the power structuring within the relationships.

The triple helix model encompasses the main activators of innovation with considerable emphasis on research (and invention) – and so, can be regarded as a ‘core’ model (producing a ‘knowledge economy’). The further two helixes are contextual – the quadruple examining innovation in the developments of the ‘knowledge society’; and the quintuple incorporating the ‘natural’ environments of ecological and economic systems. Thus, it may be very easy for economic, or financial, variables to play multiple roles by impacting several helixes – which, of course, dilutes the weighting of other variables. Notably, the natural environment achieves a ‘voice’ through human representations only – and many of those persons are subject to other influences too (as in motivated reasoning, and in power-based and political models of actions).

The underpinning intention of the innovation models is to foster innovation through cooperation and collaboration with re-location and restructuring of the boundaries across which competition operates. The rationale is articulated to be that cooperation promotes advances and innovation (see, n.b., Dawkins, 1976), as has been demonstrated to be highly effective in Darwinian evolution (and, anecdotally, in development of human societies).

Importantly, since the late twentieth century, market capitalism has extended significantly and, under a variety of national regimes, private capitalism has been in ascendancy – with foci of self-benefit and competition. Thus, the capitalist fundamentals of (own) profit maximisation and growth (of revenue – market and market share) have flourished – as in

Trump's 'America First' perspective and activities; through which the prevailing global power structure has facilitated greater degradation of the natural environment and so, putting more pressure on recovery initiatives. Such stark reversions to old, imperialist perspectives seem to be more widespread than may be realised.

The 'Belt and Road' initiative was announced and adopted by the government of China in 2013 – largely following ancient routes of trade (the 'silk road' and routes of maritime exploration and trade – the explorations of admiral Zheng He) to denote the silk road economic belt and the 21st century maritime silk road. Part of that initiative is the adoption of the triple helix model of innovation, and mode 2 learning, to foster development of a knowledge economy.

Despite its notorious inward focus and closed borders of the past, China has an ancient history of extensive international trade over long distances and occasional domination of vast areas (the Mongol Empire). Quite recently it has suffered hugely from imperialism – of Britain in the 'Opium wars' and consequent colonisations; and of Japan in war, massacres and occupation during the first half of the twentieth century. Even during the Mao era, China was active overseas, constructing infrastructure in southern Africa and conducting trade for extensive importing of raw materials. Such activities expanded in scope and location under the 'open door policy' of Deng Xiao Ping to include projects in North Africa, the Middle East, and Europe.

Using announcements of President Xi Jinping of China, primarily, the Organisation for Economic Cooperation and Development (OECD, 2018) has categorized the motivations for the Belt and Road initiative to be connectivity, openness, innovation, sustainable development, energy and food security, more balanced regional development, and improving efficiency. Over 70 countries have agreed to participate in the initiative and many projects, mostly for transport and energy, have been undertaken. However, funding and construction arrangements for such major projects are complex and, given the size and strategic nature of many, are of great political sensitivity; thus, some projects have suffered disruption.

The Belt and Road constitutes a progression of development of, largely, Chinese-funded (and, often, constructed) infrastructure projects. The internet is a manifestation of the globalization of information but globalization is occurring extensively in physical developments also – for both, ownership is obscure and control manifestly difficult. Further, the distribution of costs and benefits of both project realisation and operation may be quite fuzzy and subject to diversity of important perspectives from participating nations, social groups, and globally.

What does all that mean for innovation, and for the planet and its life forms?

## **DISCUSSION**

Analysis of the consequences of any change (or, indeed, maintenance of the status quo), whether as a forecast or forensically, should examine quantities, their attributes, and distributions. Without attention to distributions, quantifications are not very meaningful. Evaluation takes analyses a step further through inclusion of a value system (what is good, bad, important, unimportant) to apply to the results of analysis, perhaps on a contingency basis.

[The research of Schwartz, and others, indicates that peoples' value systems comprise common constructs, with similar associations between them; but that differences occur due to different weightings applied to those value constructs – see, e.g., Schwartz and Bilsky (1987); Schwartz and Sagie (2000); Schwartz and Bardi (2001).]

Given the fundamental relationship between matter and energy, convertibility between various forms of energy, and laws of conservation, Earth's major problems, propagated by its human inhabitants, comprise resource depletion (changing forms of matter), pollution (changing forms of matter and energy), and global warming (atmospheric change – altering the boundary conditions of the planet).

Today, global warming and (plastics and greenhouse gasses) pollution have gained importance, and recognition, as globally vital issues – prompting re-cycling and sustainable energy initiatives. Resource depletion has not gained such attention.

Innovatory initiatives are extensive – wind farms, solar panels, electric vehicles of many forms (batteries consume 'rare earths' – so named for very logical reason), more insulated buildings, recovery and recycling of (some) materials, etc. However, others seem less meritorious (!) – redundancy of electronic equipment, unavailability of individual components, sealed/unrepairable units, etc.

There seem to be extensive, vested interests promoting short-term use and discard (even if elements of what is discarded are recycled). Recycling is not free, even if it is financially less expensive than new provision – it uses energy and does produce waste.

A quite embryonic movement is occurring towards maintainability and repairability and some elementary publicity and legislation has occurred. The glamour remains with what is new; old, repaired, second-hand is stigmatised. There is a perceptual/attitudinal/values human problem which gives rise to a barrier – exacerbated since the latter part of the twentieth century via levels of wealth and affluence, coupled with (expected and, often lauded) high levels of exclusive self-centrism.

Attention to design and realisation is attractive; attention to deconstruction and disposal (much) less so. In construction and built environment fields people are educated and trained to realise and operate projects (buildings, etc.) efficiently – usually based on prevailing financial quantifications – and, sometimes, with regard to effectiveness (but, again, as determined by paymasters, and regulators). Drives for financial efficiency of buildings promotes maximisation of plot ratio and minimisation of circulation space – so corridors may be narrow, (fire escape) staircases minimised, and service ducts crammed full to the extent that maintenance, repairs and replacements are inordinately difficult.

Whilst understandably (see, e.g., Morris, 2011), great attention is devoted to the front end of projects, and, increasingly, to operating projects in use (facilities management has replaced maintenance management), the end of life of projects receives minimal attention (beyond the demolition sector).

A fundamental problem with environmental issues arises because they are global. It is difficult enough to address problems at the micro levels (individual organisations; projects; local areas, etc.) but, at the macro level(s) ‘The Tragedy of the Commons’ (Garrett, 1968) applies often. The effects may be mitigated through legislation, although policing and enforcement may be extremely difficult (and expensive) – as with ‘The Polluter Pays’ principle; lack of control of ‘social media’. The underpinning problem is that the action (pollution, consumption) is individual/local whilst the detrimental consequence is global and so, there is a major issue of responsibility (and ‘intelligent/responsible behaviour’) for the detrimental consequences. Individual greed and self-benefit are very strong.

Market forces, even when coupled with legislation, such as the ‘cap and licencing’ approach adopted in the European Union for ‘Carbon Trading’, seems to have limited effect, even within its domestic jurisdiction. Those who pollute can avoid restriction through financial means so, trading must be coupled with stringent capping to be really effective.

International agreements, such as ‘The Paris Climate Accord’, provide only loose commitment (witness the withdrawal of USA under Trump), which indicates that something far stronger and more enduring is essential.

As the underpinning assumptions of the various forms of market (monopoly) capitalism evidently hold (notably, pursuit of self-benefit as the pervading goal), control of consequent organisational and individual behaviour must comprise:

- clear and simple rules
- effective communication
- unavoidable responsibility
- effective policing and sanctions.

Real or perceived deficiencies in control systems encourage flaunting and circumventions, as in tax avoidance and evasion, to reduce the effectiveness and efficiency of the attempted control. If the persons responsible for the negative environmental consequences enjoy indemnity (e.g., by their employing organisation paying a fine), then, they are quite free to perpetuate such consequences – but are much less likely to do so if they are held to account personally.

So, if ‘top-down’ mechanisms fail, what about ‘bottom-up’ possibilities? Modern (political) history includes some notable successes – the abolition of UK’s ‘Community Charge’ (poll tax); the abolition of slavery; the ‘Suffragette Movement’. [The ‘Me Too’ and ‘Black Lives Matter’ movements are evolving.]

Studies of culture, development and change (e.g., Hofstede, 2001; Harris and Ogbonna, 2011) reveal that impositions are of limited effect (people comply with them grudgingly and to limited extents) and, usually, are temporary. Only by convincing the majority of people that the change is appropriate – and so, the change is incorporated into the people’s beliefs, and value system – will a change be effective and permanent. That indicates that highly popular, bottom-up initiatives are likely to succeed – from an individual to a group, through progressively larger social institutions to universal (such as basic democracy; human rights).

Two perspectives on (national) culture that are particularly germane are whether people regard themselves as independent of or interdependent with their context (n.b., natural environment) (Hall, 1976; Hall and Hall, 1990; Watkin, 1976; 1979; Markus and Kitayama, 1991); and whether people are subject to shame or guilt regarding (discovery of) negative consequences of their behaviour (Benedict, 1946). In a shame-culture, emotion is a reaction to criticism by others and is deeply rooted in the external environment which emphasises standards imposed on the individual by society (an outside-in effect). In contrast, guilt-cultures operate through individuals developing conscience and so, generate inner standards of behaviour according to absolute moral standards of society. Guilt cultures are self-regulating whilst shame cultures self-regulate on the basis of the probability of discovery (of a transgression – which is less effective and less efficient).

The effect of time – specifically, timings of activities (commonly measured through financial costs and incomes) – is hugely significant to outcomes of analyses of projects. By far, the normal approach is to ‘discount’ the future (due to liquidity preference) to yield a Net Present Value (NPV) for the total project (that may include disposal).

For the health of the Earth, and future life on this planet, shouldn’t the future be ‘enhanced’, rather than discounted in quantified analyses? That enhancing would give effective consequence to the mantra ‘We do not inherit the Earth from our ancestors, we borrow it from our children’. Such an approach supplements the essential of including externalities (costs and benefits which fall on society rather than the internal project participants – e.g., pollution) in the total analysis and evaluation (i.e., to internalize all externalities).

If the quintuple helix innovation is to operate, as has been advocated for the Belt and Road initiative, it is imperative to require project analyses and evaluations to include deconstruction and disposal and to advance beyond financially-based analyses that can be distorted and manipulated so easily.

## CONCLUSIONS

Borrowing from motivation theory and culture change theory, intrinsic factors are far more powerful and enduring than extrinsic factors and so, a change of peoples’ beliefs and values is required to bring about effective and enduring change in behaviour. That suggests that bottom-up initiatives are more likely to be successful and enduring. Top-down initiatives must be well-founded and accompanied by a protracted and convincing programme of education which is communicated effectively to the populace for them to become committed to its objectives and, hence, to change behaviour accordingly.

We need to adopt the fundamental, but stringent, goal of real sustainability. ‘Greening’ is only a partial initiative and, as such, can be dangerously inadequate by engendering complacency. Rigorous environmental audits are essential which incorporate all forms of energy and material resources over the full life cycle of projects (from inception through disposal) and use metrics that are appropriate, direct measures of what is consumed (as a person on a weight-losing diet counts calories in meals, rather than financial cost). Surrogate, financial metrics are inappropriate as they are far too susceptible to manipulations.

Terminology is important – terms carry huge amounts of meaning; only once we have a name for something, can we recognise it. So, we should move away from considering ‘scarcity’ (limited in supply), which underpins the price mechanism and, instead, adopt ‘rarity’ (small, finite quantity and difficult to find/acquire) which should invoke the idea of consumption’s reducing the world’s total quantity of each resource as it is consumed. The price mechanism’s usual focus is on the present (with input from the past), only speculation has a future orientation. But it is in the future where sustainability, or lack of it, resides.

The embryonic movement towards (ease of) maintenance and repair is highly laudable and a valuable compliment to re-cycling. However, that requires education and training of people to carry out the maintenance and repairs and commitments by designers and producers of the artefacts and components. This is a must for sustainability.

Buildings and infrastructure must incorporate design and construction for ease of deconstruction and maximisation of easy reclamation of constituents for re-use and re-cycling. Legislators and educators must address that challenge too as, especially in view of prevailing (financial) analysis techniques, ‘market forces’ are failing miserably.

Discounting the future is inappropriate. Such analytic techniques should be reversed so that the future is enhanced (analogous to risk analyses) due to its importance and associated unknowns. A further consideration in this domain is the current lack of knowledge (and awareness) of the damage human action continue to cause and so, enhancing the future makes some attempt to allow for those unknowns.

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# CRITICAL SUCCESS FACTORS (CSF) OF SUSTAINABILITY IMPLEMENTATION IN MALAYSIA

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## Abstract

Sustainable development is vital for management and protection of the environment, where the issues of a sustainable development deal with a wide range of factors within the local and global level, making sustainable development as a standard issue to a different angle of the business sector. Thus, it leads to different work practices, and it is often seen in many cases of various organisations. The motives of imposing sustainable development inside the Higher Education Institutions are, broadly speaking, to tackle the challenges of Higher Education Institutions and to come out with the critical success factor can boost the implementation. The aim of this paper is therefore to examine the factors critical for the success of sustainability implementation assessment for Private Higher Education Institutions in Malaysia. Through questionnaire survey on 75 and analysis via Rasch Model, 18 attributes on critical success factors on the sustainability implementation assessment for Private Higher Education Institutions in Malaysia have been discussed. From the finding, it is perceived that the successful sustainability implementation assessment should start from the support and direct involvement of the Private Higher Education Institutions' management. The academia should integrate sustainability implementation in teaching and research, and this would further drive to collaboration extension and support within inter-department and vice versa. Further discussion may subsequently enhance the sustainability implementation assessment in the right direction. Eventually, the staff and faculty members may also enhance their level of knowledge towards sustainability implementation assessment.

**Keywords:** *Critical success factors; SDG 4; sustainability implementation.*

## INTRODUCTION

Sustainable development is vital for management and protection of the environment, where the issues of a sustainable development deal with a wide range of factors within the local and global level, making sustainable development as a standard issue to a different angle of the business sector (Bert et al., 2008). Thus, it leads to different work practices, and it is often seen in many cases of various organisations (Chris et al., 2006). The World Commission on Environment and Development (WCED) asserts that sustainable development requires the simultaneous adoption of three bottom-line ideas, including environmental quality, economic prosperity and social equity (Chris et al., 2006).

The attachment of the reasonable advancement particular idea utilised within the Brundtland Report followed back in 1974 when Sustainable Societies was discussed in the World Council of Churches given equitable distribution (Lozano, 2008). Those fundamental accomplishments of the Brundtland Report have brought maintainable advancement of the standard universal political agenda and straightforward meaning that are broadly cited worldwide (Lozano, 2008; Reid, 1995). There are two main issues in Higher Education Institutions relating to the environmental factors, which are reducing energy consumption and waste as well as turning the curriculum into a green syllabus (Roy et al., 2008). Hence, the fundamental of the

sustainable development concept can be engaging. Sustainability implementation in Higher Education Institutions aims to ensure the institutions' organisation and management are in a proper and right track concerning the environment and society. Although there are undoubtedly some Higher Education Institutions that are already on their way to embodying some of the ideas, achieving change at most Higher Education Institutions around the world will require tremendous effort (Ferrer-Balas et al., 2008). This paper is studying on the critical success factors of sustainability implementation in Higher Education Institutions particularly to private institutions.

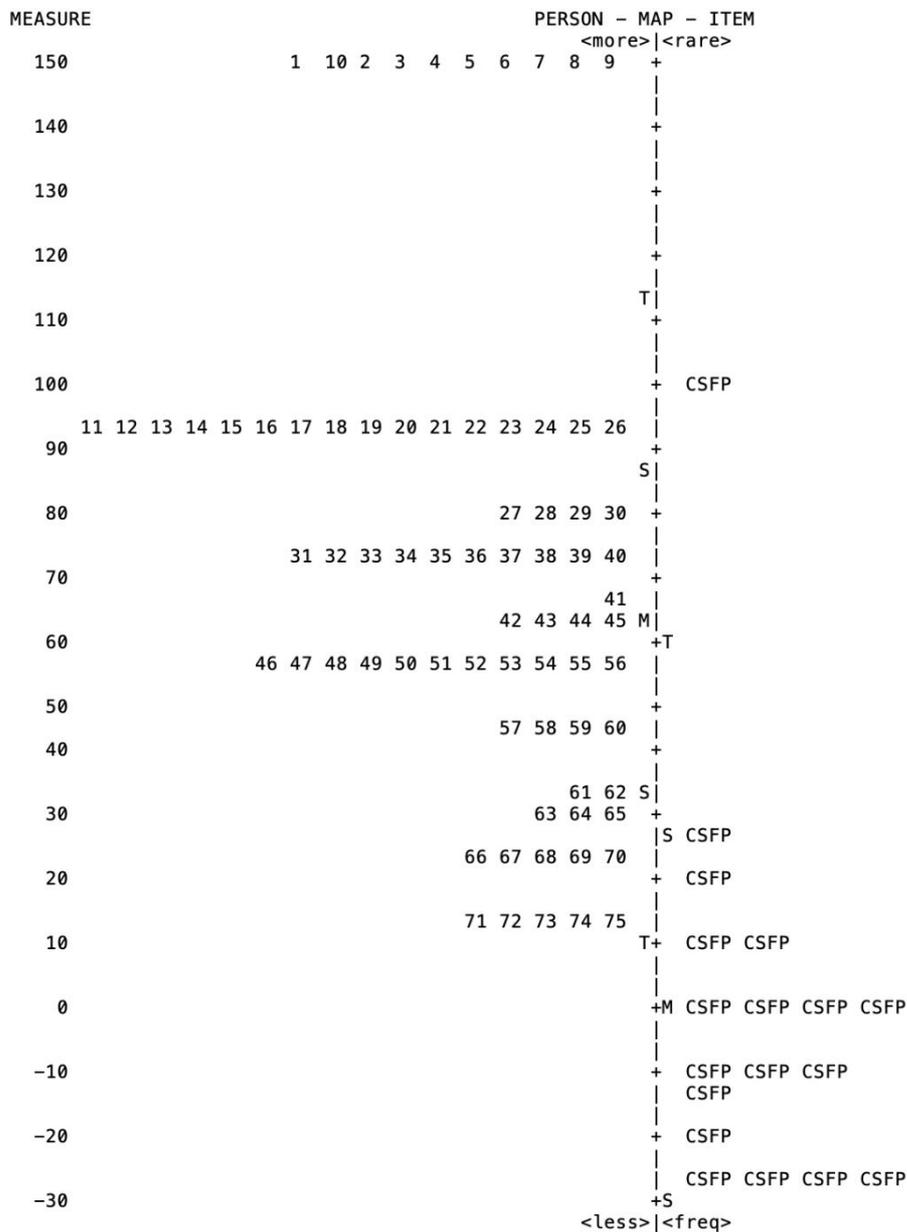
According to Shiel et al. (2015) and further emphasised by Disterheft et al. (2015), the changes in Higher Education Institutions are not as more comfortable as flown in mind, where there is a conflict or divergence in vision and perception from different stakeholders in the management of Higher Education Institutions in the sustainability implementation assessment. Even though there are constraint factors of sustainability implementation assessment in Higher Education Institutions, they still have a low probability of becoming success factors, regardless of the context. For example, in the perspective of lack of policymaking, to promote sustainability implementation and its assessment, the existence of organisational structures with restricted disciplines or the academic conservatism or traditions that tie Higher Education Institutions to the old mechanism of solo mentality is remained to occur (Lozano et al., 2013a). However, these constraints at the level of organisation can become the triggers, so that other stakeholders of the academic community can launch small strategies and mobilise peers to develop and scale their efforts (Brinkhurst et al., 2011). Table 1 illustrates the critical success factors (CSF) and strategies for sustainability implementation assessment in the Higher Education Institutions based on Lozano (2009).

**Table 1.** Critical Success Factors (CSF) and Strategies for Sustainability Implementation Assessment in The Higher Education Institutions

No.	Critical Success Factors	Strategies
1.	Internal Structures of Higher Education Institutions	<ul style="list-style-type: none"> <li>i. Teaching based on real life problems, which the collaborative cooperation is needed from students, academicians and academic staff.</li> <li>ii. Research and teaching can be integrated to generate a self-regulated process of mutual learning among the actors involved.</li> <li>iii. Each institution had mechanisms in place to monitor sustainability measures, such as energy consumption and carbon production.</li> <li>iv. Flexible institutional management in sustainability implementation assessment.</li> <li>v. All factors involve the well-known concept of sustainability implementation assessment in Higher Education Institutions.</li> </ul>
2.	External Factors to the Institutions	<ul style="list-style-type: none"> <li>i. External reputation of image, goodwill and credibility of Higher Education Institutions.</li> <li>ii. Make the assessment and certification as quality driver to measure the successful sustainability implementation concept in Higher Education Institutions.</li> <li>iii. Support programme incentives from the government.</li> <li>iv. Assessment by international experts to encourage Higher Education Institutions to establish the sustainability implementation.</li> <li>v. External financing programme to support sustainability implementation initiatives.</li> </ul>
3.	Stakeholders	<ul style="list-style-type: none"> <li>i. The commitment of the professors and the personnel, management and board and the students with compromising of the faculty and the staff.</li> <li>ii. Provide relevant information to be transmitted from academic side to government agencies and public.</li> <li>iii. Academic staff actively work on sustainability knowledge to be delivered to the students, who soon are going to be future leaders.</li> </ul>

No.	Critical Success Factors	Strategies
		iv. Increase of environmental awareness of internal stakeholders. v. Recognition of the work of the leader and his team.
4.	Institutional Framework	i. The integration of sustainability implementation into Higher Education Institutions policies, strategic plan, missions, goals and objectives. ii. Management of Higher Education Institutions highly support towards sustainability implementation assessment.
5.	Resources	i. The availability of source of fund and people who are responsible on sustainability implementation assessment of Higher Education Institutions.

(Source: Lozano, 2009)



**Figure 1.** Person-Construct distribution map to investigate the critical success factors (CSF) in the sustainability implementation assessment at Private Higher Education Institutions in Malaysia

## RESEARCH BACKGROUND

The questionnaire survey is basically designed to collect the same data via literature review yet from the primary sources in a sustainability implementation assessment framework in Private Higher Education Institutions in Malaysia, as well as the constraint factors in sustainability implementation assessment in Private Higher Education Institution in Malaysia. Items in the questionnaire have been developed based on the input gathered thru rigorous literature review, thus they are in-line with the listed objectives of this study.

Questionnaire survey is a systematic method of gathering information from a target population and is analysed with appropriate statistical techniques for quantitative study. Questionnaire survey is commonly used among the researchers (Orozco et al., 2014; Deng et al., 2013; Tan et al., 2012). Likert scale is a psychometric scale commonly used in research regarding to questionnaires survey. Respondents specify their level of agreement on a symmetric agree-disagree scale for a series of statements while responding to a particular Likert questionnaire item. The range of Likert scale captures the concentration of their approaches for a given item (Barua, 2013). This study uses five-point Likert scale of agreement and importance, which are commonly used for scales (Likert, 1932).

For this questionnaire survey sampling design used a purposive sample, where non-probability sample is selected based on characteristics of a population and the research objectives of this study. This study is conducted in Private Higher Education Institutions in Malaysia with University status. The Private Higher Education Institutions are identified based on the list from Malaysia Association of Private Colleges and Universities (MAPCU).

According to MAPCU (2018), there are 69 Private Higher Education Institutions being the member and 29 from them are Private Higher Education Institutions with university status. These Higher Education Institutions are also accredited by Malaysian Qualification Agency (MQA), recognised by Ministry of Education Malaysia (MOE) and operationally complied with IPTS Guidelines Act 555.

All the data gathered from the questionnaire survey is analysed via the Rasch model using WINSTEPS version 3.69.1.16 software. There are five analysis in the Rasch model, which are reliability and validity analysis, organisation misfit analysis, unidimensionality analysis, item misfit analysis and Person-Item distribution map analysis. Rasch model analysis is used because it changes the concept of reliability from creating a fit of the data into constructing a reliable measurement instrument (Said, 2016). Baghaei (2008) states one of the advantages of the Rasch model is that it builds a hypothetical unidimensional line along which items and persons identified according to their difficulty and ability measures are shown in the Person Item Distribution Map (PIDM). As Bond and Fox (2001) mentioned, the Rasch model is a prescriptive model in which how the data fit the model is investigated instead of the more classical statistical problem of how the model fits the data. Scholten (2011) further explained that the data are required to fit the model, and when they do not, items that show misfits discarded until a satisfactory fit obtained.

Thus, the Rasch model analysis is done in this study following Bond and Fox (2007), who explain that the Rasch model's logit value is the unit of measurement at an interval level instead of the ordinary number. In the Rasch model analysis, this study adopts summary

statistics, item characteristic curve scalogram, person item distribution map (PIDM), and person and item measure order used. The analysis shows both person and item measures to indicate that the respondent is completing the survey. At the same time, the respondent understands the questions given, while the item in the survey is understood and answered.

One example of a study using Rasch model analysis is Othman et al. (2014), who assessed construct validity and reliability of the competitiveness scale using the Rasch model analysis approach on the Malaysian Higher Education Institutions, where the items are quantitatively analysed using WINSTEPS software 3.72.3 based on the Rasch model to assess the suitability of items. Previously, Huang and Peng (2012) used the Rasch model in Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) to analyse the Tourism Destination Competitiveness (TDC) of nine Asian countries: China, Hong Kong, Japan, Korea, Malaysia, Singapore, Taiwan, Thailand and the Philippines. From the data collected, the fuzzy weights of the TDC criteria were generated with the Rasch model. Reliability and validity in the Rasch model analysis include the organisation and item reliability.

## DATA ANALYSIS AND FINDING

**Table 2.** Summary of 25 Constructs (Non-Extreme) to Investigate the Critical Success Factors (CSF) in The Sustainability Implementation Assessment at Private Higher Education Institutions in Malaysia

	Total Score	Count	Measure	Model Error	INFIT		OUTFIT	
					MNSQ	ZSTD	MNSQ	ZSTD
MEAN	349.9	75.0	.00	2.66	.03	-1.08	.00	-5.71
S.D	32.6	.0	29.39	.77	.04	.17	.00	2.74
MAX.	370.0	75.0	97.60	3.35	.14	-.73	.01	-2.86
MIN.	227.0	75.0	-27.47	1.39	.01	-1.23	.00	-9.90
Real SMSE	2.76	TRUE S.D	28.43	SEPARATION	10.30	CONSTRUCT RELIABILITY		0.99
Model S.E.	2.76	TRUE S.D	28.43	SEPARATION	10.30	CONSTRUCT RELIABILITY		0.99
S. E. of constructs	MEAN	6.93						

The input for research objective is with 25 constructs measured. Table 2 shows 25 constructs (non-extreme) are reporting the value of person reliability  $\beta = .99$  with 0.20 Standard Error (SE), suggesting that the respondents were competent to answer the questionnaire survey (Fisher, 2007). This indicates that the 25 constructs in investigating the critical success factors (CSF) in the sustainability implementation assessment at Private Higher Education Institutions in Malaysia have an excellent range of difficulties in measuring the organisation ability. Organisation fit statistics investigation on outfit on Mean Square (OMNSQ) and z-score (OZSTD) show that the OMNSQ is 0.00 and OZSTD is -5.71, which is near to expectation 1 and 0. This reveals that 25 constructs are targeting the right type of respondents in measuring the latent traits and produced data is at a reasonable prediction level of the responses to the constructs. The maximum organisation ability is  $\beta_{max} = +97.60$  logit, and the minimum measure is  $\beta_{min} = -27.47$  logit. The organisation mean  $\beta_{mean} = 0.00$  logit reveals that most of the respondents find the important to understand the CSF of sustainability implementation assessment in Private Higher Education Institutions in Malaysia.

## Unidimensionality Analysis

The principal component analysis (PCA) shows that the raw variance explained by measures was approximately 99.0 percent lower compared to the expected target of 99.3

percent as shown in Table 3, which shows good quality criteria of variance in data explained by measures as stated by Fisher (2007). In addition, the unexplained variance in the 1 contrast is also in good quality criteria (Fisher, 2007), which is 0.0 percent. This can be concluded that the 25 constructs in investigating the critical success factors (CSF) in the sustainability implementation assessment in Private Higher Education Institutions in Malaysia have one single overarching dimension.

**Table 3.** Standardised Residual Variance (in Eigenvalue Units)

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

Table 4 shows the standardised residual loadings for construct (sorted by loading) to investigate the CSF in the sustainability implementation assessment at Private Higher Education Institutions in Malaysia. There are nine constructs, which range of measure is from 0.43 *logit* to 97.60 *logit* and nine constructs, which range of measure is from -27.47 *logit* to -8.19 *logit*. The range of Infit MNSQ is within 0.01 *logit* to 0.14 *logit*, while for the Outfit MNSQ is within 0.00 *logit* to 0.01 *logit*, which show that there are no misfit constructs among the 18 constructs. In overall, all 18 constructs are unidimensional with good internal consistency and measure what it should be measured.

**Table 4.** Standardised Residual Loadings for Construct (Sorted by Loading) to Investigate the Critical Success Factors (CSF) in The Sustainability Implementation Assessment at Private Higher Education Institutions in Malaysia

Contrast	Loading	Measure	MNSQ		Construct	
			Infit	Outfit		
1	1	0.93	-8.19	0.02	0.00	E1_CSFPH1_1
1	1	0.93	-8.19	0.02	0.00	E13_CSFPH13_13
1	1	0.93	-8.19	0.02	0.00	E15_CSFPH15_15
1	1	0.86	0.43	0.01	0.00	E3_CSFPH3_3
1	1	0.86	0.43	0.01	0.00	E6_CSFPH6_6
1	1	0.86	0.43	0.01	0.00	E12_CSFPH12_12
1	1	0.86	0.43	0.01	0.00	E17_CSFPH17_17
1	1	0.83	-27.47	0.01	0.00	E2_CSFPH2_2
1	1	0.83	-27.47	0.01	0.00	E8_CSFPH8_8
1	1	0.83	-27.47	0.01	0.00	E14_CSFPH14_14
1	1	0.83	-27.47	0.01	0.00	E16_CSFPH16_16
1	1	0.58	-19.48	0.05	0.01	E11_CSFPH11_11
1	2	0.09	27.26	0.03	0.01	E9_CSFPH9_9
1	3	-0.62	10.67	0.02	0.00	E4_CSFPH4_4
1	3	-0.62	10.67	0.02	0.00	E18_CSFPH18_18
1	2	-0.27	-13.97	0.08	0.01	E7_CSFPH7_7
1	2	-0.21	19.97	0.14	0.01	E10_CSFPH10_10
1	2	-0.01	97.60	0.14	0.01	E5_CSFPH5_5

Indicator:

Code	Construct
CSFPHEI 1	Teaching based on real-life problems, which the collaborative cooperation is needed from students, academicians and academic staff
CSFPHEI 2	Research and teaching are integrated to generate a self-regulated process of mutual learning among the actors involved
CSFPHEI 3	Each institution had mechanisms in place to monitor sustainability measures, such as energy consumption and carbon production
CSFPHEI 4	Flexible institutional management in sustainability implementation assessment
CSFPHEI 5	All factors involve the well-known concept of sustainability implementation assessment in Higher Education Institutions
CSFPHEI 6	External reputation of image, goodwill and credibility of Higher Education Institutions
CSFPHEI 7	Make the assessment and certification of a quality driver to measure the successful sustainability implementation concept in Higher Education Institutions
CSFPHEI 8	Support programme incentives from the government
CSFPHEI 9	Assessment by international experts to encourage Higher Education Institutions to establish sustainability implementation
CSFPHEI 10	External financing program to support sustainability initiatives
CSFPHEI 11	The commitment of the academicians, stakeholders and the students with compromising of the faculty and the staff
CSFPHEI 12	Provide relevant information to be transmitted from the academic side to government agencies and public
CSFPHEI 13	Academic staff actively work on sustainability knowledge to be delivered to the students, who will soon be future leaders
CSFPHEI 14	Increase of environmental awareness of internal stakeholders
CSFPHEI 15	Recognition of the work of the leader and his team
CSFPHEI 16	The integration of sustainability into Higher Education Institutions policies, strategic plan, missions, goals and objectives
CSFPHEI 17	Management of Higher Education Institutions positively supports sustainability implementation assessment
CSFPHEI 18	Availability of source of funds and people to be responsible for sustainability implementation assessment in Higher Education Institutions

Table 5 shows the measure order of 18 constructs in investigating the critical success factors (CSF) in the sustainability implementation assessment in Private Higher Education Institutions in Malaysia. The constructs are sorted based on their measured value, which the positive value is less aware constructs while negative value is the aware constructs, based on Construct mean  $\mu_{mean} = 0.00$  logit as the cut-off point.

**Table 5.** Measure Order of The Constructs in Investigating the Critical Success Factors (CSF) in the Sustainability Implementation Assessment at Private Higher Education Institutions in Malaysia

Construct	Measure	Model SE	Remarks
E5_CSFPHEI_5	97.6	1.5	Less important
E9_CSFPHEI_9	27.26	1.39	Less important
E10_CSFPHEI_10	19.97	1.52	Less important
E4_CSFPHEI_4	10.67	2.35	Less important
E18_CSFPHEI_18	10.67	2.35	Less important
E3_CSFPHEI_3	0.43	3.31	Less important
E6_CSFPHEI_6	0.43	3.31	Less important
E12_CSFPHEI_12	0.43	3.31	Less important
E17_CSFPHEI_17	0.43	3.31	Less important
E1_CSFPHEI_1	-8.19	2.89	Important
E13_CSFPHEI_13	-8.19	2.89	Important
E15_CSFPHEI_15	-8.19	2.89	Important
E7_CSFPHEI_7	-13.97	1.73	Important
E11_CSFPHEI_11	-19.48	1.71	Important
E2_CSFPHEI_2	-27.47	3.35	Important
E8_CSFPHEI_8	-27.47	3.35	Important
E14_CSFPHEI_14	-27.47	3.35	Important
E16_CSFPHEI_16	-27.47	3.35	Important

**Table 6.** Matrix of Categorisation to Investigate the Critical Success Factors (CSF) in The Sustainability Implementation Assessment at Private Higher Education Institutions in Malaysia

Categories	Logit	n	%
Extremely important	0.00 logit to $\infty$	35	46.67
Moderately important	-8.19 logit to 0.00 logit	27	36
Not important	$\infty$ to -8.19 logit	14	18.67

## DISCUSSION AND CONCLUSION

In investigating the critical success factors (CSF) in sustainability implementation assessment, from the original 25 constructs, only 15 constructs are accepted to be included in the framework, where three most agreed constructs are: academic staff actively work on sustainability knowledge to be delivered to the students, who are soon going to be future leaders (E13), management of Higher Education Institutions highly support towards sustainability implementation assessment (E17), and provide relevant information to be transmitted from academic side to government agencies and to the public.

The incorporation of sustainability implementation is accepted by many but rejected by the Private Higher Education Institutions (Lozano, 2013). Thus, it is important for Private Higher Education Institutions management officials to understand the constraint factors that create this resistance by their community. The participation of stakeholders, assessment, transparency and reporting play key roles in helping to ensure the involvement and commitment of key stakeholders in the Private Higher Education Institutions.

Developing and introducing new forms of learning that can help people to understand and engage in sustainability implementation assessment. Among these new forms of learning require multi-stakeholder interaction, meaning making, negotiation, dealing with competing claims, handling diversity of perspectives (cultural, disciplinary, socio-economic, etc.) and the resolving of real issues as they emerge in everyday life at home, in the Private Higher Education Institutions, in the community or in the workplace.

In the critical success factors (CSF) in the sustainability implementation assessment, the CSF that have been agreed by the respondents are: research and teaching can be integrated to generate a self-regulated process of mutual learning among the actors involved, support programme incentives from the government, the commitment of the professors and the personnel, management, and board and the students with compromising of the faculty and the staff, and recognition of the work of the leader and his team.

It is observed by this study that the CSF which bring success in the sustainability implementation assessment always starts in the right direction when it is adopted in teaching and delivery. The process involves teaching methodology and approach to the student that starts by integrating the mutual learning. Thus, it can be a success by having full commitment by the teaching skill and professors, who are the experts on the subject matters. After all, the other CSF is also significant only if it receives the strong support from the academic and faculty staff, where these recognitions may boost their spirit for further improvement.

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# FACILITIES MANAGEMENT (FM) PERFORMANCE IN HIGH-RISE RESIDENTIAL BUILDINGS: EVALUATION USING PERFORMANCE MEASUREMENT SYSTEM

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## Abstract

Within the Facilities Management (FM) context, the Performance Measurement System (PMS) serves as an essential tool for assessing and reflecting on the quality of FM service delivered. The remarkable contribution of PMS has been affirmed by numerous researchers and FM practitioners. Nevertheless, there is a lack of acknowledgment of the adoption of PMS in the Malaysian FM industry, specifically in high-rise residential buildings. Stratified residential properties have become a trend in modern days for Malaysians due to the scarcity of land and high density of population in urban areas. However, FM performance is always a critical issue in high-rise residential buildings in Malaysia. Hence, there is a need to study the practice of PMS among FM and property management practitioners in Malaysia, specifically in high-rise residential buildings. This study was limited to the opinions and data obtained from property managers and facility managers in high-rise residential buildings in Klang Valley where a qualitative research method was adopted. The findings of this research showed that is still room for improvement for a better implementation of PMS in the Malaysian FM and PM industry particularly high-rise residential buildings in Malaysia. This study sought to fill in the research gap by exploring the current knowledge, extent of utilisation and ways to enhance the adoption of standardised PMS in high-rise residential buildings. The research outcomes can provide a reference for future researchers to further explore the implementation of PMS in other types of buildings namely institutional buildings, offices, hotels etc.

**Keywords:** *Facilities Management (FM); Performance Measurement System (PMS); High-Rise Residential Buildings; Malaysia*

## INTRODUCTION

To achieve the required standards and service level of facilities management (FM) performance, a performance measurement system (PMS) needs to be incorporated in the current FM industry. This is affirmed by Myeda (2013) that a PMS that integrates the adoption of framework or performance measures, allows better focus on the specific performance targets effectively. In fact, FM can bring significant contribution; hence, it is crucial to determine and measure its extent of support, adaptability to the changing needs of organisations as well as its contribution towards productivity, profitability, service, and quality (Amaratunga et al., 2000). Besides, Amaratunga et al. (2000) also ascertained that the FM budget of an organisation usually takes thirty to forty percent of the expenses, which is the second in cost to payroll; this marks the importance of high performance in FM. In other words, there is a need to integrate PMS in the current FM practice as performance measurement is essential in the FM context.

Over the years, the discussions on performance measurement are getting deeper and more intense. In the past twenty years, performance measurement has even caught a great amount of attention from numerous researchers and practitioners (Parida & Kumar, 2006). “What gets measured gets done” and “you cannot manage what you cannot measure” are the common adages in the management texts (Amaratunga, 2000) (cited in Myeda, 2013). To put these perceptions in the FM context, there is a need to assess and reflect on the output of FM service

delivery before the FM practitioners can develop a holistic strategy in managing the facilities. Sapri and Pitt (2005) agreed that performance measurement is essential to justify the general management and to support FM practice.

As for the Malaysian context, it is found that the FM industry is still in the infancy stage. Myeda and Pitt (2012) discovered that the FM industry in Malaysia is yet to be fully developed due to: lack of recognition and support from the government or registered authorised bodies on FM profession, abstruseness on the profession of FM manager and limitation on obtaining publicity and professional recognition on the profession of FM manager. Consequently, most of the FM practitioners only concentrate on managing the built environment from the operational perspective, as to keep the buildings functioning; however, the FM service providers neglect the importance of assessing and improving the performance of the FM services delivered. Myeda and Pitt (2012) found that despite the adoption of PMS is still relatively low among the FM practitioners in Malaysia, the FM practitioners that implement PMS acknowledge the contribution of PMS towards the improvement of their daily service delivery.

Within FM, every type of facility is unique as it requires different skill sets to fulfil the demands of occupants or corporate organisation. In the case of multi-unit residential facilities which operate on a full-time basis, round the clock in a week, it involves numerous individual resident concerns and requirements which are mostly subjective (Facility Management Association of Australia [FMA], 2012). Besides, according to FMA (2012), the features that distinguish multi-unit residential from other types of buildings (such as hotels, office buildings, universities, etc.) include various emotions involved, different perceptions on the priorities, occupancy and ownership of the buildings. Hence, a high FM performance level and a well-established PMS are crucial especially in high-rise residential buildings as to counter the occupants' concerns on FM issues. In Malaysia, the demand for high-rise residential buildings in the urban area is increasing due to spiking housing prices in landed units, city propagation and attractive integrated facilities provided (Abd-Wahab et al., 2015). Despite that, the FM aspects of high-rise residential buildings are rarely being discussed.

The facility management issues arisen in high-rise residential buildings should not be disregarded as unimportant and insignificant. This is because high-rise complexes such as tower blocks and apartment towers need the additional provision of adequate and efficient FM service delivery to attract the occupiers – the citizenry (Olanrele et al., 2014). Managing and maintaining high-rise residential housing is challenging and complicated as it demands the FM practitioners to be equipped with different skill sets in dealing with the building operation issues as well as the residents' feedbacks. Thus, the FM and property management practitioners need to ensure the level of service delivered is to the standards and to the satisfaction of building end users in high-rise residential buildings by integrating performance measurement systems in daily service delivery.

## **PROBLEM STATEMENT**

Most studies carried out on PMS in the FM industry merely focus on the issues and proposed framework in adopting PMS in FM, but little research investigates the existing PMS being employed in the current FM industry and the extent of utilisation of PMS in the current FM industry. Myeda (2013) affirmed that the constructs of performance measurement (PM)

are not well-established and not standardised in FM practices although the field of PM is not new. Hence, further investigation and studies are required. Amaratunga (2001) believed that researchers in the FM industry have still yet to investigate the concepts of PM which are well-developed in other fields and they do not take the complexity of PM at FM organisational level into consideration. In short, there is limited literature on the current standards and extent of utilisation of PM monitoring approaches in the FM context, taking the complexity and uniqueness of PM in each type of development into account.

Literature had emphasised the remarkable contribution of PMS implementation in improving the service delivery and work performance, yet there is little research on the adoption of PMS in the FM industry in Malaysia (Myeda & Pitt, 2012). Hence, taking the complexity of PMS at FM organisational level and the uniqueness of FM service delivery in various buildings into account, this study sought to fill in the research gap by exploring the current knowledge, extent of utilisation and ways to enhance the adoption of standardised PMS in high-rise residential buildings.

### PMS IN FM

Neely et al. (1995, as cited in Tangen, 2003), National Academies of Sciences, Engineering, and Medicine, (2010) and Sorooshian et al. (2016) have shared similar perception on performance measurement system (PMS) where it refers to “a set of metrics” to evaluate and measure the “efficiency and effectiveness of actions”. To link this definition to FM context, the question arises as to how the FM performance measurement system can be aligned for the measurement and with the relevant contingencies in the FM practice (Amaratunga, 2001). The concept of performance measurement adopted in the study is demonstrated in Figure 1. The concept is generated based on the definition presented by various authors to fill in the research gap where there is a lack of clarification on the terms used in the performance measurement field.

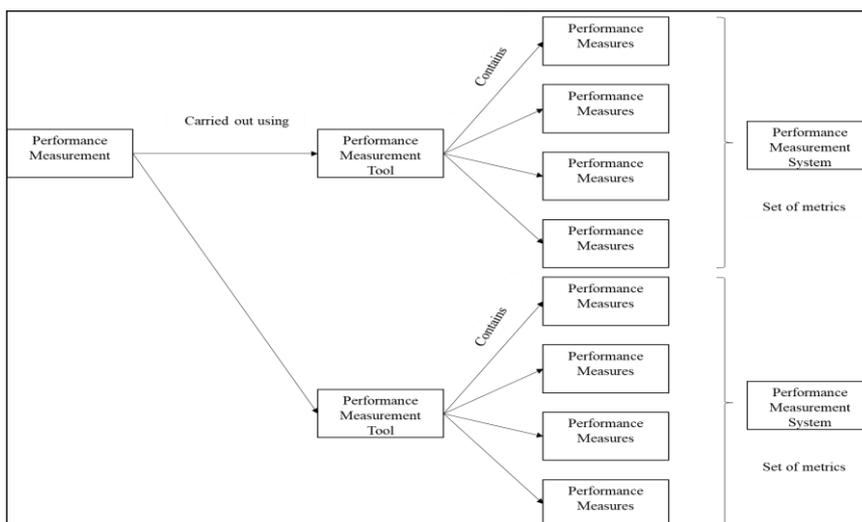


Figure 1. Concept of Performance Measurement Undertaken

## FM PERFORMANCE MEASUREMENT TOOLS

Lavy et al. (2010) ascertained that majority of the FM performance measurement exercises include post occupancy evaluation (POE), balanced score card (BSC), benchmarking and measurement using metrics of key performance indicators (KPIs). Service level agreement (SLA), is however a clearly defined statement where FM services are contracted out to service providers in the western world (Olanrele et al., 2014) where FM practitioners also utilise SLA to measure the FM performance by comparing the performance criteria from the SLA with the actual services received.

### Post Occupancy Evaluation (POE)

Post occupancy evaluation (POE) is a survey or a set of data where the building end user's opinions are adopted in the systematic assessment of the buildings in use (Thaddi & Admane, 2015). According to Meir et al. (2009), the tools adopted in POE comprises of: analysis of building plans, monitoring of indoor environment (IEQ), indoor air quality (IAQ) and thermal performance as well as surveys include the conduct of interviews (structured and semi-structured), distribution of user satisfaction questionnaires, walk-throughs and observations. This indicates that POE concentrates on the building issues which are directly affecting the satisfaction of the residents. Since POE evaluates the performance from the user's perspective, the user's needs are taken into consideration; however, POE is more on measuring the success of a change rather than the basic performance and it does not include financial performance criteria (Koleoso et al., 2013).

### Balanced Score Card (BSC)

Amaratunga (2001) asserted that the balanced score card (BSC) is a management framework that "tells the story" of the organisation's strategic objectives with the inclusion of both financial and non-financial measures. On top of that, Amaratunga et al. (2000) suggested that the balanced score card translates the visions of an organisation into a list of performance indicators which are allocated among four perspectives:

- Customer: How must the organisation look to their customers?
- Internal processes: What are the internal processes that the organisation must perform well?
- Financial: How will the organisation look to its stakeholders?
- Innovation: How can the organisation enhance its learning and growth?

However, despite the versatility of BSC in measuring both hard financial and soft user satisfaction perspectives, Koleoso et al. (2013) found that it is hard to identify a set of indices that links to the strategic objectives of individual organisations.

### Benchmarking

Benchmarking is a systematic process of assessing performance that uses a set of performance criteria to seek improvement beyond best practice (Booty, 2009). Sapri and Pitt (2005) argued that many believe that benchmarking in FM aspect is merely on cost comparing levels; hence, they revealed several FM aspects that can be benchmarked:

- Space use: Space use which determines the costs of the premises and floor areas can be benchmarked for the comparison maintenance and cleaning cost.
- FM management: Strategic and tactical FM operations can be benchmarked in terms of effectiveness and cost.
- Computer-aided FM systems: The service help desk can be benchmarked in terms of costs and effectiveness.

On the other hand, Koleoso et al. (2013) maintained that benchmarking is useful to specify the needs for financial control rather than the nature and scope of the specific improvement.

### **Key Performance Indicators (KPIs)**

Koleoso et al. (2013) observed that key performance indicators (KPIs) are general indicators of performance concerning the critical aspects of outcomes. Lavy et al. (2010) affirmed that it is crucial to set out a list of KPIs to construct effective performance evaluation metrics that indicate the performance of the facility in a holistic way. Booty (2009) further explained the essential criteria for effective KPIs as follows: motivate the right behaviour, hard to be manipulated to be “made nicer” and minimise the effort to measure.

### **Service Level Agreements (SLA)**

Atkin and Brooks (2009) defined a service level agreement (SLA) as a statement of intentions between the service providers and the customer (recipient of the service) establishing a specified level of service. With similar perceptions, Booty (2009) observed that all parties are enabled to examine the current level of service received by the customers by utilising the common metrics of quality, speed and accuracy stated in the SLA. He further elaborated an effective SLA with a detailed definition of outcomes from the elements of services can determine the standards or level of performance that must be met or exceeded by the service providers. On the contrary, Koleoso et al. (2013) argued that even though it is less complex to adopt SLA by comparing the performance with the requirements set out in SLA, it is still more an operational indicator instead of a critical success measure. This is because the level of service or performance standards specified in the SLA might not be directly contributing to the strategic objectives of an organisation.

From the literature, it is found that the performance measures that are often being discussed by the researchers include financial measures, customer’s satisfaction measures and measures based on organisational objectives. Another interesting finding is that the performance measurement tools reviewed have complemented or have been complemented by other performance measurement tools. Certain features of the tools have also been combined to create a more holistic manner of measuring the FM tools (Koleoso et al., 2013). Therefore, the pertinent question that arise is whether there is a more developed and standardised approach towards the FM performance measurement.

## **EVALUATION OF FM PERFORMANCE IN HIGH-RISE RESIDENTIAL BUILDINGS**

Evaluation of FM performance in high-rise residential buildings is often associated with the assessment of the satisfaction level of the residents on the quality of FM services received. Lai (2010) then identified customer satisfaction survey is useful to investigate the service

quality of FM in multi-storey residential buildings by discovering the quality of service perceived by the building occupants. The author also found that the attributes of FM services adopted for assessment differ, depending on the provisions of the buildings; hence, instead of classifying the attributes according to the dimensions set out by Parasuraman et al. (1985, as cited in Lai, 2010), he categorised the attributes into five aspects (Table 1).

**Table 1.** Main Aspects of FM Services for Residential Buildings (Source: Lai, 2010, p.16)

1. Repair and Maintenance	2. Security Service
<ul style="list-style-type: none"> <li>• Uniform and appearance of technicians</li> <li>• Attitude and manner of technicians</li> <li>• Professional knowledge of technicians</li> <li>• Electricity supply system</li> <li>• Potable water supply system</li> <li>• Flushing water supply system</li> <li>• Elevator system Intercom system and TV reception</li> <li>• Ventilation / air conditioning system</li> <li>• Fire services system</li> <li>• Grounds and building fabric</li> </ul>	<ul style="list-style-type: none"> <li>• Uniform and appearance of security staff</li> <li>• Attitude and manner of security staff</li> <li>• Professional knowledge of security staff</li> <li>• Communication ability of security staff</li> <li>• Initiative of providing assistance</li> <li>• Handling the register of visitors</li> <li>• Security facilities (e.g., CCTV)</li> <li>• Security control and patrol</li> </ul>
3. Cleaning Service	4. General Management Service
<ul style="list-style-type: none"> <li>• Uniform and appearance of cleaners</li> <li>• Attitude and manner of cleaners</li> <li>• Cleanliness of lobbies and corridors</li> <li>• Cleanliness of lift interiors</li> <li>• Cleanliness of washrooms</li> <li>• Cleanliness of staircases</li> <li>• Cleanliness of grounds</li> <li>• Arrangement of waste collection</li> </ul>	<ul style="list-style-type: none"> <li>• Uniform and appearance of management staff</li> <li>• Attitude and manner of management staff</li> <li>• Professional knowledge of management staff</li> <li>• Efficiency of handling complaints</li> <li>• Communication with residents</li> <li>• Ability of handling emergency situation</li> <li>• Response to resident requests</li> <li>• Arrangement of recreational activities</li> </ul>
5. Landscape and Leisure Facilities	
<ul style="list-style-type: none"> <li>• Aesthetics and tidiness of plants</li> <li>• Pest control</li> <li>• Environmental protection measures</li> <li>• Recreational facilities (e.g., play equipment)</li> <li>• Leisure amenities (e.g., seating bench)</li> </ul>	

## EXTENT OF UTILISATION OF PMS IN HIGH RISE RESIDENTIAL BUILDINGS

Lai (2010) argued that the level of importance on the aspects of FM services perceived by the residents is crucial to be incorporated in the performance measurement practice to ensure a holistic evaluation of service quality in high-rise residential buildings. Similarly, Olanrele and Thontteh (2014) also opined that the residents' expectation and perception on aspects of FM services should be considered in the FM performance measurement. These highlighted that the performance measurement tools employed in multi-unit residential buildings must take the user's perception of the level of importance of FM services into consideration. From the existing literature, various performance measurement tools with different features are used to evaluate the service quality of FM works in high-rise residential buildings. Besides, Olanrele and Thontteh (2014) also noted the use of benchmarking, balanced score cards and key performance index in performance measurement in a similar context.

Olanrele and Thontteh (2014) maintained that a balance of qualitative and quantitative measurement of service quality of FM services is essential. Hence, it can be observed from the performance measurement practice on FM services in high-rise residential buildings that a combination of performance measurement tools is adopted to evaluate the service quality of main FM aspects. Both studies of Lai (2010) as well as Olanrele and Thontteh (2014)

employed service quality (Gap) Score or SERVQUAL to identify the gaps in FM service delivery. Parasuraman et al. (1990, as cited in Olanrele and Thontteh, 2014, p.149) acknowledged SERVQUAL as a quality measurement tool commonly used to assess consumers' perceptions in customer satisfaction studies and the authors listed the five generic dimensions of SERVQUAL as follows:

- Tangibility—in terms of physical facilities, equipment and personnel
- Reliability—relating to the service accuracy
- Responsiveness—prompt service delivery
- Assurance—competence, courtesy, and credibility
- Empathy—access, communication, understanding the customer.

On the other hand, quantitative measurements on the service quality of FM aspects are carried out using post-occupancy evaluation and satisfaction index. Importance and performance ratings on each FM aspect in high-rise residential buildings are obtained from the residents through a customer satisfaction survey (Lai, 2010). Thaddi and Admane (2015) also noted that post evaluation surveys on residential buildings establish how well the buildings meet the residents' requirements, their expectation and their satisfaction level towards the built environment. Lai (2012) provided a closer approach of performance measurement to PMS, which is the performance-importance-cost (PIC) model, where it offers a multi-dimensional evaluation of FM performance in high-rise residential buildings. He further affirmed that the PIC model does not only help in evaluating the outcome of the performance of FM services and measuring the cost input to the services but also determining the cost-effectiveness of the FM services. This implies that the satisfaction level of the residents can be viewed from another perspective where cost-effectiveness in the delivery of FM services can be considered during the performance measurement.

## **SOLUTIONS OF ENHANCING THE ADOPTION OF STANDARDISED PMS IN HIGH-RISE RESIDENTIAL BUILDINGS**

As identified in previous sections, the FM industry in Malaysia is still at the infancy stage and the practice of FM is still immature due to lack of FM guidelines and professional recognition of facility managers. Findings from previous sections also demonstrate the lack of standardisation in the FM performance measurement practice in high-rise residential buildings. This implies the need to explore better approaches in implementing standardised PMS in high-rise residential buildings. Key suggestions and recommendations from FM industry players to improve the overall FM practice in Malaysia are summarised by Mohd Noor & Pitt (2010): best practice guidelines in FM, qualification of facility managers, certification of FM and review on existing legislative perspective on FM practice.

Firstly, there is a strong demand for a standard guideline for a good FM practice from the authorities to enhance the quality of service and level of professionalism in managing high-rise residential properties (Tiun, 2006). Myeda and Pitt (2014) described that the absence of the FM department in the authorities to establish guidelines and control on quality as well as an assessment on FM performance has contributed to the difficulty to evaluate FM discipline in Malaysia. Mohd Nasir and Aziz (2019) added that it is recommended that a maintenance management guideline is established to standardise the practice of managing maintenance, cleaning, and security aspects of the buildings.

Besides, FMA (2012) also emphasised that the formal qualification of facility managers in FM or a relevant discipline is crucial while appointing the facility manager in high-rise residential buildings. In the Malaysian context, Mohd Noor & Pitt (2010) added that tertiary education institutions in Malaysia should collaborate to form FM training modules that are highly competent to the renowned international FM institution. For instance, research and development, commercialisations and internships should be included in the FM tertiary programmes to develop necessary professional competency for facility managers (Mohd Noor & Pitt, 2010). Nik Mat et al. (2011) highlighted that it is essential for FM or maintenance managers to understand the strengths, weaknesses, significance of the FM services delivered as well as tangible and intangible values of the buildings by measuring the performance of FM services.

Lastly, Myeda and Pitt (2012) pointed out that the profession of FM managers was often confused with property managers and maintenance managers, which led to the lack of publicity and professional recognition on the roles of FM managers in Malaysia. Mohd Noor and Pitt (2010) then again suggested CIDB establish a certification process that will mark the competency level of FM practitioners to standardise the FM practices in Malaysia. Amaratunga (2001) evinced that FM managers are required by senior managers to become more accountable and reliable to support the business objectives with the FM's contribution. This implies that performance measurement has become one of the essential competencies of a professional facility manager for the reasons of making justification to core business and supporting the core business within FM (Amaratunga, 2001).

## **RESEARCH METHODOLOGY**

### **Research Technique**

#### *Qualitative Research Method*

DeFranzo (2020) asserted that qualitative research is primarily exploratory, intending to obtain an understanding of underlying opinions and to uncover trends in certain topics. Besides, Kuada (2012) suggested that the qualitative research method is highly recommended for research concerning obtaining new insights into the phenomenon which the researcher is investigating. This implies that a qualitative research method is a suitable approach for this research which aims to explore the extent of utilisation of PMS in the Malaysian FM industry.

Adams (2015) recommended semi-structured interviews for research that aims to obtain independent opinions of every individual in a group with open-ended questions. He added that these open-ended questions will then be associated with follow-up "why" or "how" questions. Hence, the semi-structured interview is the best-suited research data collection method for this research as the primary aim of this study is to investigate is there an established system to evaluate FM performance and the 'hows' of implementing PMS system in high-rise residential buildings.

#### *Sampling Method*

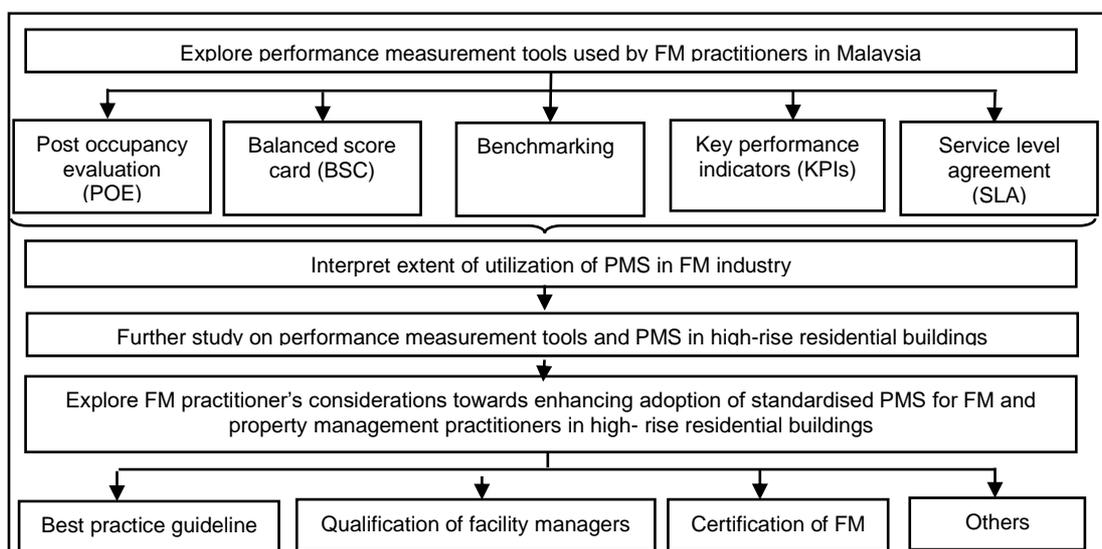
Purposive sampling method is used where the individuals who participated in this study were selected based on their experience, knowledge and availability on the subject matters.

## Target Population and Scope

The target population for this study was property managers and facilities managers in Malaysia. The study population would be focusing on the property management and facilities management practitioners, including building maintenance managers and property managers, who currently work or have the experience of working in the industry in high-rise residential buildings in Klang Valley. The reason being the management of high rise or strata residential properties are recognised as property management or PM in Malaysia. Hence, both PM and FM practitioners participated in this research. The sampling frame was registered members of The Board of Valuers, Appraisers and Estate Agents Malaysia (BOVAEA) as provided by the membership directory.

## Conceptual Framework

A conceptual framework for this study is illustrated in the Figure 2 to encapsulate the variables so that the information collected can be synthesised and captured to achieve the research objectives.



**Figure 2.** Conceptual Framework

## Data Analysis

Thematic analysis was adopted for this research as this is in line with Alhojailan's (2012) recommendation that thematic analysis is best suited for research that aims to discover with interpretations. In line with Alhojailan's (2012) explanation on phases in data reduction, the data collected from the 6 respondents involved in this research was tabulated in an organised and systematic manner using Microsoft Word. Then, the data was read several times to visualise the full picture of the data and link the ideas together. Secondly, the keywords from the responses were highlighted. The key ideas were identified based on the research objectives on the extent of utilisation of PMS in FM and strata building as well as ways to enhance standardised PMS. After that, the key ideas were broken down into several themes as the first level of the themes. The second level of the themes (sub-themes) were identified under each

first level theme. Subsequently, the data were organised and presented in the form of tables to display the patterns of sub-themes which were then analysed and highlighted in conclusion.

## ANALYSIS AND DISCUSSION OF RESEARCH FINDINGS

### Extent of Utilisation of PMS in FM

#### *Implementation of PMS in Property Management or Facilities Management Practice*

Myeda and Pitt (2012) found that 60% of the respondents consisting of FM practitioners in Malaysia reported that they have not implemented PMS for their FM practice. This is in contrast to the research findings whereby the respondents confirmed they had implemented PMS in their property management or facilities management practice. This includes to measure FM performance for collection and record of data, issues resolutions, and matters pertaining to cost as well as improvement of performance as illustrated in Table 2. It was found that the standardised method or PMS applied by the respondents are efficient as it captured the important aspects in which the property management or facilities management practitioners focus on. This is in line with Tangen's (2002, as cited in Tangen, 2003) observation that the performance measures or indicators are comprehensive and can be achieved by a limited number of performance measures from both financial and non-financial aspects.

**Table 2.** Summary of Sub-Themes on Standardised Method to Measure FM Performance

Themes	Sub-Theme	Respondent					
		R1	R2	R3	R4	R5	R6
Standardised method to measure FM performance	A1a-i Collection and record of data	✓	✓				
	A1a-ii Resolve issues	✓	✓		✓		
	A1a-iii Cost involved	✓	✓	✓	✓	✓	
	A1a-iv Improve performance	✓	✓	✓			

#### *Performance Measurement Tools in FM*

It was also discovered that the literature findings on the common performance measurement tools being adopted by the practitioners in FM and PM industry are aligned with the interviewees' responses as shown in Table 3. Moreover, it is worth noting that most of the respondents have adopted different combinations of the tools namely post occupancy evaluation, balanced scorecard, benchmarking, key performance indicators and service level agreement in their practice. The responses collected are aligned with the literature findings where benchmarking, KPI and service level agreement are closely related while they are being used as performance measurement tools. Two respondents shared the similar opinions where they adopted benchmarking, KPI and service level agreement (SLA) to measure the FM performance in respective property management practice. One of them explicitly stated that "they (the tools) are interconnected...otherwise what one measure without the others wouldn't help...". On the other hand, one of the respondents stated that only Key Performance Indicator (KPI) is implemented in their day-to-day practice as it allows them to simplify the process of monitoring and assessing the FM performance. This is aligned with Booty's (2009) opinion that KPIs should minimise the effort to measure.

**Table 3.** Summary of Performance Measurement Tools Adopted in FM and PM Industry

Themes	Respondent					
	R1	R2	R3	R4	R5	R6
A2a Post occupancy evaluation (POE)					✓	
A2b Balanced scorecard (BSC)			✓			
A2c Benchmarking		✓	✓	✓		
A2d Key performance indicators (KPIs)	✓	✓	✓	✓	✓	✓
A2e Service level agreement (SLA)		✓	✓	✓		✓

### *Extent of PMS in FM*

The significant performance indicators or metrics were identified such as budget or cost saving, closing rate, approved budget, feedback from survey and understanding of job scope as demonstrated in Table 4. All respondents concurred the importance of establishing a budget and adhere to the budget approved to ensure the projects are healthy financially. However, only a few respondents acknowledged the role of performance measurement tools in monitoring the financial performance. This reveals that the performance measurement practice is still not widely established among the practitioners. Besides, it was found that most respondents rely on respective performance measurement tools to measure the indicators revolving around the extent of customer's satisfaction towards FM service delivery. Furthermore, every respondent shares distinctive opinions on the tools applied to measure the extent of FM service fulfilling the organisational objectives. Overall, the performance indicators shared by the interviewees resonates with, Lavy's et al. (2010) proposal on performance metrics in FM namely financial, physical, functional and survey-based indicators. It was further discovered that every interviewee had adopted different performance measurement tools to measure FM performance based on the indicators.

**Table 4.** Summary of Sub-themes on Performance Indicators

Themes	Sub-Theme	Respondent					
		R1	R2	R3	R4	R5	R6
Financial performance	A3a-i Budget/Cost Saving	✓	✓	✓	✓	✓	✓
Extent of customer's satisfaction towards FM service delivery	A3b-i Agreed turnaround times/ closing rate	✓			✓		✓
	A3b-ii Approved budgets			✓			✓
	A3b-iii Feedback from survey		✓			✓	
Extent of FM service fulfilling the organisational objectives	A3c-i Understanding of job scope	✓	✓	✓	✓	✓	
	A3c-ii Approved budgets						✓

## **Extent of Utilisation of PMS in FM in High Rise Residential Buildings**

### *Implementation of PMS in High Rise Residential Buildings*

All respondents reverted that the performance measurement system being applied in strata or high-rise residential buildings are similar to other types of buildings. However, they highlighted the difference between strata high rise properties and other types of buildings in the industry is on costing and the decision-making by the committee namely joint management body (JMB) or Management Corporation (MC).

The important attributes or indicators adopted by the respondents in high rise residential buildings focused on cost significant and customer satisfaction aspects. This is affirmed by four of the respondents that elevator breakdown can lead to a great cost impact and customer dissatisfaction. As from services aspects, the performance measures or metrics used are mostly based on customer satisfaction where number of complaints, feedback and comment will be taken into consideration while assessing the FM performance in this aspect. This is in line with the literature findings that the residents' expectation and perception on aspects of FM services should be considered in the FM performance measurement (Olanrele and Thontteh, 2014).

**Table 5.** Summary of Sub-Themes on Performance Metrics in FM Performance in High-Rise Residential Buildings

Themes	Sub-Theme	Respondent					
		R1	R2	R3	R4	R5	R6
Method/tools/ system adopted to measure FM performance in strata properties	B1a-i Cost aspect		✓			✓	
	B1a-ii Human aspect	✓		✓	✓	✓	✓
Effectiveness of method/tools/ system adopted to measure FM performance in strata properties	B1b-i Technology	✓	✓		✓		✓
	B1b-ii Staff behaviour			✓	✓	✓	

### *Extent of Utilisation of PMS in High Rise Residential Building*

On top of that, it was also found that performance measurement is carried out in terms of the five aspects of FM performance in high-rise residential buildings namely maintenance, security, cleaning, landscape and general management as illustrated in Table 6. For maintenance aspect, the respondents further listed the items that they will implement performance measurement such as lift, electricity supply, firefighting system and building fabric. The attributes employed by the FM and PM practitioners are in line with the categorisation proposed by Lai (2010). One of the worth noting findings is that manual ways of measuring the FM performance still being applied by the practitioners where the staff will be sent to site to do spot check on the level of service delivered by the service providers.

**Table 6.** Summary of Sub-Themes on Aspects of FM Performance in High-Rise Residential Buildings

Themes	Sub-Theme	Respondent					
		R1	R2	R3	R4	R5	R6
Maintenance	B2a-i Lift		✓	✓	✓	✓	
	B2a-ii Electricity supply		✓	✓		✓	
	B2a-iii Fire-fighting system		✓		✓	✓	
	B2a-iv Building fabric		✓				
Services	B2b-i Security	✓	✓	✓	✓	✓	
	B2b-ii Cleaning	✓		✓	✓		
	B2b-iii Landscape		✓				
	B2b-iv General Management	✓			✓		

## **Ways to Enhance the Adoption of Standardised PMS in High Rise Residential Buildings**

### *Best Practice Guideline*

Tiun (2006) affirmed that there is a strong demand for a standard guideline for a good FM practice from the authorities to enhance the quality of service and level of professionalism in managing high-rise residential properties. This is consistent with the findings where most of the respondents agreed that they are following the guideline in their day-to-day property management practice in strata properties. The respondents further confirmed that the best practice guideline adopted by their companies are helpful and ensure that their sites or projects can be properly managed. However, some respondents also pointed out that the standard guidelines are still yet to be established due to the variations and problems that occur at different sites. Hence, to add on to Tiun's (2006) observation, the standard guideline for a better practice in measuring and managing the FM performance shall consider the variations of different strata properties managed from time to time.

### *Qualification of Academic and Technical Competency*

The respondents concurred that qualification of FM or PM managers in terms of managerial skill, operational or technical skill as well as academic or educational background is essential in enhancing a better adoption of PMS in strata properties. This is in accordance with the opinions of Nik Mat et al. (2011) where FM and PM managers should possess the competency to analyse the adoption of maintenance services and respective sub-contractors. One of the respondents gave a novel idea where he opined that if paymasters or the condo building owners accepted to adopt such performance measurement system with a systematic and quantitative measurement, then when achieved, to reward whoever is performing well in their practice. This will encourage the adoption of a standardised PMS in strata properties.

### *FM/PM Managers' Certification*

The importance of certification of FM and PM managers are acknowledged by all respondents where it was suggested that Malaysian Institute of Property and Facility Managers (MIPFM) to increase the awareness as well as the standard of knowledge of the industry. This is not in accordance with Mohd Noor and Pitt's opinions (2010) who suggested a different organisation, CIDB, to establish a certification process that will mark the competency level of FM practitioners to standardise the FM practices in Malaysia. It is also discovered that it is crucial to ensure on site and structured training are provided not only to the practitioners at managerial roles, but to site people on site to ensure better adoption of PMS in high-rise residential building.

## **CONCLUSION AND RECOMMENDATION**

The key features and significance of PMS were identified where the FM or PM practitioners affirmed that they have employed the method to measure FM performance for collection and record of data, issues resolutions, matters pertaining cost as well as improvement of performance. It was also discovered that the literature findings on the common performance measurement tools being adopted by the practitioners in FM and PM

industry are aligned with the interviewees' responses. Moreover, it is worth noting that the interviewees have adopted different combinations of the tools namely post occupancy evaluation, balanced scorecard, benchmarking, key performance indicators and service level agreement in their practice. It was also found that in terms of the five aspects of FM performance in high-rise residential buildings namely maintenance, security, cleaning, landscape and general management, all respondents focused the most on cost significant and secondly on customer satisfaction in their performance measurement practice. Hence, the Malaysian FM and PM industry should be cognizant of the current issues pertaining to performance measurement practice. Motivation and encouragement shall be provided to the FM and PM organization to enhance the digitalisation of PMS and elevation of the standard of knowledge as well as behaviour among the building executives.

Overall, this study had contributed to a better understanding on implementation of performance measurement system (PMS) in facilities and property management specifically for high-rise residential buildings in Malaysia. It is recommended for future researchers to adopt a different research method such as case studies and observation to establish a more comprehensive understanding on the PMS applied in the industry. The opinions of FM and PM practitioners at executive level shall also be included for further studies on this topic. As presented in previous sections, it was found that technology deployment and staff behaviour can be the booster for a better implementation of PMS in the Malaysian FM and PM industry. As such, future researchers are suggested to consider these aspects for further research on this subject.

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# CRITICAL SUCCESS FACTORS TOWARDS ETENDERING IMPLEMENTATION IN CONSTRUCTION INDUSTRY: A LITERATURE REVIEW

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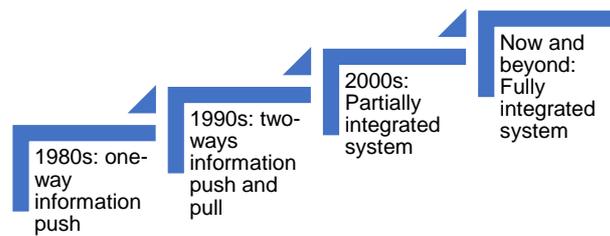
## Abstract

Tendering is the process for the project owner to select a suitable contractor for the project as a delivery partner by submitting the right price and proposing time delivery within the anticipated quality. In the construction industry, the tendering process is still somewhat manual based. Otherwise, it is partially in electronic mode, with the tender notice is advertised through online platforms while tender assessment and reporting are still done manually. Critical Success Factors (CSF) of eTendering implementation are indicators for opportunities, activities, or conditions required to implement eTendering in construction project delivery successfully. This study aims to identify the CSF of eTendering implementation in the construction project. This CSF are the factors identified to ensure the success of the eTendering implementation in projects. A literature review has been conducted, which about 19 indexed papers fall from year 2013 to 2020 were considered as resources where the elements of CSF further divided into: People (Skill – 2 constructs and staff – 4 constructs), Process (Practice – 14 constructs and Procurers – 7 constructs), Work Environment (Leadership – 10 constructs, management – nine constructs, cultural – 6 constructs and structure – 5 constructs), Technology (System and software – 12 constructs and networking – 4 constructs) and Service Provider (Communication – 4 constructs, market – 5 constructs and technical – 9 constructs). These make a total of five themes, 13 sub-themes and 91 constructs of CSF of eTendering implementation has been identified. Therefore, this study's finding on CSF of eTendering implementation is further beneficial to the construction players to ensure project success. The finding shows the network security concerns of eTendering implementation is a priority in the construction industry.

**Keywords:** *eTendering; Critical Success Factors; construction industry*

## INTRODUCTION

Tendering is the process of selecting a suitable contractor to deliver the clients preference on the project. The Royal Institution of Chartered Surveyor (RICS, 2014) defined that tendering is about setting the right price for on-time delivery and within the anticipated quality of the project. By having a conventional arrangement of the tendering procedure, tonnes of paper-based information in drawings and tender documents are transmitted and exchanged among construction project team members. Where the construction players are supposed to shift from conventional and move to Industrial Revolution 4.0 (IR 4.0) practices. Figure 1 shows the evolution of tendering practices in chronology. The contractors used to obtain the printed version of tender documents bundle even since the 1980s, followed by Compact Disc (CD) based saved version in the year 2000. Until recently, the practices begin shifting toward web-based collaborative platforms under IR 4.0. Yet, the implementation is still at a minimum.



**Figure 1.** Evolution of Tendering Practices (Simon and Yan, 2009)

By looking at Malaysia's construction industry practices, the tendering process is still in a conventional basis where the process is partially in electronic mode, with the tender notice being advertised through online platforms through the internet while tender assessment and reporting are done manually (CIDB, 2015; Pasiopoulos, Siskou, Galanis and Prezerakos, 2013; Lou, 2007). In Malaysia's perspective, eProcurement is also known as “*ePerolehan*” (Pasiopoulos et al., 2013). As highlighted by Wimalasena and Gunatilake (2018), all research done by previous scholars are based on eProcurement instead of eTendering in the construction industry where eProcurement is widely used for goods and services supply chain instead of being used for construction projects (RICS, 2014). There is a need to conduct a research study on eTendering implementation in the Malaysian construction industry.

The construction industry is progressing in line with IR 4.0 with the introduction of the eTendering system, which also acts as an alternative web-based system in electronically procuring services and goods. As referred for previous scholars, eTendering transforms the conventional way of procurement into an internet-based system, making it more efficient and cost-effective, where the immense development of eTendering offers sophisticated and standardised platforms that can be accessed via computers and smartphones (Fong and Zhuang, 2009; Koondhar, Rind, Hub and Shaikh, 2014; Nasrun et al., 2017).

Despite the fact that the benefits of eTendering may offer, the construction sector is still slow in adopting compared to the production and services sectors (Laryea and Ibem, 2014). This is because organisations are not ready to shift from conventional to technology practices nor to focus on post-adoption. In addition, construction activities are more complex and fall into its responsibility for promoting and implementing eTendering into the procurement procedures, especially the tendering process, which can be costly (Pasiopoulos et al., 2013).

By speaking about conducting and even practising eProcurement, the inaccuracy may occur due to various issues ranging from human carelessness, discrepancies between documents, wrongly transferring figures, error in summation, etc. Numerous companies employ additional staffing to ensure and enhance the quality of works. According to Eadie, Perera and Heaney (2010) highlighted that construction procurement is looking forward to a shorter, systematic and reliable tendering process. Thus, a study on CSF of eTendering implementation in construction projects is essential to ensure project success (Aziz and Salleh, 2011; Moath et al., 2018). This study may further enhance the tendering process in many ways, especially when construction activities are more complex than services or goods procurement. Therefore, the objective of this study is to identify and evaluate the CSF of eTendering Implementation towards the construction industry. These CSF are the factors determined to ensure the success of the eTendering implementation in construction projects.

The user can use these factors to guide the eTendering implementation for the construction projects.

## LITERATURE REVIEW

National Implementation Research Network (NIRN) defined that Critical Success Factor (CSF) as a key capacity and infrastructure that influence success and the core components needed to initiate and support the eTendering implementation, especially for the construction industry. Janse (2019) asserted that CSF are indicators for opportunities, factors or conditions required to achieve the objectives within a project.

### *Critical Success Factors (CSF) of eTendering Implementation*

The eTendering implementation for construction projects has been introduced years back globally, but each country varies the implementation. In Malaysia, eTendering was jointly initiated by Construction Industry Development Board (CIDB) and Public Works Department (PWD). Both agencies are actively implementing eTendering however, the eTendering implementation is mainly on services and goods supply contracts but has yet to be well implemented in building construction projects.

By referring to Table 1, the CSF of eTendering implementation can be divided into five main themes – People, Process, Work Environment, Technology and Service Provider. Every five themes are further divided into 13 sub-theme and 91 constructs. For the first theme-people, under the sub-theme of skill, the most times referred is eTendering knowledge for staff having the highest times referred and followed by the second theme is the availability of the effective regulation system and security of the process. The third theme is Top or strategic management commitment for eTendering, and the fourth theme is security concerns having the highest times referred. The highest times referred to in the fifth theme is cooperation with tenderers and subcontractors or suppliers and technical infrastructure within the construction industry. Amongst the themes, the highest times referred is network security concerns.

By referring to Table 1 above, the theme known as people consists of staff and skill sub-themes. Skill can be further enhanced through education or training where it may turn the employees understanding of eTendering concepts and implementation (Mohammadi, 2013; Mathenge and Wausi, 2018). As highlighted by previous scholars, sufficient knowledge of the staff in the eTendering process and system is a critical factor in delivering well (Vaidya, Sajeev and Callender 2006; Oyediran and Akintola 2011; Asnudin 2012; Rahayu, Saleh and Prasetyo 2013; Mangitung and Novitasari, 2015).

Qusef and Daradkah (2019) highlighted that one of the importance of eTendering implementation is to achieve high-security measures involving seller, buyer and any moderator between the parties involved in the process. Further discussed by Prasetyo (2019), it is important to implement eTendering through standard system that further comply with the regulation and guide by the laws and regulations. From Table 2, its indicates that the availability of an effective regulation system and security of the process are the highly referred constructs under the themes of process.

**Table 1.** Critical Success Factors (CSF) of eTendering Implementation

Theme	Sub-Theme	Ref Code	Baller, Dutta, and Larvin (2016)	Goulding and Lou (2013)	Moath Al-Yahya, et al. (2018)	Poire, Staub-French and Forgues (2015)	Rafferty, et al. (2013)	Tai (2013)	Zunk, et al. (2014)	Patel, Satndrakumar and Rajesh (2016)	Zainon, Skitmore and Mohd Rahim (2020)	Tan and Suhaida (2016)	Shukla, Khan and Shah (2016)	Moath and Panuwatwanich (2017)	Mathenge and Wausi (2018)	Mangitung and Novitasari (2015)	Ibem et al. (2016)	Sunmola and Shehu (2020)	Ari Prasetyo (2019)	Afolabi et al. (2019)	Wimalasena and Gunatilake (2017)	Total Time Referred			
People	Skill	CSF-Pe-SK01	√						√	√				√							√	5			
		CSF-Pe-SK02	√						√	√					√	√					√	√	7		
	Staff	CSF-Pe-SF01	√										√			√	√				√	√	6		
		CSF-Pe-SF02	√																				√	2	
CSF-Pe-SF03		√							√												√	√	4		
CSF-Pe-SF04		√																				√	2		
Process	Practice	CSF-Pr-Pa01	√						√		√	√						√				√	6		
		CSF-Pr-Pa02	√									√	√											3	
		CSF-Pr-Pa03	√																					√	7
		CSF-Pr-Pa04	√							√		√	√				√				√	√		7	
		CSF-Pr-Pa05	√												√									2	
		CSF-Pr-Pa06	√												√									2	
		CSF-Pr-Pa07	√												√									2	
		CSF-Pr-Pa08	√										√	√							√	√		5	
		CSF-Pr-Pa09	√											√								√		3	
		CSF-Pr-Pa10	√																					1	
		CSF-Pr-Pa11	√																					1	
		CSF-Pr-Pa12	√																					1	
		CSF-Pr-Pa13	√														√			√				3	
		CSF-Pr-Pa14	√											√		√	√			√				5	
Procurement	Procurers	CSF-Pr-Po01	√							√	√	√	√			√					√		7		
		CSF-Pr-Po02	√																					1	
		CSF-Pr-Po03	√																		√	√		3	
		CSF-Pr-Po04	√									√			√				√		√	√		6	
		CSF-Pr-Po05	√							√														2	
		CSF-Pr-Po06	√																√					2	
		CSF-Pr-Po07	√																					1	
Work Environment	Leadership	CSF-WE-Le01	√	√																			2		
		CSF-WE-Le02	√							√			√		√					√	√	√		7	
		CSF-WE-Le03	√																√					2	
		CSF-WE-Le04	√																					1	
		CSF-WE-Le05	√										√		√						√			4	
		CSF-WE-Le06	√											√			√							3	
		CSF-WE-Le07	√							√					√									3	
		CSF-WE-Le08	√																					1	
		CSF-WE-Le09	√											√							√			3	
		CSF-WE-Le10	√																		√	√		3	
Management	Management	CSF-WE-Mg01	√																				1		
		CSF-WE-Mg02	√																				1		
		CSF-WE-Mg03	√										√	√						√	√		5		
		CSF-WE-Mg04	√									√	√	√		√				√			6		



Theme	Sub-Theme	Ref Code	Baller, Dutta, and Lanvin (2016)	Goulding and Lou (2013)	Moath Al-Yahya, et al. (2018)	Poire, Staub-French and Forgues (2015)	Rafferty, et al. (2013)	Tai (2013)	Zunk, et al. (2014)	Patel, Satndrakumar and Rajesh (2016)	Zainon, Skitmore and Mohd Rahim (2020)	Tan and Suhaida (2016)	Shukla, Khan and Shah (2016)	Moath and Panuwatwanich (2017)	Mathenge and Wausi (2018)	Mangitung and Novitasari (2015)	Ibern et al. (2016)	Sunmola and Shehu (2020)	Ari Prasetyo (2019)	Afolabi et al. (2019)	Wimalasena and Gunatilake (2017)	Total Time Referred	
		CSF-SP-Tn02	√	√																		2	
		CSF-SP-Tn03	√							√			√		√								4
		CSF-SP-Tn04	√										√										2
		CSF-SP-Tn05	√									√	√	√		√	√						6
		CSF-SP-Tn06	√									√											2
		CSF-SP-Tn07	√										√							√			3
	Technical	CSF-SP-Tn08	√										√										2
		CSF-SP-Tn09	√								√							√					3

Table 2. Legend

Ref Code	Construct
CSF-Pe-SK01	Skilled staff (technical expertise)
CSF-Pe-SK02	eTendering knowledge for staff
CSF-Pe-SF01	availability of Adequate resources (staff)
CSF-Pe-SF02	Staff turnover
CSF-Pe-SF03	Development of confidence to use new technologies
CSF-Pe-SF04	Risk-oriented attitude of staff when using eTendering
CSF-Pr-Pa01	The legal position of eTendering
CSF-Pr-Pa02	Different national approaches to eTendering law
CSF-Pr-Pa03	Pertinent case law
CSF-Pr-Pa04	Availability of effective regulation system
CSF-Pr-Pa05	Clarity of tenderer information law
CSF-Pr-Pa06	Clarity of tenderee information law
CSF-Pr-Pa07	Clarity of supplier information law
CSF-Pr-Pa08	Legality of electronic signatures
CSF-Pr-Pa09	Enforceability of electronic contracts
CSF-Pr-Pa10	Accepting that the construction tendering is complex
CSF-Pr-Pa11	One-off project feature (organisation has only one project)
CSF-Pr-Pa12	Electronic format not enough for construction work specifications
CSF-Pr-Pa13	Reassembly process of data transmitted
CSF-Pr-Pa14	Locating tendering information
CSF-Pr-Po01	Security of the process
CSF-Pr-Po02	Data transmission to the wrong person
CSF-Pr-Po03	Unauthorised viewing
CSF-Pr-Po04	Confidentiality of information
CSF-Pr-Po05	Prevention of tampering with documents
CSF-Pr-Po06	Electronic bid evaluation
CSF-Pr-Po07	BIM is part of tender document
CSF-WE-Le01	Effective leadership

Ref Code	Construct
CSF-WE-Le02	Top or strategic management commitment for eTendering
CSF-WE-Le03	Flexibility of organisation's laws and systems
CSF-WE-Le04	Forum to exchange ideas
CSF-WE-Le05	Clear vision and objectives
CSF-WE-Le06	Widely accepted eTendering system solution
CSF-WE-Le07	Company policy
CSF-WE-Le08	Not top priority of the company
CSF-WE-Le09	Quantifiable indicators of success for eTendering (such as KPI)
CSF-WE-Le10	Awareness that eTendering leads to corruption
CSF-WE-Mg01	No business benefits realised
CSF-WE-Mg02	Satisfied with current practices
CSF-WE-Mg03	Organisational magnitude of changing management
CSF-WE-Mg04	Fear of change to a new system
CSF-WE-Mg05	Insufficient assessment of new system before implementation
CSF-WE-Mg06	Cost of IT investment (all costs)
CSF-WE-Mg07	eTendering systems cost (includes system licences)
CSF-WE-Mg08	eTendering implementation cost
CSF-WE-Mg09	Insufficient financial support
CSF-WE-Cu01	Bureaucratic dysfunctions
CSF-WE-Cu02	National IT policy relating to eTendering issues
CSF-WE-Cu03	Publicity about eTendering
CSF-WE-Cu04	Awareness of best practice solutions
CSF-WE-Cu05	Different organisational cultures (industry wide)
CSF-WE-Cu06	Organisational (company) culture
CSF-WE-St01	Complex organisational hierarchical structure
CSF-WE-St02	Organisational hierarchical structure doesn't support IT implementation
CSF-WE-St03	Cross-disciplinary communication
CSF-WE-St04	Tendering process standardisation
CSF-WE-St05	Quantifiable eTendering contribution to the Return On Investment (ROI)
CSF-Te-SS01	External interoperability (integration) of eTendering system
CSF-Te-SS02	IT systems (eTendering excluded) have been implemented in an ad hoc manner
CSF-Te-SS03	Investment in incompatible systems
CSF-Te-SS04	Internal interoperability (integration) concerns
CSF-Te-SS05	Challenge to find an affordable technical solution
CSF-Te-SS06	Technical standardisation issues
CSF-Te-SS07	Compatibility issues
CSF-Te-SS08	System knowledge (immaturity of technology)
CSF-Te-SS09	Inadequate knowledge in implementing an eTendering system
CSF-Te-SS10	Linking eTendering system with Enterprise Resource Planning (ERP) system
CSF-Te-SS11	Difficulty of implementing eTendering system
CSF-Te-SS12	Interoperability (integration) with current communication systems
CSF-Te-Ne01	Company access to the Internet
CSF-Te-Ne02	Security concerns
CSF-Te-Ne03	Poor IT infrastructure
CSF-Te-Ne04	Do not have IT infrastructure for eTendering (software, hardware, support and network)
CSF-SP-Co01	Need for personal contact
CSF-SP-Co02	Cooperation with tenderer and subcontractors or suppliers
CSF-SP-Co03	Involvement of design office
CSF-SP-Co04	Have business relationship with companies providing eTendering solutions
CSF-SP-Ma01	A "wait-and-see" attitude among companies

Ref Code	Construct
CSF-SP-Ma02	Demand from tenderer
CSF-SP-Ma03	Pressure from competitors
CSF-SP-Ma04	Reduced number of local companies (national or international companies became targeted)
CSF-SP-Ma05	Regulatory framework within public procurement
CSF-SP-Tn01	Tenderer, tenderer, subcontractors and suppliers have symmetry of technical readiness
CSF-SP-Tn02	Tenderer and supplier have BIM experience
CSF-SP-Tn03	Data sharing with subcontractor or supplier partners
CSF-SP-Tn04	Contractors or suppliers should have minimum technical experience
CSF-SP-Tn05	Technical infrastructure within the construction industry
CSF-SP-Tn06	Poor industry standards for information interchange
CSF-SP-Tn07	Training services for eTendering system from tenderee to tenderer
CSF-SP-Tn08	Include training procedures for eTendering system in contract
CSF-SP-Tn09	Shared technical platform between tender parties to exchange document

According to Shukla, Khan, and Shah (2016) and followed by Mathenge and Wausi (2018) mentioned that the commitment of top or strategic management is one of the CSF of eTendering implementation in the construction industry. There is a high reliance on the top management's commitment and motivation in eTendering implementation in the construction industry as they are the decision-makers in organisation and construction projects. This is reflected in Table 1, where this factor is one of the highest times referred by the previous scholar. Top management commitment plays a significant role in milestone set up, resource commitment and mandating eTendering implementation (Mohammadi, 2013; Mathenge and Wausi, 2018). As refer to Table 1, fear of change to a new system under management sub-theme, organisational (company) culture under cultural sub-theme and tendering process standardisation under structure sub-theme are highly referred by previous scholars.

Networking, one of the factors under technology themes, refers to a connection between two or more points in a network. The construction industry depends on flexible and reliable internet infrastructure for networking (Zainon, Skitmore and Rahim, 2020). As shown in Table 1, security concerns have often been referred amongst the CSF factors of eTendering implementation. According to Sunmola and Shehu (2020), the ability of the platform to be accessible in different devices such as computers and smartphones and compatible in between the eTendering system with existing electronic resource system to make this process successful. Furthermore, internal interoperability (integration) concerns also become highly referred and followed by cooperation with tenderers and subcontractors or suppliers and technical infrastructure within the construction industry.

## RESEARCH METHODOLOGY

For this study, a literature review being adopted. There are 19 indexed journals reviewed with the published year from 2013 to 2020 – the information on numbers of papers based on the year published as in Figure 2 below. The factual fact has been filtered, and only information relating to the critical success factors (CSF) of eTendering implementation is to be considered and tabulated as in Table 1.

According to Figure 2, the highest number of journals referred is year 2016 with five journals. From year 2017 until 2020, only two journals each year highlighted the CSF of eTendering implementation in the construction industry.

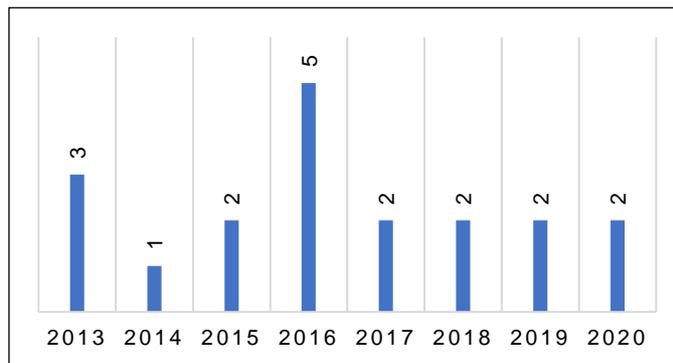


Figure 2. Number of Journals Referred Based on Year

### DATA ANALYSIS AND FINDINGS

The critical success factors (CSF) of eTendering implementation have been tabulated in Table 3 based on the highest times referred by the previous scholars. As shown in Table 3, security concern is a construct for CSF of eTendering implementation referred ten times over the eight years. Security concerns becomes the highest priority CSF of eTendering implementation in the construction industry, especially on the eTendering implementation as eTendering requires the internet platform to function. This is where the security concern comes in as it involves the database.

Table 3. Critical Success Factors (CSF) of eTendering Implementation

Theme	Sub-Theme	Ref Code	Construct	Total Time Referred
People	Skill	CSF-Pe-SK02	eTendering knowledge for staff	7
	Staff	CSF-Pe-SF01	Availability of adequate resources (staff)	6
Process	Practice	CSF-Pr-Pa04	Availability of effective regulation system	7
	Procurers	CSF-Pr-Po01	Security of the process	7
Work Environment	Leadership	CSF-WE-Le02	Top or strategic management commitment for eTendering	7
	Management	CSF-WE-Mg04	Fear of change to a new system	6
	Cultural	CSF-WE-Cu06	Organisational (company) culture	4
	Structure	CSF-WE-St04	Tendering process standardisation	4
Technology	System and Software	CSF-Te-SS04	Internal interoperability (integration) concerns	7
	Networking	CSF-Te-Ne02	Security concerns	10
Service Provider	Communication	CSF-SP-Co02	Cooperation with tenderee and subcontractor or suppliers	6
	Market	CSF-SP-Ma03	Pressure from competitors	2
	Technical	CSF-SP-Tn05	Technical infrastructure within the construction industry	6

The highest times referred has been identified and presented in Figure 3. Further from the security as highest times referred, the others constructs are knowledge for staff (skill subtheme under people), availability of effective regulation system (practice subtheme under process), security of process (procurers subtheme under process), top or strategic management commitment for eTendering (leadership subtheme under work environment), and internal interoperability (integration) concerns (system and software subtheme under technology) with seven times of referred respectively.



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