THE MEDIATION ROLE OF TRAINING ON THE RELATIONSHIP BETWEEN THE COMPETENCIES OF THE BUILDING INFORMATION MODELLING MANAGER AND THE PROJECT PERFORMANCE

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by

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"Do not judge me by my successes, judge me by how many times I fell and got back up again" – Nelson Mandela

The most valuable quotes illustrate my journey path in completing my Ph. D. There are several challenges that I go through to arrive at this stage, it was an emotional situation but I believe in myself and the ALLAH plan. Alhamdulillah, finally I completed my Ph. D.

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LIST OF ABBREVIATIONS

2D	2 Dimension
3D	3 Dimension
11th MP	Eleventh Malaysia Plan
12th MP	Twelve Malaysia Plan
4IR	Fourth Industrial Revolution
AD	Administration
AEC	Architecture, Engineering, and Construction
AFM	Asset and Facility Management
AGC	The Associated General Contractor of America
AIM	Asset Information Model
AMT	Asset Management Team
AR	Augmented Reality
AVE	Average Variance Extracted
BDS	Building Description System
BEP	BIM Execution Plan
BIM	Building Information Modelling
BIM PP	BIM Project Performance
BIM-SME	BIM-Subject Matter Expert
BPM	Building Product Model
CAD	Computer Aided Design
CIDB	Construction Industry Development Board
CITP	Construction Industry Transformation Program
CREAM	Construction Research Institute of Malaysia
CREaTE	Centre of Excellent for Engineering and Technology

CPIC	Construction Project Information Committee
CR	Composite Reliability
CSR	Critical Success Factor
CV	Convergent Validity
DOSM	Department of Statistics Malaysia
DV	Discriminant Validity
DandB	Design and Built
EIR	Exchange Information Requirement
FC	Functional
FM	Facility Management
GDP	Gross Domestic Product
GLIDE	Graphical Language for Interactive Design
GPM	Generic Building Model
HOPT	Head of Project Team
HODT	Head of Design team
HTMT	Heterotrait-Monotrait ratio of correlation
IBCH	Individual BIM Competency Hierarchy
ICI	Individual Competency Index
ICT	Information and Communication Technology
ICR	Consistency Reliability
IM	Implementation
IoT	Internet of Things
IT	Information Technology
IR	Indicator Reliability
JKR	Jabatan Kerja Raya
MCI	Malaysian Construction Industry
MCO	Movement Control Order

MEP	Mechanical. Electrical, Plumbing
MG	Managerial
MIDP	Master Information Delivery Plan
MP	Malaysia Plan
NBS	National Building Specification
OP	Operation
pHJKR	Penarafan Hijau JKR
PLS-SEM	Partial Least Squares Structural Equation Modelling
PMI	Project Information Model
PMBOK	Project Management Body of Knowledge Guide
PMCD	Project Manager Competency Development
PMT	Project Monitoring Team
PWD	Public Work Department
QUAN	Quantitative
QUAL	Qualitative
RD	Research and Development
RFID	Radio Frequency Identification
ROI	Return On Investment
RO	Research Objective
RQ	Research Question
SEM	Structural Equation Modelling
SP	Supportive
SPSS	Statistical Packages of Social Sciences
TC	Technical
TRA	Training
VIF	Variance Inflation Factor
VE	Value Engineering

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PERANAN LATIHAN SEBAGAI PENGANTARA ANTARA HUBUNGAN KOMPETENSI PENGURUS MODEL MAKLUMAT BANGUNAN DAN PRESTASI PROJEK

ABSTRAK

Pengurus BIM yang kompeten adalah penting dalam industri pembinaan, kerana peranan dan tanggungjawab mereka diperlukan sepanjang kitaran hayat sesebuah projek. Oleh itu, kompetensi yang tepat adalah penting untuk seorang pengurus BIM, kerana ia akan mempengaruhi prestasi projek melalui cara dia menguruskannya. Kajian ini bertujuan untuk meneroka peranan latihan sebagai pengantara antara hubungan kompetensi Pengurus Model Maklumat Bangunan (BIM) dan prestasi projek. Dalam kajian ini, empat objektif telah dibina, dan pendekatan kaedah campuran serentak digunakan. Temu bual telah dijalankan di kalangan 8 BIM-SME, dan hasil dapatan dianalisis melalui analisis kandungan. Sementara itu, untuk kaedah kuantitatif, borang soal selidik telah diedarkan kepada 58 Pengurus BIM dan data dianalisis menggunakan PLS-SEM. Triangulasi dapatan kualitatif dan kuantitatif telah dilakukan untuk membandingkan, membezakan dan mensintesis hasil dapatan kajian. Hasil dapatan menunjukkan hanya 5 daripada 8 set kompetensi iaitu pentadbiran (AD), keberfungsian (FC), pengurusan (MG), perlaksanaan (IM), dan penyelidikan dan pembangunan (RD) adalah penting pada tahap pertengahan sehingga pakar, manakala tiga set kompetensi lagi teknikal (TC), keoperasian (OP), dan sokongan (SP) berada pada tahap asas sehingga pertengahan. Bagi konstrak prestasi projek iaitu diagnosis, kebolehpercayaan dan pemantauan merupakan ukuran yang relevan untuk kajian ini. Hasil dapatan juga menunjukkan bahawa hanya set kompetensi perlaksanaan (IM) mempunyai kesan langsung yang signifikasi ke atas

perhubungan kompetensi pengurus BIM dan prestasi projek. Ini mungkin disebabkan oleh fakta di mana konstruk ini berkait dengan garis panduan, templat dan piawaian BIM, serta pembangunan pelan pelaksanaan BIM. Tambahan, faktor latihan sebagai pengantara dalam kajian ini, memberikan dapatan yang mengejutkan di mana ia tidak menyokong hipotesis kajian walaupun kebanyakan penyelidik telah membincangkan kepentingan latihan kepada kompetensi. Dapatan ini bercanggah mungkin disebabkan oleh faktor luaran kajian di mana saiz sampel yang digunakan adalah kecil dan hanya tertumpu kepada projek awam BIM. Walaupun dapatan daripada analisis kuantitatif ini tidak memberikan keputusan yang menggalakkan, tetapi, kajian ini perlu diberi perhatian kerana ia menyumbang kepada kajian empirikal sedia ada yang terhad mengenai kecekapan pengurus BIM dan prestasi projek. Akhir sekali, penyelidikan akan datang harus menangani batasan penyelidikan ini untuk mendapatkan hasil yang lebih baik.

THE MEDIATION ROLE OF TRAINING ON THE RELATIONSHIP BETWEEN THE COMPETENCIES OF THE BUILDING INFORMATION MODELLING MANAGER AND THE PROJECT PERFORMANCE

ABSTRACT

A competent BIM Manager is important in the construction industry, as their roles and responsibilities are needed throughout the project lifecycle. As a result, the right competencies are critical for a BIM Manager, as they will influence project performance through the way he or she manages it. This study aims to explore the mediating role of training on the relationship between the competencies of the Building Infromation Modelling (BIM) Manager and project performance. In this study, four objectives were constructed, and a concurrent mixed-methods approach was used. The interviews were conducted among the 8 BIM-SMEs, and the results were analysed through content analysis. Meanwhile, for quantitative method, questionnaire were distributed to 58 BIM Managers which the data were analysed using PLS-SEM tool. A triangulation of qualitative and quantitative findings was performed to compare, contrast, and synthesise the data. The findings revealed that only 5 out of 8 competency sets which are administration (AD), functional (FC), managerial (MG), implementation (IM), and research & development (RD) were important at the intermediate to expert levels, while another three competency sets; technical (TC), operational (OP), and supportive (SP) were at the basic to intermediate level. For the project performance constructs, the project diagnosis, reliability, and monitoring were relevant measurements. The findings also demonstrated that only implementation (IM) competency set has a significant effect on the direct relationship between the competencies of the BIM Manager and project performance. This is perhaps due to the

fact that this construct connected to the BIM guidelines, templates, and standards, as well as the development of the BIM execution plan. Furthermore, the training factor which was tested as mediator in this study, surprisingly did not support the hypothesis eventhough many scholars have discussed about training as important area to be addressed in the field of competencies. This contradict result is may be caused by external factors of the study setting where small sample size were used and current study only focus on BIM public project. Eventhough the quantitative analysis did not give favourable result, however, this study is noteworthy as it contributes to limited existing empirical study on the competencies of the BIM Manager and project performance. Ultimately, future research should address the limitations of this research to get a better result.

CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter presents an overview of the introductory chapter for this research. This chapter contains seven sections, beginning with the background of the study, followed by the problem statement which is guided to the third section that is the research question created for this research. Then, it is followed by the research objectives and the significance of the study. Thereafter, in the sixth section, the scope of the study is discussed to specifically emphasize the limitation of this research. Lastly, this chapter ends with the thesis outline.

1.2 Background of the Study

The construction industry is one of the most imperative industries. It acts as a multiplier effect on other industries by constructing buildings and facilities, that can be used by the industries to carry out their activities effectively and efficiently (Musa, 2019). Besides, this industry is significant for national development, especially in providing infrastructure and amenities for the nation such as highways, hospitals, schools, and sports complexes (Hussin, Rahman, and Memon, 2013). This industry is unique due to the dissimilarity between each developments according to the construction period, cost, scope, quality and risks, as well as the process of the development even though the project is built at the same location with the same design (Jabar et al., 2014). Moreover, the conventional construction method is still widely used among the construction players in this industry (Othuman Mydin, Sani, and Phius, 2014). As indicated by previous researchers, the conventional construction

method is less effective in managing the project performance in terms of construction time and cost. This method apparently contributes to the delay in the project scheduling and the cost overrun during the construction lifecycle due to improper planning and risk identification at the earlier stage of the project development (Aung, 2018; Hammad and Akbarnezhad, 2017). As such, Building Information Modelling (BIM) has been used to overcome the issues, as well as to improve the project delivery and the project performance.

Globally, BIM has been widely implemented in the construction industry since the mid-year of 2000 in the Architecture, Engineering, and Construction (AEC) organization with the United State of America as the first country to implement it. Nowadays, the number of BIM adopters is increasing year by year, mostly in developed and developing countries such as the United Kingdom, Germany, Australia, Hong Kong, Finland, Denmark, Singapore and China. According to O'Malley (2021), the percentage of construction companies that adopted BIM in 2021 for the United Kingdom was 73% while in Germany was 70% since the BIM becomes mandatory for these countries. Meanwhile, even though BIM is not yet mandatory, the percentage has reached 60% companies in France.

Apparently, in Malaysia, although this technology was introduced in 2007, the implementation of BIM in Malaysia is still immature after fifteen (15) years. However, the BIM adoption among the AEC companies in Malaysia has increased from 17% in 2016 to 49% in 2019. Nevertheless, it is still low compared to other Asian developing countries like Singapore, Hong Kong, and China (Ismail, Chiozzi, and Drogemuller, 2017) due to the limited of skilled BIM practitioners to lead project and the

government has not yet mandating BIM as a mandatory construction method for all types of projects (CIDB, 2017b; Roslan et al., 2019). However, in Malaysia, BIM is required to be used for a public project worth RM100 million and above (CIDB, 2017a). Parallel to the global construction industry, the Malaysian government has started to urge the construction industry to implement BIM in their construction project (Ahmad Latiffi, Mohd, and Brahim, 2014; Ghaffarianhoseini et al., 2016). This plan has been mentioned in several government five years planning for the construction industry including the Eleventh Malaysia Plan (11^{th} MP), Construction Industry Transformation Programme (CITP) 2016 – 2020, JKR Strategic Plan 2016 – 2020, Twelfth Malaysia Plan (12^{th} MP), and the latest is in the Construction 4.0 Strategic Plan 2021 – 2025. In this planning, Malaysia has targeted to achieve 50% of BIM adopters in the year 2021 and 80% by the year 2025 (Abd Rashid, 2020; CIDB, 2020a).

Thus, to achieve the target, the government aims to build BIM competence by enhancing the BIM knowledge and skills as well as providing comprehensive BIM training towards the construction players in Malaysia construction industry. Table 1.1 shows the government's five-year plan that focuses on the strategies to enhance the BIM implementation by concentrating on BIM knowledge and training.

Table 1. 1 Five-Year Strategic Planning Related to Enhancing BIM Implementation in Malaysia

No.	Malaysia's Strategic Planning	Section/Chapter	Target
1.	Eleventh Malaysia Plan (11MP) (2016 – 2020)	Chapter 8: Focus Area D: Transforming Construction	• *Strategy D1: Enhancing Knowledge Content* Increase human capital by providing adequate training and knowledge to produce a highly-skilled workforce. • *Strategy D2: Driving Productivity* Increase the project productivity and performance by adopting and utilizing modern construction methods and technologies (BIM, IBS), as well as reducing dependency on low-skilled labor.
2.	Construction Industry Transformation Programme (CITP) 2016 – 2020	Strategic Thrust Productivity: Initiative P1 (Continue investment in human capital development in construction)	• *P1a:* Streamline construction-related training programs in Malaysia • *P1b:* Strengthen reach, effectiveness and comprehensiveness of training.
		Strategic Thrust Productivity: Initiative P4 (Roll out technology advantages across project lifecycle)	• *P4a:* Facilitate BIM adoption in the construction industry via regulation • *P4b:* Establish a reference centre to support the development and the adoption of BIM and modern methods • *P4c:* Implement competencies and learning management system
3.	JKR Strategic Planning 2016 – 2020	Theme 1: Strategic 3 (T1.3): Developing Project Management Competencies	• Project management skills are required to enable the project to be carried out effectively, efficiently, and successfully. One way is through certification/recognition.
4.	Twelfth Malaysia Plan (12MP) (2021 – 2025)	Theme 1: Resetting the Economy	• *Chapter 2*: Restore Growth Momentum
		Policy Enabler 2: Accelerating Technology Adoption and Innovation	• *Chapter 11*: Boost Digitalization and Advanced Technology
5.	Construction 4.0 Strategic Plan 2021 – 2025	Strategic Thrust 3: Smart Integrated Technology, Innovation and Infrastructure	• *Strategic Objective 1:* Enforcement of new technology implementation for a local company and encourage the early implementation and adoption • *Strategic Objective 2:* Infuse emerging technologies in construction practice.

Source: (CIDB, 2015, 2020a; EPU, 2015, 2021; JKR, 2016)

Therefore, Malaysia requires current and future skilled BIM practitioners to be competent and well trained because, without a competent BIM practitioner, the industry would suffer from slow BIM implementation and fail to achieve the government target (CIDB, 2020a). Most of the previous studies have shown that the industry needs to have a large number of skilled BIM practitioners to support and lead the industry to implement BIM and the limitation of it may slow the uptake of modern technology in the Malaysian Construction Industry (MCI) (CIDB, 2015; EPU, 2015; Gathercole and Thurairajah, 2014; Rahman, Alsafouri, Tang, and Ayer, 2016; Uhm, Lee, and Jeon, 2017).

There are a few studies that have identified a variety of skilled BIM practitioners according to the BIM job titles. As discussed by Barison and Santos (2010) eight groups are identified as skilled BIM practitioners consisting of BIM Modeller, BIM Analyst, BIM Application Developer or BIM Software Developer, Modelling Specialist, BIM Facilitator, BIM Consultant, BIM Researcher, BIM Manager (also known as Project Model Manager or Modelling Manager or Model Manager) with a specific set of responsibilities. However, only three roles are highlighted as the BIM specialists that contribute both internally and externally to an organization which are BIM Modeller, BIM Coordinator, and BIM Manager. The identification is in line with studies by Uhm et al. (2017) and Davies, Wilkinson, and McMeel (2017) that acknowledged some titles in the BIM job have similarities, and duplicate the roles and the responsibilities of other titles which can be summarized into three main BIM professional or skilled BIM practitioners grouped as BIM Modeller, BIM Coordinator, and BIM Manager.

The roles of BIM Modeller and BIM Coordinator are mainly at the design stage. They are responsible for developing and coordinating in building model to ensure the model is in the best design according to the design specification, and follow the BIM standards and protocols (Davies et al., 2017). Meanwhile, the roles and the responsibilities for BIM Manager cover throughout the project development lifecycle including managing the BIM process, the project stakeholders, and the use of the model, as well as acting as a decision-maker (Barison and Santos, 2010; Davies et al., 2017). In conjunction with the continuous roles and responsibilities that need to be presented by a BIM Manager, the right competencies for a BIM Manager are vital to be identified because the project performance is influenced by the way a BIM Manager controls the project. The project will be in risk if the BIM Manager is not yet a skilled BIM-ready (Uhm et al., 2017; Zainal Abidin, Fathi, Md Daud, & Baharum, 2017).

The effectiveness and the efficiency of project management during the project development is crucial and able to influence the project performance (Ahmed & Anantatmula, 2017). Since the BIM Manager is leading the project, the competencies of a BIM Manager are highly influential in improving the project performance, especially in the decision-making process, managing and controlling the information in BIM, and ensuring the project is delivered according to the requirements (Pereira and Lima, 2018). Therefore, the project performance is important to be measured throughout the project development to ensure that it is at its best level since the aim of BIM adoption in a project is to improve the project performance (Won & Lee, 2016).

In the perspective of this research, the competencies of the BIM Manager were the main focus since the BIM Manager is responsible to lead the BIM project and it is

significant to assign a person who has BIM competencency and capability to run and to manage the BIM project lifecycle. Therefore, the competencies of the BIM Manager in terms of BIM knowledge, skill, situation enabler, and experience are vital in conducting a project. Besides, there are also additional competencies that need to be considered to ensure they are capable to manage, to control, and to monitor the BIM project efficiently and holistically (Succar, Sher, & Williams, 2013).

Although a BIM Manager have lots of experience in the construction industry, BIM technology will give them a new piece of experience in working with digitalization. Thus, comprehensive and adequate training related to BIM is necessary for the purpose to enhance their understanding and capabilities in BIM. As stated in the previous studies, the lack of BIM knowledge and formal BIM training, as well as unclear roles and responsibilities of the BIM participants will limit the potential of BIM in a project and overall collaboration (Moreno, Olbina, & Issa, 2019; Memon, Abdul Rahman, Memon, & Azman, 2014; Gu & London, 2010). Therefore, the need for a comprehensive, improved and up-to-date BIM training module is crucial, either in an organizational or tertiary education level, and it should complement with the present industry needs. BIM training is one of the driving factors that can help the industry towards BIM-literate.

A comprehensive BIM training will help BIM Managers to strengthen their BIM competencies by learning new skills, acquiring knowledge, and staying up-to-date with the industry development. Training also has a very significant role in project performance in which a highly trained BIM Manager will not only improve the individual skill and experience but will also influence the project performance due to

the improvement of capability to adapt to any new changes in the form of new technologies (Nik Adik, 2014). Since digitalization in the construction industry is emerging, extensive training can facilitate the BIM Manager to learn how to handle the BIM project lifecycle, stakeholders, BIM Model, BIM execution plan, and many more. Consequently, there is a potential relationship between the competencies of a BIM Manager and the BIM project performance with the involvement of training. Yet, this relationship has not been adequately defined. Thus, concerning this gap of knowledge, this research was developed to explore the relationship based on the problem statement that anchored this study in the next section.

1.3 Problem Statement

The transformation of the construction industry into modern construction method and technology has resulted in increased project productivity and project performance. The impressive building design with various shapes and functions is one of the improvements that can be seen everywhere, including in Malaysia. Due to that, construction projects are becoming more complex, and some of the development cannot be done through the conventional construction method (Ajugiya, Bhavsar, & Pitroda, 2016). Therefore, Building Information Modelling (BIM) was introduced to overcome the limitation of the conventional method, and at the same time improving the project performance (Ahmad Latiffi, Mohd, Kasim, and Fathi, 2013; Tahir, Haron, Alias, Harun, et al., 2018).

In this regards, to successfully implement the BIM, the key problems that contribute to the low BIM implementation should be identified to manage the problems effectively. Most of the previous literature mentioned that the “people” factor has contributed to the major problem for the low BIM implementation particularly related

to the lack of BIM Competent among the construction players in MCI (Ahmad Jamal, Mohammad, Hashim, Mohamed, & Ramli, 2019; Utomo Dwi Hatmoko, Jati; Kistianti, Frida; Khasani, 2017; Singh & Holmstrom, 2015; Enegbuma, Aliagha, Ali, & Ali, 2014; Zahrizan Zakaria, Mohamed Ali, Haron, Marshall-Ponting, & Abd Hamid, 2013; CIDB, 2015, 2020; EPU, 2015). This problem does not only happened in MCI but also in other countries that implemented the BIM. For instance, in the United Kingdom, even though this country recorded the highest BIM adopters with 73% in the year 2021 (NBS, 2019; O'Malley, 2021), they are still facing some difficulties in the digitalization process due to the lack of skilled BIM practitioners and BIM trained personnel who are competent in operating BIM (Hamma-adama and Kouider, 2019). Similarly, Singapore also faces the same issue which has prompted the Singapore government to focus on developing skilled BIM practitioners by designating "Build up BIM expertise" as one of their initiatives in preparing skilled BIM practitioners who can manage, monitor and control the BIM project efficiently (Seah, 2013; Tai Fatt, 2013; Zahriza Zakaria, Mohamed Ali, Haron, Marshall-Ponting, and Abd Hamid, 2014).

Based on the above mentioned problems, the first and foremost issue is the competencies of the BIM Manager. A BIM Manager is a change agent and the key innovator that has a significant role and responsibilities in facilitating the construction industry to transform into digitalization technology and the roles are continuous within the project lifecycle (Holzer, 2016). Therefore, in order to assume the roles and responsibilities of a BIM Manager, an individual should have the right competencies and level of competence for each competencies. Thus, an extensive research on the competencies and the level of competence required for a BIM Manager is needed to measure the competencies of the BIM Manager in MCI. It is important to have BIM

Managers with the right BIM competencies to lead the transformation of the industry into BIM because it is not an easy task to successfully implement the BIM if the industry only has limited competent BIM Managers (Ahmad Latiffi, Mohd, and Rakiman, 2016; KPMG, 2017). Therefore, this scenario has triggered the following question, **"What are the competencies and the level of competence required for BIM Managers to effectively manage the BIM project in the Malaysian construction industry?"**.

Moving next is the issues on the project performance. A competent BIM Manager with comprehensive BIM knowledge, skills, and competencies would effectively manage the project, make better decisions, and be able to contribute positively to project performance compared to the uncertified BIM Manager (Hosseini, Asce, Martek, Papadonikolaki, and Sheikhkhoshkar, 2018; McPartland, 2017). It is crucial to be concerned about the BIM project performance (Kassem, Liyana, Raoff, and Ouahrani, 2018; Teng, Tobi, and Fathi, 2018). The project performance can predict its success, and the success factor will affects the project performance (Cooke-Davies, 2002). In a BIM project, the project performance could be improved through the way a BIM Manager controls the whole project management, stakeholders' collaboration, communication, and project information physically and digitally during the project lifecycle (Ahmad Latiffi et al., 2013; Boje, Guerriero, Kubicki, and Rezgui, 2020; Klinc and Turk, 2019; Sawhney, Khanzode, and Tiwari, 2017). Most of recent studies have discussed the project performance from a general perspective as time, cost and quality performances (Franz, Leicht, Molenaar, and Messner, 2017; Franz and Messner, 2019; Gyarteng, 2014; Hadzaman, Takim, and Nawawi, 2015; Marzouk and Enaba, 2019; Phui Fung, 2015; Teng et al., 2018). However, only a few of them

focused on project performance specifically on BIM which measured the project performance through the rework and design error detection and reflection, the response time of BIM issues, the change orders, the BIM Return on Investment (ROI), the BIM model quality, and the modelling productivity (Crowther and Ajayi, 2019; Du, Liu, and Issa, 2014; Won and Lee, 2016). It is important to figure out the appropriate measurement for measuring the project performance for a BIM project to achieve the desired project and accomplish the BIM project objective (Baccarini, 1999). Therefore, this problem triggered the second question for this research **"What is the measurement that can be used to measure the BIM project performance?"**.

As mentioned by Hosseini et al. (2018), a BIM Manager is responsible for managing the entire management and administration process in a BIM project from organizing, planning, scheduling, directing, controlling, monitoring and evaluating the BIM processes. BIM Manager is also responsible for ensuring the project is aligned with the project objectives and results in a better project performance (Deutsh, 2011; Succar et al., 2013). These studies have illustrated that there is a potential relationship between the competencies of a BIM Manager and the BIM project performance either directly or indirectly as it depends on knowledge, skill, attitude, and expertise of a BIM Manager in managing the overall situation throughout the BIM project lifecycle. However, this relationship is not yet well defined in the literature. Therefore, the research identified the gap in the area of the competencies of the BIM Manager and BIM project performance. Thus, this issue and problem have triggered the third question for this research, **"Do the competencies of the BIM Manager have an impact on the BIM project performance?"**

Moving forward in this research, to positively impact the relationship between the competencies of the BIM Manager and BIM project performance, the BIM Manager should improve their competencies in BIM to enable them to manage the project effectively, both physically and digitally. Also, a BIM Manager must be proficient in building information management because it is critical to ensuring the accuracy of the entire project information. Lack of competence in managing the project information will result in project delays and errors. Thus, training is critical to overcoming this issue, improving the competencies of the BIM Manager through training is believed to positively impact the BIM project performance. Training is required to assist the BIM Manager in improving their competencies and becoming BIM competent. The combination of competencies involving knowledge and skill for a specific task with extensive training will contribute to a positive relationship between the individual's competencies and the project performance. (Al-Nabae and Sammani, 2019; Barba Aragón, Jiménez Jiménez, and Sanz Valle, 2014; Nik Adik, 2014; Tabassi and Bakar, 2009).

Choosing to dig further, training have been found to positively mediate the relationship between organizational learning, knowledge transfer, motivation enhancement, self-renewal climate, job performance, employee performance, job satisfaction, and project success (Al-harthy and Yusof, 2016; Dar, Bano, and Ahmed, 2020; Ngai, Cheung, and Yuan, 2016; Obaid, 2018; Podgórska and Pichlak, 2019; Sahebnazar and Dadfar, 2016; Sarkis, Gonzalez-Torre, and Adenso-Diaz, 2010; Shen and Tang, 2018). However, no prior research has been conducted on the role of training in mediating the relationship between the competencies of the BIM Manager and BIM project performance. In agreement, this research identified training as the potential mediator

in the relationship between the competencies of the BIM Managers and project performance. As a result, the fourth research question, **"How does training as a mediator influence the relationship between the competencies of the BIM Manager and the BIM project performance?"** .

1.4 Research Questions (RQ)

According to the statement of the research problem, there are four research questions (RQ) mentioned in this study to be answered. The research questions are;

i. What are the competencies and the level of competence required for BIM Managers to effectively manage the BIM project in the Malaysian construction industry?
ii. What is the measurement for the BIM project performance?
iii. Do the competencies of the BIM Manager have an impact on the BIM project performance?
iv. How does training as a mediator influence the relationship between the competencies of the BIM Manager and the BIM project performance?

1.5 Research Objectives (RO)

Following the previous discussion and the problem statements, this study aimed to explore the competencies of the BIM Manager towards the BIM project performance by taking into account the role of training as a mediator. To explore this research, the objectives are highlighted as follows;

i. To explore the competencies and the level of competence required for BIM Managers to effectively manage the BIM project in the Malaysian construction industry.

ii. To identify the BIM project performance measurements.

iii. To identify the significant relationship between the competencies of the BIM Manager and the BIM project performance.

iv. To determine the effect of training as a mediator on the relationship between the competencies of the BIM Manager towards the BIM project performance.

1.6 Scope of the Study

The scope of the study is establish to ensure that the research focuses on the right lead and gathers the right data to answer the research questions in this research. Thus, the scopes established for this research are limited to the following aspects;

i. In the qualitative part, the semi-structured interviews were conducted among the BIM-Subject Matter Expert (BIM-SME) from the BIM Unit of Public Work Department (PWD) and BIM CIDB who are involved in the development of the BIM manual, BIM standards, BIM roadmap, BIM training module and as accessors to the BIM Manager certificate award. Semi-structured interviews were used to explore the latest information on the current BIM scenario at MCI, the BIM Manager selection process, and the competency parameters used as an assessment to be awarded as a certified BIM Manager.

ii. In a quantitative aspect, the online survey was distributed among BIM Managers with one of the following criteria;

- ♦ Certified BIM Manager
- ♦ Completed the BIM Manager training (part 1 and part 2) from MyBIM-CIDB,
- ♦ Participants of the BIM Manager Competency Certification of CREaTE JKR (Levels 3 and 4),
- ♦ BIM Manager currently involved as a BIM Manager in 16 ongoing public BIM projects.

iii. Public BIM projects were selected based on the commencement between the years 2016 and 2020, linked to the Construction Industrial Transformation Programme (CITP) 2016 – 2020 and Eleventh Malaysia Plan (11^{th} MP).

iv. The aspects of training as the mediator were chosen to see the impact of BIM training on the relationship between the competencies of the BIM Manager towards the BIM project performance. Without the appropriate BIM training, the BIM Manager will not be able to manage, monitor and control the BIM project progress and consequently will fail to guide the project team to deliver the BIM project successfully.

v. Current study only cover BIM projects in public sector. The reasons as follows:

- In the private project, project development process and procedures are based on different regulations (typically based on United Kingdom (UK) BIM standards and framework) which are not in line with Malaysian standards and guidelines.

- Since this study focus on the BIM Managers who are certified from MyBIM-CIDB and CREaTE JKR because of higher score on the BIM Manager assessment, BIM Manager from private sector are excluded because majority of them are certified by external accreditation body.

1.7 Significance of the Study

This research contributes to an in-depth study of the competencies of the BIM Manager, which is important for the industry to ensure that the selection of a BIM Manager is done properly by placing the right person with the right competencies in the right position. A competent BIM Manager is an essential element to consider in improving BIM project performance as it will affect the way the project is being managed. Furthermore, an accurate project performance measurement also needs to be highlighted specifically for BIM projects to ensure the BIM project objective is achieved. As such, this study focuses on the relationship between the competencies of the BIM Manager and project performance. Furthermore, training as an essential construct for improving the competencies of a BIM Manager and enabling them to manage the project information both digitally and physically has been proposed. This argurement based on the fact that training always been recognized as prime engine for personal growth. A competent BIM Manager can be developed by undergoing extensive training that includes both theory and the on-the-job training. Through the extensive training, a BIM Manager can also become more knowledgable and confident in leading the project efficiently, thereby improving the project performance. Therefore, this research also explores the effect of training on the relationship between the competencies of the BIM Manager and the BIM project performance. The findings

of this research will shed some light on the competencies that need to be carefully considered in preparing a competent BIM Manager in the future. Thus, the result from this research will help individuals, organizations, industries, and academics to have a better understanding of the competencies of the BIM Manager and project performance. Ultimately, it will help the industry make better decisions when selecting a competent BIM Manager.

In terms of knowledge, this research contributes to the field of project management by providing insight into the effect of the BIM Manager competencies on the BIM project performance. The research also focuses on individual competencies that describe the competencies of the BIM Manager as antecedents, with the stated variables being the key elements. In addition, the research also provides new insights into the BIM project performance measurement that need to be considered in enhancing BIM project performance in the context of MCI. Therefore, the research also focused on enriching the human factor perspective in project management in the context of developing countries as well as in the local area. This study is also relevant to the educational sector, as it established the required competencies of the BIM Manager that can be used by educational institutions to equip their students with these competencies and produce BIM-ready graduates.

Additionally, for the construction industry perspective, the findings of this research will be significant to the construction industry as it highlighted the competencies that are critical in preparing a competent BIM Manager. Thus, it will help the industry to plan the short and long-term plannings to improve the competencies of the BIM Manager in parallel with the global market. Moreover, the research is also significant

for the industry to develop ideas for a suitable syllabus to enhance the BIM knowledge and to provide adequate training for the existing and new BIM Managers, as well as to familiarize them with the new BIM technology, be it hardware, software, or BIM devices. To ensure that prospective BIM Manager candidates have a proper awareness of the competencies and the levels of competence that required for them to be appointed as BIM Manager, the present study should be one of the references they can refer to.

This research can also be a parameter to the construction organizations in placing the right BIM Manager for their BIM project by considering all the competencies listed in this research before hiring a BIM Manager. This way, they can ensure that they are selecting the right BIM Manager with the right BIM competencies to manage the BIM project. Besides, the right BIM Manager will lead the project for better project management and enhance the project performance. For the individual, the research will give the BIM Manager candidates the information about the current industry requirement for a BIM Manager. This study will facilitate both BIM Manager candidates and the existing BIM Manager to improve their readiness to understand the roles, the competencies of a BIM Manager, and the levels of competence that required in the BIM management and technical skills, the ability to use the BIM tools as well as the ability to implement a suitable BIM technique for a BIM project. Therefore, this study also is crucial for individuals as it helps them to strengthen their competency and proficiency as BIM Managers.

1.8 Thesis Outline

In preparing for a well-organized research dissertation, a chapter layout has been developed to summarise the chapters of this dissertation into a comprehensive understanding of what will be discussed in this research.

This dissertation begins with Chapter 1 as the Introduction. This chapter discusses the main idea of this research. This includes the research background, the problem statement, the research questions, the research objectives, the scopes of the research, the significance of the study, and the outline of the thesis.

Then, Chapter 2 addresses in detail the area relevant to this research. It includes an overview of the Malaysian construction industry, Building Information Modelling (BIM), the competencies of the BIM Manager, the levels of competence for the BIM Manager, the BIM project performance measurement, and the training as the mediator. In addition, this chapter also emphasizes past studies that are closely linked to this particular topic. An extensive discussion of the mentioned topic leads to the development of the theoretical framework and the research hypotheses. At the end of this chapter, a conceptual framework for this research was developed.

Chapter 3 describes the research methodology. This chapter explains the design and the methodology of this research based on the research developed by Saunders. It includes the research philosophy, the research approach, the methodological choices, the research strategies, the time horizon, and the techniques, as well as the procedures. Besides, this chapter also explains the data sources, the sampling technique, the data collection instrument, and the analysis technique.

Next, Chapter 4 presents the analysis of the research data and highlights the major findings of the research. As the data was collected using qualitative and quantitative methods, the data were analysed and interpreted using the technique of content analysis using NVivo Plus 12 for the qualitative analysis. For quantitative analysis, Partial Least Squares Structural Equation Modelling (PLS-SEM) was used using Warp PLS 7.0. The chapter begins with the background of the respondents, followed by an analysis of the qualitative and quantitative data. The semi-structured interview was transcribed and the important content was extracted and analysed. For the online questionnaire survey, the assessment of the measurement model, the structural assessment, and the mediation analysis are presented. The results were then triangulated, compared, contrasted and synthesized to obtain the final results for this research.

Chapter 5 summarises the hypotheses and the results that emerged from the data analysis presented in Chapter 4. The hypotheses were tested, the research questions were answered, and the research objectives were discussed to ensure that each objectives were met in this research. Thus, the significant and insignificant relationships were also identified in this chapter. Finally, the mediation role also was determined based on the findings of Chapter 4.

Finally, Chapter 6 addresses the conclusions of this research and the suggestions for government, industry and academics that flow from the findings. Lastly, the limitations and the recommendations for future research are presented.

1.9 Definitions of Key Terms

Table 1.2 operationally defines the key terms that are used in this study. The definitions are drawn from the review of the literature and related studies. Although precise definitions of the terms are provided in other sources, the definitions that are given in Table 1.2 provide a basic understanding of these terms as they are used in the context of this study.

Table 1. 2 Definitions of Key Terms Used in the Study

Term	Definition
Building Information Modelling (BIM)	The integration of building information from different specialization (architecture, structure, MEP, costing, etc.) into one virtual building modelling database where the information is gathered, measured, analysed, synthesized, and modified through that digital building modelling. The efficiency and effectiveness of building information in BIM are not only dependent on the process of building information itself but it also dependent on the BIM competent to efficiently manage the project information and process both digitally and physically to ensure all the information is accurate, able to understand by the project stakeholders, and the most important is to improve the project productivity and performance.
BIM Manager	A BIM Manager is a person that can combine their construction management experience, computerization, and digitalization skills to lead and coordinate the BIM information and process in a project including developing, implementing, and managing BIM standards, coordinating and supporting the project team to ensure the information flow is accurate, assessing and resolving the BIM issue within the project as well as conducting internal BIM training for their organization.
BIM Project Performance (BIM PP)	The process of completing a project in accordance with the specific pre-set accuracy of measures that fulfil the schedule conformance, budgeted cost, design errors detected by BIM, change orders, response times of BIM issue, and BIM model quality (including effectiveness, accuracy, and usefulness).

Table 1.2 (Continued)

Term	Definition
BIM Subject Matter Expert (BIM-SME)	A professional who possess advanced knowledge and skills in BIM technology, process, and methodology. A BIM-SME typically has a deep understanding of BIM software and tools, as well as ability to apply BIM processes to building and infrastructure projects. They involve in various stages of a project, from design and construction to operation and maintenance. They also involved in developing the BIM manual, standards, templates, and guidelines for MCI.
Domain Competencies Tier	This competency tier is to measure how an individual performs multi-task activities and what method they employ to fulfil the simple or complex delivery requirement.
Primary Competency Set	This competency set is denotes the individual's professional abilities
Secondary Competency Set	This competency set represent the individual's supplementary abilities to the primary competency set.
Managerial (MG)	The decision-making abilities of an individual to drive the selection/adoption of long term strategies and initiatives (Succar et al., 2013)
Functional (FC)	This set is representing the non-technical, overall abilities required to initiates, manage and deliver projects (Succar et al., 2013)
Technical (TC)	Abilities that required an individual to generate project deliverables across disciplines and specialities (Succar et al., 2013)
Supportive (SP)	The competencies are the abilities required to main- tain information and communication technology (ICT) systems (Succar et al., 2013)
Administration (AD)	The activities required to fulfil and maintain organisational objectives (Succar et al., 2013)
Operational (OP)	Describing the practices and efforts required to deliver a project or part/aspect of a project (Succar et al., 2013)
Implementation (IM)	The activities required to introduce transforma- tive concepts and tools (revolutionary or evolutionary) into an organisation (Succar et al., 2013)
Research and Development (RD)	The activities required to evaluate existing processes, investigate new solutions and facilitate their adoption within the organisation or by the larger industry (Succar et al., 2013)

Table 1.2 (Continued)

Term	Definition
Project Reliability	Ability to perform a task as planned time-wise by measuring the BIM progress continuity/consistency, BIM planning efficiency, and BIM collaboration and education (Crowther & Ajayi, 2019)
BIM Planning Efficiency	To manage and effectively conduct the project planning with the purpose to achieve the project objective and goals (Crowther & Ajayi, 2019)
BIM Collaboration and Education	Encourage the project stakeholders' collaboration in a project by improving their skills, knowledge, and understanding of the specific BIM application and the planned activities (Crowther & Ajayi, 2019)
BIM Progress Continuity/Consistency	To ensure BIM drives the project forward and ensures the progress is retained throughout all the necessary stages (Crowther & Ajayi, 2019)
Project Monitoring	Ability to efficiently keep track of the overall aspects involved in a project like BIM assessment and directive, and BIM external technology and logic utilization (Crowther & Ajayi, 2019)
BIM Assessment and Directive	according to the past information obtained from the previous project (Crowther & Ajayi, 2019)
BIM External Technology and Logistic Utilization	Enhancing the utilization of other technologies that are related to BIM, whilst still being able to apply expert logic to further enhance the monitoring process (Crowther & Ajayi, 2019)
Project Diagnosis	Ability to identified issues and problems that occurred in the project and identified the most effective way to deal with them by considering the BIM comprehensive risk reflection, BIM timely reflection, and BIM treatment and relapse prevention (Crowther & Ajayi, 2019)
Comprehensive Risk Reflection	The ability to delve deep into identifying and mitigating risks. It is not only highlighting the risk but also involves the necessary resources to help address the issue across all relevant stages in the project (Crowther & Ajayi, 2019)
BIM Timely Risk Reflection	The early risk identification can prevent the project from being delayed and make sure all the design and construction processes can be done promptly (Crowther & Ajayi, 2019)
BIM Treatment and Relapse Prevention	This component is related to how BIM allows the project stakeholders and the software to devise solutions to mitigate the identified risk and build further solutions to prevent recurring risks in the future (Crowther & Ajayi, 2019)

Table 1.2 (Continued)

Term	Definition
Training	Training is a process of developing work-related knowledge and skills of an individual that positively impact the improvement of individual, job, and project performance.
Essential competencies	The competencies that are *highly required/critical* for a competent BIM Manager
Requisite competencies	The competencies that are *required* for a competent BIM Manager
Ancilliary competencies	This competencies is *encouraged* for a BIM Manager to possess as it can enhance the ability of a BIM Manager's knowledge and skill as well as facilitate other construction players to implement the BIM
Complementary competencies	This competencies *are not essential* for a BIM Manager but basic knowledge is still required as the added value.